

Norwegian University of Life Sciences
Faculty of Landscape and Society
Department of Urban and Regional Planning

Philosophiae Doctor (PhD)
Thesis 2021:87

Assembling drinking water quality and inequality: the case of Kaolack, Senegal

Drikkevannskvalitet som assemblage:
en casestudie av Kaolack, Senegal

Elizabeth Ann MacAfee

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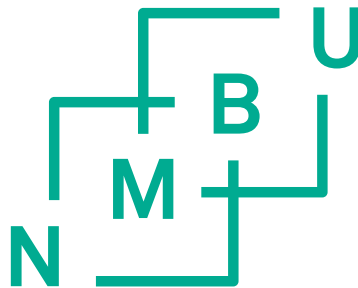
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Ås (2021)



ISSN: 1894-6402

ISBN: 978-82-575-1864-6

Thesis: 2021:87

Acknowledgements

Thank you to NMBU and BYREG for giving me the space to indulge my curiosity these three years.

I have been incredibly lucky in the supervision I have received throughout the PhD process. I would first like to thank Synne Movik, for encouragement, advice and friendship. Thank you also for always making me feel like a priority. I am also grateful to Matthew Cashmore for joining the team at the moment when I most needed assistance, and for forwarding me the first article I ever read about assemblage theory. Finally, thank you to Tim Richardson for being a critical friend, thoughtfully engaging with my ideas from the beginning and teaching me how to ski.

The discussants from the start, mid and end seminars (Esben Leifsen, Tor Arve Benjaminsen, Timos Karpouzoglou and Kathryn Furlong) provided invaluable advice and inputs at three very different moments in the PhD process. Sheena Gilchrist Lisland guided the PhD process, probably in more ways than I realise.

I would also like to acknowledge the work of the PhD thesis evaluation committee – Maria Rusca, Michele Lancione and Roberta Cucca.

In Senegal, many people shared their time, knowledge and *teranga* with me. I am indebted to Bobacar Gano and Babacar Sy for helping me to find a home in Kaolack and for the friendly company. Jamie Willard gave me a guided tour of Kaolack my first day, discovered the Bongré clando bar with me and shared her American cheese. It meant a lot to have a friend who was excited to hear about my latest peculiar Kaolack discoveries. Professor Seynabou Cissé Faye at Cheikh Anta Diop University in Dakar generously agreed to discuss water quality in Kaolack with me at length. The staff at WARC, and especially Mariane Yade, provided a welcoming space in Dakar and invaluable help to manage the practicalities of doing research in Senegal. Ndela Faye was an excellent and energetic research assistant and is a dear friend. Thank you also to Mariama Ndiaye, Adama Konaté, Fatou Sow, Adjii Thiaw, Ibrahima Thiaw, Talla Fall, Mami Ba, Moktar Fall, Josephine Ndour, Diambogne Ndour, Awa Mbaxal, Fatou Ndiaye, Youssou Thiom, Majalé

Sarr, Mame Fama Badiane, Galaaye Fall and so many others. I am forever indebted to everyone in Xol Xol, especially the Badiane family, Idy Sall and Diakhou Ndiaye for providing a home away from home I can always return to. Oulimata Diop, thank you for your patient and committed teaching of Wolof. *Jerengeenjef lol, menuma leen faay.*

I couldn't have made it through without a wonderful group of friends and colleagues here in Norway: Anette, Anita, Clayton, Conny, Erica, Hans, Ida, Ingvil, Lutgart, Neil, Noé, Marina, Rune, Veronica and of course Rebecca. Bill and Kirsti Warner, thank you for all the *koselig* dinners and great conversations. Thank you also to the friends back home who stayed in touch through this long period away, and especially to the speculative fiction book club.

Of course, thank you to my family for raising me to believe I could achieve anything I set my mind to and instilling a lifelong love of learning and reading. None of this would have been possible without your support.

And thanks always to Jack, for everything.

Summary

Declining drinking water quality poses urgent and ubiquitous problems for human health and well being. Millions of people are regularly exposed to potentially harmful substances via their drinking water, in ways that are neither uniformly distributed nor inevitable. Cities in the Global South in particular face growing drinking water quality challenges linked to rapid urbanisation, climate change and pollution. Many prevailing approaches to drinking water quality governance treat quality as a quantifiable and objective condition which can only be known by experts through scientific measurement. Increasingly, scholarly work in geography, environmental studies and cognate fields recognises that environmental problems, including drinking water quality, are more than material; they are also social and ethical challenges. There is, therefore, need for developing theoretical approaches that can encompass the social, material and ethical complexity of drinking water quality and inform improved drinking water quality governance.

In this thesis I develop a theoretical framework for drinking water quality based on the assemblage theory of Giles Deleuze and Felix Guattari as laid out in their seminal book, *A Thousand Plateaus* (1987). Framing drinking water quality as a heterogeneous assemblage, I draw on the assemblage theory concepts of abstract machines, double articulation, territory and smooth and striated space to explore how multiple assemblages of drinking water quality form and interact with the social and material territories they inhabit. I further explore the implications of an immanent ethical perspective associated with Deleuze and Guattari's assemblage ontology for ethical drinking water quality governance.

The case study of Kaolack, Senegal represents a situation where drinking water quality is more complex than it first seems. Though Kaolack is locally infamous for poor quality drinking water with high levels of salt and fluoride, the Senegalese government continues to maintain that tap water in Kaolack meets required norms for potability. Drawing on analysis of policies and plans combined with eight months of ethnographic-inspired data collection in Kaolack (observation, participation and interviews), I aim to understand how different actors presented with the same water can draw contradictory conclusions about drinking water quality. I then explore what the implications of different understandings of drinking water quality can be for disparities in access to safe and sufficient drinking water.

The main contribution of the thesis is the novel approach taken to understanding drinking water quality. The findings highlight drinking water quality as a multiplicity with entangled social, material and ethical dimensions with implications for governance. I show that drinking water quality assemblages in Kaolack are driven by different

understandings of what kind of problem drinking water quality is, challenging attempts to communicate across difference. I present how these assemblages form in Kaolack as heterogeneous collections of elements which vary in their degree of flexibility and inclusivity. I further describe how drinking water quality assemblages result in distinct patterns, relations and traces in the social and spatial territory of Kaolack, shaping distribution of access to water and exposure to potentially harmful things in water.

The thesis is original in its emphasis on drinking water quality, a topic under-represented in the critical social science literature. In addition, it contributes to a gap in the literature pertaining to theory development grounded in small- and medium-sized urban centres in Africa. This thesis further contributes to discussions about the social and material construction of environmental problems, and will be of interest to scholars interested in political ecology, science and technology studies and geographies of urban services provision.

Sammendrag

Dårlig drikkevannskvalitet utgjør en stadig økende helserisiko. Millioner av mennesker blir regelmessig utsatt for potensielt skadelige stoffer via drikkevannet. Dette er et problem som ikke er jevnt fordelt på kloden, men som ikke er uungåelig. Spesielt gjelder dette byer i det globale sør, der man står overfor sterk befolkningsvekst, klimaendringer og økt forurensning som alle er faktorer som bidrar til nedsatt kvalitet på drikkevannet. Det er en utbredt oppfatning at kvaliteten på drikkevannet må håndteres av eksperter etter vitenskapelige objektive og målbare kriterier. Ulike fagmiljøer innenfor geografi, miljøstudier og tilgrensende fagfelt anerkjenner i stadig økende grad at miljøspørsmål, inkludert spørsmål om kvaliteten på drikkevannet, handler om mer enn bare det materielle; De inneholder også sosiale og etiske elementer. Det er derfor behov for å utvikle teoretiske tilnærminger til drikkevannskvalitet som beylser og forener den sosiale, materielle og etiske kompleksiteten knyttet til drikkevannskvalitet og slik bidra til bedre forvaltning.

I denne avhandlingen utvikler jeg et teoretisk rammeverk for drikkevannskvalitet basert på en teori om *assemblage* som Giles Deleuze og Felix Guattari presenterer i den innflytelsesrike boken *A Thousand Plateaus* (1987). *Assemblage* oversettes gjerne til *ansamling(er)* i norsk akademisk litteratur¹. Gjennom å se på drikkevannskvalitet som heterogene ansamlinger, anvender jeg konsepter fra ansamlingsteori som *abstract machines*, *double articulation*, *territory* og *smooth and striated space*. Jeg utforsker hvordan drikkevannskvalitet som ulike ansamlinger former, og blir formet av, de sosiale og materielle territoriene som disse ansamlingene omfatter. Videre utforsker jeg hvilken betydning det iboende etiske perspektivet i den ontologien som Deleuze og Guattaris bygger på i sin ansamlingsteori har for forvaltning av drikkevannskvalitet.

Casestudien av Kaolack i Senegal er et eksempel på en by der kvaliteten på drikkevannet er mer sammensatt enn det synes å være ved første øyekast. Selv om Kaolack er lokalt beryktet for dårlig drikkevannskvalitet med høye nivåer av salt og fluor, står den senegalesiske regjeringen fast ved at vann fra springen i Kaolack oppfyller de normene som er fastlagt og trygt kan drikkes. Basert på en analyse av policy-dokumenter og planer i kombinasjon med åtte måneder med etnografisk-inspirert datainnsamling i Kaolack (observasjon, deltakelse og intervjuer), tilstreber jeg å forstå hvordan ulike aktører i sin vurdering av det samme drikkevannet trekker motstridende konklusjoner om kvaliteten av dette. Deretter utforsker jeg hvilke konsekvenser ulike forståelser av drikkevannskvalitet kan få for ulik tilgang til trygt og tilstrekkelig drikkevann.

¹ Wanvik, T., & Haarstad, H. (2015). Råvaresonens geografi: stedersom flerdimensjonale ansamlinger. In M. Aure, N. G. Berg, J. Cruickshank, & B. Dale (Eds.), *Med sans for sted: Nyere teorier*: Fagbokforlaget.

Avhandlingens hovedbidrag er en ny tilnærming til forståelse av drikkevannskvalitet. Funnene fremhever drikkevannskvalitet som et mangfold med komplekse sosiale, materielle og etiske dimensjoner som har betydning for samstyring. Gjennom case-studiet i Kalolack viser jeg at ansamlinger av drikkevannskvalitet er drevet av ulike oppfatninger av hva slags problem drikkevannskvalitet representerer, hvilket igjen gjør det utfordrende å komme til enighet. I denne byen fomes drikkevannskvalitet som heterogene ansamlinger der ulike bestanddeler spiller sammen og varierer i graden av fleksibilitet og inkludering. Jeg illustrerer videre hvordan drikkevannskvalitet som ansamlinger resulterer i tydelige mønstre og relasjoner og etterlater seg spor i Kaolacks sosiale og romlige territorium. Dette påvirker fordelingen i tilgang til drikkevann og eksponering for potensielt skadelige stoffer i drikkevannet.

Avhandlingen er original i sin vektlegging av drikkevannskvalitet, et tema som er underrepresentert i den kritiske samfunnsvitenskapelige litteraturen. I tillegg bidrar den til å tette et gap i litteraturen knyttet til teoriutvikling forankret i små og mellomstore bysentra i Afrika. Denne avhandlingen bidrar videre til å løfte diskusjoner om den sosiale og materielle konstruksjonen av miljøproblemer, og vil være av interesse for forskere som er interessert i politisk økologi, vitenskaps- og teknologistudier og geografier av infrastrukturer.

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List of Acronyms

AMCOW – African Council of Ministers on Water

ANSD – Agence Nationale de Statistique et de la Démographie (National Agency for Statistics and Demographics)

ANT – Actor-Network Theory

ASN – Association Sénégalaise de normalisation (Senegalese association for setting of norms)

DGPRES – Direction de la gestion et de la planification des ressources en eau (Office for the management and planning of water resources)

JICA – Japan International Cooperation Agency

NGO – Non-governmental organisation

NSD – Norsk senter for forskningsdata (Norwegian centre for research data)

PAGIRE (IWRM) – Plan d'action pour la gestion intégrée des ressources en eau (National integrated water resource management action plan)

PEPAM – Programme d'eau potable et d'assainissement du Millénaire (Millennium water and sanitation program in Senegal)

PSE – Plan Sénégal Émergent

SDE – Sénégalaise des Eaux (Public-Private Partnership provider of urban drinking water in Senegal)

SDG – Sustainable Development Goal

SONES – Société nationale des eaux sénégalaise (National Society for Senegalese Water)

STS – Science and Technology Studies

USAID – United States Agency for International Development

WARC – West African Centre for Research

WHO/OMS – World Health Organization (Organisation Mondiale de Santé)

Chapter 1. Introduction

Drinking water quality poses urgent and ubiquitous problems for human health and well being. Worldwide, nearly two million children die each year from water-related diarrhoeal disease (Corcoran, 2010). Hundreds of millions of people suffer regularly from the health impacts of consuming contaminated water (Corcoran, 2010; IFPRI & VEOLIA, 2015). By some estimates, up to four billion people still do not have access to safe drinking water without point of use treatment (Biswas & Tortajada, 2019). Pressures from rapid urbanisation, climate change, pollution and shifting land use mean many urban areas struggle to maintain adequate water supplies (Dos Santos et al., 2017). While the challenges posed by declining water quality exist everywhere, they are most urgent in the Global South. In Sub-Saharan Africa, 54% of the urban population lacks access to safely managed drinking water despite long-running global efforts to improve water security (WHO & UNICEF, 2017). As extreme as statistics about drinking water can be, they probably dramatically underestimate the real scope of problems (Mitlin, Beard, Satterthwaite, & Du, 2019). Furthermore, the harms and benefits of drinking water quality variations are not distributed evenly across cities (Rusca, Boakye-Ansah, Loftus, Ferrero, & van der Zaag, 2017); burdens fall disproportionately on low-income households and particularly women (Sultana, 2011). Given this growing water quality crisis (Corcoran, 2010; IFPRI & VEOLIA, 2015), improved understanding of the complicated social, material and ethical aspects of water quality is urgently required.

Water quality challenges current frameworks for theorisation as well as for governance (Bjornlund, Nickum, & Stephan, 2018; Cisneros, 2018). Entangled social and material attributes of water quality are inseparable in practice, but analysts have tended towards focusing on one or the other because it can be difficult to look at both (Gunda, Hess, Hornberger, & Worland, 2019). The idea of water quality appears deceptively straightforward and yet there can be deep misunderstandings about water quality problems (Bouleau & Pont, 2015; Freitag, 2014). In the case of drinking water, consumers and the state often understand quality and risks differently (de França Doria, Pidgeon, &

Hunter, 2009; Lavie, Crombé, & Marshall, 2020; Spackman & Burlingame, 2018). Assessments of pollution or contamination contain assumptions about where, when and how much of certain things should be present in water, and who may be exposed to them (Garcier, 2010). Some aspects of water quality can be personal, intermittent or manifest over an extended period of time (Biswas & Tortajada, 2019; Zwarteveen et al., 2017). Questions about access, scarcity and sustainability are inseparable from concerns about water quality. Water quality relations tend to stretch across scales and include trade-offs between competing priorities (Perreault, 2014). Balancing the relations between consumption, production and domestic requirements for water, human and ecological needs or current and future problems precipitate complex normative and ethical conundrums (Hall, Van Koppen, & Van Houweling, 2014; Pahl-Wostl, Palmer, & Richards, 2013). Lack of awareness of these complexities limits theorisations of water quality and can challenge attempts at governance that frame water quality as a primarily technical or apolitical phenomenon which can be objectively known.

In light of these challenges, the ambition of my dissertation is to consider the socio-material complexity of water quality and ask what its implications are for governance and theoretical framings of drinking water quality. I focus on drinking water quality, broadly defined as suitability of water for human consumption. To explore these topics, I develop a case study of a medium-sized city in Senegal where drinking water quality has long been considered problematic in multiple ways. I propose assemblage theory as one potential approach to analysing the socio-material complexity of drinking water quality and incorporating ethical concerns in its governance.

From scarcity to quality

Sustainable Development Goal (SDG) 6.1 aims towards achieving safe and sufficient drinking water for all people at all times, but access to enough water continues to steal the spotlight while exposure to hazards in drinking water remains in the shadows (Perreault, 2014). Water scarcity, in terms of reduced or threatened water supply and access, has been increasingly central to global discourses about water. A quick search of online news articles

yields a plethora of headlines like “The wars of the future will be fought over water not oil” (Whigham, 2018) or “Day Zero: Where Next?” (Heggie, 2020). Critical social scientists have unpacked apocalyptic claims about scarcity and shown that in many cases scarcity is a materially and socially co-produced result of power relations and distributive inequality more than an objective condition where water is lacking (Budds, 2016; Budds & Hinojosa, 2012; Mehta, 2007, 2010).

Water quality has not yet received such critical attention (Karpouzoglou, 2012; Lavie et al., 2020; Rusca et al., 2017). In much of the social science literature attending to water and water infrastructure, water quality is often acknowledged in a tangential or secondary role relative to issues of access, supply and quantity. Water quality tends to appear as an afterthought in framings of water issues; it receives perfunctory secondhand mentions in conversations about water security (*safe* and *sufficient*) or is tacked on to descriptions of an ideal situation (water supply of adequate quantity *and* quality).

Neglect of water quality in scholarly literature has parallels in practice that can have problematic consequences. Issues of quantity and quality are intertwined, but sometimes increasing access to water that contains harmful substances does more harm than good (Sultana, 2011). Insufficient attention to implications of actions taken to improve access to water for water quality, well intentioned though they may be, can have disastrous consequences. For example, in Bangladesh in the 1990’s millions of tube wells were installed by public and private actors with the purpose of making groundwater more accessible in areas where surface water was polluted or unavailable. By the time odourless and tasteless arsenic was identified in tube wells across the Bengal Delta more than thirty-five million people were estimated to be at-risk of chronic arsenic poisoning (Sultana, 2011)².

To some extent the secondary position of quality may be related to framings of water-related challenges in different paradigms. Disciplinary work tends to prioritise based on perspectives and expertise in particular fields (Cook & Bakker, 2012). For example, in the

² Chronic exposure to arsenic can result in “cancer, organ failure and untimely death” (Sultana, 2011, p. 165).

fields of hydrology or geosciences the focus is often on groundwater variability or shifts in the hydrological cycle, in agriculture studies the primary concerns are inputs for food security and in public health studies prevention and assessment of drinking water contamination are central (Cook & Bakker, 2012). Studies of the political economy of drinking water service provision often target the wide-reaching impacts of privatisation and shifts in water governance regimes on access to (and to a lesser extent quality of) water (Bakker, 2003). Focusing on one aspect of water access and security can lead to neglect of other areas. This can be illustrated by household water insecurity perspectives, which in their current form may obscure assumptions about what uses of water are most important. An overfocus on consumptive use arguably downplays the centrality of productive and domestic water use for human well-being and flourishing (Hall et al., 2014; Mehta, 2014).

Even when water quality is the central concern, issues remain with how it is framed and governed. Standardised approaches to water quality can conceal the negotiations and decision-making behind guidelines and requirements. Quality is always defined relative to values and intended use (Berry, Jackson, Saito, & Forline, 2018) and definitions of water pollution are based on normative assumptions (Garcier, 2010). Of the seventy thousand compounds and substances potentially present in water, countries typically monitor and regulate only between forty and seventy (Cisneros, 2018). The selection of these parameters depends on costs and technological challenges, political will and knowledge about effects to name just a few factors (Cisneros, 2018). Furthermore, context shapes which aspects of drinking water quality are considered most relevant. Discourses around water quality in the Global South often focus on public health, highlighting disparities caused by inadequate access to sanitation infrastructure and exposure to polluting industries (Karpouzoglou, Marshall, & Mehta, 2018). Yet sanitation and micro-biological contamination are not the only potential sources of harms in drinking water. Non-anthropogenic substances in groundwater, such as arsenic, iron and fluoride also have potentially serious chronic health impacts (Cisneros, 2018). Despite these complications, current ways of measuring and responding to drinking water quality tend to assume that ‘...all potential hazards are known, are measurable and have been considered’ (Charles, Nowicki, & Bartram, 2020, p. 2).

In contrast to this assumption, there are clear instances of flexibility and debatable practices in the setting of standards and thresholds for drinking water quality at the international level. Frisbee, Mitchell and Sarkar (2015) describe several problematic instances in the World Health Organisation (WHO) guidelines for inorganic substances in drinking water. The WHO working group for the most recent revision of the guidelines determined that manganese was not problematic for health until levels above what they considered past the threshold of acceptability. They therefore opted not to include a health-based standard for manganese in the revised version of the guidelines. However, in Bangladesh and other countries, studies have shown that people continue to consume water at levels far in excess of the WHO-determined threshold for likely rejection (Frisbie, Ortega, Maynard, & Sarkar, 2002, in Frisbee et. al, 2015). The lack of a health-based standard therefore allows governments to decline to monitor manganese, potentially exposing their populations to health risks, including neurological disorders. Elsewhere in the WHO guidelines, ongoing debates about acute versus chronic effects from nickel potentially shift the threshold for potability; a rounding error in the calculations for boron allows the quantity of boron in drinking water to be up to twenty percent higher than it would be otherwise; and some of the literature cited by the WHO is out of date or not publicly available, posing problems for transparency (Frisbie et al., 2015). In addition, not everything that potentially impacts on human health is included in drinking water quality standards. Excessive intake of salt in drinking water, for example, has been shown to potentially increase risk of miscarriages or maternal mortality and yet salt is not included in any international drinking water quality standards relative to health (Damania, Desbureaux, Rodella, Russ, & Zaveri, 2019).

Furthermore, many drinking water sources have long been judged based on the presence of *E. coli* as a faecal indicator bacteria, despite the fact that *E. coli* does not actually meet all of the WHO's criteria for a high-quality indicator (Charles et al., 2020). The presence of *E. coli* does not always directly indicate contamination that is harmful to people (Arce-Nazario, 2018). In Puerto Rico, for instance, almost all surface water contains a strain of *E. coli* that does not pose a threat to human health. Still, the local water provider opts not to use surface water as a source of drinking water because it cannot pass basic tests for

potability based on the presence of *E. coli* (Arce-Nazario, 2018). Because of these types of incongruencies, Charles, Nowicki and Bartram (2020) advocate for reconsidering how we evaluate drinking water systems to focus more on safety and less on discrete measurements of quality. They argue that, for systems vulnerable to contamination, measuring selected indicators in a series of instances does not actually confirm that a drinking water delivery system is secure and will remain so (Charles et al., 2020).

Water quality is often presented in policies and regulations as a level of acceptable deviation from pre-determined norms determined by experts. In the United States, for example, drinking water quality is not defined as purity but relative to a limit of permissible impurity (Spackman & Burlingame, 2018). However, values of certain substances dropping below certain thresholds can also be problematic. For some aspects of water quality (like dissolved oxygen for fish) perfectly pure water is not ideal, and human bodies need some of the compounds in water other than H₂O (Cisneros, 2018). Good water quality often comprises a range of values, not a point, and its boundaries are open to renegotiation and fluidity. All of these examples in combination provide further support for the claim that water quality is more complex than it first seems.

In addition, in many contexts data is lacking on water quality and it is not feasible to consistently measure all potentially harmful substances in drinking water (Damanian et al., 2019). In light of such limitations, the WHO supports assessing drinking water sources based on whether they are safely managed or “improved” as a supplement to quantitative measurement of substances in water. Improved sources include tap water and well water, among others. Some experts contest the growing ubiquity of the improved versus non-improved paradigm, because improved sources are not always guaranteed free from contamination (Bain et al., 2012). Requirements for access are conflated with safety and quality, which are used almost interchangeably (Bain et al., 2012). They express concern that the structure of goals for increasing access to drinking water incentivises construction of improved sources more than maintenance of the quality of existing sources (Bain et al., 2012).

The WHO Guidelines for Drinking Water Quality further state that ‘Every effort should be made to achieve drinking water that is *as safe as practicable*’ (WHO, 2017a, p. 1, emphasis added). States’ obligation to provide safe and sufficient water to their citizens is ‘often circumscribed by financial affordability or other factors’ (Miroso & Harris, 2012, p. 938). Thresholds for appropriate costs from an economic or industry perspective are not necessarily compatible with what might be best for human health, and the definition of “best available technology” may contain language prioritising financial viability for private actors (Liboiron, Tironi, & Calvillo, 2018). Tensions between the precautionary principle and expensive treatment options for emerging contaminants trouble planning and management decisions (Hotchkiss et al., 2008). Rising costs of mitigating pollution to provide safe water for everyone raise questions about feasibility and alternative models for service provision (Boakye-Ansah, Schwartz, & Zwarteven, 2021; Robak & Bjornlund, 2018).

Water quality problems can also be (intentionally or otherwise) obscured, with effects that are not uniformly distributed. Different ways of knowing water quality are not equally recognised (Karpouzoglou & Zimmer, 2016). In Karpouzoglou and Zimmer’s (2016) study of informal settlements in Delhi, India, for instance, they found that inhabitants’ knowledge of wastewater impacts was not accorded the same level of legitimacy as the knowledges of experts or municipal staff. The inhabitants were thus unable to make claims to the state about their exposure to untreated wastewater. Relatedly, in the recent water quality crisis in Flint, Michigan residents expressed concern for years over the deteriorating quality of their tap water. Despite ongoing criticism, ‘...state officials initially treated complaints about water quality as little more than a nuisance, even when confronted at community meetings by residents carrying jugs of brown tap water [...] Officials [...] noted that environmental laws do not require them to regulate the aesthetic qualities of water’ (Boelens, Vos, & Perreault, 2018, p. 37). Eventually it was clear that management decisions with regards to infrastructure maintenance and sources of water had exposed tens of thousands of primarily low-income and minority people to lead and other harmful substances in water. Definitions and interpretations of what characteristics of water could be considered indicators of poor quality had effectively marginalised consumers from Flint.

A situation unfolded where consumers' experiences were not considered valid evidence of problems. Over the course of this dissertation I show that the experiences of consumers in Delhi and Flint are not exceptional. Politics and power relations regularly bubble beneath the surface of the taken-for-granted concept of water quality.

While moral and ethical questions are frequently elevated in debates over privatisation, the Human Right to Water and sustainability (Miroso & Harris, 2012), such questions receive limited attention compared to the technical aspects of water resources management (Schmidt, 2010). On the contrary, a global discourse around water has emerged that sees water problems as quantifiable, universal and solvable by technical and rational means (Schmidt & Peppard, 2014). Such a view often obscures the role of values and normative positions in judgments about water by focusing on narratives of urgency and crisis (Schmidt & Peppard, 2014, p. 533). This trend towards foregrounding the technical and minimising the moral and ethical is particularly prevalent for water quality. Water quality is always deeply connected to knowledge, values and politics, including with regards to prioritising certain uses of water (Berry et al., 2018). Complexity and uncertainty further confound attempts to manage water resources in an objective, rational manner and pose profound challenges for answering the question "What is the right thing to do?"

Assembling drinking water quality

The socio-material complexity and embedded ethical concerns of drinking water quality governance challenge current theoretical frameworks. Giles Deleuze and Felix Guattari's philosophical project of assemblage theory may offer insights that complement and extend existing literature on drinking water quality governance. Assemblages are defined as heterogeneous collections of human, non-human and more intangible elements, and assemblage theory provides tools for understanding how those elements come to be allied with each other and either hold together or fall apart. Assemblage theory is an approach to understanding the world which focuses on formation and transformation: an ontology of becoming rather than the more common focus on being (Adkins, 2015). Research using the conceptual apparatus of assemblage theory asks questions about what things can be, how

they come to be and how they might become something else (C. McFarlane, 2011a). Deleuze and Guattari develop the concept of assemblages in much of their work, with a particular focus on understanding how assemblages form in the book *A Thousand Plateaus*. An additional goal of *A Thousand Plateaus* is to show that if we transform old ways of seeing the world there is potential to uncover new spaces of possibility (Deleuze & Guattari, 1987).

Another potential contribution of assemblage theory is as a coherent grounding for ethical drinking water quality governance. Those tasked with governance of drinking water quality often encounter value-laden complex problems with multiple incommensurable implications (Bjornlund et al., 2018; Cisneros, 2018). Balancing these implications is not a straightforward task, and planners and managers of drinking water systems are currently lacking well-articulated foundations for ethical decision making (Brown & Schmidt, 2010b). Assemblage theory is increasingly used to analyse social phenomena, for example seawater desalination projects (Williams, 2018), pollution of rivers (Gorostiza & Sauri, 2017) and regulation of maritime activities (Bear, 2013; Jay, 2019). However, potential for incorporating the ethical implications of Deleuze and Guattari's ontology is not yet being realized alongside empirical work (Frichot, 2012) or in practice (Banville & Torres, 2017; Purcell, 2013).

A water ethics approach grounded in assemblage theory may offer alternative views better suited to water quality problems than what has been possible using water justice approaches, which have been widely applied to inequitable water access and distribution. A water justice framing attends to inclusiveness and participation, equitable distribution of water-related hazards and benefits, recognition of distinct values and knowledges and care for the environment (Boelens, Perreault, & Vos, 2018; Zwarteveen & Boelens, 2014). Water justice approaches are limited by difficulties in moving from identifying and describing situations of water injustice to answering questions about what should be done. In part these challenges arise because the central pillars of water justice (distribution, representation, participation and environment) can be in tension or competition with each other (Zwarteveen & Boelens, 2014). Thus there can be co-existing or competing equally legitimate claims for water justice. Furthermore, the decision to intervene in a combined

social and hydrological system will always concern value judgements about who, or what, is the most marginalised and thus the most deserving of assistance, or who has the right to make claims about water and water quality (Delli Priscoli, Dooge, & Llamas, 2004). Increasing the availability or quality of water in one place or for one type of use logically leads to a decrease in availability or quality elsewhere. Therefore the ideal of water justice is something we strive for but may never fully achieve.

A growing field of study and debate around water ethics entails a different but related discourse which may address some limitations of the water justice framing. Ethical examination of drinking water service provision can potentially expand our understandings of how different actors navigate normative issues in their own contexts (Furlong, Carré, & Guerrero, 2017). This field includes a series of case studies and reports on water ethics by the UNESCO Commission on the Ethics of Scientific Knowledge and Technology (Delli Priscoli et al., 2004) and a collection of seminar inputs from the Marcelino Botín Foundation in Spain called *Water Ethics* (Llamas, Cortina, & Mukherji, 2009). While these works have made valuable contributions to the conversation about water ethics, their focus often remains on management and governance in terms of what not to do. They aim, among other things, to prevent selfish behaviour by individuals and corporations who threaten valuable resources (Groenfeldt, 2019). The positive potential for ethics as a way of identifying solutions, foregrounding values and encouraging people to be creative and imaginative is less present in this applied literature (Groenfeldt, 2019).

In addition, while reports and statements on application-oriented water ethics have strong reference to real-world situations, they sometimes appear to be written without the input of philosophers or people trained in ethics, meaning they may lack coherent and consistent foundations for their claims (Kowarsch, 2011). However, a growing subset of human geography proposes a pragmatic, embodied and learned form of ethics (Barnett, 2011, 2012) incorporating the more-than-human (Richardson-Ngwenya & Nightingale, 2018). With a few exceptions (Furlong et al., 2017), these perspectives on ethics have only been applied to water access issues in limited ways, and not yet extended to drinking water quality. Bringing these debates from geography into conversation with Deleuze and

Guattari's ethical thought to consider ethical drinking water quality governance may spark new insights. Therefore in my study I explore an immanent form of drinking water quality ethics based on an assemblage theory ontology. I develop this immanent perspective on drinking water quality ethics along with reflections on the empirical case of Kaolack, Senegal. This engagement with ethics for drinking water quality governance is woven throughout the thesis and culminates in a discussion of the implications of drinking water quality ethics in the conclusion.

Aim of the study and research questions

A core aim of this study is to rethink drinking water quality as a phenomenon which is at once more-than-social and more-than-material. I assess the merits of assemblage theory as an approach to revealing the socio-material complexity of drinking water quality, and I further consider whether an analytical framework based on the ontology and selected concepts from assemblage theory can help to better understand ethical aspects of drinking water quality governance. To do this I develop a qualitative case study of Kaolack, Senegal, a medium sized city in Senegal notorious for poor drinking water quality.

The following questions guide my research:

- 1- *What can assemblage theory contribute to understanding drinking water quality?*
- 2- *How is drinking water quality assembled in Kaolack and what do such drinking water quality assemblages do?*
- 3- *What are the implications of conceptualising drinking water quality as assemblages for governance?*

The first question reflects a theoretical interest in interrogating the concept of drinking water quality and the multiplicity of ways water quality can be known. Having identified some shortcomings in the way drinking water quality has been theorised in the literature, in my project I explore the potential of assemblage theory to contribute to existing theoretical debates about water and water quality. With the second question I apply tools from assemblage theory to a case study of Kaolack, Senegal. One goal of this application is

to improve understanding of the complex nature of drinking water quality in Kaolack. Another goal is to reflect on the utility of assemblage theory's sometimes abstract and philosophical concepts and ontological suppositions in an empirical setting. Using the third question, and building on the empirical foundations from research question two, I discuss the implications of drinking water quality assemblages for inequalities and whether an assemblage theory perspective on drinking water quality can give any new insights for ethical drinking water quality governance.

An overarching contention of this research is that drinking water quality matters, not just in terms of whether it is good or bad, but in how certain assemblages of drinking water quality come to be seen as inevitable. Understanding drinking water quality as a heterogeneous assemblage of component parts draws attention to processes of formation and how, despite the fact that drinking water quality is typically considered straightforward, technical and objective, it is in fact a multiplicity that could be assembled differently. Assemblages are always approached viewed as temporary stabilisations of ongoing processes of transformation. Therefore assemblage theory provides a lens through which to consider and take seriously the complicated multiple materialities, geographies and relationalities of drinking water quality governance.

While Deleuze and Guattari did not write about drinking water quality, and to my knowledge assemblage theory has not been used to look at drinking water quality in this way, concepts are meant to be applied (Deleuze & Guattari, 1994). Applying assemblage theory to empirical situations is a way to investigate selected concepts and ontological positions and how they can build understanding of governance challenges (Buchanan, 2011). A portion of this thesis is therefore exploratory, examining how assemblage theory can be used for empirical analyses of drinking water quality. Undertaking analysis of drinking water quality using assemblage theory tools enables me to discuss what its potential contributions and limitations are.

The case: Kaolack, Senegal

The site I have chosen to conduct this research is Kaolack, Senegal. Kaolack is characterised by extensive social and material complexity in terms of its water supplies. The city and region of Kaolack are infamous in Senegal for high levels of fluoride and salinity in drinking water (S. Faye et al., 2005). At the same time, Senegal as a whole is widely portrayed as a success story for improvements in access to drinking water, especially in urban areas (Pezon, 2018). I was drawn to this case by curiosity about these complex and seemingly contradictory narratives about drinking water quality in Kaolack – on the one hand the optimistic narrative propagated by the state and on the other the everyday experiences of consumers. Using a qualitative case study developed over eight months in Senegal I employ assemblage theory to explore the coexisting perspectives and experiences of drinking water quality in Kaolack. I also consider what the implications of multiple assemblages of drinking water quality can mean for how water is accessed in the city.

Furthermore, like many small and medium-sized urban centres, Kaolack has thus far been overlooked in much social science research. Research on water in Senegal has predominantly focused either on Dakar and its surroundings, coastal cities including St. Louis and Cap Skirring or rural agricultural communities. Research in medium sized cities such as Kaolack is important, as urban expansion in sub-Saharan Africa (and elsewhere) is projected largely in secondary cities and on the periphery of existing cities (UN Habitat, 2013). In many places this growth is forecasted to be rapid and unprecedented. These cities are often underrepresented in favour of research on capital cities or large urban agglomerations which may experience different dynamics than those of small and medium-sized urban centres (Ruszczuk, Nugraha, & de Villiers, 2020). Instead of recognising and exploring the diversity of such cities, researchers tend to generalise based on a few well-studied sites and underemphasise the important role small and medium-sized cities play in national and global processes (Satterthwaite, 2021). Therefore, my selection of Kaolack reflects both an interest in the complex and specific nature of the city's drinking water problems and the relative under-representation of cities like Kaolack in the literature.

Outline of the thesis

In Chapter 2 I critically engage with existing literature on drinking water quality in the social sciences. I identify developments in how drinking water quality has been considered thus far in different social science disciplines including science and technology studies (STS), political ecology and geography. In particular I show how these different literatures approach the social and material features of drinking water quality from varied directions and emphases, foreshadowing my contention that assemblage theory could provide a middle ground that connects the social, material and ethical aspects of drinking water quality coherently.

I present the theoretical framework in Chapter 3. I begin by outlining the ontology and fundamental ethical perspectives of *A Thousand Plateaus* which ground my particular interpretation of assemblage theory. I then address critiques from current debates on assemblage theory and elaborate my position within these debates. In addition, I explore potential points of resonance between current debates on a southern urban critique (Lawhon & Truelove, 2020) and assemblage theory, focusing on the potential contribution of assemblage theory in a southern urban context. Despite tensions, some southern urban theoretical traditions share commitments with assemblage theory, particularly relating to the emphasis in both on the situatedness of all knowledge and the centrality of socio-material practices.

Chapter 3 is also where I introduce the key concepts from *A Thousand Plateaus* that I use in my analysis of drinking water quality assemblages in Kaolack. These concepts are: assemblages, abstract machines, double articulation, territory and smooth and striated space. With the exception of assemblages, these concepts are frequently under-represented in empirical studies using assemblage theory. I argue that engaging with these concepts can move applications from assemblage as a metaphor or descriptor to deeper analytical contributions. To close the theoretical framework chapter I put forward drinking water quality as a model for assemblage theory concepts, laying the groundwork for how these concepts will be applied in my empirical analyses.

In Chapter 4 I describe the research design and methods for my dissertation. The methods I use in this study include interviews, observation and participation and document analysis. I pay particular attention in this chapter to the influence of assemblage theory perspectives on my processes of data collection and analysis. Applying assemblage theory to data collection and analysis requires commitment to an open-ended perspective where the most important actors are not pre-determined but emerge through engagement with sites and situations (Bueger, 2014). This provides an opportunity to take note of agential actors that might be overlooked in other approaches. Therefore my multi-method research design allowed me to consider a blend of material and social elements in assemblages, all of which have the potential to matter. Finally, I reflect on the role of epistemology, research ethics and positionality in the design and implementation of such a project.

In Chapter 5 I provide context for the case study of drinking water quality in Kaolack, and argue for the selection of Kaolack as the case study site. I first introduce key governance actors and legal and political frameworks for drinking water quality and access in Senegal at the national level. I then describe in detail the availability and quality of drinking water in Kaolack, along with situating the ways people access drinking water in Kaolack in a broader context.

The subsequent three chapters represent the empirical contribution of this thesis. Each chapter of the findings is arranged around a sub-question of research question 2. I apply selected concepts from assemblage theory to address the form and formation of drinking water quality assemblages in Kaolack. The findings chapters are mapped in Figure 1, along with the core concepts used in each chapter. At the conclusion of each chapter I engage with research question three by considering the ethical implications of the findings.

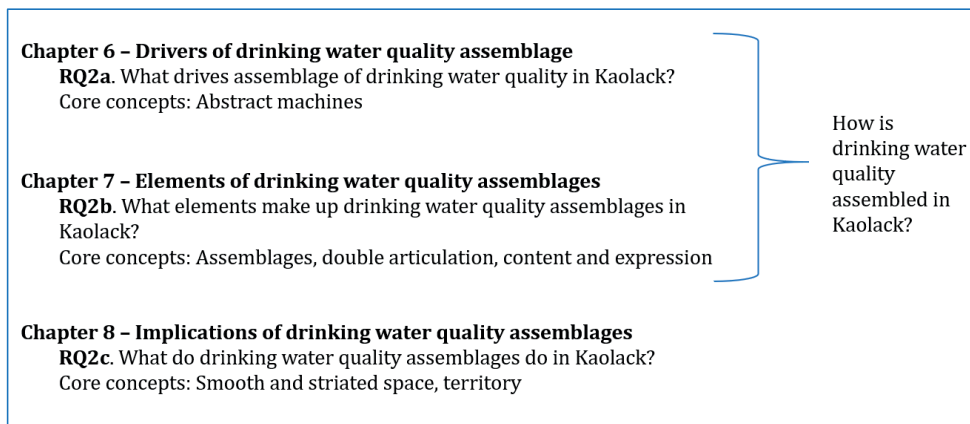


Figure 1. Outline of findings chapters, associated research questions and core concepts

First, Chapter 6 presents the possibilities for assemblages to form in Kaolack. Chapter 6 is oriented towards research question 2a: *What drives assemblage of drinking water quality in Kaolack?* I identify key actors in multiple assemblages of drinking water quality in Kaolack and explore how assemblages faced with the same fundamental problem of drinking water quality coexist in tension. I propose the concept of abstract machines to show how the guiding principles, problem framings and concrete problematisations of drinking water quality shape what kinds of assemblages are possible.

In Chapter 7 I address the formation of assemblages with research question 2b: *What elements make up drinking water quality assemblages in Kaolack?* I describe how the practices of various actors lead to the selection and organisation of the heterogeneous elements that make up drinking water quality assemblages in Kaolack through a process called double articulation. By describing this process, I show how each assemblage of drinking water quality is composed of unique and provisional combinations of elements. In particular, I present how the Senegalese state positions itself as a central purveyor and creator of drinking water quality knowledges. I then argue that the Senegalese state's rigid ways of knowing drinking water quality contribute to important blind spots and boundaries around who is able to participate in conversations about drinking water quality and thus

affect the assemblages. I also delve into the ethical implications of inclusion and exclusion of certain drinking water quality elements.

Finally, in Chapter 8 I turn to research question 2c: *What do drinking water quality assemblages do in Kaolack?* I describe how drinking water quality assemblages inhabit and are inscribed on the territory of the city in ways that are more or less fixed, using the Deleuzoguattarian concepts of smooth and striated space to analyse these processes. I argue that, via these processes of smoothing and striation, assemblages have repercussions for who has access to drinking water or is exposed to harmful things in drinking water. I situate my contribution in this chapter by describing several concepts that have been used to conceptualise and categorise the spatialities of heterogeneous ways of accessing drinking water in the Global South in anthropology, geography and urban studies literatures. I argue that the concepts of smoothing and striation facilitate and deepen understanding of how the social and material act on and interact with each other, with spatial and ethical implications.

I conclude in Chapter 9 by synthesising the key contributions of the thesis and proposing avenues for further research. I note how in each strand of the thesis (theoretical, empirical and philosophical) directing my gaze towards certain facets of drinking water quality has enabled distinct contributions to understanding drinking water quality assemblages in Kaolack. Finally, I return to research question 3 to discuss what the broader implications of drinking water quality assemblages are for governance. I argue that the embedded ethical considerations of assemblage theory can expand consideration of the ethical features of drinking water quality governance. Therefore I articulate the final reflections of the thesis by gathering the ethical reflections presented in each findings chapter. I consider what the ethical aspects of assemblage theory, specifically immanence and affect, entail for governance of drinking water quality in Kaolack and elsewhere.

Chapter 2. Interpreting drinking water quality in the social sciences

In this chapter I explore what can be drawn out of existing work on water and water quality as a combined social and material entity to build a stronger theoretical understanding of water quality which can act as a foundation for my research study³. I critically engage with ways water quality has been considered in a range of social science studies, primarily in geography, anthropology, STS, political ecology and cognate traditions, as these have engaged most with issues of water quality thus far⁴. Throughout this chapter I argue that despite a growing body of scholarship, there remains a need for a theoretical framework that can supplement existing approaches and more comprehensively embrace the complexity and multiplicity of water quality. I establish a gap in current theorisation of water quality, subsequently arguing that assemblage theory can fit in the middle space of current debates by considering drinking water quality as an entangled multiplicity which is more-than-social and more-than-material (Chapter 3). This review is directly linked to the objective of my thesis, which is to rethink the socio-material complexity of drinking water quality in order to say something about how drinking water quality governance could be improved by considering both social and material aspects.

The natural sciences, and to some extent public health studies, tend to assume drinking water quality is a technical and apolitical object that can be known by measuring quantities of pre-determined substances in water (Pine & Liboiron, 2015). There is more nuance in most social science literature about water quality. Still, this field could benefit from stronger theorisation of the socio-material nature of drinking water quality (Lavie et al., 2020; Rusca et al., 2017). I identify three main approaches in the social science literature to theorising water quality, including: studies of water quality as a political and social construct; a primarily materialist body of literature on non-human and more-than-human agency of water and infrastructure; and scholarship that describes how social factors shape material

³ Although my focus is on drinking water quality, I include studies of water quality for other uses in this review because of their relevance to understanding existing empirical and theoretical engagement with these related topics.

⁴ The literature review consisted of a search of Google Scholar and scholarly databases using keywords and reference tracing.

realities of inequality and exposure. I further describe the interdisciplinary field of socio-hydrology which aims to integrate social elements into hydrological analyses (Rusca & Di Baldassarre, 2019). I show that, despite efforts to incorporate both material and social facets of water quality in each of these approaches, limitations remain. In social constructivist literatures, water quality is conceptualised as an entity which is primarily social. In materialist studies of water and infrastructure the influence of materiality on social relations is the focus, and in the political ecology and environmental justice studies the influence of social relations on material distributions of water quality is emphasised. Socio-hydrological studies include material and social processes as distinct but related, with a focus on materiality. Thus there is space in the literature for a balanced perspective which does not assume the centrality of either the social or material. Assemblage theory may offer such a perspective (Figure 2).

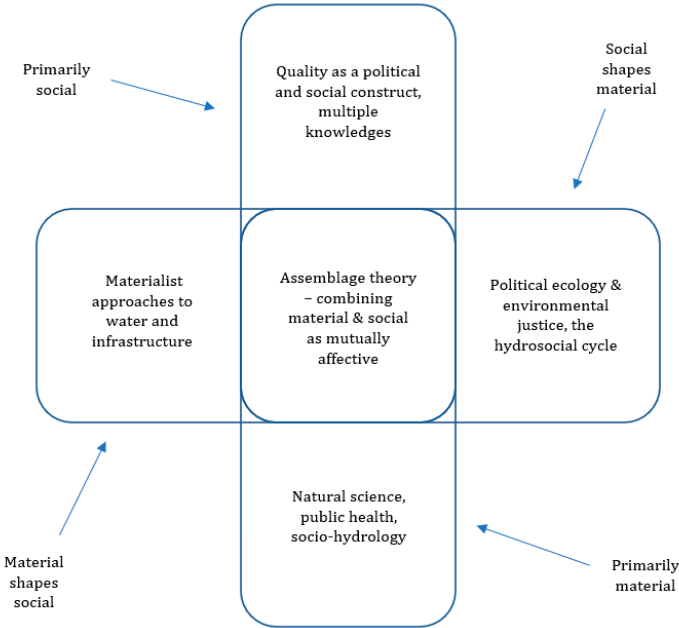


Figure 2. Interpreting drinking water quality as a social and/or material entity

Political and social construction of water quality

In social constructivist approaches water quality is understood to be politically contingent and produced by humans through processes of social and political negotiation. For instance, Bouleau and Pont (2015) trace negotiations of surface water quality definitions in the European Water Framework Directive. They argue that the idea of “reference conditions”, which became instrumental to the Water Framework Directive, were not actually based on current scientific theories about ecology and river water quality, but were rather based on what suited the needs of the European Union at that time for implementable quantitative norms. Thus river water quality became a part of the co-production of science and social order (Bouleau & Pont, 2015). Pine and Liboiron (2015) give another example of the UK Rivers Pollution Prevention Act. In 1887, policy makers agreed on what scientists considered an arbitrary distinction between potable and non-potable water. Acknowledging that pure water does not exist in nature they decided that to qualify as potable water had to have been filtered using modern techniques (Pine & Liboiron, 2015). Chemists further decided that science was not good enough yet to determine if germs remained in water after treatment, so they selected nitrogen as an indicator that could indicate the presence of upstream organic material. They referred to this indicator as “previous sewage contamination”, knowing that if consumers believed that they were drinking faeces they would get angry and demand better water quality from the government (Pine & Liboiron, 2015). The way this data was framed was an intentional and explicitly activist use of measurement, with the goal of banning raw sewage disposal into local waterways. The chemists used their expertise to select and create evocative forms of data that would involve the population in advocating for their desired drinking water quality management actions (Pine & Liboiron, 2015).

Work on water in STS and geography shows that measurement and standard setting practices shape rather than reflect the world. What is measured, how, where and when play important roles in the kinds of knowledge that are created. For example, a review of fifty-seven studies found that drinking water quality declines significantly after collection if water is stored or transported (Wright, Gundry, & Conroy, 2004). Thus the authors argued

that the goal of measurement plays an important role in results; if the intention is improved health for consumers water quality monitoring should happen at the point of use, whereas if the goal is quality of service it makes sense to measure at point of delivery (Wright et al., 2004).

Historical, anthropological and STS studies show that the current focus on water quality as something which must be measurable developed gradually and is entangled with politics (Pine & Liboiron, 2015). Conflation of measurement with knowing can be observed in many scientific fields. For drinking water quality this insistence on measurement is especially challenging because consumers are influenced by organoleptics (taste, smell, sight) to a large extent (de França Doria et al., 2009) and these things are notoriously difficult to quantify (Spackman & Burlingame, 2018). This tension leads to a ‘tug-of-war between potability and palatability’ in some municipal water service situations (Spackman & Burlingame, 2018, p. 350).

Quantitative measurement contains – and masks – moral judgments about the right way for things to be (Pine & Liboiron, 2015). Garcier (2010), for instance, traced ideas of water pollution as they have been constructed over time, showing that pollution is not determined by any essential characteristics or quantities of substances in water. He draws on the work of Mary Douglas in her now classic anthropology text *Purity and Danger*, as she defines pollution as “matter out of place” (Douglas, 1966). Similarly, current work in STS on toxicity, contamination and pollution provides insights into how water quality could be nuanced theoretically. These works aspire to challenge definitions of toxicity that focus on “wayward molecules behaving badly” (Liboiron et al., 2018), and argue that locating responsibility for toxicity within polluting particles reproduces situated ideas of good, proper relations (Calvillo, 2018). Pollution is thus a social category that should be understood relative to normative frameworks that define legitimate locations for certain types of materials (Garcier, 2010). Whether non-H₂O things in water are seen as impurities to be removed or valued essential components is influenced by a combination of water knowledge and values (Berry et al., 2018) which are not inherently of equivalent weight (Tadaki & Sinner, 2014).

An important theme in these works is understanding who has the power to construct social reality. Participation and representation in knowledge production are important aspects of environmental governance debates, not least those concerning water (Karpouzoglou & Zimmer, 2016; Zwarteven & Boelens, 2014). Knowledge, ontological positions and constructs ‘... stem from, are related to, favour and help bring about certain ways of ordering the world – and of distributing wealth and risks – and not others’ (Zwarteven, 2015, p. 10). Rather than acknowledging multiple sources or kinds of water knowledges as potentially being able to speak about water quality, there is a tendency to simply claim that available knowledge is insufficient, and this can be a political act (Zwarteven et al., 2017). In addition, exclusionary political practices perpetuate conditions of illegibility, ambiguity and invisibility around drinking water supplies that can be used to shift responsibility and promote certain kinds of solutions (or no solutions) (Truelove, 2018). Some authors take the question of knowledge politics a step further, arguing that there are multiple ontologies of water (Barnes & Alatout, 2012; Wilson & Inkster, 2018; Yates, Harris, & Wilson, 2017). While these studies are not for the most part explicitly focused on water quality, they inherently include quality and highlight that there are different ways of knowing and understanding things about what water is and in what ways water has value.

While these studies make important contributions to understanding social and political constructions of water quality, they can skew too far towards the social and neglect the material somewhat. Water quality challenges social constructivist perspectives because there are chemical and biophysical characteristics and properties of water and things in water that have the potential to impact on human health and the environment; therefore water quality cannot be exclusively a social construct. In the next section I turn to another field of study that returns the material to a central role in analysis and shows how the materiality of water and infrastructure shape social relations.

Materialist approaches to water and infrastructure

In contrast to the social constructivist approaches in the previous section, a group of materialist approaches based on actor-network theory (ANT) and related theoretical

perspectives attribute agency to the non-human or more-than human world. These studies emphasise the influence of materiality on social relations. Such approaches claim that water and infrastructure are not inert background for social relations; they are active participants in shaping them (Bakker, 2012). Water, for instance, is considered an actor and the material characteristics of water contribute to its unruliness, stabilizing and disrupting social orders in often unpredictable ways (Linton & Budds, 2014). A classic example of this is in Bakker's (2004) work where she outlines how water behaves "uncooperatively", resisting attempts at commodification and privatization.

These authors have pushed the boundaries of water research by arguing that neither water's social nor material aspects can be considered in isolation. This body of studies consider water to be 'multiple, not only in its meanings, but more importantly, in its very materiality' (Barnes & Alatout, 2012, p. 484). Studies in this field highlight the many unique characteristics of water that shape its agential capacities and social relationality, highlighting water's '...fluidity, its transformative capacities, its conductivity and its connectivity' (Strang, 2014, p. 1). Others further explore how changing one part of water's ecologies sets in motion a domino effect for associated social institutions (Orlove & Caton, 2010).

A distinct "water bias" can be identified in these literatures, leading to underrepresentation of the qualities of water and substances carried in water (Parrinello & Kondolf, 2021). These substances have largely been treated as background noise, subject to being passively absorbed, carried or distributed. While water's ability to carry and redistribute things is often referred to among its active capacities, aspects like sediment receive limited attention (De Micheaux, Mukherjee, & Kull, 2018; Parrinello & Kondolf, 2021). This could be addressed by incorporating the ways water may also be transformed by objects and substances mixed into and alongside it. Extending the analytical frame to include the substances in water as actors could be a way to build on these analyses and bring water quality more into the picture.

Literature in geography and anthropology has applied materialist perspectives to infrastructure, with a similarly limited theorisation of water quality. Several case studies using ANT-inspired approaches have shown how outside of or alongside centralized infrastructure networks technologies can be causal actors. Kooy and Bakker's (2008b) study of Jakarta, Indonesia exemplifies the political nature of water infrastructure and shows how the distributed materiality of piped water services has been used as a technology of governance with spatial, discursive and material components. Through their analysis they raise questions about who is perceived to need water and what kinds of water they need, linked to colonial conceptions of what a "modern" citizen-subject looks like. In many of these studies technologies are attributed a form of agency; they shape both flows of water and social relationships. Some examples of these purportedly agential technologies are: water meters (Loftus, 2006), efficiency technologies (Furlong, 2011), barrels, cisterns and buckets (Meehan, 2014), pumps (De Laet & Mol, 2000) and tube wells (Birkenholtz, 2014). Detailed engagement with water quality is notably absent in these articles. Neither Meehan (2014), Loftus (2006) nor Furlong (2011) mention water quality explicitly. Both De Laet & Mol (2000) and Birkenholtz (2014) address water quality only briefly, in reference to the need for technologies to be properly maintained and assembled to prevent contamination with *E. coli* and contribute to health (De Laet & Mol, 2000) and the general lack of groundwater monitoring for quality or quantity (Birkenholtz, 2014).

Building on such studies of water delivery infrastructures, scholars in geography and international relations have shown how technological interventions aimed at altering water quality subsequently influence social and political relations (Swyngedouw & Williams, 2016). For example, the increasing availability of desalination technology has played an important role in shifting technopolitical regimes and international relations (Feitelson & Rosenthal, 2012; Usher, 2019). Water vending machines have been used to study the commodification of, not just water, but water quality, simultaneously shifting the responsibility for water provision from the state to companies and transforming people from citizens into consumers (Jepson & Brown, 2014; Vandewalle & Jepson, 2015). However, in the majority of these studies the technology itself is the object of inquiry,

endowed with the potential for agency and relationality, while the things targeted for removal from water are passive recipients of this action.

Critiques of ANT and other non-human theories of agency have argued that they under-emphasize the role of human intentions and social relations of power in their analyses (Kirsch & Mitchell, 2004). There is a concern that portraying human actions as nothing more than the emergent result of networks undermines critical inquiry and makes accountability impossible (Bennett, 2010). Therefore, although there is a dearth of research applying ANT-inspired approaches to water quality, applying these perspectives to water quality would not manage to fulfil the objectives of my thesis to incorporate the social, material and, most directly, ethical aspects of drinking water quality governance and so I do not pursue this approach.

In this section I have presented a collection of approaches to water and infrastructure that arguably focus too much on the material to the neglect of the social (though they attempt to incorporate both); I now turn to a field with the opposite difficulty.

Political ecology and environmental justice

Another approach to water quality in the social sciences highlights the political and power-infused processes that perpetuate distributive inequalities. In this literature, social relations influence the materiality of access to water and exposure to potentially harmful substances in water. In contrast to the first section of this chapter where the focus is on how water quality itself can be socially constructed, these studies accept a fairly straightforward understanding of good and bad water quality and then examine the social and spatial distribution of vulnerability and risks. These types of studies are often concerned with quantifying distance from hazards, non-compliance and the political nature of exposure (Arce-Nazario, 2018). Much environmental justice literature falls into this category, as do political ecology studies of drinking water quality. Environmental justice literature has so far largely focused on North America, looking at pollution from industry and siting of waste, often showing how vulnerable minorities or low-income groups are the most likely to be

exposed to harm (Ranganathan & Balazs, 2015). Political ecology considers similar problems, often in the Global South, asking questions about what kind of power relations allow inequality to emerge and persist and who wins or loses (Ranganathan & Balazs, 2015).

Some studies exploring the everyday experiences of urban resource users, often in the Global South, typify this approach. Such studies consider how social relations and power shape heterogeneous experiences of water and water quality. A foundational claim in this body of work is that while water quality decline is often portrayed as neutral and directly solvable, politics and power play an important role in determining where water quality decline occurs and who is exposed to pollution (Karpouzoglou et al., 2018). Although water flows through a hydrological (and social) cycle, not every associated piece flows at the same rate; material and discursive characteristics of environments cause pollution to accumulate in certain bodies, locations and waters (Perreault, 2014).

These analyses often consider the role of power, politics and governance as they relate to the social and spatial distribution of access to resources through networked services (ie. Gandy, 2004). For instance, situated analyses of water networks show differences in water pressure linked to pipe sizes and power relations between neighbourhoods (Anand, 2011; Björkman, 2015). Other studies argue that developmental, operational and maintenance-related factors can lead to unequal distribution of drinking water quality between low- and high-income neighbourhoods (See also Alda-Vidal, Kooy, & Rusca, 2018; Boakye-Ansah, Ferrero, Rusca, & Van Der Zaag, 2016; Rusca et al., 2017). The abilities of users to communicate and contest deficiencies depends on their socio-economic status (Kjellén, 2006), and the emotional weight and labour of care fall largely on women (Sultana, 2011).

In urban political ecology in particular, the concept of the hydrosocial cycle has emerged as a way to compensate for what is seen as chronic overemphasis on positivist and overly technical approaches to water. The hydrosocial cycle constitutes a conceptual framework put forward by social scientists, typically relying on qualitative in-depth case studies (Wesselink, Kooy, & Warner, 2017). The hydrosocial cycle has been proposed as a way of

showing the “social nature of water” and separating water as a socially constructed object from H₂O (Linton & Budds, 2014; Swyngedouw, 2009). These approaches encourage researchers to consider water as a socio-natural hybrid embroiled in historical social relations, cultural contexts and hydrological conditions (Linton & Budds, 2014; Swyngedouw, 2006). Hydrosocial scholars argue that water and society are inseparable, internally related and ‘should be considered hybrids rather than pre-given entities’ (Linton & Budds, 2014). Because of this internal relationship, the focus of research is not on the relationship between water and society (which are in effect two parts of the same whole), but rather on the relationships that they together have to other objects and phenomena that constitute them (Swyngedouw, 2009). However, although the goal of hydrosocial analysis is to incorporate both social and material aspects of water, the social tends to dominate over the material.

Socio-hydrology

In an emerging field of study called socio-hydrology, scholars advocate for an interdisciplinary approach to water that incorporates both natural and social factors. This field has grown out of a desire to acknowledge that social and hydrological systems are mutually influential. Socio-hydrology is largely engaged in by hydrologists and natural scientists who see the importance of incorporating social factors into quantitative models and hypotheses (Wesselink et al., 2017). While these attempts are admirable, in most cases thus far the inclusion of social factors tends towards approaches that assume straightforward causal relations between quantitative socio-economic figures and hydrological processes and vice versa (Wesselink et al., 2017). Despite its interdisciplinarity, socio-hydrology retains a materialist bias wherein social aspects are incorporated into analyses primarily in the form of quantitative demographic and settlement patterns, technology and economic analyses (Rusca & Di Baldassarre, 2019). Efforts to bring together social and hydrological knowledges in socio-hydrology are most productive when they include insights from context-sensitive qualitative traditions, for example in critical resource geographies, although tensions over the role of measurement,

calculability and generalisability can make bridging these approaches challenging (Rusca & Di Baldassarre, 2019).

Final reflections

In this chapter I have shown that prominent approaches to water quality in the social science literature tend to focus on either social or material aspects of water quality. Even in blended perspectives that incorporate both social relations and materiality, there are general assumptions about which will be more important that precede analysis. These assumptions therefore limit the possibility for a balanced perspective that sees the social and material as having equivalent potential to shape outcomes. The concept of the hydrosocial cycle and the field of socio-hydrology represent two approaches to incorporating both material and social aspects of hydrological processes. However, in both cases either the material or social are still assumed to inhabit a privileged position over the other.

One solution to this imbalance could be to include both hydrosocial and socio-hydrological perspectives in analyses. Tensions between fundamental and epistemological positions challenge this combination. Socio-hydrology is quantitatively oriented and more likely to focus on how material processes shape social outcomes, while the hydrosocial cycle aims to consider the social and material as hybrid but leans towards portraying social relations as more important. Furthermore, the internal relationship between water and society posited by scholars working with the hydrosocial cycle corresponds to a fundamentally different epistemology from socio-hydrology, which views the relationship between water and society as external (Rusca & Di Baldassarre, 2019). This depth of difference can pose challenges for collaboration, albeit not insurmountable ones (Rusca & Di Baldassarre, 2019).

I position assemblage theory as an alternative to the hydrosocial cycle, wherein elements in assemblages are viewed as being in relations of exteriority (DeLanda, 2016). Exteriority means that while water and society can be mutually influential, there is always potential for

them to behave differently in different relations which condition but do not determine their identities (DeLanda, 2016). Therefore, assemblage theory may be better suited than hydrosocial perspectives to collaboration with hydrology, resulting in an opportunity to develop a balanced socio-material understanding of water quality⁵. Given the challenges and gaps I have identified in current social science literature on water quality, assemblage theory may offer a way to balance the social and material aspects of water quality. Assemblage theory further contributes a coherent ontological position including ethics, as I will discuss in the following chapter.

⁵ In Chapter 4 I elaborate further on how assemblage theory may encourage epistemological pluralism which can facilitate transdisciplinary collaborations.

Chapter 3. Theoretical framework

The theoretical framework for this thesis is based on an ontology and selected concepts from the philosophy of Giles Deleuze and Felix Guattari. In particular, I draw on the book *A Thousand Plateaus* (1987). Deleuze and Guattari's work has been applied in a variety of contexts under the umbrella of assemblage theory. In this chapter I present my interpretation of assemblage theory and situate it within this broad field. I attempt to stay quite close to the original text to explore the potential for applying such a distinct perspective to empirical work⁶.

I begin by describing an assemblage theory ontology and selected critiques of this perspective. I also comment on the position of assemblage theory perspectives in larger debates, including those originating from southern urban critiques. Next I describe concepts from *A Thousand Plateaus* that I rely on in my analysis. I then present some of the many applications and variations of assemblage theory, situating my study in this broad field. Finally, I introduce the idea of drinking water quality as a model for assemblage theory concepts, which begins to build the foundation for analysis in the findings chapters.

Ontology of assemblage theory

To fully grasp the originality and potential of Deleuze and Guattari's work, it is important to understand the ontological underpinnings of how they see the world. The ontology of assemblage theory put forward by Deleuze and Guattari is more than a collection of concepts, or a metaphor of assembling heterogeneous elements – it is a coherent and unique perspective on how social entities come to be (Anderson, Kearnes, McFarlane, & Swanton, 2012). This ontology encourages a certain kind of sensibility and awareness of symmetry that changes the way the world is understood (Farías & Bender, 2012). Through this lens, assemblage theory directs researchers' attention to processes of transformation, relationality and ethics. Analysts working with an assemblage theory ontology strive to be

⁶ My interpretation of *A Thousand Plateaus* is greatly aided by Adkin's (2015) Critical Introduction and Guide.

open minded and avoid defining in advance which elements matter most (Bueger & Liebetrau, 2021 (forthcoming)). They begin from a position that ‘doings and sayings, humans and non-humans are given equal weight’ and then determine through empirical investigation what relations and capacities are most important in a particular situation (Bueger & Liebetrau, 2021 (forthcoming), p. 7).

There is great variety in the secondary literature on assemblage theory. Some interpretations strive to stay faithful to the original text, while others are inspired by Deleuze and Guattari but develop in distinct directions (Buchanan, 2017). Many researchers interpret assemblage theory via secondary literature (for example: Delanda, 2000, 2006; Hillier, 2007; Rachman, 2000). While there can be benefits to approaching assemblage theory more generally, it is common for scholars to apply a metaphor of assemblage stripped of some of its ontological originality and context (See Buchanan, 2020 for a critique of over-reliance on secondary sources in assemblage thinking; Purcell, 2013). So even though I rely on this secondary literature for support in answering questions like “what would an assemblage methodology look like?” or “how does one analyse an assemblage?” I am trying to interpret Deleuze and Guattari directly as much as possible, in order to explore the potential of this kind of approach to aid in considering the combined material, social and ethical aspects of drinking water quality.

In this section I present the foundations of an assemblage ontology. I divide this into discussions of: flat ontology; difference and becoming; and ethics. I then engage with critiques of the assemblage ontology, drawing primarily on debates in the urban studies and geography literatures⁷. For each critique I provide rebuttals, arguing that in many cases criticisms aimed at assemblage theory relate to misunderstandings or misinterpretations of the implications of a flat ontology.

⁷ A lively debate about assemblages in urban studies and geography emerged in a the scholarly journal *City* in 2011. This began with an article by McFarlane, which was critiqued quite strongly by Brenner et al (2011). A group of scholars then wrote responses and McFarlane and Brenner closed out the debate in a final issue.

Flat ontology

Deleuze and Guattari's work is associated with a flat ontology. In this section I briefly describe what is meant by a flat ontology in assemblage theory, and then outline what this perspective does for particular understandings of causality, structure and agency. Flat ontologies do not assume hierarchies between entities and categories but rather begin from a space of equivalence and trace the emergence of difference as it actually occurs (Kinkaid, 2020b). Thus assemblage analyses should begin from the perspective that all things are equally important (Müller, 2015), and aim to overcome distinctions between categories like subject and object or who or what is allowed to have agency (Kinkaid, 2020b). The status of all assemblages is the same at the start of analysis, which allows us to compare across scales and consider relations between things that previously were considered members of different categories (DeLanda, 2016). Assemblage theory thus requires researchers to remain quite close to the empirical because the objects and phenomena they study are so complex that one may not know what they are looking for until they find it (Farías, 2011).

Causality in assemblage theory emerges in specific interactions between agents, and is not attributed directly to humans or non-humans (Anderson et al., 2012). This is another way the ontology is considered to be "flat", because no one agent or type of agent is assumed to be more or less causally active at the start. Such an emergent understanding of causality means assemblages can have capacities to act that are more than the sum of their parts (Anderson et al., 2012). Furthermore, causal relationships are entirely contingent and '...only [have] determinacy when read retroactively; [they] could always have happened otherwise' (Holland, 2013, p. 19). This awareness of complexity and particular understanding of causality play an important role in how structure and agency are viewed in assemblage theory.

In a flat ontology, the influence of external structural forces should not be assumed. Causal actors, including structures, emerge relationally through assemblages; structures are not outside assemblages working on them, but participants in webs of relations (C. McFarlane, 2011a). Therefore, in assemblage theory, categories like race and capitalism are never

explanatory on their own (C. McFarlane, 2011d). Each category and structure must be explained. Thus analyses using assemblage approaches "...seek to replace abstractions with concrete histories of the processes by which entities are formed and made to endure" (Acuto & Curtis, 2014, p. 7). For instance, Latour (2005) unpacks the idea of "the social". He says that social factors are an abstract idea that cannot explain the existence or persistence of other phenomena (Latour, 2005). This challenges explanations from Marxist political economy, among others, that emphasise the role of global forces and "context of contexts" (C. McFarlane, 2011d).

Agency, as it is conceptualised in Deleuzoguattarian assemblage thinking, is basically the capacity to act: to have an affect in the world or conversely to be affected by the world (Deleuze & Guattari, 1987). To have an affect is to cause something to happen (or not happen). Agency boils down to a body becoming active in association with other bodies (Stark & Roffe, 2015). As with structures, when analysing assemblages, one should not assume that every entity (be it material or immaterial) has agency *a priori*. Instead, analysts trace empirically how each element in an assemblage comes to matter (Angelo, 2011). Therefore, through the process of analysing or describing assemblages it gradually becomes clear which elements are most agential in that particular context (Müller, 2015).

Despite the possibility for any body to have agency, for Deleuze and Guattari, human actions are the only ones able to be the subject of philosophical inquiry (Buchanan, 2020). This is because although the material can be active, non-humans do not have the same kind of awareness and intentionality as humans (Buchanan, 2020). The purpose of assemblage theory analysis for Deleuze and Guattari is to examine what humans do; 'neither geology nor biology is our destiny' (Buchanan, 2020, p. 36). The ethical imperatives in Capitalism and Schizophrenia are to make yourself a "body without organs" and embrace a state of becoming (Bowden, 2020). Body without organs is a neologism from Deleuze and Guattari's collaborative work that mainly corresponds to releasing oneself from constraining structures and unleashing one's creative potential (Bowden, 2020). For these imperatives to make sense, Deleuze and Guattari's understanding of ethics requires the presence of an intentional human subject (Bowden, 2020). Without human agency and intention, there is

no clear distinction between action and any other type of event. However, human intention can be seen as one among many causal actors which is expressed immanently alongside other ontologically equivalent entities (Bowden, 2020).

Difference and becoming

Another fundamental aspect of an assemblage ontology is a deep concern with both difference and becoming. Deleuze and Guattari's interpretation of difference and becoming is linked to their exploration of the idea of continuity (Adkins, 2015). In Deleuze's work prior to *A Thousand Plateaus*, including the book *Difference and Repetition* (1994) and his co-authored work with Guattari in *Anti-Oedipus* (1983), he was in many ways developing a philosophical argument against a metaphysics of discontinuity (Adkins, 2015). Discontinuity refers to a Platonic conception of metaphysics and the distinctions "between virtue and virtuous acts, between beauty and beautiful things, between the good and particular goods" (Adkins, 2015, p. 1). These pairs are seen as belonging to different orders of being. They are entirely different types of entity, although they can be seen as similar or analogous. Deleuze and Guattari reject this claim and instead say that all things are made up of the same substance, a univocity of being.

"Oneness of being" does not equate to "sameness of being". Entities which have long been seen as distinct categories differ in degree rather than in kind (Adkins, 2015, p. 6). *A Thousand Plateaus* departs from this point and builds a new way of seeing the world in terms of continuity (Adkins, 2015). Some critics of assemblage theory argue that continuity's alignment with an associated flat ontology makes it impossible to understand difference; if everything is made of the same substance how can anything be different (Adkins, 2015)? This critique originates from a belief that if entities differ in ontological kind they are analogous but not comparable (Adkins, 2015). Deleuze and Guattari say entities do not differ in ontological kind, therefore they are not analogous. They are the same and therefore comparable (Adkins, 2015). Thus continuity actually facilitates understanding of true difference.

In addition, an ontology of becoming is inherent in every part of *A Thousand Plateaus*. In an ontology of becoming, the world consists of unstable assemblages in constant states of becoming and change, where stability is the exception not the rule (Deleuze & Guattari, 1987). For Deleuze and Guattari becoming means that there is no end point because everything is always continuously moving and transforming. Things do not have a history; they are their history (Holland, 2013). When we encounter an entity that appears fixed and stable, the condition of stability remains the temporary culmination of an ongoing process of becoming, even if it lasts a long time (Holland, 2013).

These perspectives on continuity and becoming alter how we perceive the world and the kinds of questions we ask. Instead of focusing on form, our attention should be on processes of formation (Müller & Schurr, 2016). When something seems to be stable questions follow about how it got this way, why it stays this way or whether it might eventually fall apart. What had to be assembled for this thing to act in the ways it does? How else could this phenomena have occurred? Therefore, researchers working with assemblage theory explore processes of how the world becomes the way it is and ask if and how things could be different (C. McFarlane, 2011a; Tampio, 2014). There is something inherently normative about these questions because we would not need to change the world if we were fully satisfied with how it is already. However, Deleuze and Guattari do not encourage judgement based on moral ideas of good and evil, but rather evaluation based on an immanent ethical position.

Immanent ethics in an assemblage ontology

Deleuze and Guattari's ethical position can be framed around the ideas of immanence and affect. I address each of these concepts in turn and then describe how they relate to each other. Immanence refers to a form of ethics which 'resides within (rather than above or outside) matter and practice' in contrast with transcendence which is external to or above its object (Coleman & Ringrose, 2013). Consequently when scholars refer to an immanent ethical position in Deleuze and Guattari's work they are referring to how, for them, ethics is concerned with situated evaluation of an action in terms of its mode of existence. Ethics

contrasts with morality which entails judgment relative to an external ideal (Smith, 2011). In other words, ethics refers to a 'way of assessing what we do in terms of ways of existing in the world' whereas morality represents a 'set of constraining rules that judge actions and intentions in relation to transcendent values of good and evil' (Marks, 2010, p. 87). This lack of transcendent norms on which to base judgements may appear problematic, but for Deleuze the urge to judge is something that should be overcome (Banville & Torres, 2017). Furthermore the ethical distinction is not good versus evil, but rather good versus bad (Deleuze, 1988 in Bryant, 2011) or more precisely, better versus worse. Deleuze cannot support an ethics relying on transcendence because this would be at odds with his underlying ontological and philosophical claims (Bryant, 2011), specifically the metaphysics of continuity I described in the previous section.

Continuity reinforces the idea of immanence over transcendence because it means there is no possibility of 'spiritual or immaterial dimensions of being that are ontologically and epistemologically distinct from *a priori* material reality' (Karaman, 2012, p. 1208). Relatedly, while some philosophical traditions have traditionally held process and outcome as ontologically separate, continuity places them in one category where they emerge together and express each other. To better understand this view it is helpful to consider two other common streams of moral philosophy: deontological and teleological ethics. Deontological ethics, born out of the work of Immanuel Kant, focuses on the process of ethical decision making and the idea that one should only act in a way that such actions could be the grounds for a universal law (Kant, 1785). Thus the right action is right, even if the outcome is undesirable. Teleological ethics, also known as consequentialism or utilitarianism, is outcome-focused, arguing that the right action is the one with the maximum benefit for the largest number of people (Bentham, 1970). The distinction between deontological and teleological ethics is at its heart a divide between process and outcome. Deleuze and Guattari collapse this distinction using their metaphysics of continuity. Thus ethics becomes more about what is possible than what should happen or even how it happens (Banville & Torres, 2017).

Alongside immanence, Baruch Spinoza's framing of ethics around the idea of affect was highly influential for Deleuze. Affect refers to the capacity of a body to act or be acted on, and affectivity is an inherently positive '...force that aims at fulfilling the subject's capacity for interaction and freedom' (Braidotti, 2006, p. 148). Ethical action increases the power of bodies in the world to affect and be affected (Bogue, 2007). A body or entity is only good or bad in terms of what it does, thus there can be good or bad affects but not inherently good or bad things. Good affects and modes of existence increase our power to act through positive relations. Bad affects decrease our power because they in some way do not agree with our nature. These encouragements to seek out positive affects for our own bodies can at first seem to minimize our responsibility to others (Bignall, 2010). But in fact what Deleuze and Guattari advocate for is mutually positive affective relations between bodies (Bignall, 2010).

The ethical link between immanence and affect is that transcendence harms us by demanding we do impossible things, thus limiting our potential to affect or be affected in positive ways (Smith, 2011). For example, in both deontological and teleological ethical thought there is assumed to be a universal ideal we can judge actions against, such as justice. Justice represents a limit we strive for but may never reach (Philippopoulos-Mihalopoulos, 2014). Consider the idea of water justice mentioned in the introduction (Chapter 1). There cannot be a final ideal end state where water justice is achieved because one individual or group getting more is always tied to another getting less. The goal should be good or better because "best" does not exist. Thus, '[justice] can by no means be a solution to an existing dilemma, merely the event that opens up new opportunities for transformation, even while remaining within reach but unachievable...' (Ansaloni & Tedeschi, 2016, p. 325). The fact that we can never reach justice or satisfy our duty to the other is why transcendence separates us from our ability to act (Smith, 2011). Failure to achieve a perfect condition of justice does not have to be viewed as a clear failure, provided that there is movement towards a situation with more positive affects. So the ethical question becomes: do shifts in relationships 'expand or diminish the capacities of human or non-human entities to thrive?' (Harris, 2020, p. 274). Thus it can be argued that Deleuze's

project is an affirmative attempt to free thought from the power of the negative (Roberts & Dewsbury, 2021).

Deleuzian ethical perspectives also attend to the non-human and view ethics as emerging out of complex webs of relationships. When we focus on affect in the context of immanent and relational causality which is not the exclusive purview of humans, the mind/body dualism that is fundamental to Cartesian ethics must also be rejected (Richardson-Ngwenya & Nightingale, 2018). Ethics does not only belong to human minds; it is located in complex and entangled webs of human and non-human relations. This perspective results in a diverse and dynamic form of ethics (Richardson-Ngwenya & Nightingale, 2018). The risk with such a shift is that 'attending to non-human agencies is taken as an end in itself rather than a means for evaluating our modes of thought and the styles of life these modes entail' (Roberts & Dewsbury, 2021, p. 2). As a result, consideration of immanent ethical perspectives requires deep and ongoing reflexivity.

An alternative perspective associated with pragmatism and analytical philosophy asserts that it is not necessary to get bogged down in questions of ontology to make claims about ethics (Barnett, 2010). Proponents of this position advocate instead for a form of "practical reason" which is based on intuition and experience (Barnett, 2010, 2011). Despite differences in the foundations for their claims, pragmatic geographers also argue for a form of ethics that is situational, learned, individual and grounded in the everyday (Furlong et al, 2017). Collier & Lakoff (2007), for instance, propose that one particular understanding of living a good and ethical life emerges in each set of complex, problematic or uncertain conditions. I sympathise with their desire to focus more on an applied and concrete approach, but I think there is value in an ontologically cohesive framing of ethics, such as the one found in Deleuze and Guattari's work. Furthermore the emphasis on mutually positive affects among humans and non-humans brings something new to discussions of ethics, as do explorations of responsibility to oneself and the other in work on immanent ethics (for example, Bignall, 2010). Finally, the affirmative nature of Deleuze and Guattari's ethical thinking offers potential for freedom and creativity that encourages a new and more ethical way of living (Purcell, 2013; Roberts & Dewsbury, 2021).

Critiques of assemblage theory ontology

Assemblage theory is contentious. Some scholars find assemblage theory provides opportunities to expand our understandings of social phenomena, while others consider assemblage to be an empty meaningless concept lacking history and political sensitivity (Tonkiss, 2011). Many critiques of assemblage theory stem from particular interpretations of the flat ontology underlying its claims. For instance, because of their distinctive views on structure and context, assemblage ontologies have been accused of being blind to inequality, injustice and marginalisation. This criticism stems from a belief that context has an ambiguous status in assemblage theory (Brenner, Madden, & Wachsmuth, 2011; Wachsmuth, Madden, & Brenner, 2011). Critics consider rejection of the explanatory power of contextual factors to amount to a neglect of context rooted in “naïve objectivism” (Brenner et al., 2011). This tension around structure runs through debates on context in assemblage theory (Russell, Pusey, & Chatterton, 2011). However, critiques that centre on a lack of attention to context misunderstand the role of structures in a flat ontology. The intention is not to replace or reject structural categories but to say that social scientists should study how structures emerge relationally (C. McFarlane, 2011d).

In addition, relational understandings of agency create tensions in writing about assemblages concerning the role of human intentionality. Critics argue that if everything is assembled according to forces and flows which do not have to be human then we are necessarily denying the specificity and uniqueness of human intention. Some scholars interpret Deleuze as essentially denying humans agency (i.e. Massumi, 2002, cited in Bowden, 2015). In this reading, human volition is an epiphenomenon and humans and their actions are products or conduits for a more virtual version of agency. Others see space for human agency in Deleuze, connected to but separate from non-human agency and leaving space for human intention (Bowden, 2015). Building on the distributed understanding of causality introduced previously, human intention may influence outcomes, but it is never the sole determinant of those outcomes (Bowden, 2020). Still, opening up the potential for agency to include non-human actors can be seen as levelling out reality in a way that lacks sense and can challenge attempts to be critical (Anderson & McFarlane, 2011). Bennett

(2005, 2010) wrestles with this conundrum, asking whether in fact it is more useful to adopt a distributed understanding of causality and to “avoid a politics of blame” or to maintain a focus on human actors in order to hold individuals accountable. She comes to the conclusion that even while attributing some agency to non-human actors we should not abandon all attempts at accountability.

Another critique of assemblage theory is that it is devoid of power (Kinkaid, 2020a). A flat-ontology, where everything is equivalent, is seen as obscuring the possibility for unequal power relations. But such a neglect of power is not a methodological or analytical fault of assemblage theory (Kinkaid, 2020b). Problems start from a misunderstanding of flat ontology. Deleuze and Guattari did not intend to ignore the possibility of hierarchy or difference and say that everything is the same (Kinkaid, 2020b). Instead of assuming the presence of power or attributing it to particular actors based on their inherent characteristics, assemblage theory analyses call for tracing how power emerges relationally (Farías, 2011; Müller, 2015). Analysis should begin from a flat surface wherein all elements in an assemblage are ontologically equivalent, but the surface does not have to remain flat. The capacities or powers of some entities can tilt or tip the scales (Philippopoulos-Mihalopoulos, 2014). Therefore in analysis power should not be assumed or attributed to certain types of actor, but documented empirically. The act of tracing the histories of assemblages can make embedded power relations visible and help to develop a firmer basis for critique (Acuto & Curtis, 2014). Power in assemblages is plural, relational and emergent. So rather than being apolitical and devoid of power, the ontology of assemblage theory allows for power but does not take it for granted.

As a result of its emphasis on becoming, another criticism levelled at assemblage theory is that analysts can be so swept up in the potential for transformation and fluidity that they forget to consider why some things do not change (Wachsmuth et al., 2011). However, stability and change are not binary essential characteristics of entities which are either stable or changing. On the contrary, stability and change are tendencies (Adkins, 2015). Entities differ in their degree of stability and degree of change – a balancing act between the “ephemeral” and the “structural” (Marcus & Saka, 2006). Therefore, an over-emphasis

on flexibility is not an inherent characteristic of an assemblage ontology. Saldanha (2006, 2012), for example, has used an assemblage theory perspective to consider why some social structures, like race and gender, can be stable and difficult to change while others are always in flux.

Finally, critics argue that assemblage analysts struggle to move beyond analysis to propose solutions (Buchanan, 2011). Foucault's introduction to *Anti-Oedipus*, for example, frames the ethical positions in Deleuze and Guattari's work entirely around a series of negative statements such as don't be a fascist, don't be paranoid, sad, hierarchical and so on (Foucault, 1983). Because he does not elaborate on any positive suggestions for decision-making, it remains unclear what ought to be done based on Deleuzian ethics (Buchanan, 2011). The lack of explicit instruction about how to proceed in a more just or ethical way represents a common critique of assemblage theory: first that applications tend to be analytical without ever offering solutions, and second that they are decontextualised and apolitical (Brenner et al., 2011). However, although Deleuze and Guattari reject some versions of normativity, they are not amoral nihilists – as some critics have claimed – they simply espouse an immanent ethical perspective, as described in the previous section (Jun, 2011). An immanent ethical perspective refers to a commitment to situated assessment of actions in terms of their mode of being rather than judgement relative to external ideals. This view of ethics represents a contribution to current debates on water ethics and water justice and may offer a way forward that balances awareness of established values and principles with encouragement for how to proceed.

Situating my approach to assemblages

My work in this thesis has been inspired by a broad range of empirical approaches to assemblage theory. Building on the original ideas and concepts of Deleuze and Guattari, scholars working in the fields of anthropology, policy studies, education, planning and geography, among others, have transported the concept of assemblage into the realm of empirical research. Applications cover a wide array of topics including, but not limited to: cities as assemblages (C. McFarlane, 2011b); the risks and benefits of public art displays

(Hillier, 2011); hydraulic fracturing (fracking) (Kroepsch, 2019); global governance and counter-piracy measures (Bueger, 2018); responses to homelessness (Baker & McGuirk, 2017; Lancione, 2013); and seawater desalination projects (Williams, 2018). Though there are some differences in how the concept of assemblage is applied in these areas, they frequently share a focus on practices and processes of assembling heterogeneous elements which can be both human and non-human (Baker & McGuirk, 2017). Assemblage theory approaches also share an interest in avoiding reification and breaking down categories that seem unproblematic into their component parts (Acuto & Curtis, 2014). Use of assemblage theory has also been linked to ‘...normative commitments to explore how... socio-material networks are produced, to whose potential benefit, and to how they might be imagined differently’ (Anderson & McFarlane, 2011; C. McFarlane, 2011a; Williams, 2018, p. 34).

Despite many similarities, within assemblage theory-inspired research there are multiple interpretations and approaches which are more or less engaged with Deleuze and Guattari’s original articulation of assemblage theory in *A Thousand Plateaus*. Widespread application of assemblage theory concepts can in some iterations depart significantly from the original aims of Deleuze and Guattari (Buchanan, 2017; Bueger, 2014). Scholars like Donna Haraway and Bruno Latour have been influenced by Deleuze and Guattari’s work, resulting in related but distinct assemblage-inspired approaches (Greenhough, 2011). In other studies, assemblage theory ideas have been applied productively, albeit in a somewhat superficial way via secondary literature with only perfunctory references to Deleuze as the source of the concept of assemblage (Buchanan, 2017; Bueger, 2014; Purcell, 2013). For example, I identified only one article in my literature review applying a variant of assemblage theory specifically to water quality. The authors only loosely engage with the details of assemblage theory and do not cite Deleuze and Guattari’s work (Gorostiza & Sauri, 2017). While these extensions of assemblage theory open up fruitful avenues for inquiry of their own, Anderson et. al (2012) lament that the concept of assemblage has widely been used simply to describe a particular type of socio-spatial relation rather than highlighting the dynamism and potentiality intended (Müller & Schurr, 2016).

Deleuzoguattarian scholars including Ian Buchanan (Buchanan, 2017, 2020) have raised their voices in support of approaches which remain faithful to the ontology of Deleuze and Guattari throughout analysis and argued that an assemblage theory ontology can provide new and deeper ways of understanding the world. In particular Deleuze and Guattari's views on continuity, becoming and ethics are under-explored and potentially path-breaking (Adkins, 2015; Holland, 2013). I situate my dissertation in this school of thought, which sees value and coherence in engaging with *A Thousand Plateaus* directly rather than primarily through secondary sources.

In the field of geography, much engagement with assemblage theory happens via the work of Manuel Delanda. Delanda (2006, 2016) is widely cited for his re-interpretation of Deleuze and Guattari's assemblage thinking which draws heavily on complexity theory. He tries to articulate concrete and practical ways of using assemblage theory to understand the world, which is something that exists objectively and can be known, while still remaining at the level of highly philosophical project (Bueger, 2014). However, Delanda's return to the mathematical and scientific origins of Deleuze and Guattari's concepts risks minimizing the open and metaphysical potential of their work (Frichot, 2012). Much Delanda-inspired research also neglects some of the concepts I find most productive in *A Thousand Plateaus*, such as abstract machines and the double articulation. One original contribution of my thesis, therefore, is a commitment to applying lesser known concepts from assemblage theory.

To find studies that deeply engage with concepts beyond assemblage from *A Thousand Plateaus* requires a broad search strategy. Thus in my work I draw inspiration from planning, international relations, policy studies, education and geography. This wide net approach allows me to bring diverse perspectives together in unique ways. Some practical in-depth applications of assemblage theory in empirical analyses have been very helpful in developing my engagement with assemblage thinking, even when their empirical topic is distant from mine. Among these are: Day & Walker (2013, energy vulnerability), Bennett (2005, an electricity blackout), Barry (2013, development of an oil pipeline) and Dovey (Dovey, 2013, architecture). An edited volume by Hickey-Moody and Malins (2008)

explores a variety of contemporary social issues using Deleuzian-inspired concepts. The authors of this volume call for broader engagement with the practical potential of Deleuze's work for rethinking an expanding range of social phenomena. Day and Walker (2013) in particular approach their engagement with assemblages as an experiment, asking what assemblage thinking has to offer that other approaches to their field may not. Dovey (2013) similarly selects some tools from assemblage theory to reconsider architectural forms, stating that 'The ultimate test lies in practice – what new ways of thinking... does it open up?' (p. 6). Banville and Torres (2017) further ask what new and even revolutionary contribution Deleuze and Guattari's ethical framework can bring to their study of planning in Montreal. These speculative and experimental approaches inspire my application of assemblage theory concepts to the case study of drinking water quality in Kaolack, Senegal.

Reflections on an encounter between Deleuze and Southern Urbanism

Empirically speaking, another place I situate my work is alongside literatures that analyse heterogeneous infrastructures and urban water security in the Global South. The siting of my study has led me to engage with this field, and so it seems natural to consider assemblage theory in conversation with existing works on water in southern cities. Assemblage theory's 'potential can only be realised in conjunction with different urban critical, activist and marginalised knowledges' (C. McFarlane, 2011c, p. 731), including southern urban perspectives. Therefore, in this section I bring assemblage theory into conversation with literature describing an emerging body of southern urban theory. I begin by outlining some of the key characteristics of a southern urban critique in geography, urban studies and urban political ecology. I then consider what aspects of this southern urban critique may or may not be compatible with Deleuze and Guattari's vision for assemblage theory. I conclude that though there may be some contradictions or contradictory applications between Deleuze and Guattari's work and the broad aims of a southern urban critique, there may also be opportunities for productive conversation (Bignall & Patton, 2010 and additional chapters in this edited collection).

In the last twenty years or so there has been a dramatic increase in scholarly attention to cities in the Global South (Lawhon & Truelove, 2020). This body of work includes multiple overlapping arguments that constitute a form of southern urban critique (Lawhon & Truelove, 2020). First, there are scholars who argue that cities in the Global South, and African cities in particular, are empirically distinct and deserve to be studied on their own terms (Schindler, 2017; Watson, 2009). Arguments about the empirical distinctiveness of African cities emphasise the depth of difference between cities of the North and South (Watson, 2006). Postcolonial scholars have long argued that Western theories fail to account for the diverse experiences and agencies of people around the world (Lawhon, Silver, Ernstson, & Pierce, 2016). In response to this degree of difference, Ernstson and others have argued that there should be less focus on external structures, like liberalism and colonialism, and more on incremental change, resistance from below and the everyday practices of urban residents (2014). A focus on practices and everyday urbanism does not entail rejecting structure in favour of agency or vice versa (Pieterse, 2008). The aim should be to empirically document what actually happens in African cities and then consider how it speaks back to theory (from anywhere) (Pieterse, 2008). Rather than imposing external explanations onto diverse and fluctuating contexts, 'To take African cities seriously means to provide texture to the barrage of statistical portraits or structural explanations' (Ernstson et al., 2014, p. 1567). Similar arguments have been made by assemblage theorists who assert that structures and contexts are not universalising causal influences that can explain social phenomena, but rather themselves assembled through practice (see MacFarlane, 2011d and the earlier section on structure and agency in an assemblage ontology in this chapter).

A second point made by southern urban theorists is that past scholarly work on African cities has often been empirically rich and practice-oriented but theoretically thin (Ernstson et al., 2014; Mbembé & Nuttall, 2004). Thus scholars of African urbanism could potentially benefit from greater engagement with philosophy and the humanities (Mbembé & Nuttall, 2004). Proponents of southern urban theory have responded to a developmentalist critique of African scholarship as too focused on practice and policy relevance, to the detriment of theory (Ernstson et al., 2014). In some cases the applied nature of research poses challenges

for research on African cities to be seen as relevant elsewhere (Mbembé & Nuttall, 2004). The opposite critique has been aimed at assemblage theory-based analyses which are seen as lacking practical applicability. Instead of focusing on solutions, assemblage theory struggles to answer questions about what one should do (Buchanan, 2011). Critics of assemblage theory thus perceive a risk of endless description and infinite chains of relations which never arrive at explanation (Müller, 2015). Perhaps, then, assemblage theory and southern urbanism can be complementary. The encounter between them could result in a combination of theoretically informed thick description and engaged, action-oriented analyses.

The next form of southern urban critique advocates for recognising the context-specific nature of all theory. These scholars consider it problematic that much theory and knowledge production, including about African cities, is centred in the global North and advocates for recognising the situatedness of all theory (Myers, 2011; Robinson, 2013; Roy, 2009, 2014). They also support greater engagement with locally specific intellectual traditions and highlight particular conceptual directions in Africa-focused literatures (Ernstson et al., 2014). The aim of this argument is not to reject any theory that originates from outside Africa or the Global South. On the contrary, southern and postcolonial theorists have fruitfully exchanged with, for example, the work of Foucault (Mbembe, 2019). The point is, rather than uncritically applying frameworks from the North or West, researchers are called to reflect on the roots of theory and how it translates across contexts (Roy, 2009). This position reflects a growing awareness that mainstream theory originating in the North (broadly encompassing Europe and North America) often lacks relevance for southern cities (Ernstson et al., 2014) and has included calls for “provincializing”, “decentering” and “situating” urban theory (Lawhon, Ernstson, & Silver, 2014; Mbembé & Nuttall, 2004; Watson, 2009). This tension is present in my work, surrounding the choice to apply the theoretical perspectives of two white French men to a study of Senegal. Especially in Senegal, which was colonized by France, imposing French knowledges and worldviews could be seen as a neo-colonial decision (or at least oversight). However, there are particular aspects of Deleuze and Guattari’s philosophy that may allow it to be compatible with some scholarship on southern urbanism. In addition, some of Deleuze and

Guattari's political commitments and ethical positions demonstrate that they were implicitly aligned with postcolonial perspectives, even if they did not explicitly claim allegiance to such struggles in their published works (Bignall & Patton, 2010).

Potential synergies between assemblage theory and southern urbanism are not immediately obvious. Indeed, Deleuze and Guattari's conceptual vocabulary has been criticized for exoticism and appropriation. This stems in part from their use of concepts like "nomadism", which further call into question assemblage theory's applicability to work in the Global South (Holland, 2003; Wuthnow, 2002). Despite the potentially problematic position of Deleuze and Guattari within a tradition of French philosophers and intellectuals, a deeper look at the context in which Deleuze and Guattari were writing, and their political and ethical commitments, complicates this picture. Understanding assemblage theory – and any theory for that matter – requires careful attention to its roots (Russell et al, 2011). Felix Guattari, for instance, was a militant communist interested in radical experimental psychological practice (Russell et al, 2011). Gilles Deleuze was publicly quite supportive of decolonial struggles in Algeria and Palestine (Bignall & Patton, 2010). *A Thousand Plateaus* was written after student protests swept through France. Deleuze and Guattari were a product of this time period, interested in exploring and understanding what kind of world could emerge in its wake.

There may also be parallels between the argument against structuralist explanations of southern urbanism and Deleuze and Guattari's conviction that philosophy (and life itself) is held back and limited by rigid external conceptual frames (see the earlier section in this chapter on immanence and ethics in assemblage theory). Both traditions reject universality and emphasise the importance of specificity. Lastly, methods associated with a situated or provincialized vision of political ecology (Lawhon et al., 2014) could be compatible with those recommended for empirical application of assemblage theory (Baker & McGuirk, 2017; Rankin, 2011). In both cases scholars argue for ethnographic attention to detail,

practice-oriented empirical work and a focus on how relations shape reality in ways that are always context specific⁸.

In this encounter, Deleuze and Guattari's ideas about assemblages are not intended to displace the knowledges and theories of southern urban or post-colonial traditions. Ideally, an assemblage ontology could supplement the empirical depth of everyday urban analyses, while simultaneously being challenged and pushed by them. As Deleuze once said in an interview with Claire Parnet (1977), a conversation initiates and involves both parties in becoming something new and different that exceeds both. Parties are drawn together by shared problems that they define and transform together (Bignall & Patton, 2010; Deleuze & Parnet, 1977). I continue to develop the encounter between assemblage theory and southern urbanism in order to understand what can emerge from this meeting in the findings chapters⁹.

Core concepts

In this thesis I have selected concepts with potential for exploring how drinking water quality assemblages form in particular contexts, and what the implications of these assemblages are. The role of a theoretical framework should not be to describe something that we already feel we know in different words, but to help us understand phenomena more deeply or in a new way (Buchanan, 2017). For such a purpose, the works of Deleuze and Guattari provide a unique foundation based on concepts including assemblage, abstract machines, double articulation, territory and smooth and striated space.

I strive to apply these concepts analytically in a way that stays faithful to Deleuze and Guattari's philosophy. Such an approach can provide analytical depth to examination of socio-material phenomena which are always engaged in an ongoing process of becoming. However, a distinct challenge in selecting concepts from Deleuze and Guattari's work is the

⁸ For examples of this approach see the work of AbdouMaliq Simone (Simone, 2004, 2010).

⁹ In Chapter 8 in particular, the way I present my findings is inspired by extensive reading in critical infrastructure studies and works that portray everyday urbanism as embodied and relational. These literatures have influenced the vocabulary and sensitivity of how I present my empirical work.

tension between describing a framework for analysis and staying open to transformation. Though the concepts provided in *A Thousand Plateaus* can be useful for understanding processes and types of assemblage, there is a risk of constraining analysis to fit the forms of the concepts (Tonkiss, 2011). Checking boxes in a template is contrary to the core emphasis on becoming, change and flexibility that ideally should run through assemblage theory. I therefore work to avoid indiscriminately applying these concepts and instead reflexively ask what they contribute and how they function in contact with my empirical work. Buchanan (2011) suggests creative, confident and well-argued (mis)interpretation as the best way to engage with Deleuze. He says Deleuze and Guattari encourage this approach through their own appropriation and re-use of other philosophers' concepts to make their arguments. Deleuze and Guattari use concepts in a way that is inspired by, but would not necessarily always be recognisable to, their original authors (Buchanan, 2011). However, analysts applying assemblage theory should attempt to be true to Deleuze and Guattari's original intentions and ontological commitments, otherwise the lineage of the concept is broken and it becomes something else entirely (Buchanan, 2020).

Another challenge is the somewhat mystical and idiosyncratic nature of Deleuze and Guattari's writing. Concepts like abstract machines and strata can be alienating for researchers approaching assemblage theory from other traditions. I attempt in my thesis to strike a balance that captures the open-ended and creative spirit of assemblage thinking while remaining accessible, but these are ongoing sources of tension.

Throughout this thesis I explore the potential of selected concepts for deeper engagement with the social and material complexity of drinking water quality using assemblage theory. First is the core concept of **assemblage**, which Deleuze himself identifies as the central idea in *A Thousand Plateaus* (Deleuze & Parnet, 1977). Next are **abstract machines**, which encompass the processes shaping conditions of possibility for assemblages to form. Then I discuss how assemblages form through processes of **double articulation**, leading to the inclusion and exclusion of heterogeneous elements. These processes of inclusion and exclusion define the **territory** of an assemblage, which encompasses social, material and

spatial elements. Finally I move to a discussion of what assemblages do, using the paired concepts of **smooth** and **striated** space.

Because there are so many concepts and varied definitions, even within Deleuze and Guattari's work, it is necessary to identify the area of text you plan to engage with and your path through that text (Abrahams, 2019). I focus on Plateau 3 in *A Thousand Plateaus* for the discussion of abstract machines and the double articulation. Plateau 3 is the chapter with which most geographers and planning theorists have engaged because it elaborates the processes of how assemblages form. Plateaus 12 and 14 provide the foundation for the discussion of processes of smoothing and striation. Plateau 14 is the most explicitly spatial of the chapters, although the concepts of smoothing and striation are discussed in Plateau 12 as well. Plateau 12 discusses processes of knowledge production at length. Table 1 shows the chapters in *A Thousand Plateaus* I rely on most, including key concepts and their particular utility for my work.

Table 1. Chapters in A Thousand Plateaus and key concepts used to analyse drinking water quality assemblages

Chapter in <i>A Thousand Plateaus</i>	Core topic addressed in this chapter	Key concepts	Utility of this chapter for analysis of drinking water quality assemblages
Plateau 3 - 10,000 BC: The Geology of Morals (Who Does the Earth Think It Is?)	Discussing the problem of how assemblages develop tendencies towards stasis or change	Assemblages, abstract machines, double articulation	Emphasis on processes of how assemblages form
Plateau 12 - 1227: Treatise on Nomadology - The War Machine	Exploring how the state and its outside tend towards different ways of constituting and occupying territory	Smooth and striated space; territory; varied forms of knowledge production	Offers a way of understanding how state and alternative ways of producing knowledge conceptualise or express drinking water quality
Plateau 14 - 1440: The Smooth and the Striated	Outlining six different models for how assemblages can tend towards models of smoothness or striation	Smooth and striated space	Provides models for understanding how drinking water quality flows and territories form and interact

Assemblage remains a popular place to start engaging with Deleuze and Guattari's work, perhaps in part because the concept can be presented in a fairly simple and accessible manner. The empirical potential of concepts in addition to assemblage has not been thoroughly explored in secondary literature as yet (Buchanan, 2020). But assemblage is one among many concepts which together constitute a coherent framework. To realise the full potential of assemblage theory for analysis, other concepts from *A Thousand Plateaus* might also be brought into play. For instance, the double articulation and abstract machines provide important insights into how assemblages form and why they form in certain ways. The concepts of territory and smooth and striated space further assist with a conceptual link between what assemblages are and what they do. Proponents of assemblage thinking claim its main benefits are that it allows us to bring together the material and social into one cohesive assemblage, and also a focus on formation rather than simply form (Anderson et al., 2012; Müller & Schurr, 2016). If this is the case, skipping over the tools Deleuze and Guattari give us to understand these processes and combinations is a missed opportunity.

Assemblages

An assemblage is a heterogeneous collection of elements brought together in temporary relations. Heterogeneity here refers to the fact that components in an assemblage may be human, non-human and immaterial entities. Assemblages are not things in the world. As emergent patterns of relations, they explain the existence of things in the world (Buchanan, 2017). Furthermore, the relations that make up an assemblage "...are not subordinated to the essence of things. Rather they come into being via practice" (Hillier, 2007, p. 58). Elements in an assemblage can include anything from material objects like the water in a swimming pool and the chlorine used to keep it clean to the time it takes to fill the pool, the energy needed to heat the water and the aspirations one has to a certain lifestyle when they bought a house with a swimming pool in the garden. Together these could be said to comprise a "swimming pool assemblage".

This broad, open and inclusive definition can be seen as a shortcoming of the concept of assemblage. Critics wonder, if anything can be an element in an assemblage, does that mean that everything is (Wachsmuth et al., 2011)? However, there can be limits to what is able to become an element in a given assemblage. These limits are not due to any essential characteristics of the elements themselves but their capacity to form relations with other elements in a particular moment. As a consequence of the different energies and roles of things, there can be elements within an assemblage that are in tension but still manage to hold together (Bennett, 2010; Li, 2007a). The result is a contingent whole with emergent characteristics and capacities which are different from the sum of its parts.

Deleuze and Guattari use the concepts of rhizomes and trees to describe different patterns of assemblages. The concept is loosely based on a biological metaphor distinguishing between two types of plants. A rhizome has no clear beginning, end or direction, unlike trees (Deleuze & Guattari, 1987). Rhizomes are characterised by unpredictability and emergence, with constantly transforming non-hierarchical relations (Hillier & Abrahams, 2013). If you cut off a rhizome or interrupt its growth, it will spring up somewhere else. In contrast, trees are linear; they start from a seed and grow upwards from their roots (Deleuze & Guattari, 1987). Deleuze and Guattari argue that the arborescent style of thought blocks off alternative possibilities by implying that there is one logical direction in which all things should proceed. I find this limiting of possibility to be quite similar to the discussion of immanence and transcendence. It also has many parallels to smooth and striated space. Therefore, to avoid redundancy I do not include the concept of rhizomes in my analysis.

Assemblage is an English translation of *agencement* from Deleuze & Guattari's original French text. Not everyone is pleased with this translation. Some argue that "arrangement" would be a more suitable term than assemblage, implying some kind of structure and relationship between component parts (Savage, 2019). This contrasts with "assortment", for instance, which would be more like a pile of unrelated objects (Savage, 2019). Agencement implies agency, an active gathering of elements based on ongoing practices and relations (Braun, 2008). However, the resultant assemblage does not consist of a

unified whole in which parts fuse together. The multiplicity of heterogeneous parts maintain their independent identities in relations of exteriority, meaning in a different situation they would be able to enter into different relationships in which their capacities might be exercised differently (Anderson et al., 2012). Each assemblage is a proper noun written with capital letters like a hurricane or a military exercise, because in each case it is assembled anew based on its relations and surroundings in a particular moment (Nail, 2017).

Every actor contributes to the making of a unique assemblage situated in space and time. Actors may have their own motivations and objectives that shape their practices of assemblage, and their strategic and intentional action can play an important role in how assemblages develop (Savage, 2019). Conflicts and tensions may arise around framings of issues and what elements are included or excluded (Hillier, 2011). In a given situation, certain actors may be more or less persuasive and thus more able to shape outcomes. Therefore, despite the fact that assemblages may develop into somewhat coherent entities, an assemblage remains a multiplicity without a single essence or rationality (Li, 2007a). We do not need to attribute an all-knowing master plan to any one actor, because in practice there may not be anyone pulling the strings and even those who try to shape outcomes are often surprised by the results of their actions (Li, 2007a).

Assemblages may overlap, and they can coexist without displacing one another. For instance, Hillier (2011) describes multiple assemblages that coalesce around an issue, in her case a public art installation on a beach. She identifies groups of actors constructing distinct assemblages relative to the installation: an environmental “risk assemblage”, a “tourism assemblage”, a human focused “safety assemblage” and an “economic assemblage”. In each assemblage the object of interest is the same, but approached from a different angle such that it becomes ‘a site of affective contradiction and political conflict’ (Hillier, 2011, p. 862). To understand these processes Hillier suggests mapping the boundaries around what constitutes an assemblage, as observed in repeated material and discursive practices or patterns of relations (2011). Mapping out the processes of how

assemblages form is useful because it reminds us that there is no true start or end point, which is why Deleuze and Guattari encourage us to grasp assemblages in the middle.

Further, 'It is not just the so-called "application" of the assemblage that is practical or political, but the very construction of the assemblage—the way it is arranged or laid out' (Nail, 2017, p. 28). As described in the earlier section on ontology, causality emerges out of the patterns of relations between elements in assemblages, so how assemblages form influences how they act and their affects. Relations between elements are immanent to the actions of participants (Holland, 2013). Each assemblage forms according to their abstract machine, as I describe in the following section.

Abstract machines: conditions of possibility for assemblages

A central concept for understanding how assemblages form is the abstract machine. Abstract machines are abstract in three senses. First, they function similarly across multiple contexts, like how for Foucault disciplinary power is in prisons, but also schools, barracks and factories (Holland, 2013). Further, an abstract machine is 'a machine because it "works" - meaning it influences our behaviour - and it is abstract because it has no material or tangible form' (Buchanan, 2020, p. 46). Finally, abstract is not the opposite of concrete; it is the opposite of discrete. An abstract machine describes the limits of continuous variation an assemblage can undergo while still being itself (Adkins, 2015). Abstract machines can also be conceptualised as an overarching problem for which each assemblage is one possible solution. In assemblage theory, problems '...are not to be thought in the usual sense as obstacles in need of overcoming...' but rather 'problematic[s], a horizon that indicates the limits of thought' (Adkins, 2015, p. 199). The concept of abstract machines is useful for considering how an entity is problematised and in what ways that problematisation limits or unleashes certain possibilities. Abstract machines as elements within assemblages are limiting because they only allow actors to see some of the infinite potential ways an assemblage could form, but as a concept they reopen for analysis of these potentials (Lancione, 2011).

Another way to think of abstract machines is as guiding principles that shape the development of particular assemblages. For example, Lancione (2013) describes how abstract machines of bureaucracy, work and love shape assemblages of homelessness in Turin. These three sets of guiding principles shape the conditions of possibility in which particular contents of the experience of homelessness are expressed as assemblages (Lancione, 2013). Abstract machines as guiding principles can to some extent reflect the objectives of various actors. Although no human actor can fully direct an assemblage and individuals or groups of actors are themselves not monolithic, together the intentions of various actors come together to influence how assemblages form. Maintaining awareness of the role of actors (be they human or non-human) helps to avoid the “passive voice politics” assemblage theory has been accused of (By authors like Brenner et al., 2011). Instead of describing how assemblages are anonymously stabilised, structured, dismantled and so on, assemblage analysts continue to ask who or what is doing these things, to whom and for whose benefit. Assemblages are emergent, practical achievements which require work and are open to contestation and tension (Bueger, 2018). This work includes practices like classifying, sorting and defining objects and their roles (Bueger, 2018). Thus in a particular context, encompassing the intentions of actors alongside place, time and available materials, a different abstract machine results in a different assemblage.

Double articulation: formation of assemblages

The formation of assemblages is guided by an abstract machine, and occurs through a process called double articulation, sometimes also referred to as stratification¹⁰. The double articulation consists of two steps: selection of elements and arranging those elements into

¹⁰ Strata, as the ingredients combined in the double articulation, can be considered foundational to understanding how assemblages form (Buchanan, 2020). Deleuze and Guattari describe how three basic categories of strata (organic, physical and social) form through distinct processes and then assemblages emerge when these strata encounter each other (Buchanan, 2020). I found that approaching the empirical data with these predetermined categories in mind limited analysis by encouraging me try to fit everything into one of the categories. This undermined my intended emphasis on heterogeneity and becoming. Though my analysis is informed by an awareness of strata, the concept does not appear in my conceptual framework.

somewhat stable patterns of relations. These two steps refer to content and expression of assemblages.

The first articulation consists of selecting content. Assemblages form in an environment that contains all the possible unformed materials and matters that can be a part of their territory (Bonta & Protevi, 2004).. This articulation can be thought of as a filter or sieve which selects which elements are included while the second involves binding these elements together to form entities (Abrahams, 2016). When analysing assemblages it is important to consider the potential for a wide range of elements to be present and how the particular characteristics of those elements can shape the process of the double articulation. A heterogeneous collection of elements – including from orders of existence generally considered separate such as architectural, technological, emotional and discursive – work together and affect each other in complex, multi-directional ways to produce something (Feely, 2020). Using a geological metaphor, Deleuze and Guattari refer to the first articulation of the physical strata as “sedimentation”.

Following the geological metaphor, the second articulation is “folding”, or the transition from content to expression which transforms layers of sediment into sedimentary rock. The second articulation gives a stable form to selected materials, leading to ‘the creation of new entities with emergent properties’ (Bonta & Protevi, 2004, p. 151; Deleuze & Guattari, 1987). When the selected elements achieve consistency, they become part of a territory (Adkins, 2015).

Territory

Territory is neither a spatial nor a material concept in assemblage theory. It can have spatial and material components but neither is primary (Buchanan, 2020; Hillier & Abrahams, 2013). Deleuze and Guattari use the term territory in a social sense as well to refer to sites of political engagement, wherein territorialisation seeks to limit or constrain certain possibilities for action (Hillier & Abrahams, 2013; Li, 2007a). This process of territorialisation strengthens and sharpens boundaries around assemblages, leading to

some things being within the territory of the assemblage and others remaining outside (Bueger, 2014). For example, UNESCO classifies what sorts of monuments and landscapes may be considered world cultural heritage and which may not (Bueger, 2014). They define and strengthen the boundaries around, and internal homogeneity of, the assemblage of World Cultural Heritage, without which there would still be historical monuments and landscapes but they would not necessarily be considered members of the same group. The assemblage of World Cultural Heritage has implications, and a monument in this category may attract funding for preservation and restoration or entice more visiting tourists than one which has not met the standards for inclusion. Deterritorialisation is the inverse of this process. Where territorialisation increases uniformity and consistency, deterritorialisation reopens an assemblage to heterogeneity and possibility (Hillier & Abrahams, 2013)¹¹.

Affects emerge within and beyond the territory of an assemblage, always releasing potentials that are more than the sum of the assembled parts (Deleuze & Guattari, 1987, p. 374). Therefore the concept of territory is important to understanding both the formation of the first articulation (content) and the affects associated with the second articulation (expression). In the findings chapters of my thesis I use the concept of territory to encompass two things. In Chapter 7, territorialisation refers to the boundaries around assemblages and how firm or flexible they are in incorporating different elements, while in Chapter 8 I use the concept of territory to discuss the spatialities of what drinking water quality assemblages do. These spatialities are further explored using the concepts of smoothing and striation, which I introduce in the following section.

Smoothing and striation: What do assemblages do?

Until this point the presented concepts concern what constitutes an assemblage in terms of content and expression. However, 'Assemblages are not defined by their components; they

¹¹ The concept of "lines of flight" refers to the path down which an assemblage travels towards deterritorialisation. Deterritorialisation is an important process in the formation and dissolution of assemblages. In my empirical data I did not find much evidence of assemblages falling apart and becoming something new. This is not to say that such deterritorialisation is impossible, but I did not observe it in Kaolack. In a different context, it could indeed be quite interesting to explore how drinking water quality assemblages fall apart or reform into something new, however this topic is not covered in my thesis.

are defined, rather, by what they produce' (Buchanan, 2020, p. 47). In order to discuss how assemblages act and what they do, I use concepts from Plateau 14, arguably the most spatial of the chapters in *A Thousand Plateaus* (Adkins, 2015). In this chapter Deleuze and Guattari propose the terms smooth and striated to encapsulate different tendencies assemblages may have, particularly towards certain kinds of form or ways of interacting with space. The distinction between smooth and striated is not intended to label two types of assemblage but rather to describe two kinds of tendencies that assemblages have in different ratios (Adkins, 2015). Plateau 14 considers extremes of each model and how they may vary.

Striation refers to a process of restricting and compartmentalising reality into segments and repetitive patterns. Striated space is homogeneous, "making everything subject to the same rule, the same coding", whereas smooth space "entangles the heterogeneous" (Adkins, 2015, p. 232). Conversely, smooth space is an open space of flows, movement and potential. Smoothing and striating are processes which are never complete. We never observe a perfectly smooth or perfectly striated space (Bonta & Protevi, 2004).

Deleuze and Guattari describe two types of cloth which provide archetypes of smoothing and striation. Fabric is striated, made up of woven horizontal and vertical patterns. In contrast, felt has no distinct pattern. The striated form of fabric is homogenizing and limiting, while felt is an aggregate which can be expanded *ad infinitum* (Adkins, 2015, p. 232). The concepts of smooth and striated space have also been used to describe how: the ocean itself is a smooth space of flows which is striated by navigational charts and boundaries (Bear, 2013; Jay, 2019); minoritarian cultures produce smooth pockets of informality and creativity within the grids and lines of a city (Malins, 2007); the jungle as a smooth space resists attempts at striation by scientists (Aroles & McLean, 2019) and potential wind energy production sites are simultaneously defined by the smooth spaces of wind and the striated spaces of administrative regulations for agriculture and tourism (Labussière & Nadai, 2014). Striation is often associated with the state apparatus and its desire to restrict the free movement of bodies to their proper place (Deleuze & Guattari, 1987).

While Deleuze and Guattari seem to express a normative preference towards smoothness, they also warn us not to remove all striation at once as this can lead to a kind of suicidal collapse (Deleuze & Guattari, 1987). The ethical imperatives implicit in several of the other plateaus (Plateau 6 on making yourself a body without organs, Plateau 10 on becomings) seem to encourage us to reach for smooth space, but the authors warn that ‘...smooth spaces are not in themselves liberatory... Never believe a smooth space will suffice to save us’ (Deleuze & Guattari, 1987, p. 581). Not all striation is inherently negative, and not all smoothing is inherently positive. As with everything in a Deleuzoguattarian ontology, it is a question of situated affects and becoming. In a particular case, what does striation (or smoothness) do?

Having generally introduced the concepts of assemblage theory that I will use to develop my theoretical framework, I now turn to a description of how these concepts can be applied to drinking water quality as an assemblage.

Drinking water quality assemblages

Explanations of concepts from *A Thousand Plateaus* vary between being so simplistic some of their explanatory power is lost and so complicated and convoluted that it can be difficult to understand how they might be applied to empirical work. To compensate, Deleuze and Guattari rely heavily on examples. Every chapter of *A Thousand Plateaus* overflows with models of how concepts could manifest in different fields - from physics to music, art and evolutionary theory. In my thesis, drinking water quality is the organising idea or model for the concepts. In line with the ontology of becoming present throughout assemblage theory, drinking water quality is the temporary result of ongoing processes. Drinking water quality assemblages emerge in the meeting of particular human and non-human, material and immaterial elements. The provisional patterns of relations between these elements have affects in the world. These ideas will be developed further in the findings chapters along with empirical examples from Kaolack. In this section I propose four distinct but related categories of material elements that can be included in assemblages of drinking water quality (Table 2): 1) the potentials and properties of water and substances in water; 2)

characteristics of drinking water sources and their surroundings; 3) human bodies and their differing levels of vulnerability to drinking water hazards; and 4) the apparatuses used to produce information about water quality.

Table 2. Material elements of drinking water quality

Category of elements	Content	Expression
Water	Properties of water and its unique chemical and physical structure	Potential to bond with, dissolve and contain contaminants, pathogens and so on
Substances in water	Fluoride, salt, bleach, bubbles, sediment, microbes and viruses	Potential affects on human bodies and health
Drinking water sources	Elements of drinking water sources such as: groundwater, pipes, buckets, bags, bottles, etc.	Tap water, well water, bag water, bottled water
Human bodies	Individual humans	Vulnerability to drinking water hazards
Apparatuses used to produce information about drinking water quality (state, scientific, expert)	Scientific equipment – beakers, pipettes, salinometers, reagents, other tools for sampling and testing water	Knowledge - Data, numbers, reports
Apparatuses used to produce information about drinking water quality (consumers)	Human sensory apparatus – noses, mouths, eyes, bodies	Embodied sensory impressions and perceptions – sight, smell, taste, feelings

Materiality of drinking water quality

The characteristics of water and things in water are central elements in drinking water quality assemblages. The capacities and potentials of water are shaped by its unique physical and chemical structure. Water is particularly efficient at dissolving other compounds due to its polarity and the nature of the bonds between hydrogen and oxygen. All living things require clean water to survive. Thus water is exceptional and irreplaceable. As I pointed out in Chapter 2, the importance of water’s materiality in co-constituting social relations has received some attention in geography, urban political ecology and anthropology literatures already (Bakker, 2012; Strang, 2014). Some recent scholarship has identified this as a “water bias” that, while making significant contributions to our understandings of human-environment interactions, has neglected the possibility for other substances in water to be equally consequential (Parrinello & Kondolf, 2021).

The physical capacities and affects of certain things in water within assemblages of drinking water quality are also important elements. These relational capacities have to do with the ways certain substances behave in water, and also how those substances interact with human bodies. For instance, bacteria, viruses and protozoans grow well in water, as do many plants and animals. Water temperatures between twenty-five and fifty degrees Celsius provide an optimal environment for legionella to grow (WHO, 2011). Some things in water can cause illness almost immediately (i.e. E. coli and cholera), while others may take years to accumulate and manifest (i.e. arsenic, fluoride and some endocrine disruptors). Impacts can also vary based on quantity and duration of exposure (i.e. lead and mercury). Further, some pathogens in water can cause severe or life-threatening diseases, such as hepatitis or typhoid. After exposure to some water-borne pathogens people develop lifelong immunity, like Hepatitis A, while for others, like *Campylobacter*, immunity is temporary (WHO, 2011). In other cases substances in water can have positive effects from the perspective of humans. Chlorine and iodine, for instance, are added to drinking water for the purpose of purification because they can kill potentially harmful viruses and bacteria.

As described in Chapter 4, in assemblage theory there is an emergent understanding of causality. This means material elements, including substances in water, do not necessarily causally determine particular outcomes based only on their presence. They have potentials which may be realised through relations. For example, high concentrations of arsenic in groundwater in rural Bangladesh were not problematic until development actors constructed tube wells across a vulnerable region, causing a public health crisis for thirty-five million people (Sultana, 2011). Fluoride can similarly be present in groundwater for millennia without doing anything. It only starts to interact with human bodies when water containing fluoride is brought above ground and given to people to drink.

The second important group of material elements pertains to the characteristics of drinking water sources and their surroundings. Water tends to escape – it evaporates, leaks, spills and seeps. Because of this it has to be held in assorted containers to get from wherever it starts out to where people will drink it, whether this is a bag, bottle, pipe, bucket or cup.

These things associated with water potentially influence its perceived and physical qualities. Pipes and bags keep water from escaping but they can also rust or leach plastic into the water they contain, thus transforming its quality and blurring the distinction between quality of source and quality of water. Vulnerability of drinking water systems to contamination vary. For tap water, things like inconsistent flow rates and intermittency make it more likely for bacteria or other contaminants to grow and then be dislodged into water (Ercumen et al., 2015). Whether or not a well or a bucket has a cover can make it more or less vulnerable to dust, bacteria or other objects falling in. Qualities of a source of water can also include things like distance from where water will be consumed and amount of time required to collect and transport water.

Third, the characteristics of particular human bodies that water comes into contact with when consumed shape their vulnerability to certain hazards in drinking water. Important aspects of human bodies and their differences comprise more than genetics. The WHO identifies specific vulnerable subpopulations including “the young, the elderly, pregnant women, the immunocompromised” (WHO, 2011, p. 124). Factors like disease (i.e. HIV/AIDS, diabetes, tuberculosis), malnutrition and poverty can also play a role.

A final category of material elements of note is the ways drinking water quality is encountered by human actors. This category consists of the materiality of how people become aware of what is in water. What kind of knowledges can be produced by a drinking water quality assemblage is in part shaped by the encounter between water (and things in and around water) and material elements associated with scientific or sensory ways of knowing drinking water quality. An assemblage theory approach draws our attention to the materiality of how knowledges are created and shows the importance of materiality for what kind of knowledges are possible (Srnicek, 2014). A knowledge assemblage is “...inseparable from measuring instruments, data tools, computer models and physical models, archives, databases and from all the material means we use to communicate research findings” (Srnicek, 2014, p. 42). I expand this idea of knowledge assemblages from the scientific realm of experts to include how consumers sense drinking water quality with their eyes, noses and mouths. The human sensory apparatus results in embodied

experiences including taste, smell, sight, temperature, texture and so on which are key factors informing consumer decision making (de França Doria, Pidgeon, & Hunter, 2009). Human eyes, noses and mouths are sensitive to different things than the scientific equipment the state uses to determine water quality.

These apparatuses vary in degree of sensitivity, what they are designed to detect and what kind of information they produce. Experts and scientists detect drinking water quality with their tests, samples and equipment. A salinometer will produce a series of numbers informing the user of conductivity indicating salt content of water, while a human mouth and tongue will detect the presence of salt in a visceral way. Detection by human senses is not inherently less correct or accurate than that of scientific equipment but may be more difficult to communicate verbally, quantify or compare across contexts (Spackman, 2018). Which of these ways of encountering drinking water quality is given precedence relates to with which elements are gathered in the territory of an assemblage. How these different aspects of materiality relate to each other also concerns what is in the water and how detectable it is for different ways of encountering water.

Social elements of drinking water quality

Drinking water quality assemblages also contain social elements. These elements for the most part involve the relations underpinning quality, including, among other things: values, perceptions, discourses and knowledges. Knowledges about drinking water quality both emerge through drinking water quality assemblages and become elements in those assemblages. They also contribute to processes of smoothing and striating socio-spatial territories within and external to assemblages (Chapters 7 & 8). In the encounter between the previously described material elements in drinking water quality assemblages, certain kinds of knowledges become possible. These knowledges are then shared and translated between human actors, shaping their understandings of drinking water quality and how they choose to respond. With this focus on knowledges I do not intend to restrict understanding of drinking water quality knowledge to a formal, instrumental definition. On the contrary, drinking water quality assemblages can also produce more subconscious or

ephemeral forms of perceptions, ideas and impressions. In my application of assemblage theory I adhere to a post-structural understanding of knowledges in which the *a priori* existence of a distinct and knowable reality is not assumed (Hillier, 2005). I reflect on the role of epistemology and its relationship to an assemblage ontology in greater detail in Chapter 4.

In a drinking water quality assemblage certain kinds of knowledges might be generated, highlighted, included or excluded. Characteristics of knowledges can be important for whether they are included in an assemblage or not, for instance whether knowledge was made by experts using scientific techniques or by ordinary individuals using their senses. The “same” knowledge might also lead to different actions or conclusions in a different assemblage. Some forms of knowledge may be blocked from participating meaningfully in an assemblage or positioned in a hierarchy relative to other types of knowledge. Other knowledge may be contained within the territory of one assemblage and therefore made unavailable to others, raising issues of transparency and representation.

Deleuze and Guattari identify certain patterns in how the state produces and shares knowledge compared to non-state forms of knowledge (Deleuze & Guattari, 1987). They note that the core differences between state and other forms of knowledge production have to do with how they understand reality. The state primarily aligns with the aforementioned ontology of being, and views knowledge as the purview of experts. Alternative forms of knowledge production tend to be situated, messy and contingent, based on a world of flows and formations where every entity is in a constant state of becoming and heterogeneity (Adkins, 2015).

Thus for drinking water quality, it is possible to identify a state way of knowing drinking water quality associated with expert assessments of water, and then other forms of knowledge which exist outside the state paradigm. Making a binary distinction between state and alternative ways of producing and experiencing knowledge can be misleading, because in fact they always exist in mixtures rather than pure forms. However, it can still be useful to consider the distinction between them in order to draw our focus to the

fundamental tensions at play between various assemblages. The state, which is itself a multiplicity, often tries to limit and control alternative forms of knowledge-making (Deleuze & Guattari, 1987). In other words, the state, through its practices, prevents other forms of knowledge from being active participants in assemblages of drinking water quality. In state forms of science, numbers are a tool used to gain mastery of matter (Adkins, 2015). The state uses processes of counting, measuring and controlling as tools of governing.

Individual and collective understandings and definitions of quality also change. This includes both what drinking water quality is and what can be known about it. For example, the WHO began publishing International Standards for Drinking Water in 1958. After three editions of those standards, they published the first Guidelines for Drinking Water Quality in 1984. After a series of rolling revisions and addenda the current Guidelines for Drinking Water Quality are the fourth edition, which is still regularly updated as new scientific evidence becomes available or new information and challenges come to light. For instance, emerging contaminants like endocrine disrupting compounds are novel actors in the drinking water quality assemblage, and awareness of their problematic effects continues to grow.

Finally, drinking water quality is one among several possible water qualities. Drinking as an intended use is one part of a larger water quality assemblage. Depending on the interests of actors involved, environmental or agricultural water quality could be considered more important than drinking water quality. Such an assemblage would highlight elements with the potential to be harmful to animals or plants more than people. The thresholds would also likely be set at different levels because a fish might be more or less sensitive to particular things in water than humans. Also things like recreational water quality can necessitate different standards from drinking water quality because people might be willing to swim in water that they would not necessarily drink. So values and intended use play an important role in terms of which aspects of quality or types of qualities are considered a priority (Berry et al., 2018). For the purposes of my thesis I have chosen to

focus on drinking water quality, but other focuses could also be productively considered using an assemblage framework.

Assemblage theory is a useful tool to understand drinking water quality because it draws our attention to the importance of material and social elements in tandem. Breaking an assemblage into its component parts in analysis further shows how deeply they are intertwined, and how certain elements must be present to some extent for drinking water quality to emerge. For instance if there was no human being present to drink water, or if there was no potential for illness associated with substances in water, drinking water quality would be irrelevant. If water had different physical and chemical properties that made it less prone to absorbing such substances, or was not necessary and irreplaceable for all life, again drinking water quality would be far less crucial. Furthermore, the word “quality” itself implies a normative understanding of what is desirable. Considering the multiplicity of elements that may be a part of a drinking water quality assemblage demonstrates that drinking water quality is not just about whether water is good or bad. Drinking water quality emerges contextually in a series of relations, as will be the topic of the findings chapters.

Chapter 4. Research design and methods

In this chapter I present the overall research design and methodology of the dissertation. The empirical material for this dissertation consists of data collected during eight months of qualitative data collection in Kaolack, Senegal, from April to December 2019. I begin the chapter by justifying the selection of a multimethod qualitative case study design in conjunction with the theoretical framework. I also present the selected qualitative methods. The research approach is grounded in three primary methods of data collection: 1) observation and participation, 2) interviews and 3) document review. Subsequently, I outline the analytical framework and process, including the role of assemblage theory in shaping the research design. Finally, I reflect on research ethics, positionality and challenges.

Methods

The choice to use assemblage theory as the theoretical framework for this study has important methodological and analytical implications. Deleuze and Guattari's work has in many cases been left to the realm of theory, making it difficult to immediately link assemblage theory to one kind of methodological approach (Coleman & Ringrose, 2013). This means there is some degree of flexibility involved in designing an assemblage theory study, which encourages developing 'concepts and methodologies that are specific, relevant or appropriate to the problem at stake' (Coleman & Ringrose, 2013, p. 3). In assemblage approaches no assumptions should be made about what can be related, or about what actor in assemblage is dominant (Müller, 2015). Instead, '... assemblage thinking requires careful consideration of how different materials might matter within assemblages...' (C. McFarlane, 2011a, p. 215). A study relying on assemblage theory as a framework therefore calls for use of multiple methods which allow one to consider the object of study (in my case drinking water quality) from several angles. In a review of thirty studies using a materialist assemblage ontology, Fox & Alldred found that all relied on multiple qualitative methods (2015). They suggest that perhaps the appeal of qualitative methodologies for assemblage research is that these methods may be particularly useful in aiding development of a rich

understanding of context, including multiple scales of relations and affective flows that blur boundaries between matter and meaning (Fox & Alldred, 2015). In line with this trend, I used multiple forms of qualitative data collection to develop an in-depth understanding of the phenomenon under study (Table 3).

Table 3. Data collection methods

Data collection type	Total number	Timeframe
<i>Observation and participation</i>		
Extended in-home observations	50+ visits in 16 homes	Throughout stay in Senegal, April-December 2019
Other informal/unstructured conversations and observations	Uncountable	Throughout stay in Senegal, April-December 2019
Auto-ethnographic participation and reflection on my own drinking water quality practices	Uncountable	Throughout stay in Senegal, April-December 2019
<i>Interviews</i>		
Interviews with actors in the water sector	17	May-October 2019
Household interviews	84	September-November 2019
Interviews with sellers of well water	4	November 2019
Interviews with sellers of filtered water	18	November-December 2019
<i>Document review</i>		
Collection and review of laws, policies and plans pertaining to drinking water quality	-	January 2019 – December 2020

Additionally, in an assemblage theory ontology there is a challenge to re-orient qualitative tools of social inquiry from their traditional focus on human actions, experiences and reflections (Fox & Alldred, 2015). Instead, the attention of the researcher should be on affective relations between elements in assemblages, whether they are human or non-human (Fox & Alldred, 2015). Baker and McGuirk (2017) suggest three practices to operationalize commitments of assemblage thinking: adopting an ethnographic sensibility, tracing sites and situations and revealing labours of assemblage. Thus assemblage theory is well suited to the ethnographic approaches and case study design I used in data collection, as well as to my aim of understanding the implications of how drinking water quality assemblages form in Kaolack.

Assemblage theory became important to my work during and after fieldwork, as I became interested in more-than-human and relational approaches to geographical inquiry. The fact that theory did not precede data collection could be a weakness because ideally I could have focused more explicitly throughout my time in Kaolack on identifying and describing heterogeneous assemblages of drinking water quality. However, it is also possible that identifying the theoretical framework in advance could have constrained or shaped what I found. I arrived in Kaolack trying to keep an open mind to the extent possible, and my engagement with theory emerged iteratively out of the process.

Observation and participation

While I would not say that I conducted a full ethnography as a part of this study, I maintained an ethnographic sensibility in my approach. This approach is justified because, as described previously, for assemblage theory informed studies there is a need to remain open to the possibility for heterogeneous and unexpected elements to become important (Müller, 2015). In addition, many studies that I engage with in my thesis engage with utilise similar methods to explore drinking water access and infrastructural heterogeneity in the Global South. Therefore incorporating observation and participation into my study facilitates conversation with relevant empirical cases.

I considered approximately the first month and a half of my time in Kaolack to be an exploratory phase, during which time I focused on building relationships with various people and familiarizing myself with the drinking water landscape of Kaolack. A key activity during this time was auto-ethnographic documentation of my own journey to identify and procure drinking water that met my personal standards for cost, taste, safety and ease of access. I found that asking people for advice about drinking water led to many intriguing conversations and advice from my neighbours and acquaintances which helped me to understand the diverse options for drinking water in Kaolack. In addition, a measure of 'embodied knowledge of a city or local literacy' can be gained by walking and observing closely one's surroundings (Pierce & Lawhon, 2015, p. 1). Extensive walks around several

neighbourhoods of Kaolack were an important way for me to gain and maintain familiarity with Kaolack during my stay.

In addition, I cultivated social relationships with several households and individuals and often spent entire days visiting with families in their homes to share meals or break fast during the month of Ramadan. I also undertook extended periods of participant observation with actors with a stake in drinking water quality governance and drinking water provision. In one case, the owner of a reverse osmosis water kiosk invited me back several times to observe, drink tea and for one full day to sell all the water myself under the supervision of the usual manager. During these periods I was able to take detailed notes about the customers and their interactions, and to have many impromptu conversations.

Based on my readings of reports about Kaolack prior to arriving, I had been under the impression that the majority of people in urban areas primarily consume tap water. The Urban Diagnostic Report for Kaolack in 2019, for example, claimed 98% of households are connected to the piped network. Covering the city largely by walking in my first weeks there I became increasingly aware of the large quantities of off-network water circulating in jerry cans, bottles and bags – in cars, motorcycles, donkey carts and on foot (Figure 3). Given now familiar complaints about the quality of tap water I began to try to understand the relationship between these many different sources of drinking water and quality.



Figure 3. Photos of water transport in Kaolack

I talked about water quality with everyone all the time. I talked about it in taxis, at the post office, in my French lessons, on the street and while I was eating breakfast. Some of my most

fruitful conversations were more informal. People would ask me why I had come to Kaolack and once I explained they would launch into long and detailed explanations of the way things are in Kaolack, their opinions about politics, how things got the way they are and so on. By taking the time to get to know people personally, meet or speak to them on a regular basis (often via WhatsApp vocal notes) I found that they were often happy to connect me to more people to talk to and explore new parts of the city with me. This continued throughout my stay, and in this way I gradually expanded my familiarity with Kaolack and its peculiarities. In addition, from the beginning of my project and continuing throughout the writing process, I regularly checked prominent Senegalese news outlets for stories about drinking water, and I use Google Scholar to search for relevant academic literature in both French and English. Some news reports and screenshots from Facebook and other websites are included in the results section, as they provide illustrative examples of how drinking water quality is described.

Throughout my research process I kept detailed daily field notes. I also sent biweekly updates to my supervisors in Norway which was helpful both to keep them informed of my progress and to provided me with opportunities to regularly take a step back and reflect on what I was learning. The writing of field notes entails choices about what data are important to record, representing a kind of proto-analysis and early identification and development of themes (Ryan & Bernard, 2003). I recorded many personal reflections and ideas about new directions in these notes, alongside significant direct quotes from formal and informal conversations. I also used situational maps to organise my understanding of the complex systems around drinking water quality. Clarke argues for 'situational analysis' to be one part of field work process, working with not yet coded 'but carefully read and somewhat digested data' (2003). Situational maps can be used as a tool to advance theoretical sampling, and also to focus analysis on what elements (human and non-human things) matter or make a difference (Clarke, 2003).

Interviews

Throughout my time in Senegal I conducted interviews which varied in sampling strategy and degree of structuredness. Informal conversations and observation in the exploratory phase provided background knowledge that allowed me to develop targeted questions for these interviews. To understand interfaces between governing practices of assembling drinking water and the everyday practices of consumers, I conducted interviews with both key informants involved in provisioning, governing and planning for drinking water in Kaolack and household interviews. All interviews were conducted in either Wolof or French, often a mixture of the two. I transcribed all interviews as soon as possible after they were complete. I found the rapid turnaround was useful so that I could add detailed notes and reflections while the experience was still fresh in my mind.

Key informant interviews were semi-structured and included actors involved in management of and planning for drinking water resources, public health actors and distributors and sellers of drinking water. Semi-structured interviews can allow the researcher to remain open to new and unexpected ideas. While the researcher does to some extent guide the conversation towards suggested themes, they can also ensure interview participants have the scope to develop their responses or bring up topics they find important (Desai & Potter, 2006). I therefore tried to approach these key informant interviews as more of an opportunity for mutual learning and sharing of understanding and positions than extraction of information (Brinkmann & Kvale, 2015). Before each interview I developed a list of questions to guide the conversation, but I also aimed to provide space for participants to discuss any topics they felt were relevant to drinking water access and quality. However, under this umbrella of key informant interviews, those which were with governance and planning actors were open-ended, while those with well water and filtered water sellers were directed by a standard list of questions (Appendix 4).

I targeted sampling to include the perspectives of multiple stakeholder groups in governance, planning and provision of drinking water. This included representatives of the private company that manages urban drinking water service provision in Senegal, the

Hygiene Service, the mayor's office, the regional prefect's office, the local urban planning office, the Ministry of Environment, the urban sanitation office, and so on. I also interviewed four well water sellers and visited eighteen filtered water kiosks for semi-structured interviews. For each group of providers and governance actors, I asked questions about their role in providing drinking water, how their water differed from other options available in Kaolack, the rules and regulations they must follow and their relationships with their customers. I was therefore able to obtain a broad picture of drinking water quality in Kaolack and Senegal in general. This process lasted throughout my time in Senegal, and was supplemented by three trips to Dakar for interviews with national governance actors and a researcher from the University of Cheikh Anta Diop who has conducted hydrological studies of water quality in the Kaolack region. I was limited by the availability and willingness to participate of government officials and employees of the drinking water utility, as will be discussed in the section on research limitations.

I also conducted structured household interviews (84 in total). The structured format of these interviews allowed me to target conversations towards specific topics and seek out trends in responses. In the household interviews topics included perceptions of various sources of drinking water in Kaolack and their impacts on health and well-being, household access practices and preferences and relationships with drinking water providers and governance actors. These interviews aimed to engage a broad sample of the population of Kaolack, spread over several neighbourhoods in the city. I intentionally selected neighbourhoods for interviews based on where I had been told water quality was a particular challenge or that water access practices could be of interest. As the interview process continued I followed suggestions from interview participants and other connections into a few different areas in the city, a mixed form of theoretical and snowball sampling.

With the aid of a research assistant, the household interviews consisted of a verbally administered questionnaire with some yes or no and some more open-ended questions (Appendix 4). The research assistant accompanied me to household interviews and interviews with sellers of filtered and well water. She introduced me and my project and

administered the questionnaires while I took notes and occasionally asked follow up questions. The research assistant had training and experience conducting household surveys for non-governmental organisations (NGOs), which was both an asset and a bit of a challenge. She was comfortable approaching potential participants and explaining the study. However, she was more familiar with a system of yes/no answers or simple filling in of blanks so it was a challenge at first to get her to slow down and allow people to elaborate their responses. Luckily it seemed like she became more curious and interested in the project as we progressed and started to engage more and more in conversation with people as we went on. Our conversations after interviews were complete often helped to clarify and grow my understanding.

Document review

Document review and analysis provided a secondary method to supplement and provide background information for the findings of interviews, observation and participation. The reviewed documents are listed in Chapter 5 (Tables 4, 5 & 6). The documents include laws, policies, plans and reports pertaining to drinking water quality in Kaolack and Senegal. I took detailed notes about the content and sources of each document, including how the Senegalese state and international organisations define and respond to drinking water quality. I supplemented and compared these notes with the results of the other methods, specifically considering similarities and differences in how drinking water quality is defined and responded to by consumers, providers and diverse state actors.

Research design: case study and delimitation of the case

Case studies are an effective way to explore complex social phenomena which are difficult to separate from their context, often through direct observation, interviews and immersion in a phenomena or event (Yin, 2009). A case study design allows the researcher to answer “how” questions along with “why” or “what happened” questions by incorporating multiple sources of evidence (Yin, 2009). In addition, intensive long-term involvement ‘provides more complete data about specific situations and events than any other method’ (Maxwell,

2012, p. 244). To incorporate observation effectively, one needs to dedicate significant time and should ideally be able to live in the area under study for several months (Desai & Potter, 2006). Each type of research design has implications for the type of results produced; case study research encourages strong in-depth description but may be limited in terms of generalisability and broader empirical applicability (Yin, 2009). However, if the purpose of the case study includes theoretical development – as it does in my research – then one could argue for a form of analytical generalisability from the case (Yin, 2009).

Senegal is a interesting location to study drinking water quality governance¹². Since 1994 the public private partnership for urban drinking water service provision has succeeded in dramatically increasing access to water in urban households. Senegal has thus been lauded by the international community as a successful example of the benefits of private involvement in the urban service sector (Pezon, 2018). Still, diarrhoeal disease, often attributed to water-borne infectious diseases, is the leading cause of death in children under five years old in Senegal (GBD, 2015). As I will discuss further in Chapter 5, Kaolack faces unique drinking water quality challenges which make it a fruitful location for this study. I chose to focus on the city as a whole rather than one neighbourhood because governance of and planning for drinking water quality happens at the city or national scale in Senegal. I wanted to follow and understand the diverse ways water flows through and is accessed in Kaolack and I felt that limiting myself to a single neighbourhood could cause me to miss some of the variety.

Analytical Framework

In this section I present the analytical framework, beginning with how I selected and implemented an abductive approach to iteratively working between theory and empirical

¹² Working in Senegal was also a pragmatic choice for me based on my previous experience and connections. I discuss the benefits and drawbacks of this choice further in the upcoming section on research ethics and positionality.

data. Next I describe my process of analysing and describing assemblages of drinking water quality, and outline the details of my process of conducting interview and text analysis.

I used an abductive approach to engage with empirical data, which Alvesson and Sköldbberg (2009) describe as 'a repeated process of alternating between empirically-laden theory and theory-laden empirical "facts"' which can develop and deepen understanding of both' (p. 5). An abductive approach combines elements of deductive and inductive approaches, iteratively moving between theoretical and empirical material. Thus in my analysis I consider examples from the academic literature on assemblage theory to help with development of categories, not assuming that these categories will be present in the sources of data particular to my case.

The analytical process has been guided but not limited by empirical and theoretical categories in the literature. This tension around simplification and categorisation runs through my thesis because it is necessary to make some categories to draw conclusions and be able to describe patterns. However, assemblage theory calls on analysts to remain open to ongoing becoming and potential in ways that make categorisation seem limiting. Furthermore, some elements exceed pre-defined categories or exist on their peripheries. For example, I describe material and social elements in drinking water quality assemblages, but there are immaterial entities (i.e.. time and labour) which are neither precisely social nor material. In addition, some social entities are arguably material and vice versa. Given these challenges, I strove to be reflexive about the usefulness of categories for achieving my goals.

When I came to a point when I felt stuck or that the theory was not quite able to explain observed phenomena, I noted these challenges and considered if there could be other theoretical tools better suited to my data, or I reflected on how the theory could be refined or expanded. At the stage of discussing my findings, I decided that it is necessary to be flexible with the terminology from assemblage theory. In part this is because the conceptual vocabulary of Deleuze and Guattari can be quite opaque and abstract and I aim for my research to be a bit more accessible and practical. I try to stay faithful to the ontology of

assemblage theory, interpreting and being flexible with Deleuze and Guattari's conceptual apparatus while remaining loyal to their way of understanding reality (Bignall & Patton, 2010).

Analysing and describing assemblages

Analyses of assemblages are oriented to what things do more than what they are, not assuming essences and focusing on relationality (Bueger, 2014). Therefore 'assemblage theory ... follows a distinct style of analysis primarily interested in empirically describing practices of assembling' (Bueger, 2018, p. 619). One way to present the analysis of an assemblage is through active narratives, telling stories about how a group of elements is gathered together and stabilized or destabilized and how it behaves in the world (Lejano, 2017). A challenge for assemblage theory based analyses is to show how multiple, processual and fluid processes of assemblage are and can be while telling a story about a particular moment (Bueger, 2014). Therefore the findings of my thesis represent a snapshot of a moment in time, during an ongoing and unfinished process.

Furthermore, a critique of assemblage theory is that analysts risk falling into a trap of endless description without ever reaching any meaningful conclusions (Allen, 2011; Bueger & Liebetrau, 2021 (forthcoming)). Clear indicators of the extent of assemblages do not exist, but must rather be determined by the analyst based on immersion in the empirical data and decisions about the story they are telling (Bueger & Liebetrau, 2021 (forthcoming)). Water (H₂O), for example, is itself a complex thing made up of relationships between hydrogen and oxygen, which then exhibits emergent capacities to bond with other molecules and compounds. This is why water is sometimes called the universal solvent; it is never found in nature as truly pure isolated H₂O but always in mixtures. In describing assemblages of drinking water quality I could follow the materiality all the way down to this level, but I am not convinced this would contribute anything to my aims of speaking about inequality or the relations between governing and consumer assemblages. At some point it becomes necessary to limit to some extent the boundaries of what can be included in a research assemblage, and to remain within these limits (Greenhough, 2012). This delineation is a

political choice that should be well thought out (Greenhough, 2012). For the purposes of this dissertation I view assemblages through clusters of material and discursive practices and highlight those practices that most matter for the formation and stabilisation of drinking water quality assemblages in Kaolack.

Interview and text analysis

Li (2007a) says practices of assemblage are ‘the ongoing labour of bringing disparate elements together and forging connections between them’ (abstract). But how exactly does one look at a series of texts or observations and identify a practice? In working with the textual data I identified repeated instances of connections being made discursively between different elements that may be a part of drinking water quality. I began my engagement with collected interview transcripts, documents and field notes with a series of detailed readings during which I took notes and tried to gradually identify patterns (in the form of similar repeated statements or groups of statements) in how drinking water quality is described by various actors and relative to particular sources of water. I used a combination of Excel and OneNote to highlight groups of statements that share a particular orientation towards quality, ways of knowing about quality, accountability for quality and so on. The initial codes were what Yin (2015) would consider open or *in vivo* codes, staying quite close to the data and even directly repeating statements made by interview participants in some cases. Based on these highlighted patterns and deep readings, I began to group statements into categories like “health problems”, “taste” and other embodied sensory perceptions, “cost”, “availability”, “labour required”, links between quality and particular sources, knowledges or shared stories. I began this stage of analysis and coding while still in Senegal. In the process of repeatedly returning to the data I fine-tuned categories, grouped things in different ways and updated the categories as I learned new information. As I moved deeper into the literature on assemblage theory, I began to view the categories I was developing as elements in multiple assemblages of drinking water quality (Figure 4).

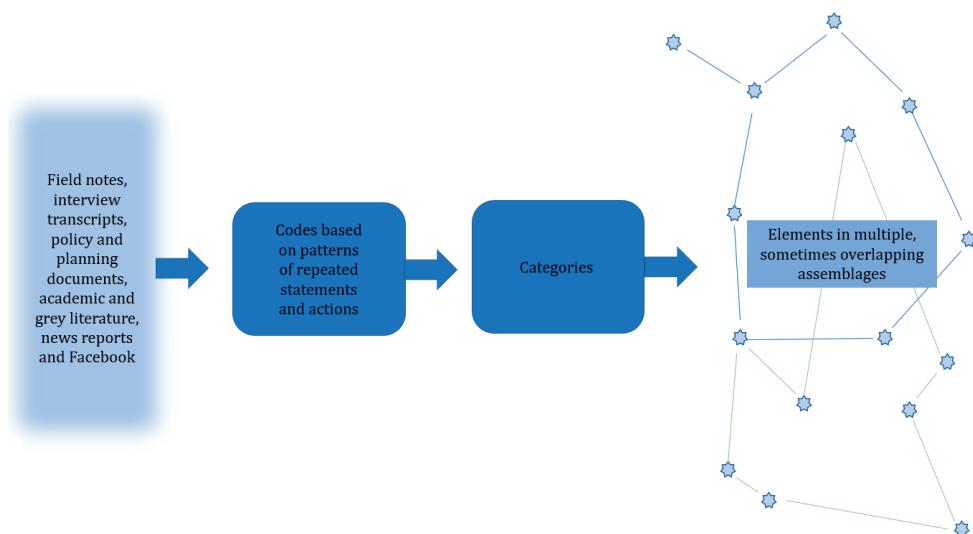


Figure 4. Analytical process: codes and categories represent elements in assemblages of drinking water quality

While coding can be a valuable way of approaching data, such a linear approach is not entirely aligned with a Deleuzian way of looking at the world. Coding processes can struggle to incorporate complexity and difference (MacLure, 2013). However, taking the time to be immersed in the data, experimenting and following the things that catch your attention can allow for valuable insights to emerge. In this way “The process of coding is both active and passive - a matter of both actively *making* sense yet also of accommodating something ineffable that is already “there” (MacLure, 2013, p. 174).

Research ethics and positionality

As a foreign researcher working in a resource-poor area, my position and inherent power relationships in the researcher-participant relationship require careful reflection (Desai & Potter, 2006). It is, however, important not to assume that informants and participants are inherently powerless. In situations where I interviewed government functionaries or representatives it was quite clear that although I come from a position of privilege, the power was held by the person in control of access to people and information I needed to

conduct my study (See a further discussion of distinctions between power and privilege in research settings in Birkinshaw, 2017). Of course, this relationship varies based on who one is speaking to. In household interviews I was careful to emphasise the voluntary nature of participation, along with the possibility to decline to answer any questions or revoke consent at any point. In all cases, my age and gender (relatively young and female) had a clear influence on my role in Senegalese society and the types of things people felt comfortable saying to me.

Furthermore, it was sometimes challenging to explain to people with very limited prior interaction with researchers (especially social science researchers) that I was not associated with any kind of NGO or charitable organisation involved in creating a project to solve their water quality problems. In other moments interview participants assumed I was affiliated with the tap water provider (Sénégalaise des Eaux (SDE)), despite my claims to the contrary. This may have coloured some responses, and led to people either trying to give feedback to SDE through me or entice me to direct project funding in a way that would benefit them.

Another challenge in researching inequalities and injustices is maintaining a neutral position. By choosing a particular representation of an assemblage a researcher is making a choice to describe the assemblage one way and not others or to highlight certain actors (Greenhough, 2012). These choices reflect the position of the researcher and power relations. Furthermore, no story of an assemblage can ever be considered finite or complete because assemblages are always in the making (Bueger, 2014). While it can be tempting to assign blame to certain actors who seem to perpetuate systems of injustice, I found it helpful to consider Li's (2007b) assertion that in many cases 'the will to improve can be taken at its word' (p. 9). Though there may be harmful externalities of certain actions, most people do not set out with the intention to exclude or expose others to harm.

My ability to engage with people in Kaolack was greatly facilitated by the fact that I am fluent in Wolof, which is the "urban lingua franca" of Senegal (McLaughlin, 2008). I learned Wolof while working as a US Peace Corps volunteer in the rural health sector from 2011-

2013 and maintained my competency through regular phone calls and a visit in 2015. The connections I made through Peace Corps were very valuable to me during this field work. The family that hosted me while I was a volunteer, although they live in a different region, have many connections in Kaolack. They generously introduced me to some helpful and kind people who were happy to show me around, discuss drinking water quality *ad infinitum* and host me for lunch whenever I needed company. Current Peace Corps volunteers and staff were also very helpful; they helped me find a place to live, introduced me to health and other actors and were generally very interested in talking about my research and sharing their own impressions and understandings. Although the selection of cases and research problems based on personal and professional experience can introduce bias, it can also strengthen research design and ‘...provide you with a valuable source of insight, theory and data on the phenomena you are studying’ (Maxwell, 2012, p 220).

My project adheres to the NMBU Ethics Guidelines (Adopted by the University Board 26 November, 2015), and the Guidelines for Research Ethics in the Social Sciences, Humanities, Law and Theology of the Norwegian National Research Ethics Committee (June, 2016). In accordance with these guidelines, I obtained informed consent from all study participants, and strove throughout the project to maintain ‘Integrity in documentation, consistency in argumentation, impartiality in assessment and openness regarding uncertainty ...’ (NESH, 2016, p. 10). Consent to participate was primarily obtained orally following an explanation of myself and the aims of my project. Some interview participants agreed to be recorded, others did not. In instances where interviews were recorded I transcribed them as soon as possible after the interview. I anonymized responses and used initials or codes to refer to people in my field notes. The code list is stored in a password protected document.

Both the afore-mentioned guidelines emphasise that ethical research comes with social responsibility and should endeavour to be of use to society. This includes the responsibility to publish and disseminate results. For research in developing countries there needs to be consideration of appropriate ways to disseminate information, within the limits of confidence and confidentiality. I have agreed with several research participants to share copies of my published results via email, including a representative of Swiss Fresh Water, a

professor at the University Cheikh Anta Diop in Dakar, SDE and the national office for the management and planning of water resources (Direction de la gestion et de la planification des ressources en eau (DGPRES)). I will also be sending copies of the completed thesis to the West African Research Centre (WARC) and the Senegalese Ministry of Scientific Research as agreed to during my application for research clearance (Appendix 1, Appendix 2).

My research has been assessed by the Norwegian Centre for Research Data (NSD) regarding the processing of personal data and has been deemed low-risk (Appendix 3). All project information is kept securely on university server rather than stored directly on my laptop.

Research challenges

I began the field work process aspiring to conduct a consistently paced, structured study and quickly learned (or remembered) that “*yaqamti yaqula*” (Wolof proverb: being in a hurry will make you crazy)¹³. Despite my enthusiasm at the start of my stay there are certain rhythms of life in Senegal that cannot be subverted. I arrived one week before the beginning of Ramadan, at a time of year when afternoon temperatures often rise above forty degrees. No one was available to schedule meetings with me, but many people were happy to nap under a tree together and have a brief chat after sundown. Various holidays, festivals and weather events challenged my progress, but also provided opportunities for learning and growing my relationships with people. I had to loosen my grip on my vision of the best and most beautiful research process and be flexible in my plans. In retrospect I appreciate some of these involuntary long pauses, as they gave me time to reflect, reorient and decide what to pursue and what to let go.

Another challenge for dealing with a subjective and personal topic like drinking water quality is that Wolof is not my first language. While I have lived and worked in Wolof-speaking communities for nearly three years and feel quite confident in my abilities, there is always a risk that some subtlety or nuance will be lost. Direct translation is also difficult. For example, the Wolof language does not have a word that directly translates to “water

¹³ All translations in this document are my own.

quality” with all of the connotations I would attach to it. I explored this with people when I first arrived in Senegal, and found that for people who understand some French they prefer to simply use the French phrase *qualité de l’eau*. Several Wolof words were suggested to me to encompass “quality”, each of which is a part of what I see as the bigger assemblage. Some examples of these are *baax* (good), *neex* (pleasant), *sett* (clean), *sel* (clean in a healthy way), *baax thi werguyaram* (good for the well being of one’s body), or the negative inverse of each of these. I think that in terms of the questions I am posing this diversity of terms is not a problem. In household interviews I asked several open-ended questions that allowed people to fill in their own concepts of what is important to them when deciding which water they would choose to drink and provide to their families. Therefore, when I asked questions like “what do you think about (____) source of water?” or “how do you decide what water is best to drink?” I received a range of answers including not only perceptions of cleanliness and taste, but also affordability, accessibility, consistency of taste and availability, water pressure, convenience, temperature and so on. Anything people used to describe properties of water and sources of water I consider as elements in the assemblage of drinking water quality. So I am fitting these under the umbrella of “quality” but this is my construct and my decision on the grouping.

Access to interview participants can be a common challenge (Desai & Potter, 2006), and I definitely experienced that some individuals were more willing to talk to me than others. While I met many people who were genuinely interested in having conversations and went out of their way to be accommodating, some did not want to say anything without their employer present, some simply declined and others expressed interest but found it difficult to fit me into their schedule. I tried to be reasonably persistent in a respectful and friendly way, and in most cases it was worth the wait. I also found on multiple occasions while I was waiting outside an office someone else would come talk to me and these informal conversations could be just as illuminating as the ones I had scheduled. For SDE in particular I had hoped to interview more staff members and observe their water quality management practices, but the timing was not ideal. They were not very open to conversation with me, at least in part because they were in the process of settling a series of complaints and lawsuits with the Senegalese government about the upcoming

termination of their contract. Conversely, the Hygiene Service and the mayor's office were the most open to my continuous presence. I therefore visited them regularly in what started as more targeted conversations and gradually turned into accompanying them into the field to see their work, general observation, conversation and shared meals.

The selection of a city that does not traditionally attract much research interest also shaped my experience. Without a university in the area or other groups of researchers nearby, I spent most of my time with neighbours and friends local to Kaolack. I occasionally felt that I was missing out on a part of the field work experience, wherein researchers build networks of local and foreign academics who have come to a place and can discuss their perspectives regularly. This independence was at times isolating and challenging, but I came to see it as a strength of my data collection process as it caused me to be more immersed in the local milieu.

Something I did not do as a part of data collection was take my own measurements of water quality in Kaolack. I am lacking in both equipment and expertise to do this well, and I felt that for the purposes of understanding how drinking water quality is assembled by actors in Kaolack this would not be relevant. Adding my own claims about particular things in water would in fact be contrary to my aims, which include arguing that the selection of what to measure, where, when, and so on are political choices made by actors in their context.

Epistemological reflections

My interpretation of the ontological position of assemblage theory was presented in the previous chapter. I now reflect on the epistemological presuppositions upon which my methodology is grounded. Assemblage theory is not clearly linked to a particular disciplinary tradition, but the commitments it entails could be described as post-structural (Hillier, 2005). This post-structural tendency concerns the fact that, as discussed in Chapter 3, while assemblage theorists recognise the importance of structures, the purpose of analysis is not to seek out underlying structures and mechanisms as explanatory (Hillier & Abrahams, 2013). Instead, the important questions become about how specific structures

function and continue to exist (C. McFarlane, 2011d). In addition, assemblage theory as it was written by Deleuze and Guattari does not really assume a particular epistemology (Holland, 2013). It is more common to hear discussions of ontology with regards to assemblages than epistemology.

However, while no one way of knowing or form of knowledge is explicitly favoured, it is possible to identify a particular view of knowledge within *A Thousand Plateaus* (Deleuze & Guattari, 1987). Especially in Plateau 12 in the discussion of minor and state science, it appears that Deleuze and Guattari consider all knowledge to be situated, contingent and relational (Deleuze & Guattari, 1987). Knowledge emerges in encounters between people (in their context, with their history) and various other human and non-human actors. Given this perspective, researchers are not considered neutral observers discovering reality and writing reports that precisely describe that reality. On the contrary, we are interpreters developing reflections on data based on our own position and pre-conceptions (Alvesson & Sköldberg, 2009). This does not necessarily discredit the conclusions drawn, but it does mean that the researcher must reflect carefully on their interpretations. For instance, in my case it is important to acknowledge that the process of mapping assemblages is based on my own creation of categories grounded in observation and reflection. I did not discover pre-existing assemblages in the world simply waiting to be described, but transformed them and brought them into being in my process of analysis (Greenhough, 2012).

Such an epistemological position differs from natural science or positivist approaches that envision a world waiting to be properly discovered and see knowledge as a potentially objective depiction of reality. In my interpretation of an epistemology compatible with assemblage theory no one field of human knowledge takes priority over the others. All knowledges emerge out of their traditions and contexts in contact with the object of enquiry. Any view of the world will always be partial and limited by pre-existing biases. Thus I do not judge existing work on drinking water quality for producing knowledge the “wrong” way. Instead, by identifying multiple knowledges, including embodied and experiential perspectives, I aim to expand and connect each field of knowledge outside itself. In this way I draw attention to the partial-ness and situatedness of all knowledge. The

purpose of analysing drinking water quality assemblages is not to find a new version of the right knowledge about drinking water quality but to keep difference alive and better understand such difference. Therefore, during data collection and analysis I considered the conditions of possibility for difference and what can be learned from the coexistence of contradictory knowledges.

Knowledge relations are mutually affective. This relational epistemology therefore implies that in making knowledge about an object, that object is changed and so is the person who considers it. In writing this thesis and seeking out knowledge about drinking water quality in Kaolack I was changed. Each thing I learned influenced what I looked for in the next interaction or encounter. Then when I returned to the scholarly literature, I viewed it through the eyes of my new self, influenced by the experiences I had in Kaolack. After considering the literature I would return to the field, sensitive to new relations and connections in light of what I had read and experienced. Similarly, my engagement with assemblage theory started as a search for a tool I could use to capture the complex multiplicities of drinking water quality I was encountering in Kaolack. After nearly two years of engagement with this way of thinking I feel my thoughts on the world have shifted and I am more aware of the implications of becoming, transcendence and non-human agency around me. What began as simple use of a tool led me to question and alter my epistemological beliefs. At the same time, in my application of assemblage theory I pushed the empirical boundaries of the theory and thus changed it as well.

In relation to empirical data, assemblage theory analyses do not consider the responses of participants (or researchers) as subjective reports on a distinct reality, but rather see these reports as reflections of relations within assemblages (Fox & Alldred, 2015). The role of the researcher as an active participant in constructing a particular research assemblage must always be kept in mind (Fox & Alldred, 2015; Greenhough, 2012). While maintaining an attentiveness to relations of power and politics that make certain assemblages possible, an assemblage theory researcher must also consider their own power in deciding to describe assemblages in certain ways and not others. I aim to stay faithful to this perspective in my analysis of drinking water quality assemblages. The questions I ask of the data are not

simply about who said what, but also what conditions and relations made it possible for them to say such things.

This epistemology has additional implications for what criteria for research quality are deemed most appropriate. While in quantitative research the convention is to examine reliability and validity of results, qualitative research is more often evaluated based on rigor and trustworthiness (Bryman, 2012). Rigor and trustworthiness in research can be achieved by being explicit about decisions, systematic and transparent about data collection and processes of analysis and openly acknowledging and describing assumptions and positionality (Yin, 2015). I have tried to maintain all of these aspects, as discussed throughout this chapter. Another common way of increasing the reliability of results is triangulation. Triangulation in a traditional sense refers to validating knowledge by showing that different approaches result in the same findings or comparing alternative perspectives to whatever knowledge of an object or phenomena is deemed to be correct (Campbell, 2002). Such an approach is clearly in conflict with the assemblage theory epistemology I have described because it assumes the possibility of arriving at one correct knowledge. The process I have used is more closely related to feminist triangulation where the aim is to consider (in as open a way as possible) why and how multiple knowledges can be different and produce different truths which may or may not be compatible (Hesse-Biber, 2012; Nightingale, 2003).

Summary

In this chapter I have argued for a particular approach to data collection and analysis aligned with the commitments of assemblage theory. Such an approach does not assume which human or non-human actors will be most important in advance, but rather allows for understanding to emerge through deep engagement with context. This approach reflects the ontological and epistemological perspectives of assemblage theory as laid out in Deleuze and Guattari's work and described here and in Chapter 3. Thus empirical studies that apply assemblage theory concepts are well suited to the use of multiple qualitative methods which provide a broad perspective on the object under study (Fox & Alldred,

2015). Having established the methodological and analytical approach, I will now give a detailed introduction to the case in Chapter 5 and present the results of my study in Chapters 6, 7 and 8.

Chapter 5. Drinking water in Kaolack, Senegal

In this chapter I describe the drinking water situation in Senegal, focusing on Kaolack in particular. I then present detailed background information on the quality and availability of drinking water in Kaolack. I highlight aspects of drinking water quality that make Kaolack a particularly pertinent case for analysis of the socio-material complexity of drinking water quality assemblages. Where relevant, I situate my commentary on drinking water quality and access practices in a broader context of drinking water access and infrastructure studies. Next I present some key political and legal actors involved with management and governance of drinking water in Senegal, and outline current laws and policies for governance of drinking water resources. Finally, I describe some current and proposed actions for dealing with drinking water quality problems as they appear in Senegalese planning documents such as the national integrated water resource management (IWRM) plan and national strategy for improvement of water quality.

Senegal and drinking water

The Republic of Senegal is a country in francophone West Africa with approximately fifteen million residents. The climate is predominately hot and dry, with a short rainy season between June and September (World Bank, 2020). Senegal gained independence from French colonisation in 1960 and has since experienced several peaceful transitions of political power which have earned it a reputation as one of the most stable democracies in the region (World Bank, 2020). The population of Senegal is increasingly urban, young and growing rapidly (Plan Sénégal Émergent (PSE), 2014). In 1960 23% of the population of Senegal lived in cities (World Bank, 2016). The urban population is expected to climb to 60% by 2030, nearly tripling in only thirty years (World Bank, 2016). Despite recent investment in infrastructure, education and industry much of Senegal still struggles with poverty and distribution of access to basic services (PSE, 2014).

Senegal's improvements in urban drinking water access are often described by the government and international actors as a dramatic success story (Torres, Briceño-

Garmendia, & Dominguez, 2011). According to official statistics, between 1990 and 2015 the number of households connected to piped water in Senegal rose by 33% (Pezon, 2018), and the percentage of urban households with access to improved drinking water is reported at levels as high as 93% (Ndiaye, Dedehouanou, & Diop, 2013, citing WHO-UNICEF 2012). These rates of connection are significantly higher than those of neighbouring countries in West Africa, and situate Senegal among middle-income countries in Africa (Torres et al., 2011). Dramatic increases in access to water and sanitation services are attributed to utility reforms and a programme supporting connections for low-income households (Torres et al., 2011).

However, critical reports on the drinking water supply sector in Senegal abound with contradictions to this optimistic narrative. There are increasing calls to revise figures downwards to reflect both the actual quantity and quality of water available from centralised network connections. Rates of rural access lag behind, and significant regional disparities remain (Torres et al., 2011). A French Development Agency report published in 2018 about the challenges faced by the public private partnership responsible for urban water supply begins by lauding increased connectivity in urban areas in Senegal, highlighting the 98% water supply coverage in Dakar (Pezon, 2018). A few pages later a section “Dakar Deprived of Water” lists significant outages: ‘July 2008 (14 days), June 2010 (10 days), May-June 2011 (12 days) and April 2012 (8 days)’, and an infamous 3-week long service disruption in 2013 (Pezon, 2018, citing Diop, 2014, p. 29). A survey commissioned by the UN Development Programme in 2016 found a majority of registered tap water users in Senegal are dissatisfied with their water service because of frequent interruptions, water with unpleasant taste, smell or colour and low water pressure (Pezon, 2018). The water utility company continues to report compliance with WHO potability standards, feeding distrust between the company and consumers (Diop, 2014).

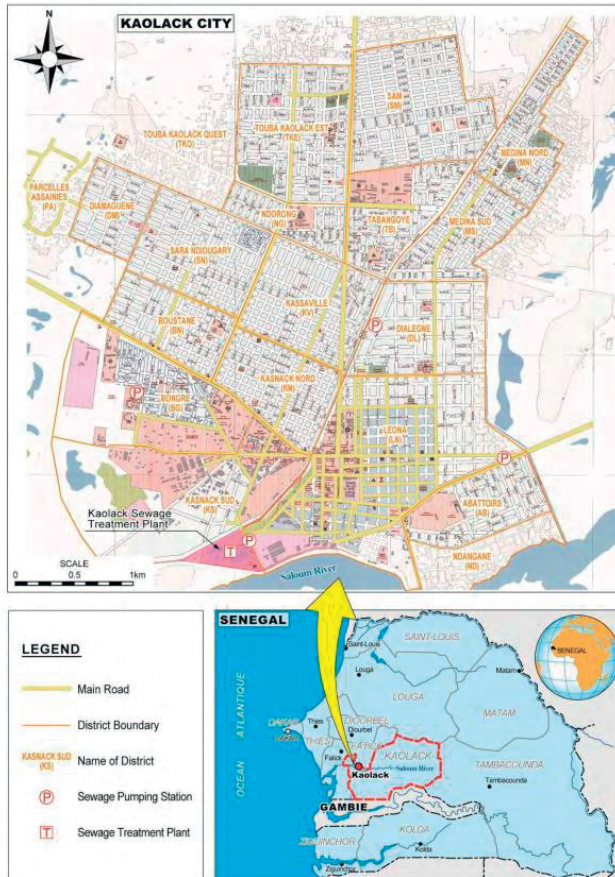


Figure 5. Map of Kaolack (JICA, 2014, p. vii)

Because of Senegal's diverse hydrogeological conditions on the southern edge of the Sahel, different regions of Senegal face different drinking water challenges (DGPPE, 2016, 2018). In the hot and dry Northeast access to water is problematic; although the quality and quantity of water is adequate, the aquifer is quite deep and there can be long distances between deep-bore wells (DGPPE, 2016). In densely populated urban areas, for example suburbs of Dakar, drinking water resources are highly susceptible to pollution from

improper disposal of household or industrial waste (Madioune, Faye, & Faye, 2011)¹⁴. Nitrates and pesticides threaten areas with shallow groundwater along the Senegal River and Lac de Guiers, which provides a significant source of drinking water for the capital and nearby urban centres. In the South and Southeast naturally occurring iron in groundwater poses public health problems, as do arsenic and mercury from artisanal gold mining operations (DGPRES, 2016). In central and coastal areas high levels of fluoride and increasing salinisation threaten many communities (DGPRES, 2016, 2018). The case study site for my dissertation, Kaolack, is located in this central zone (Figure 5).

Kaolack and drinking water

The modern-day city of Kaolack occupies part of the historic territories of the kingdoms of Sine and Saloum, founded in the 14th century. In the early 1860's the French colonial governor of Senegal, Louis Faidherbe established a fort near the Saloum River between the villages of Kahola and Kahone and named it Kaolack (Badiane, 2004). The French army used this military outpost as a base during conflicts with the local Sereer communities. The fort itself was contested by the king (Bur du Sine et du Saloum) for several years after its construction, but eventually a treaty was signed ceding the land to the French. The growth of the city of Kaolack escalated in the early 1900's with the development of the port, a railroad and paved roads for export of peanuts from further inland (Badiane, 2004). Most research on urbanisation patterns, public health and access to resources in Senegal has taken place in large cities, with a dearth of publications focused on secondary cities (Thiam et al., 2017).

Kaolack is currently the 5th largest city in Senegal, with a population of 310,066 as of the most recent census (ANSD, 2019, p. 21). The Kaolack Region is a productive agricultural area colloquially known as the "Peanut Basin" (Basin arachidier). Kaolack's port on the Saloum River has historically been an important source of income, though in recent decades traffic has decreased as many ships are routed through major seaports in Banjul and Dakar

¹⁴ Interview 15-07-19, SCF

(Badiane, 2004). Though the city remains an important agriculture and trade hub with road connections to every region of Senegal, Mali, the Gambia and Guinea, Kaolack is in a state of ongoing decline (Badiane, 2004). Inadequate management of solid waste, particularly around the central market, and frequent flooding in the rainy season contribute to Kaolack's notoriety as the dirtiest city in Senegal¹⁵. The city centre neighbourhood currently known as Leona contains the oldest buildings in Kaolack, some of which date from the colonial period. The urban area has gradually expanded north and west since it was established. Settlements now extend into salty floodplain areas called tannes (UN Habitat, 2009). Most neighbourhoods throughout the city consist of a mix of rural looking houses and luxurious villas, although there are some neighbourhoods which could be considered more wealthy than others. For example, the neighbourhood of Medina Mbaye has strong ties to a diaspora population and religious groups including the Mouride brotherhood and is generally home to higher income families. Abbatoirs and Ndagane by the river are less wealthy and experience higher levels of environmental degradation. The neighbourhoods of Thioffack and Saam to the north of the city are primarily informal settlements expanding past the city limits with limited connectivity to water and electricity infrastructure.

As is the case in many cities in arid areas of Sub-Saharan Africa, provision of safe and sufficient water for the population is a perpetual challenge in Kaolack. The city is located in a hyper-saline tidally influenced estuary on the banks of the Saloum River (Dieng et al., 2017). The only available surface water, in the river, is far too salty for drinking or

¹⁵ This thorough and shockingly honest description of the current state of the environment around Kaolack sums up its reputation quite well:

Kaolack offers the visitor a bewildering and distressing sight in terms of environmental degradation. The stretch of water that separates Kaolack and Kahone is a wild deposit of plastic bags and other solid and liquid wastes that constitute a visual aggression that also contributes to the disfigurement of Kaolack. The populations of this hyper-polluted zone cohabit with difficulty with this filth. A noxious smell coming from the putrefaction of waste permanently pollutes the air that these Kaolackois breathe. Living in the houses adjoining the inlet, from Pont Noiro (Niore Bridge) to the entrance to Medina Baye, is a nightmare that only the victims can describe. The other entries of Kaolack offer the same face (Kaolack Urban Development Plan, p. 240).

agricultural use, so surrounding areas are almost entirely dependent on groundwater (Dieng et al., 2017)¹⁶. The two sources of groundwater in Kaolack are the Maastrichtian aquifer, with an average depth of about three-hundred meters, and the much shallower Continental Terminal aquifer (Diène, Kane, & Dethie, 2014). Risk of salt infiltration from sea water and the saline Saloum River has led the national water authority to promote use of the deep Maastrichtian aquifer as an alternative to the Continental Terminal, but this is not without problems (S. Faye et al., 2005). The Maastrichtian aquifer is also slightly saline and contains significant quantities of fluoride – in some cases up to five times WHO recommendations (S. Faye et al., 2005).

Extended exposure to excessive fluoride causes a condition called fluorosis. When exposure happens in early childhood, dental fluorosis is ‘characterised by discoloured, blackened, mottled, or chalky white teeth’ (UNICEF, 1999). Chronic intake of fluoride can also cause ‘severe and permanent bone and joint deformations of skeletal fluorosis’ in both children and adults (UNICEF, 1999, p. 11). Furthermore, the tap water in Kaolack often has a briny, unpleasant taste and light brown colour (Agence Belge de Développement, 2013). Within Senegal, Kaolack is infamous for these water quality issues, and long-term residents of the region are considered recognisable by the colour of their teeth.

Access to drinking water in Kaolack

In cities across the Global South, people access water in a variety of ways. Social studies of urban water infrastructure (broadly associated with science and technology studies, geography, anthropology and cognate fields) have documented this diversity at length (Jaglin, 2004, 2012). Variation both within and between households, including over time, is

¹⁶ It is challenging to lay out the background of water quality in the Kaolack region without giving some kind of privileged position to the way it has been presented in academic and grey literature. Although there may be limitations to the studies that produced this knowledge, I feel it is still useful to give a description of the hydrological context, in full recognition of the fact that this information may be contested. The challenge is to ‘take due notice of natural scientific accounts of the specificity of particular materials, while not assuming that this specificity should be understood only in natural scientific terms’ (Barry, 2013, p. 13).

the rule, rather than an exception (Wutich et al., 2017). Even when tap water is widely available, alternative sources of water persist, and the choice to rely on a variety of sources cannot always be directly linked to obvious reasons like price or quality (Furlong, 2014). The urban poor, in particular, access water from multiple sources, ensuring flexibility and security in the case that a primary source becomes unavailable (Peloso & Morinville, 2014) and maintaining some level of autonomy from the state system (Meehan, 2014). Ongoing variation in water access practices is also prevalent in Kaolack.

Every neighbourhood in Kaolack is connected to the water infrastructure network, either via private spigots inside homes or public standpipes (UN Habitat, 2009). The network includes more than seven hundred subsidised connections intended to make tap water more accessible to low-income households (UN Habitat, 2009). Despite increases in connectivity, substandard tap water quality remains a significant challenge for health (ANSD, 2019) and can lead users to exit the centralised network in favour of informal or alternative options (Kjellén, 2006). While tap water is required to meet quality assurance standards - and the municipal provider claims it does - the vast majority of people I spoke to in Kaolack expressed profound dissatisfaction with the state of affairs, and many prefer to obtain their drinking water elsewhere. Therefore in Kaolack many alternative sources of drinking water exist, including broadly tap water, bag water, bottled water, well water and filtered water.

Tap water in Kaolack can either be purchased directly or indirectly. Direct customers of the municipal water provider have taps inside their homes. In most households I visited there is only one main tap inside the walls of the compound where the household refills containers and carries water to where it will be used (for drinking, laundry, flushing toilets, cleaning, bathing, cooking and so on) or family members sit together and fill up jerry cans all at once when the flow is strong and then use the water throughout the day. In household interviews I encountered a handful of recently constructed houses of wealthy people that had multiple taps inside the house, for instance in a kitchen and bathroom, but in my experience this is unusual. Households can also purchase water from public standpipes. In this case there is a tap in the street which remains locked unless an attendant is present to

sell the water. The attendants I spoke to are older women who place a chair in the shade near the spigot to spend their afternoons chatting with customers and collecting fees. However, tap water is only one mode by which residents of Kaolack access water.

Across West Africa in the last three decades, sales of small bags of drinking water known as sachet water have exploded (Stoler, 2017). In line with this trend, sachets are a ubiquitous alternative to tap water in Kaolack. I noted more than one hundred brands of sachet water being sold and consumed in the city, some of which are produced locally and others which come from as far away as Ghana. While nearly every bag I collected was printed with some kind of claim about hygiene and treatment, some contain filtered water, some have chlorine added and some are simply collected from a local well or tap. Even though these are small quantities of water, usually 400 to 500 mL of water per bag, this can represent a sizeable flow of water into and through the city. Bags of water are often sold in bulk in small corner shops or individually near restaurants, in the market or around transit areas. Often the sellers are entrepreneurial women, weaving through town with baskets full of frozen bags of water balanced on their heads. While bag water represents a convenient and affordable source of drinking water for many people, there is a downside¹⁷. Bags of water are generally consumed by biting off one corner, drinking the contents all at once and then dropping the empty plastic bag on the ground. The quantities of waste are significant, plugging up drainage canals and drifting in the wind and sand everywhere you go.

Bottled water represents another option for widely trusted drinking water. Globally, bottled water consumption continues to grow, often fuelled by a distrust of tap water services encouraged by bottled water companies themselves (Pacheco-Vega, 2019). In Kaolack, two national companies (Kirene and Casamançaise) sell most of the bottled water, but more are making inroads into the market. Almost all bottled water comes from inside Senegal, but outside Kaolack, and relative to bag water consumption the quantity is quite limited. Bottled water is for sale in 1.5 or 10 litre increments in many shops, but it is

¹⁷ Sachet water typically costs 400 xof (6.4 nok or \$0.75 USD) for a bulk package. Individual sachets cost 50 cfa (0.39 nok or \$0.09 USD) when frozen or 25 cfa (0.79 nok or \$0.05 USD) when warm [All exchange rates from 05-01-21].

relatively expensive and mostly only accessible to wealthier households¹⁸. Sometimes when I would buy a 10 litre bottle for myself it would be dusty, as if it had been sitting in the shop for some time.

Well water, primarily sourced from the north and northwest parts of the city, is the oldest way of accessing water in Kaolack and remains the primary source of drinking water for some families. Drivers of donkey carts deliver well water in jerry cans to every neighbourhood in Kaolack. Some households or mosques have wells on their property and may choose to sell water to neighbours by volume¹⁹, but the area where this is possible is shrinking as salinization creeps northward from the river. In the neighbourhood of Thioffack, for instance, a few people mentioned to me having previously had a well in their compound or surrounding area which is now closed off because the water is no longer suitable for drinking. Well water sellers I interviewed described visiting several neighbourhoods each day to sell water. In some cases individual customers have the phone number of a seller and will ask them to come by with a delivery, but I was told this is not common. In general people see a cart passing by, flag them down and buy as much as they need or can afford.

A new addition to the drinking water landscape in Kaolack is filtered water from mobile reverse osmosis filtration systems. These filtration systems can process up to four thousand litres per day and new kiosks are opening every month. This trend is not limited to Senegal. Small-scale reverse osmosis treatment is becoming increasingly efficient and affordable, and can present a viable alternative source of safe drinking water (Boden & Subban, 2018). The most common brand of filtered water in Kaolack is Diam-O, which uses machines provided and maintained by a Swiss company called Swiss Fresh Water. There are over thirty Diam-O kiosks in the city. Two other filtration companies, Pur-O and Claire Eau are proliferating as well. Filtered water is twice as expensive as well water, but many customers

¹⁸ 1.5 L of bottled water costs 400 xof (6.4 nok or \$0.75 USD) and 10 L costs 1000 xof (15.9 nok or \$1.87 USD).

¹⁹ The typical cost for well water delivery is 125 xof (1.96 nok or \$0.23 USD) for 20 L, more expensive than tap water but still considered affordable by many.

are willing to pay for what they believe to be the cleanest and most secure option²⁰. Individual households could also install point-of-use water filtration systems in homes (as Vandewalle & Jepson observed along the US-Mexico border (2015)) but this is not something I witnessed in Kaolack.

Unusual or uncommon drinking water sources underscore the diversity of potential options for obtaining drinking water. One of my neighbours, an employee of an international power company, said his employer regularly sends him jugs of drinking water from Dakar (two hundred kilometres away) so he will not have to drink the tap water in Kaolack. I also spoke to an older woman whose son commutes to a town forty kilometres away with good tasting water, where he fills up jerry cans for her before he returns home each evening. These practices also vary throughout the year. For example, some people collect rain water in barrels for household use and drinking during the rainy season. During religious festivals, like the annual religious pilgrimage to the Medina Mbaye neighbourhood, a huge influx of guests mean water pressure throughout the city decreases dramatically and tanker trucks bring water into crowded areas and give drinking water away for free. All of this goes to show that even in households and neighbourhoods which are served by the central tap water network, drinking water access is anything but uniform.

While small-scale water vending can be a way of filling gaps in the government's ability to provide safe and secure drinking water to their population, the possibility of inequalities in access to clean water and exposure to hazards in drinking water remains (Wutich, Beresford, & Carvajal, 2016). Sources of drinking water vary in quality and price, introducing the potential for inequality in terms of who has access to enough consistently clean and safe water. For instance, in higher-income neighbourhoods infrastructure is often better maintained. Sometimes low-income urban neighbourhoods are not connected to centralised tap water and so they must purchase other sources of water from tankers, wells, packaged water vendors, and so on which may not be closely monitored for compliance with quality standards (UNESCO, 2019). Low-income households also habitually pay more

²⁰ I was among the filtered water customers. 10 L of filtered water costs 125 xof (1.96 nok or \$0.23) with an additional charge of 50 or 100 xof for delivery.

for lower quality drinking water services (UNESCO, 2019). In addition to seeking out alternative sources, many households and individuals in Kaolack treat their water by adding chlorine or a product called Aquatabs (available locally in shops and pharmacies), waiting for sediment to sink out and straining water through a cloth and so on. The costs of customising drinking water quality in such ways are often higher for low-income households (Robak & Bjornlund, 2018). The amount of labour put into collecting water for household use can be much more time consuming and even dangerous for some households than others (Truelove, 2011). In particular, women suffer more physical and emotional stress and have to put more labour into obtaining drinking water and coping with drinking water-related health and financial problems (Sultana, 2011).

Urban drinking water actors in Senegal

In this section I will introduce key international, national and local actors involved in governance of drinking water in Senegal. At the international level the WHO have positioned themselves as the global authority on drinking water quality, publishing extensive guidelines for countries to develop their own national standards. The WHO guidance documents centre around the regularly updated Guidelines for Drinking Water Quality (WHO, 2017a), which establish a particular view of what can be included in the conversation about drinking water quality. Within Senegal drinking water quality falls into two spheres of governing which can be loosely subdivided into a hygiene and public health focused side and a service provision side, sustained by different but overlapping groups of actors and interests. The Société nationale des eaux sénégalaise (SONES) is the national government actor primarily responsible for ensuring the provision of safe drinking water in urban areas.

In Senegal since 1995 there has been a public private partnership for urban drinking water services consisting of an *affermage* contract between SONES, the private company SDE (a division of the international company Eranove) and the state (UNDP, 2012). What this contract entails is that SONES, on behalf of the Senegalese government, retains responsibility for large investments in water infrastructure, while SDE takes responsibility

for implementation, network maintenance and providing potable water to consumers at a rate agreed upon with the government. During my field work the private company responsible for urban drinking water was still SDE; they have since been replaced by Sen-Eau (a division of the international company Group Suez)²¹. SDE monitors the quality of their water regularly and delivers monthly reports to SONES. Because of the specific legal and contractual roles assigned to SONES and SDE, their approaches to maintaining or improving quality differ (Diop, 2014). SDE cleans and maintains existing infrastructure and chlorinates the water, while SONES plans and implements larger projects for treatment plants or water transfers. Three independent laboratories also have contracts with SONES to conduct sporadic random sampling of the network within different regions of Senegal. These laboratories report directly to SONES on their findings. One of these laboratories is based in Kaolack, supported by the local subsidiary of a large international NGO. The standards used to determine whether drinking water is of adequate quality are based on the WHO Guidelines for Drinking Water Quality and norms established by the Senegalese Association for Normalisation (ASN). The DGPRES works with SONES to establish policies and plans with regards to drinking water resources, such as the national IWRM action plan (Plan d'action de gestion intégrée des ressources en eau (PAGIRE)).

While SDE, SONES and their independent monitors focus on tap water, the Hygiene Service under the Ministry of Health and Social Action monitors other water intended for human consumption. Working with nationally established standards, regional and city level teams within the Hygiene Service test well water, bag water, bottled water and filtered water and issue citations or revoke rights to sell in cases where standards are not met. They also partner with NGOs and international organisations like UNICEF to do community education about hygiene.

Development organisations and NGOs participate in establishment of national policies and plans for drinking water access and quality (for example Caritas and members of the PS-Eau network). The most recent iteration of the national IWRM plan (PAGIRE 2018-2030),

²¹ Group Suez and Eranove are both French companies.

as one example, was financed and supported by the Belgian Development Agency. Another role NGOs play is conducting studies and publishing reports on drinking water quality, sometimes in collaboration with and sometimes independent from academic researchers. The declared purposes of these reports are to support and justify projects NGOs implement and to inform policy making and planning.

While other actors may not be directly tasked with management or governance of drinking water quality, they nevertheless have a stake in improving, protecting or knowing water quality. In Kaolack some of these actors include the Ministry of Environment, the Office of Urban Planning and Development, healthcare workers, the national sanitation organisation, the Ministry of Hydrology, the community surveyor's office of the mayor and the prefecture.

The actors I have presented up to this point have largely been those involved in managing or governing drinking water quality. Consumers of drinking water, on the other hand, are equally as invested in drinking water quality, although they may define and respond to it in different ways. Consumers are not a homogenous group. Even within households what water people consume and what characteristics of that water they are most concerned about varies significantly (Wutich et al., 2017). Additionally, people who sell water play a role. Their objective is to sell a product, and so their drinking water quality practices are oriented towards enticing people to purchase the water they provide. They must also meet governmental requirements which allow them to continue selling. These requirements and standards, as elaborated in relevant laws and policies, are the topic of the following section.

Key documents for governance of drinking water quality in Kaolack

Several documents contain requirements and guidelines for how drinking water quality should be governed in Senegal, including national level laws and policies. Among these, the WHO Guidelines for Drinking Water Quality are referred to extensively. Also in my interviews and conversations with policy makers, planners and sellers of water, the WHO's priority compounds and thresholds were mentioned several times as the gold standard. The primary guiding principle of the WHO guidelines is that 'Safe drinking water, as defined by

the guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages' (WHO, 2017a, p.1).

Although national norms for quality of water for human consumption have been established (NS 05-033-1996, Norme sénégalaise sur la qualité des eaux d'alimentation humaine) (Table 4), Senegal did not yet have legally binding standardized national requirements for water quality as of 2007 (PAGIRE, 2007). This may be addressed as a part of the current development of a national strategy for improvement of drinking water quality (DGPRES, 2016)²². The primary law for water quality is the Loi Portant le Code de l'eau (Loi n. 81-13, 1981) which says about quality: 'The Code also emphasizes health aspects, because it incorporates the standards defined by the World Health Organization, while adapting them *to our level of development* and to the nature of our hydraulic works' (emphasis added). A revision of the national water law is in process, and in the meantime policies have largely relied on the WHO guidelines to set goals for potability. Interestingly, the norms recommended by the WHO and those set by the ASN are not exactly aligned. In the case of fluoride, for instance, the WHO standard is 1 mg/L, while the ASN sets the limit at 0.8 mg/L (Agence Belge de Développement, 2013)²³.

Table 4. Key laws and norms for drinking water quality in Senegal

National legal frameworks	Year
Law concerning the water code (Loi n 81-13 du 4 mars 1981 portant Code de l'Eau)	1981
Norms for the quality of water for human consumption (NS 05-033-1996, Norme sénégalaise sur la qualité des eaux d'alimentation humaine)	1996
Law governing the provision of potable water and sanitation (Loi sur le Service Public de l'eau potable et de l'assainissement (SPEPA)) (2008)	2008

²² At the time of writing this thesis, the finalised national strategy for improvement of water quality was not yet publicly available.

²³ WHO standards may not be applicable for fluoride in hot, dry countries like Senegal where the daily intake of water is likely to be higher than 2L/day. See - Brouwer, I., De Bruin, A., Dirks, O. B., & Hautvast, J. (1988). Unsuitability of World Health Organisation guidelines for fluoride concentrations in drinking water in Senegal. *The Lancet*, 331(8579), 223-225.

A variety of plans with relevance for drinking water quality also exist (Table 5). One of the most influential of these is the national IWRM plan. Development of Senegal's first IWRM action plan began in 2004 and implementation took place from 2007-2015. The current national IWRM plan is for the period from 2018-2030. In addition, the in-process national strategy for improvement of drinking water quality specifically aims at developing coherent national plans to ensure safe and sufficient drinking water for everyone (DGPRES, 2016). The Plan Senegal Emergent (PSE) is an important policy document that lays out the key strategic foci of Senegalese president Macky Sall. The PSE does not directly focus on water, but does mention the urgency of drinking water quality challenges in certain regions. Specifically for Kaolack, drinking water quality is discussed in the community investment plan for 2013-2018, a report on the situation of various ongoing and completed projects in the city and region, and the urban development plan Horizon 2037.

Table 5. Plans addressing drinking water quality in Senegal and Kaolack

Policies and plans included in document analysis	Year	Source
<i>National level plans</i>		
IWRM Action Plan (PAGIRE, 2007)	2007	DGPRE
National IWRM Plan 2018-2030 (PAGIRE 2018-2030)	2018	DGPRE
PSE (2014)	2014	Office of the President
Strategic Report: Study for the elaboration of a national strategy for the improvement of drinking water quality in Senegal (Rapport Stratégie: Étude pour l'élaboration d'une stratégie nationale de l'Amélioration de la Qualité de l'eau potable au Senegal) (2016)	2016	DGPRE
<i>Kaolack regional and urban plans</i>		
Situation of projects and plans in the Kaolack Region, final version (Situation des projets et programmes de la région de Kaolack version final) (2017)	2017	Central office for economic policy and planning, regional planning office of Kaolack (Direction General de la planification et des politiques économiques - Service Régional de la Planification de Kaolack)
Kaolack community investment plan 2013-2018 (Plan d'investissement communal de Kaolack 2013-2018)	2013	Senegalese-German program for support for decentralisation and local development (Programme Sénégalais-Allemand d'Appui à la Décentralisation et au Développement Local)
Provisional draft of the Urban Development Plan for Kaolack, Horizon 2037 (Plan Directeur d'urbanisme de Kaolack "Horizon 2037": Rapport Diagnostic (version provisoire)) (2019)	2019	Ministry of urban renewal, habitat and lifestyle, central office for urban planning and architecture (Ministère du renouveau urbain de l'habitat et du cadre de vie, Direction général de l'urbanisme et de l'architecture)

Much of the data on drinking water quality in Kaolack represents outputs of collaborations between government actors (primarily the DGPRE or ASN) and NGOs or international organisations like the Belgian Development Agency, USAID, UN Habitat and JICA (Table 6). These include studies about solutions to drinking water quality constraints (like large scale water transfers) or various types of filtration (Lagaude, Kirsche, & Travi, 1988) alongside

financial analyses and feasibility studies. Epidemiological and public health studies about how compounds like fluoride and salt affect health are also common (Agence Belge de Développement, 2013; DGPRE, 2011). Many of these studies fall under the umbrella of the programme for potable water and sanitation in the millennium (Programme d'eau potable et d'assainissement du millénaire (PEPAM)) which was completed in 2015.

Table 6. Studies on drinking water quality in Kaolack

Name	Year	Organization
Report on the economic and social situation in the Kaolack Region (Situation Economique et Sociale de la Region de Kaolack)	2016	Association des normes Sénégalais
City Profile of Kaolack	2009	UN-Habitat
Epidemiological study in the Diourbel, Fatick, Kaffrine and Kaolack regions mapping the impact of fluorosis in the zone (Enquête épidémiologique dans les régions de Diourbel, de Fatick, de Kaffrine et de Kaolack afin de cartographier l'impact de la fluorose dans la zone)	2011	DGPRE
PEPAM-AQUA Fluoride and salt in water	2013	Agence Belge de Développement
Blue book country report: Senegal (Livre bleu / Rapport pays : Sénégal)	2009	Senagrosol-Consult
Water Supply and Sanitation in Senegal: Turning finance into services for 2015 and beyond: An African Council of Ministers on Water (AMCOW) Country Status Overview	2011	AMCOW

To sum up, even within Senegal, residents of Kaolack find themselves in a unique situation with regards to drinking water quality, and particularly the high content of salt and fluoride in tap water. Many strategies are available to consumers to access alternative sources of drinking water. There are pros and cons to these varied sources of drinking water with regards to their quality, and the state and consumers are not always in agreement about which sources of water are the most safe for drinking. In the next chapters I will present the findings of the thesis, where I engage with the social, material and ethical complexity of drinking water quality governance in Kaolack using assemblage theory.

Chapter 6. Findings I – Possibilities for Drinking Water Quality Assemblages in Kaolack

Outline of the findings chapters

In this and the following chapters I develop a theoretically-informed depiction of drinking water quality assemblages in Kaolack, Senegal. The findings chapters build on the idea that drinking water quality is an assemblage. Essentially, this is a claim that drinking water quality emerges in an encounter between heterogeneous elements (material and social) that are brought together in shifting relations in a particular location and moment. The ways that these elements are arranged have affects, which shape the ways people access drinking water and experience drinking water quality. Because of the manifold possibilities of combining elements in varying ways, there can be multiple coexisting drinking water quality assemblages.

The goal of these empirically oriented chapters is to answer Research Question 2, which can be sub-divided into three parts. Each sub-question is the topic of one chapter. First, how is drinking water quality assembled in Kaolack? This question is further broken into two sub-questions, the first focused on possibilities for how assemblages form and the second on elements in assemblages. Research question 2a uses the word assemblage as a verb, while research question 2b treats it as a noun. As discussed in Chapter 3, the original French term *agencement* encompasses both these understandings of assemblage as a heterogeneous collection of things (noun) and the agency involved in arranging these elements into provisional forms or patterns of relations (verb). Finally, I pose the question what do drinking water quality assemblages do in Kaolack (research question 2c)? At the end of each chapter I engage with the ethical aspects of drinking water quality governance and planning that have been made visible through my analysis. I note specific ethical moments that emerge throughout the findings and relate them to a Deleuzoguattarian immanent ethical perspective.

Describing assemblages in a way that is ontologically cohesive is a challenge, and drawing boundaries around what constitutes an assemblage is not a straightforward task. In the case of drinking water quality assemblages in Kaolack I have identified clusters of repeated material and social practices and claims about drinking water quality that cohere into temporary assemblages. I reflect on this process in more depth in the analytical framework section of Chapter 4. The first purpose of mapping out multiple coexisting assemblages in such a way is to highlight multi-level and underrecognized relationships. Such complexity might be missed in an overfocus on either national level regulations and expert conversations about drinking water quality or consumer perspectives. The same could be said for focusing primarily on either the material or social aspects of drinking water quality. Secondly, I foreground the contingency of drinking water quality assemblages through a focus on how heterogeneous elements are included or excluded via practices. This focus on contingency brings to the surface the idea that things always could have been different, and that assemblages are not stable but rather always in a process of becoming. Third, I move beyond description of what assemblages are and ask what their implications may be for access to safe drinking water and exposure to potentially harmful things in water in Kaolack.

Abstract machines: conditions of possibility for drinking water quality assemblages in Kaolack

I begin this chapter by identifying drinking water quality assemblages and describing the conditions of possibility guiding how drinking water quality assemblages can form in Kaolack. Abstract machine is the core concept used to explore the ways drinking water quality is framed as a problem within the assemblages I identified during field work. Throughout this chapter I introduce seven categories of assemblages of drinking water quality present in Kaolack. I describe each assemblage via its abstract machine, which shapes the processes of how drinking water quality assemblages form and act.

In the theoretical framework I defined abstract machines as conditions of possibility for how certain assemblages form. To give this concept a more practical aspect, I approach the

abstract machines of drinking water quality in Kaolack in three ways (Figure 7). First, I identify drivers of drinking water quality assemblages. Drivers of assemblages refer to the guiding principles that shape the need for an assemblage to exist. Next, I consider what kind of problem drinking water quality is in the assemblages I identify. For instance, drinking water quality in each assemblage may represent a technical problem which is considered universal and translatable across contexts, or it may be personal and situated. Finally, I describe the specifics of how drinking water quality is framed as a problem within each assemblage. Abstract machines implicate certain accountable parties and types of solutions, and those accountable parties work back on the abstract machines in a mutually reinforcing system. Such an approach owes much to the conceptualisations of problematisations in the writings of Foucault and scholars who rely on his work (Legg, 2011). The idea that problematisations can be identified by considering the assumptions inherent in chosen solutions in particular is inspired by the policy studies work of Carole Bacchi (Bacchi, 2012a, 2012b).

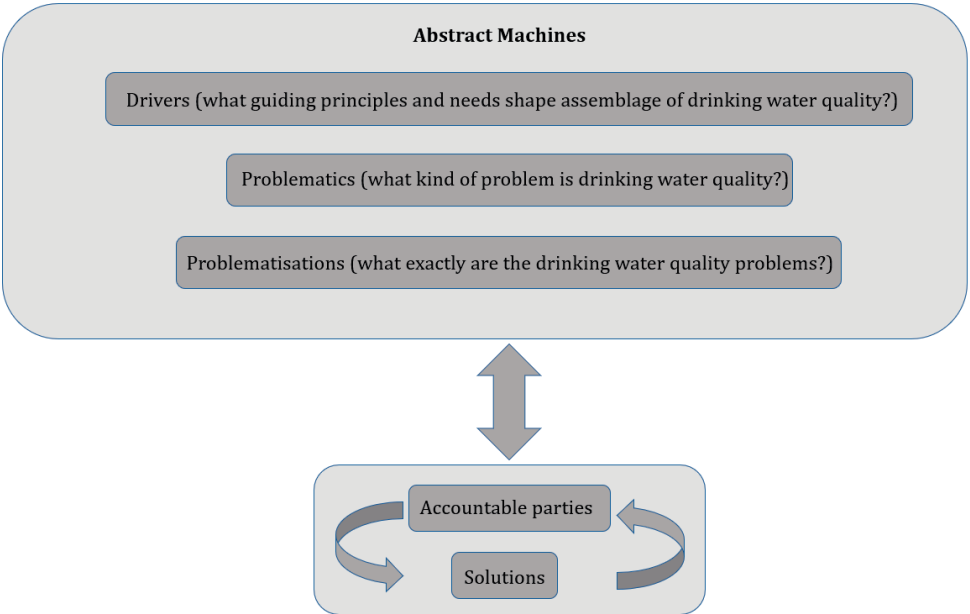


Figure 6. Abstract machines of drinking water quality

Based on my data analysis, I suggest that the assemblages of drinking water quality in Kaolack consist of four variations on state assemblages which share an interest in governing drinking water quality at the global, national and local levels; two types of provision assemblage associated with tap water and other sources of drinking water which are more or less independent of the tap water network; and consumer assemblages of drinking water quality, which represent quality as it is known and understood by people who purchase water for consumption. Consumers are not a homogeneous group, but for the purpose of comparison and analysis I have identified patterns in their assemblage processes in Kaolack. Therefore I refer to a loose aggregate of many different consumer assemblages with some shared characteristics. An individual or group of actors can participate in multiple assemblages relative to a single issue. Everyone drinks water so everyone must be part of Consumer Assemblages, but some actors simultaneously take part in Everyday Governing Assemblages or Provision Assemblages as well. There can also be certain key actors which play disproportionately directive roles for how an assemblage forms. The power to direct and limit the capacities of elements to affect and be affected in an assemblage emerges through patterns of relations (Fox & Alldred, 2015).

The terms I use to name assemblages and capture the core problematisations of each group emerged from my engagement with collected empirical data. The names I have given them reflect their tendencies more than their types, and as will quickly become clear the boundaries between them are not always distinct. Assemblages are not only oriented towards governing, profit or consumption. They interact and mix continuously as they form and reform. In order to talk about assemblages, however, it is helpful to give them each provisional labels.

At its heart, the problem of drinking water quality is that people need to drink water to survive, and water quality varies both over space and time and according to personal and societal preferences. There are also variations in how drinking water quality is understood and framed as a problem by different individuals and groups. When we consider drinking water quality as a problematic object, this raises practical questions about what escapes or

is excluded from a drinking water quality assemblage (the topic of Chapter 7), and also what is possible with regards to drinking water quality assemblages.

Drinking water quality can be problematic in multiple ways. For instance, drinking water quality can be seen as primarily a public health or hygiene problem caused by inadequate sanitation infrastructure or a lack of cleanliness and handwashing among the population. Alternatively, drinking water quality challenges could be blamed on factories which discharge their waste into rivers, or it could be a non-anthropogenic issue of aquifers naturally rich in arsenic, fluoride or salt. Variations in drinking water quality can also be an environmental justice problem, where the problem is understanding how and why some groups are more impacted than others by sub-standard drinking water. In each of these cases, there is some matter of concern that implies corrective action. Table 7 shows the assemblages that will be addressed in this chapter, along with the core actors, drivers and problematics that constitute their abstract machines.

Table 7. Assemblages of drinking water quality in Kaolack with their core actors, drivers and problematics

Drinking Water Quality Assemblages	Core Actors	Drivers of drinking water quality assemblages	Drinking water quality problematics
Global Health Assemblage	WHO and associated international bodies	International public health, standardisation and progress towards selected priority indicators	Technical, solvable, universal, quantifiable, goal-oriented, long-term
Senegalese State Assemblages	SONES; ASN; DGPRES; Ministry of Health Closely aligned with the norms of the international community, including the WHO and associated international bodies	Governing, national level public health and progress towards selected priority indicators	Technical, solvable, universal, quantifiable, goal-oriented, long-term
Senegalese State Assemblages (Kaolack-specific problems)	Urban Planning Directorate, Office of the Mayor	Governing, improvement relative to current conditions	Technical, solvable, particular to Kaolack, quantifiable, goal-oriented, long term
Everyday Governing Assemblages	Independent NGO laboratory Hygiene Service	Pragmatism, public health, protecting the population from illness	Flexible within the confines of what kind of equipment and knowledge is available, aligned with goals of the Senegalese State, immediate
Tap water Provision Assemblage	SDE	Profit maximisation and compliance with contractual obligations	Technical, solvable, universal, quantifiable, goal-oriented
Non-network Provision Assemblages	Well water sellers, filtered water kiosks, bottled and bag water manufacturers and sellers	Profit maximisation and customer satisfaction, meeting state requirements for quality	Personal, embodied, flexible, situational
Consumer Assemblages	Everyone who drinks water	Preference, availability, necessity	Personal, embodied, flexible, situational

Problematisations are intimately connected to solutions and human intentions to act in response to individual drinking water quality assemblages. Therefore, for each abstract machine described in this chapter I consider proposed or enacted solutions to drinking water quality problems as ways of understanding the functioning of distinct abstract machines. These solutions implicate particular actors in knowing and responding to drinking water quality, and so I also identify the particular actors or groups of actors considered capable of or accountable for acting. Furthermore, the involvement of particular actors in a central role can change what types of solutions are seen as viable or desirable in a particular context²⁴. I return to the implications of the intentions and actions associated with each type of assemblage in more detail in Chapter 8.

Abstract machines shape the conditions of possibility for the form and nature of assemblages of drinking water quality. By considering these conditions of possibility in concrete ways associated with the drivers, problematics and problematisations contained in each assemblage, we can understand more about what makes the development of certain assemblages in Kaolack possible, and also how assemblages diverge and exist in tension. I will describe these aspects for each of the types of assemblages of drinking water quality in Kaolack in turn.

Global Health and Senegalese State Assemblages

The first assemblages I address are a group of state-centred assemblages of drinking water quality at the national and international levels: the Senegalese State Assemblage and Global Health Assemblage. I direct most of my analytical attention to the Senegalese State Assemblage at the national level, as it is most directly relevant to how drinking water quality is assembled in Kaolack. Although I do not go into detail about problem framings of the Global Health Assemblage, it is an important component of the Senegalese State Assemblage. The national and international levels are entangled. In Senegal, as in many

²⁴ I established in the Chapter 3 that in assemblage theory human intention is one among many immanently causal actors (Bowden, 2020). So humans can intend to do things but their intentions are not directly linked to effects or outcomes. An actor planning to do something does not ensure that such a thing will occur. Nor can we consider an outcome and trace its origins directly back to a plan or intention.

countries, the current WHO Guidelines for Drinking Water Quality (WHO, 2011) play an important role in how the state defines and responds to drinking water quality (Diop, 2014). Key actors in the Senegalese State Assemblage of drinking water quality are those laid out in Chapter 5 including: SONES, the DGPRE, Ministry of Health and ASN²⁵. At the international level key actors include the WHO, UNICEF, UN-Water and other NGOs and intergovernmental organisations.

For State Assemblages of drinking water quality the process of assemblage is driven by a need to govern the population and promote public health. Therefore in both cases I have identified the guiding principles of these assemblages as governing and progress towards measurable health-related indicators. By governing I refer to the state's actions in striving to shape the behaviour of various groups of actors with regards to protecting and ensuring drinking water quality. The indicators the Senegalese state and WHO utilise include health-based targets, percentage of households with access to improved and safely-managed sources and chemical, radiological, microbial and acceptability aspects (WHO, 2011). Progress typically refers to achieving demonstrable reductions in the quantity of certain things in water relative to these indicators and increases in the proportion of households with improved access. State Assemblages are fairly stable in the sense that their forms are written in legal documents that are only revised every few decades, policies that last several years and planning documents with distant end-dates like the Horizon 2037 of Kaolack²⁶.

The Senegalese state strives to provide clean and safe drinking water to citizens in order to ensure the health and well-being of their population and to achieve SDG 6 and other national and international commitments. To interface with the Global Health Assemblage, the abstract machine of the Senegalese State Assemblage of drinking water quality needs quality to be an entity which has clear links to health and is translatable and repeatable across all situations. Their need to demonstrate measurable progress towards public health

²⁵ I identified and described important actors for drinking water quality at the national, international and local levels in Chapter 5.

²⁶ The existing water law is from 1981 and is under revision at the time of writing. The WHO revises their guidelines for drinking water quality more frequently and the current 4th edition of the guidelines is from 2011.

goals shapes the formation of the Senegalese State Assemblage of drinking water quality by requiring measurable quantitative indicators aligned with the norms of the international community. Drinking water quality emerges from this perspective as a technical, solvable problem. This process is also shaped by aspirations to meet specific goals, requiring particular actions. The Senegalese State Assemblage of drinking water quality is outlined in several documents including a national IWRM Plan, a national strategy for improvement of drinking water quality and legislation which specifies requirements for water to be considered potable (Chapter 5).

The focus on quantifiable and measurable indicators implicates experts in the process of knowing and determining appropriate responses to drinking water quality. This is a mutually reinforcing process because experts bring a particular way of seeing the world in terms of their expertise and what is visible using the tools they have²⁷. Because experts are trained to collect data and see the world in terms of quantitative, measurable objects and clear cause-effect relationships, they view drinking water quality primarily in this way.

In Senegalese government documents, drinking water quality is both framed as a problem for the state and individuals in different instances. For example, in the DGPRE's national strategy document on developing a policy for the improvement of drinking water quality (2016)²⁸, three axes are proposed for improving drinking water quality: 1) build infrastructure to improve water quality: identify and implement efficient technical solutions that can be supported by the population to improve physio-chemical and bacteriological quality of the water distributed and consumed; 2) put in place monitoring and protection systems for water quality and improve the state of knowledge related to the quality of resources; and 3) put in place an operational and effective governance of water quality (DGPRE, 2016, p. 1). These axes and their associated actions primarily implicate the state in solving drinking water quality problems. From this list we can work backwards to

²⁷ Scholars in STS have long argued that expertise shapes its object, see Collins and Evans (2002) or Pine and Liboiron (2015) for a summary of the politics of measurement.

²⁸ This document is the second deliverable in a process of developing a national strategy for the improvement of drinking water quality. The first phase consisted of a report on the status of drinking water quality in Senegal.

see what should be the three main problems which can be addressed by these solutions: 1) a lack of technical infrastructure to improve quality; 2) insufficient knowledge and data about quality; and 3) ineffective governance. I identified three categories of causes of inadequate drinking water quality: collection and distribution of water without appropriate treatment to remove naturally occurring salt, fluoride and iron; collection and distribution of water without appropriate treatment for man-made contamination due to agriculture, mining, inadequate sanitation or poor hygiene behaviour; and a lack of or inadequately adapted technical solutions for improving the quality of water (DGPPE, 2016, p. 10).

A later section within this same document presents socio-economic factors leading to consumption of poor quality water and approaches the problem from a different angle (DGPPE, 2016). The list of factors includes: high price and inability or unwillingness to pay for treated water; habits of depending on wells for water of inferior quality which are more exposed to degradation; and ignorance and bad practices in terms of hygiene and protection. Here the core issue appears not to be the quality of the water itself, but the consumption of that water by recalcitrant consumers. Thus the solutions proposed in this section pertain to information, education, capacity building and improved governance. This perspective is reflected in some solutions proposed in the updated PAGIRE (2018), which proposes creation of a water police to safeguard resources, education and accountability for users and expansion of systems of monitoring and protection (p. 55). These actions are largely oriented towards altering consumer behaviours.

The most recent national IWRM Plan (PAGIRE, 2018) has a different emphasis, as the plan is intended to be comprehensive and not solely focused on drinking water. The plan lists five strategic axes for future water management: water quality and services; knowledge and research action about water; vulnerability to climate change; valorising water for growing food security; and governance management and information systems. Thus one of the broad problems identified is inadequate water quality, on a level with a dearth of knowledge and information about water and uncertainty about the impacts of climate change, particularly for agriculture. In this plan, increasing knowledge about water quality at the national level is the first step towards improving water quality and distribution of

adequate quantities of water to the population. Actions outlined in the IWRM plan fall largely under the purview of the state, and the plan highlights greater need for collaboration among different national level offices and branches of government to make progress possible. Meanwhile public health oriented policies and plans tend to prioritise hygiene issues that individuals can take responsibility for such as handwashing, household chlorination and filtration, proper storage and avoiding open defecation (National Water Sanitation and Hygiene plan, under PAGIRE, 2018). Perspectives on drinking water quality as a naturally occurring, anthropogenic or hygienic problem have implications for who is held accountable or expected to respond.

Alongside the problem framings of drinking water quality in national level policy document and plans, the Senegalese government acknowledges that Kaolack has particular drinking water quality issues which require attention. These locally-specific problem framings can be aligned with particular types of solutions to drinking water quality challenges in Kaolack. For instance, the urban planning directorate development plan for Kaolack describes some potential solutions to drinking water quality problems (Cabinet d'Architecture et d'Urbanisme du Senegal, 2019). Plans for improving drinking water quality in the city emphasise large-scale infrastructure projects. Individual behaviours of consumers appear to a lesser extent. Some of the strategies under consideration are building large pipelines to transfer water from regions with better quality water into Kaolack; mixing water from the shallow and deep aquifers thus diluting both fluoride and salt; and constructing two large-scale desalination plants to treat groundwater^{29,30}. Thus for the most part the problems of drinking water quality in Kaolack are framed at the level of the city and can be uniformly addressed at the level of the city. At the time of writing this thesis funds have not been obtained to implement any of these proposed solutions³¹. So while the knowledge

²⁹ Interview DGPRES: FN-26-04-19

³⁰ Key informant interviews are presented using codes for the name of each participant and date of interview [Interview LOCATION: Name Code-DD-MM-YR]. For household interviews, well water seller interviews and filtered water seller interviews, the name code is replaced by a location code and interview number [Interview TYPE: Location Code-Interview Number-DD-MM-YR]. If the response is attributed to multiple participants on multiple dates the question number is used instead [Interview TYPE: Question number].

³¹ Field notes from Mayor's Office SS-13-05-19

exists and technology has been identified to improve drinking water quality, resources and political will are lacking³².

While the Senegalese State and Global Health Assemblages of drinking water quality set out aspirational goals for drinking water quality in line with their drive for progress, the core actors also pragmatically recognise constraints on the capacity of the state³³. The language of the WHO and Senegalese water law allow the state to avoid setting unachievable goals by tying the setting of drinking water quality standards to capabilities of a local government or provider to implement those standards. For example, the Senegalese water law says: 'The Code emphasizes health aspects, because it incorporates the standards defined by the World Health Organization, while adapting them *to our level of development* and to the nature of our hydraulic works' (Loi Portant le Code de L'eau; Loi n. 81-12, 1981; Emphasis added). The WHO allows for these kinds of provisions as well, as in the introduction to the Guidelines for Drinking Water Quality which specifies that every effort should be made for water to be "as safe as is practicable" (WHO, 2017a, p. 1). Because of these stipulations and the realities of implementation, the idealised versions of drinking water quality as it appears in policies, laws and plans do not always reflect what happens on the ground. In the next section I present two Everyday Governing Assemblages associated with tap water and non-network drinking water.

Everyday Governing Assemblages

Local level governance of drinking water quality in Kaolack is complicated by the fact that not all drinking water in Senegal is governed in the same way, or by the same actors. I therefore delineate to two distinct Everyday Governing Assemblages. The first is associated with the practices of an independent NGO laboratory and the second with the Hygiene Service. For tap water quality, SONES and SDE maintain a contractual relationship with an independent NGO laboratory which monitors water according to pre-determined priority indicators. The NGO laboratory reports to directly to SONES, and does not share testing

³² Interview Kaolack Urban Planning Directorate, DBU-30-07-19

³³ Field notes from Hygiene Service 19 and 29 August 2019; Interview ADC-05-09-19

results with SDE, therefore maintaining neutrality and independence from the provider. There are three of these laboratories in Senegal; each laboratory is responsible for monitoring urban tap water quality in a different region. One of these laboratories is based in Kaolack. The NGO laboratory is essentially a participant in the Senegalese State Assemblage of drinking water quality and so I will not elaborate in detail on their abstract machine. Rather than establishing their own parameters for measurement, the NGO laboratory simply monitors tap water for compliance with state-established indicators and thresholds³⁴.

The Hygiene Service is responsible for monitoring water sold for human consumption outside the tap water network. Local and regional branches share an office based in Kaolack. Both of these branches represent and report directly to the national Ministry of Health. The Hygiene Service's responsibilities are oriented towards enforcing rules about water (and food) safety. The mandate of the Hygiene Service includes all water sold for human consumption, so they test drinking water quality and issue hygiene certificates or fines for non-compliance³⁵. Staff of the Hygiene Service inform providers of non-network drinking water immediately if something unsanitary is found in water. They further issue fines or confiscate items accordingly. The tools available to the Hygiene Service and the NGO laboratory are different, as are their guiding principles.

The drivers I have identified as a part of the abstract machine of the Everyday Governing Assemblage for non-network water are governing and public health, both tempered by pragmatism³⁶. The staff of the Hygiene Service are charged with implementing the standards of the Senegalese State Assemblage to the best of their abilities, which is why pragmatism is an important factor determining their conditions of possibility. Equipment shortages and understaffing limit the scope of the Hygiene Service's activities³⁷. Bureaucratic overlaps were also identified as challenging by several interviewees, in the sense that redundancy dilutes funding and when everyone is partially responsible for

³⁴ Interview NGO laboratory: ADC-05-09-19

³⁵ Interview Hygiene Service: MSH-26-07-19

³⁶ Interviews with 4 staff members and 7 days of participant observation

³⁷ Interview Hygiene Service: CM/MSH-29-08-19

everything no one is fully responsible for anything³⁸. Despite these constraints, the staff of the Hygiene Service express a desire to protect the public from illness and serve their community, which is why I have named a second guiding principle of public health.

In Kaolack, the Hygiene Service is tasked with enforcing the standards set in the State Assemblage. The actors in the Hygiene Service associated with the Everyday Governing Assemblage view drinking water quality as a more immediate and practical problem than it appears in the written documents of the State Assemblage. While the State Assemblages make long-term plans for large-scale infrastructure investment over the long-term, the Hygiene Service staff do not have the luxury of waiting for new treatment plants to be built or pipelines to bring clean drinking water in from elsewhere. Therefore the solutions to drinking water quality problems for the Hygiene Service prioritise immediate action, for instance shutting down sources that do not meet standards and destroying compromised or expired bags of water.

The Everyday Governing Assemblages express drinking water quality as primarily a public health problem which stems from unclean behaviours at both the individual and community level. In addition, the staff of the Hygiene Service see drinking water quality, along with other threats to health, as solvable by aggressive action. The staff of the Hygiene Service can be intimidating; they dress like police and many of them are former members of the military. Their slogan is “fight dirtiness - defeat illness” (Figure 7). Water quality is a fighting matter! Things in water are the enemy.

³⁸ Interview Hygiene Service: CM/MSH-29-08-19



Figure 7. Hygiene Service slogan painted in a mural - "Fight dirtiness defeat illness". Pictures: well and bucket straining water through a cloth; man spraying insecticide to kill mosquitoes; spigot and pair of hands under running water with soap

One problem of drinking water quality for the Everyday Governing Assemblage is that people do not know how to lead hygienic lives. Citizens and providers need to be taught how to be sanitary and watched over to make sure they are not breaking rules that exist for their protection. Another assumed problem is that water vendors do not respect regulations for the water that they sell, or are unaware of the risks their practices pose. For instance, sellers of well water do not cover their wells or treat water before they sell it to consumers, or construct their wells too close to latrines or other sanitation infrastructure.

In response to drinking water quality problems the Hygiene Service tries to systematically move from neighbourhood to neighbourhood inspecting sources of water sold for human consumption. They also regularly visit points of sale including boutiques that sell bag water, filtered water kiosks and points of sale inside peoples' homes. They determine the quality of water based on field or laboratory testing and assessments of surroundings and hygiene practices. When agents find water that is potentially compromised in some way they may prevent future water sales from that source, issue fines to vendors or try to educate consumers on how to protect themselves.

Provision Assemblages

Another group of assemblages of drinking water quality in Kaolack that I identified from the empirical data are Provision Assemblages. While acknowledging the ways people access, buy and sell water in Kaolack are highly diverse, provision assemblages can be loosely divided into two groups: tap water and non-network water. In Chapter 5 I described several ways that drinking water is provided in Kaolack, including tap water, bottled water, bag water, well water, filtered water and rain water. I sometimes refer to the latter sources together as non-network sources, but there is significant variation between them. What I refer to as non-network water sources can still be somewhat linked to the tap water network, for example with filtered or bag water which use tap water to make their products. SDE, as the for-profit company tasked with delivering tap water in urban areas in Senegal in a public-private partnership (see Chapter 5), act on behalf of the Senegalese State Assemblage, but because they are focused on provision more than governance of drinking water quality I address them alongside the other capitalist actors as Provision Assemblages³⁹. In this section I show how tap water and non-network water Provision Assemblages assemble drinking water quality in different ways according to their distinct abstract machines.

For SDE as the urban tap water provider, drinking water quality problems largely arise through their relationships with the Senegalese state and consumers. SDE treats drinking water quality as a technical challenge that must be overcome. The staff of SDE are preoccupied with activities to maintain the residual chlorine content of water, absence of E. coli and so on. If SDE does not maintain adequate levels of certain substances (whether maximums or minimums) in water the state will see them as failing to meet the requirements of their contract. In addition, SDE has to deal with consumers' perceptions of drinking water quality because if consumers are not satisfied they will complain or refuse to pay for tap water⁴⁰. From the state perspective, which is more closely aligned with the

³⁹ SDE does their own monitoring and testing of the water they distribute and sell, reporting regularly to SONES.

⁴⁰ Interview SDE: YT-12-07-19

indicators SDE emphasises, drinking water quality problems are first and foremost focused on the presence of microbiological contamination tied to inadequate management of waste. In response to these concerns SDE has created extensive systems of monitoring and evaluating water in key locations throughout the network. They also regularly clean and flush the water towers and add chlorine to the system⁴¹.

Actors associated with Provision Assemblages in Kaolack view the quality of their product as a part of its monetary value, and the guiding principle driving their assemblage is maximizing profit. In these capitalist-oriented Provision Assemblages drinking water quality has become a commodity, something not everyone is entitled to unless they can pay for it. The primary objective of these actors is to sell a product, so the Provision Assemblages of drinking water quality have abstract machines oriented towards enticing people to purchase the water they provide. Because of government rules and regulations, they must also meet requirements which allow them to continue selling water. In the case of Kaolack the requirements for water providers are set out in the water laws of Senegal and the omnipresent WHO Drinking Water Quality guidelines, enforced by the Hygiene Service and the NGO laboratory.

For non-network sources, another way to consider the abstract machines of drinking water quality is that the ongoing existence of each type of water source represents a solution to a drinking water quality problem. Providers differentiate themselves and convince people to buy their products by identifying something lacking and meeting that need. So when one considers people providing and paying for a certain kind of water, what problem are they solving? For example, the owners of filtered water kiosks identify a problem in Kaolack, which is that affordable and healthy drinking water options are lacking^{42,43}. One kiosk business was founded by a person who visits Kaolack annually for a religious festival in the neighbourhood of Medina Mbaye. He noticed that the majority of guests and residents

⁴¹ Interview SDE: YT-12-07-19; Interview Rural Hydraulic Office TH-07-05-19

⁴² Filtered water seller interviews question 8: "Why does Kaolack need businesses like this?"

⁴³ The first time I reference a certain household or filtered water interview question I write the question in full and thereafter only refer to it by only by number. The interview guide with numbered questions is in Appendix 4.

relied on bag water which he considered to be of dubious quality and decided that starting a filtered water business near the mosque would be a way he could both make money and do something good for the community⁴⁴. Kiosk owners note that with even a small amount of money you can purchase enough water to supply a family's needs for a few days⁴⁵. They argue that well water, bag water and even tap water to some extent cannot be trusted because you are not able to witness their practices and the source of your water. Filtered water sold from these locally operated kiosks tries to solve these problems. Because the machines are right in front of the consumer, they can be certain that nothing is being added to the water and that quality has not declined from the point of treatment to where they receive it. Buying water from a place where one can see the treatment happen, form a relationship with a vendor one trusts and feel secure that the work is being done to a high standard provides more security than any of the other types of water available in Kaolack⁴⁶.

Another example is bag water, which is convenient, mobile, cold and affordable. Bag water sellers meet a need for consumers to have water outside their homes, or in small, trustworthy quantities. Many people in Kaolack are employed in the area around the market, surrounded by standing water and garbage. Individuals who work inside the market all day do not have access to running water nearby so they have to either bring in what they need or buy water while they are there⁴⁷. There is a similar situation when one is travelling, even across town. Temperatures can rise well over forty degrees Celsius, and waiting for a bus or taxi to fill can take hours. Bag water sellers are there, ready to give you exactly what you need in the form of 400 millilitres of ice cold water.

The abstract machines of Provision Assemblages make it possible for sellers to portray drinking water quality problems in ways that implicates their products as a solution. Because their abstract machines are driven by profit maximisation, the assemblages must be flexible and able to change based on the needs of individual consumers in any situation.

⁴⁴ Filtered water seller interview MD-11-13-11-19

⁴⁵ Filtered water seller interview question 8

⁴⁶ Filtered water seller interviews all questions

⁴⁷ Field notes from shopping in and around the Kaolack market

In the following section I describe the abstract machines of Consumer Assemblages of drinking water quality.

Consumer Assemblages

The final group of assemblages I identify are Consumer Assemblages of drinking water quality. Consumers need to obtain consistent supplies of clean and safe drinking water for themselves and their households by navigating a complex field of possibilities and limitations. There is no escaping the fact that everyone requires drinking water, so Consumer Assemblages are driven by needs that are practical and quotidian but also urgent. Consumers' drinking water quality assemblages are not written down; they are experiential and contextual. The question driving this process for most households and individuals is not a quantitative one: "what is the amount of x, y, z in this water, thus its quality", but rather a qualitative one: "does this particular instance of water meet the standards I have for determining it is safe and pleasant to drink?"⁴⁸ The problematisations inherent in the abstract machines of Consumer Assemblages of drinking water quality are expressed in consumers' decision-making processes and practices for providing drinking water to themselves and their families. The choices consumers make represent their ways of solving the problem of drinking water quality.

For example, household customisation and adaptation behaviours can be linked to particular understandings of drinking water quality problems. In Kaolack the primary ways consumers respond to drinking water quality are treating water themselves, switching sources based on concerns about drinking water quality and coping with water that is less than satisfactory but affordable and accessible. Seeking out alternatives to tap water for

⁴⁸ Household interviews questions 26-29: What do you think about tap/well/filtered/bag water in Kaolack?; question 31: How do you know if water is clean?

drinking water is quite common in Kaolack, although users with taps inside their homes continue to use tap water for most other household tasks and sometimes cooking⁴⁹.

Consumers I spoke to in household interviews and observed during home visits take action in several ways to customise or adapt to drinking water quality concerns⁵⁰. The majority of individuals who rely on well water treat it with chlorine or a product called Aquatabs to kill microbes and bacteria. Many also strain water through a cloth or decant it prior to filling their drinking water reservoir⁵¹, although some consumers expect that the delivery person will strain and decant water before bringing it to clients. People who drink tap water sometimes treat it with chlorine as well, and many household interview participants noted that the unpleasant taste of Kaolack water is less noticeable when water is cold so they either store containers in a refrigerator or add ice before drinking⁵². Consumers that rely on bottled or bag water mentioned that they trust the quality of these products and do not do any additional treatment. Decisions to respond to potential safety problems or the aesthetic characteristics of water in such ways indicate that microbiological contamination, turbidity and taste are among the top concerns of consumers in Kaolack.

Non-Senegalese residents of Kaolack make up a small portion of the population, but they have distinct ways of adapting to suspicions about tap water quality. Distinct responses imply a slightly different problematisation of drinking water quality. For instance, a small community of Lebanese business owners has been present in Kaolack for approximately three generations. They primarily drink bottled water, which is the most expensive option, but considered the best tasting and most healthy⁵³. A volunteer from a Korean development organisation who had been living in Kaolack and working at the hospital for about a year when we met said she had gotten sick from drinking bag water when she first arrived. She

⁴⁹ This varies, as some interview respondents complained about the way tap water feels in the shower or how it damages their nice clothes. When they can afford it these individuals will pay for well water for laundry, bathing and cooking (multiple household interviews).

⁵⁰ Household interviews question 24

⁵¹ Often a plastic or clay water jug with a lid that keeps water cool

⁵² Household interview responses question 42: "Can you tell me anything else about the quality of water in Kaolack?"; Field notes from multiple household visits

⁵³ Field notes CAL-19-11-19; ABB-15-11-19

continued to purchase bag water but began to boil it before drinking⁵⁴. American Peace Corps volunteers were provided ceramic filters to treat water for themselves, but they found that these did not improve the briny taste of tap water and many chose to purchase filtered water to drink in their office and bottled or bag water while they were out. I personally purchased filtered water regularly and kept it cold in a refrigerator. I then carried refilled bottles of filtered water with me whenever I went out, and often added lime juice or powdered drink mix to improve the flavour. Such choices indicate each individual or groups' problematisations of drinking water quality, and what aspects they consider to be most urgent. For instance, myself and the Lebanese residents of Kaolack were willing to pay a premium for water we considered safe and acceptable in terms of taste. Peace Corps volunteers were provided with a means of making tap water safe, but still chose to spend their limited stipends on drinking water with better flavour.

A limitation to considering actions as the main way to understand drinking water quality problematisations stems from the fact that consumers do not all have the same ability to customise their drinking water or pay for higher quality sources. Resources, financial and otherwise, are required to do these things and the available options can be limited. So in some cases it may appear that no action is being taken, but this does not mean that drinking water quality is considered unproblematic. Multiple household interview participants used the Wolof proverb 'in the absence of choices your choices are made for you' to describe how they perhaps would be doing more to ensure drinking water quality, but this is not always possible⁵⁵. The sentiment "this is the water Allah has provided to us and so we make do" was also quite common⁵⁶. For example, tap water is the least expensive option by volume once a connection is established inside a house. Households that are not connected to the tap water network have no choice but to pay a significantly higher price for tap water from public standpipes or rely on alternative sources like well water, bag water or filtered water. Households without taps in their homes are also constrained in their ability to act because they are not direct customers of SDE with customer identification numbers. These

⁵⁴ Field notes SMK-05-08-19

⁵⁵ 'Ñakk pexe, pexe la': This is a rough translation; *pexe* can also mean strategy. Household interview question 26.

⁵⁶ Household interview question 26

households therefore do not have a clear channel to make any kind of comment or complaint about the quality of the water they purchase from public standpipes or their neighbours (Grönwall, Mulenga, & McGranahan, 2010)⁵⁷. Often people with more financial resources who choose to exit the piped water network are the ones who might have had more political power to contest current conditions and demand better service (Kjellén, 2006).

Such a practice-oriented perspective on the abstract machines of Consumer Assemblages of drinking water quality is also problematic in that it foregrounds those actions that consumers are able to take themselves. Thus the burden of responsibility falls on households and individuals who may not have the capacity to obtain drinking water they consider to be of good quality. In this vein, household interview participants primarily identified someone within their household (often women) as responsible for determining whether drinking water quality is adequate and taking action if needed⁵⁸. A much smaller number of participants also noted that in an ideal situation the government or SDE should be responsible for maintaining quality of tap water but the company is not considered reliable or trustworthy⁵⁹. However, some household interview respondents also suggested city-level actions to improve the quality of tap water. Some residents of Kaolack are aware that the neighbouring city of Fatick has already constructed a drinking water treatment plant and would like to see similar action taken in Kaolack. Individuals who have spent time in Dakar or the northern regions identify water transfers from Lac de Guiers as an option to bring good quality surface water into Kaolack⁶⁰. Some participants also criticised SDE and SONES for digging deep bore wells in places where the water is salty and has fluoride, arguing that better quality hydrological or geological studies could have saved the

⁵⁷ Field notes, interviews with un-connected households

⁵⁸ Household interviews question 30: "Who is responsible for taking care of drinking water quality?" 73 interview respondents claimed individual responsibility for someone inside their household, 7 specifically said "women". Other answers were: SDE - 3, Government - 3, No one - 3.

⁵⁹ Household interviews question 30

⁶⁰ Some drinking water in Dakar and Thiès comes from Lac de Guiers via a large pipeline in addition to groundwater. However, the lake is already under pressure from this practice and extracting another city worth of water would probably not be advisable. In Dakar there are already several planned projects to supplement drinking water sources including a desalination plant on the Mamelles beach and a new treatment plant in Keur Momar Sarr (C. Faye, 2021).

population money and provided better water⁶¹. Despite these suggestions, most interview participants seem to suspect that politicians do not consider Kaolack's drinking water quality an urgent problem and would not be able to raise funds for drinking water quality improvement projects in Kaolack. They accept that they as individuals bear most of the burden of knowing and ensuring drinking water quality.

Finally, the selection or customisation of drinking water sources is not something consumers do once and then maintain consistently. Individuals may drink one kind of water at home and another at work, or they may shy away from certain sources in the rainy season when contamination is more likely. Tap water cuts off regularly in many neighbourhoods⁶², so even people who are comfortable drinking from the tap need to have back-up plans and alternatives. As the availability and materiality of drinking water sources change, so do abstract machines driving Consumer Assemblages of drinking water quality. This underscores the fact that Consumer Assemblages, and their abstract machines, are not static, but rather always shifting and transforming along with their context. The abstract machines of the assemblages described in this chapter are summarised in Table 8.

⁶¹ Household interview responses MB-25-16-09-19; Field notes MF-25-07-19

⁶² Field notes AM-05-05-19, AM-30-05-19; Household interviews question 13: "Is it common for there not to be water in your tap?" and question 14: "What alternatives do you have for when the tap water cuts off?"

Table 8. Summary of abstract machines of drinking water quality in terms of responsible parties, problems and solutions

Drinking Water Quality Assemblages	Who is responsible for drinking water quality?	What exactly is problematic about drinking water quality?	What can be done about these problems?
Senegalese State Assemblages	Scientists and experts	Technical solutions including infrastructure and treatment options are limited	Build infrastructure and treatment plants to improve physio-chemical and bacteriological quality
		Knowledge about drinking water quality is lacking	Produce more data and information about the composition of water
	Individuals and the general population	Poor and ineffective governance leading to contamination by mining, agriculture and inadequate hygiene and sanitation	Improve governance, create a water police to protect resources
Senegalese State Assemblages (Kaolack-specific problems)	Scientists and experts, planners	Natural limitations on drinking water quality in the groundwater of Kaolack	Build pipelines to bring better water in from elsewhere
			Mix water from the shallow and deep aquifer to dilute problematic salt and fluoride
			Construct two large desalination plants
			Dig new deep bore wells in parts of the city with slightly better water to dilute contaminants
Everyday Governing Assemblages	Scientists and experts Individual consumers Drinking water vendors	Public health problem caused by unclean individual or community behaviour	Fine offenders and educate consumers about hygiene and in-home water treatment
Tap water Provision Assemblage	The provider (SDE)	Poor quality can cause consumers to reject tap water or refuse to pay	Monitor water quality regularly
	Independent NGO monitors	The government may consider their contract broken if standards are not met	Chlorinate water and keep water towers clean
Non-network Provision Assemblages	Vendors and consumers	Shortage of affordable, high-quality options	Bag water
		Water needs to be safe and acceptable everywhere, not just inside homes	Filtered water
		Lack of trust of some sources	Well water
Consumer Assemblages	Someone inside the home (often women)	Certain kinds of water taste bad, smell bad or look unappealing, are inaccessible or unaffordable	Customising: treating water at home using chlorine, Aquatabs, straining through a cloth
		Some sources of water make you sick or cause fluorosis	Exiting: choosing alternative sources that meet quality standards
		Not all drinking water providers can be trusted	Coping: making peace with the water that is available

Discussion: possibilities for ethical drinking water quality governance

There are infinite potential ways for relations to form between elements in assemblages. Therefore, abstract machines matter in terms of what they make possible: how drinking water quality could be different (or not), along with the tendency of assemblages towards either stability or change. They begin to explain how, faced with the same essential problem, divergent responses can be available. In some sense, abstract machines close down the range of possibilities for assemblages by making one type of assemblage seem natural and concealing other ways for the world to be. But from the perspective of analysis, applying the concept of abstract machines re-opens the realm of possibility (Lancione, 2011). It encourages consideration of how each assemblage could always be different.

In the immanent ethical perspective associated with Deleuze and Guattari's work, the ideal is to maximise positive affects and open-ended possibilities. Ethical drinking water quality assemblages should therefore introduce creativity and flexibility into how drinking water quality problems are approached. When assessing assemblages in terms of their abstract machines, therefore, analysts should consider the potential for abstract machines to close down possibilities or, conversely, open doors to more positive affects.

Considering State Assemblages first, in what ways do their abstract machines enable or constrain positive affects? Drinking water quality assemblages have important functions for the state. They facilitate translation across contexts and awareness of progress. Data about water quality, and whether it is changing, can be an important tool to identify needs and advocate for change. However, the requirement that drinking water quality refers to the same collection of elements in multiple contexts also makes the assemblage rigid. Thus State Assemblages are less open to uncertainty and the possibility that people may disagree about what constitutes quality than they could be.

Furthermore, abstract machines and the actors and solutions they implicate are mutually reinforcing. For example, if drinking water quality is a technical, solvable problem primarily knowable by experts, experts will define quality in consistent ways that are compatible with

their world view. Such a view lends itself towards more rigid, quantitatively-oriented assemblages. On the other hand, if drinking water quality is something personal and situated, as it is for Consumer Assemblages, then drinking water quality problems and solutions are also more flexible and responsive. Because consumers lack the equipment or skills to participate in conversations about drinking water quality as a technical, scientific problem they are prevented from affecting the State Assemblage of drinking water quality. It can also become more difficult for them to benefit or learn from State Assemblages because the state is not speaking about quality in a way that is intelligible to consumers.

Consumer and State Assemblages coexist and are organised around the problem of drinking water quality, but they can still be in tension with each other. Actors associated with different assemblages of drinking water quality can struggle to communicate across their differences. Representatives of the state and consumers may believe they are talking about the same entity but find that the ways they conceptualise drinking water quality refer to something fundamentally different. These barriers to communication manifest as tension or even frustration. SDE staff are upset that consumers continue to reject water they have worked hard to provide⁶³. Consumers feel claims that water sold to them is good are misleading or disingenuous in the face of embodied experiences of negative health impacts and visible marks on the teeth of their families.

Differences between the guiding principles of assemblages can also imply distinct actions. For instance, Everyday Governing Assemblages and Provision Assemblages vary in where and when they monitor drinking water quality. The justification for their processes can be summed up in this quote from an interviewee at the Hygiene Service: 'We measure drinking water quality to protect the people, [SDE] measures because they want to sell a product'⁶⁴. These guiding principles suggest different understandings of the problem of drinking water quality as either a public health or profit maximisation challenge.

⁶³ Interview SDE: YT-12-07-19

⁶⁴ Interview Hygiene Service: LN-19-08-19

Similarly, problematics of drinking water quality can shift perceptions of what kind of problem it is possible for drinking water quality to be. They further relate to the perceived scale and timeline of drinking water quality problems. For the Senegalese State Assemblage drinking water quality is a long-term problem affecting public health as a whole. In the non-network Everyday Governing Assemblages drinking water quality is an immediate problem which can be solved through aggressive action on a small scale. For consumers quality is immediate and individual.

What these abstract machines have in common is as important as their differences. The question of what they have in common returns to a philosophical question Deleuze and Guattari have about assemblages (Deleuze & Guattari, 1987). They are interested in how much you can change something before it becomes something else (Adkins, 2015). One can add or remove some elements from an assemblage without fundamentally changing its essence or identity, but is drinking water still drinking water quality if it cannot be measured? What if it does not include taste? These answers may vary between assemblages, but the overarching abstract machine of drinking water quality remains oriented towards the suitability of water for human consumption.

In this chapter I have shown that the concept of abstract machines can help to destabilise assumptions that drinking water quality is a rigid, stable entity. At each stage, abstract machines of drinking water quality (viewed through their drivers, problematics and problematisations of quality) can shape what is included and excluded from assemblages and what the assemblages therefore do. If drinking water quality is portrayed as a transcendent idealised position, all water is judged in terms of its deviation from that ideal. Opening up the boundaries of drinking water quality to more situated and contextual understandings could therefore be considered more ethical in a Deleuzoguattarian frame.

Chapter 7. Findings II – Elements of drinking water quality assemblages in Kaolack

This chapter is about the heterogeneous elements that make up drinking water quality assemblages. Based on the specific surroundings and conditions in Kaolack, certain material and social elements are available. Therefore, in this chapter I explore what is included in, and excluded from, the assemblages of drinking water quality I identified in Kaolack. More specifically, I analyse which things in, around and about water are important (and which are not) in terms of deciding whether or not water can or should be consumed by humans.

Assemblages form through a process called double articulation, wherein the first articulation refers to content and the second to expression. The first part of the double articulation involves the selection of components, forces or relations that make up the phenomenon of drinking water quality. Elements in drinking water quality assemblages can include a range of things: the physical and material elements of water, substances in water, equipment, infrastructure and the surrounding environment, human senses, temperature, climate and so on, in contact with human bodies and social entities like knowledges, ideas, memories, values and norms. The elements in an assemblage are not a predetermined collection based on any inherent internal characteristics of the elements, nor are they a miscellaneous grouping of unrelated things. For Deleuze and Guattari, there is a degree of strategy and intentionality involved in the selection of elements (Buchanan, 2020; Hillier & Abrahams, 2013). The process of territorialising assemblages requires work, whether discursive, material or otherwise, in the form of practices that determine what is within or outside the territory of an assemblage (Bueger, 2018). The second articulation refers to what assemblages produce, or their expression. The expression of drinking water quality assemblages can range from data about quantities of things in water to contextual and embodied experiences of drinking water quality.

Introducing the elements within different assemblages will allow me to trace the territories of the assemblages of drinking water quality which were first introduced in Chapter 6. The

abstract machines presented in Chapter 6 shape the conditions of possibility for how assemblages form, what elements can be incorporated in the content of an assemblage and what kinds of relations form between elements. To reiterate, divisions between the territories of these assemblages are not decisive; the elements in assemblages are overlapping and interacting. Various assemblages act on and interact with each other.

In Chapter 3 I identified four general categories of material elements in drinking water quality assemblages: water, substances in water, sources and surroundings and ways of encountering drinking water (scientific and embodied). Now in this chapter I discuss how drinking water quality assemblages in Kaolack select from and sort available elements. I begin by introducing some of the specific material and physical elements of drinking water quality that are present in Kaolack. In the following section I address how material and social practices include, exclude or position in a hierarchy particular elements in patterns of relations. This patterning includes the ways information about drinking water quality is created and communicated. I discuss in this section how knowledges are produced within assemblages and subsequently become elements in assemblages, thus encompassing both content and expression. I continue by describing the ways social elements - including knowledges, perceptions, discourses and shared narratives about drinking water quality - participate in the formation and stabilisation of drinking water quality assemblages. The chapter closes with a discussion of the ethical aspects of the inclusion and exclusion of elements in drinking water quality assemblages.

The material environment of Kaolack

In this section I present some of the distinct materialities of the environment of Kaolack. The context of Kaolack is unique and always transforming, which contributes to the specificity of the drinking water quality assemblages that emerge there. Assemblage theory posits that context is not a passive substrate or background upon which social relations take place (C. McFarlane, 2011d). In addition, we should not approach assemblages with pre-existing assumptions about which elements will be the most influential (Müller, 2015). So rather than presenting the context of drinking water quality assemblages in Kaolack and

then assuming that context as passive or stable for the remaining chapters, I continue to return to context as something that must be described and considered as a part of what makes certain drinking water quality assemblages possible. In the later sections of this chapter I show how each type of assemblage selects different collections of elements from those present in Kaolack and positions them in variable hierarchies relative to each other. Also, as I will return to in Chapter 8, assemblages form in an environment, but they also shape it. This is a cyclical and interactive process of mutual co-production.

Substances in water

The environment of Kaolack contains distinct elements able to be included in drinking water systems including shallow and deep groundwater, river water and rain. Not all are always present or in the same state. Water from the Saloum River is always too salty for drinking, rain water harvesting is only an option during the short rainy season, well water more is likely to be contaminated in the rainy season and filtered water kiosks stop selling water when the electricity has been off too long^{65,66}. Also, groundwater in Kaolack contains compounds and substances that make the city and region particular in terms of drinking water quality (Chapter 5). Each of these things in the water of Kaolack have problematic potential health impacts of interest. For instance, the salt in groundwater and the Saloum River may be associated with hypertension and pre-eclampsia (Dieng et al., 2017; S. Faye et al., 2005). The area is also known for fluoride in the deep Maastrichtian aquifer which can cause painful bone and joint deformations or discolouration of the teeth (DGPRES, 2011). However, the tap water in urban Kaolack is not considered likely to have high levels of microbial contamination meaning there is limited risk of water-borne infectious diseases being transmitted by tap water consumption (UN Habitat, 2009). Substances vary in how detectable they are to certain individuals and groups. For the two most common substances in water in Kaolack, on the one hand, salt is very noticeable to someone drinking water because of its familiar and identifiable flavour. On the other hand, fluoride is not immediately detectable without scientific equipment. The widespread presence or absence

⁶⁵ Interview well water sellers: NA/DM-20-11-19; Interview DM-52-20-11-19; Interview TF-8-13-9-19

⁶⁶ Field notes NT-08-11-19; Interview FS-08-11-11-19; Interview FS-11-13-11-19

of these substances in water influences the overall drinking water quality assemblage of the city.

In particular, high levels of fluoride in the tap water of Kaolack complicate drinking water quality assemblages. While in some situations, fluoride is considered beneficial or even necessary to protect teeth from dental carries (although this is still being debated (Aoun, Darwiche, Al Hayek, & Doumit, 2018; Till & Green, 2020)), some studies suggest that overexposure may lead to severe and painful bone and joint deformation, decreases in IQ, acute toxicity and dental fluorosis (Aoun et al., 2018). Attempts to optimise the amount of fluoride people consume mean that it is added to water in some places and removed in others. Acceptable quantities of fluoride in drinking water vary; in 2004 the WHO decided 1.5 mg/L is an acceptable level (WHO, 2004). This threshold was updated to 1.0 mg/L in the 2011 version of the Guidelines for Drinking Water Quality, which further suggests that countries consider placing stricter requirements based on the expected water consumption of the population and exposure to fluoride from other sources (WHO, 2011, 2017a). In Senegal, the threshold for fluoride in water has been adapted to 0.8 mg/L because the climate is so hot (Lagaude et al., 1988). People in Senegal sweat more and drink more water than in cooler places, increasing the amount of fluoride they take in. Another factor is the extent to which the population relies on alternative sources of drinking water. If people primarily drink tap water, the quantity of fluoride in tap water should be lower, but if they consume a mix of sources higher quantities can be permitted (WHO, 2011). Furthermore, in Kaolack fluoride is more plentiful in the deep Maastrichtian aquifer that is the source of tap water than the shallow Continental Terminal aquifer that household wells draw from. Therefore, households that primarily rely on wells for drinking water note that their

children do not suffer from dental fluorosis to the same extent as those that consume tap water regularly⁶⁷.

Sources and surroundings

Along with the water and substances in water, other aspects of how drinking water is accessed can be elements in drinking water quality assemblages. In the Chapter 5 I described several ways people access drinking water in Kaolack. Although a large majority of households in Kaolack are connected to the piped water network, many people source drinking water from wells, reverse osmosis kiosks, bag water and rain water (seasonally). For any of the aforementioned environmental sources of water to become “drinking water” they must be collected and sometimes transported to or by consumers. During this journey the water acquires new relations and connections that affect its quality as a source of drinking water. For example, certain shallow groundwater which is reachable by household wells (not the deep Maastrichtian Aquifer, not surface water or rain water) is either pulled up by a rope and bucket or brought through a pipe by a small electric pump. Then the water may be stored in a jerry can, delivered by a donkey cart, carried on someone’s head or treated with chlorine or Aquatabs (a product sold at pharmacies for in-home water treatment). Labour and energy are exerted digging wells, pulling water out of the ground by hand or running pumps. The land a well is on may be privately owned in a home or farm or located in the grounds of a mosque, so the water is free to use for prayer ablutions or on sale for household use. Furthermore the groundwater from the shallow Continental Terminal aquifer is not likely to have high levels of fluoride or salt, but it may be at greater risk of contamination with bacteria or viruses from nearby sanitation infrastructure. All of these physical elements become a part of the identity of a particular instance of water, in this case well water.

This could always have happened differently. Instead of becoming well water, groundwater can undergo an alternate process to become tap water. In Kaolack this could also be another

⁶⁷ Household interviews question 39: Does anyone in your household have fluorosis? What causes it?; question 40: Is the prevalence of fluorosis changing in Kaolack? Does it get better or worse?

source of groundwater, from the deep Maastrichtien aquifer instead of the shallow Continental Terminal aquifer. The source then includes and is related to a different range of objects and practices. There are deep bore wells and water towers which pump water up from an average depth of three hundred meters and store it in water towers where it is treated with chlorine and regularly tested by SDE and the NGO laboratory. Now the source includes pumps, wells, electricity, labour and so on. Tap water from this system can either arrive in private taps in homes or in public standpipes in the street. These many elements constitute the materiality of drinking water quality of tap water.

In addition to the immediate surroundings of a source of drinking water, the characteristics and relations of the city itself shape the quality of sources and how they are perceived. For example, Fatick, another mid-size city about forty kilometres from Kaolack, has similar levels of naturally occurring salt and fluoride in their groundwater. A treatment plant for drinking water has been constructed in Fatick quite recently, and I was told that they received priority attention because Fatick's water quality problems are more severe than Kaolack's. This is because, even though the composition of the tap water is nearly the same, Fatick has fewer nearby areas to potentially bring water from, whereas in Kaolack shallow well water is mostly drinkable and there are nearby villages or areas where better quality water can be obtained^{68,69}. The severity of the water quality problem in Fatick is not defined exclusively by the amount of fluoride or salt in the water, but also relative to the lack of alternatives.

Encounters with drinking water quality

The physical characteristics of people in Kaolack can also play a role in their experience of drinking water quality. These characteristics change over time, as people move in and out of vulnerable periods in their lives. For instance, fluoride will not have effects on every person who encounters it. Children are more sensitive to either positive or negative effects

⁶⁸ Interview Kaolack Urban Planning Directorate: DBU-30-07-19; Field notes SS-13-05-19

⁶⁹ It was also strongly implied that the fact that a prominent political figure is from Fatick played a role in that city getting priority attention over Kaolack.

from fluoride than adults, especially between twenty-two and twenty-six months of age (WHO, 2004). Consumption of large amounts of salt is more problematic for the elderly (hypertension) and pregnant women (pre-eclampsia) than for the population at large. The population of Kaolack is very young; 43.6% of urban residents are 20 years old or younger (Cabinet d'Architecture et d'Urbanisme du Senegal, 2019). This could point to a lower degree of vulnerability to some water-borne infectious diseases.

Finally, the materiality of ways people encounter drinking water quality, either directly or via scientific equipment, play a role in the production of knowledge in drinking water quality assemblages. Later in this chapter I discuss the practices of assembling drinking water quality in Kaolack and I describe these knowledge production processes for drinking water quality in more detail.

Assembling drinking water quality in Kaolack (double articulation)

In the following sections I describe and discuss how drinking water quality is assembled in Kaolack. I divide this presentation into the four main types of assemblages I presented in Chapter 6: State Assemblages, Everyday Governing Assemblages, Provision Assemblages and Consumer Assemblages. For each of these types, I show how material and social practices of human actors select particular elements from the environment of Kaolack. These elements can be human or non-human, material or social. One area where I focus significant attention is knowledges, perceptions and impressions of drinking water quality associated with each assemblage.

I show that knowledges are produced by assemblages as the expression of temporary and shifting relations between elements. Knowledges also become elements within assemblages, and so knowledge could be categorised as both content in and expression of drinking water quality assemblages. Therefore, knowledges can fit into multiple places in this assemblage framework and will also be discussed in Chapter 8 as a tool of governance used by the state. Deleuze and Guattari suggest a distinction between state and non-state forms of knowledge production, but clarify that these are tendencies which exist in

mixtures rather than ideal types. In Kaolack as well, I show that knowledge is always a result of blended processes. As I move from the State Assemblages to Everyday Governing, Provision and Consumer Assemblages, the sources of knowledge about drinking water quality become more inclusive and territories of the assemblages become more flexible and open-ended. I expand this analysis further to show how drinking water quality knowledges and perceptions within and outside the state are formed by actors' distinct understandings of what kind of entity drinking water quality is, or can be. I argue that drinking water quality knowledges produced by the state apparatus at the international and national level are delimited in ways that create gaps between how the state and consumers understand drinking water quality. These gaps can create barriers for communication and understanding between the state and consumers.

State assemblages of drinking water quality in Kaolack

In this section I describe the practices of assemblage associated with the national and global State Assemblages of drinking water quality. I discuss how the Senegalese state, in line with the Global Health Assemblage, works to create, control and disseminate drinking water quality knowledge in line with the norms of a certain vision of expert-produced, state-sanctioned science. These practices lead to the inclusion, exclusion and positioning of certain elements of drinking water quality. I identified the form of drinking water quality for these State Assemblages in policies, plans, rules and regulations where drinking water quality takes the shape of requirements for standards and thresholds for certain contaminants in water and percentages of people with access to particular kinds of sources. I divide the practices of State Assemblages in Kaolack into those pertaining to quantification, judgement of sources and location of where drinking water quality can be known. I address each of these in turn, noting the state's practical efforts to define the boundaries of drinking water quality. I also point out that some potential elements of drinking water quality escape the confines of this assemblage, with particular implications for how consumers are able to access water or participate in drinking water quality assemblages.

Quantifying of quality

In the State Assemblage, drinking water quality should be seen and known by experts through data in the form of measurements and comparisons of quantities of material things in water to specific standards. The data produced by these measurements and comparisons are referred to more or less synonymously with properties of water. Results of measurements can take the form of numbers generated from a machine, colonies grown and counted on an augur plate or a colour spectrum that indicates approximately how much fluoride is in a sample. The water being tested is usually removed from its original source or point of consumption, abstracted from context so that tests can be performed on it elsewhere. The water itself is in the background while the main concern is what, other than water, is in a sample and how much.

Another type of element in State Assemblages of drinking water quality is potential impacts on human health. These impacts are assumed to be quantifiable, pre-determined and incorporated into standards and thresholds. However, health impacts have been abstracted to the point that they are no longer easily translatable to many people – for instance through reference to the concepts of disability adjusted life years⁷⁰, number of milligrams per litre or tolerable burden of disease. This intangible jargon does not conjure up images of upset stomachs, discoloured teeth or hypertension. Abstract interpretations of health impacts also obscure the differences between people, or the same people over time, and give the impression that the number of disability adjusted life years (or whichever relevant indicator) is the same for everyone. Such abstractions and technical language about water quality can limit participation of, and contestation by, non-experts (Karpouzoglou, 2012). Li (2007a) named such practices “rendering technical”, further emphasising the separation of environmental problems from their broader social and political contexts.

The Senegalese State Assemblage of drinking water quality is grounded in recommendations for priority compounds in water that are detailed in the WHO guidelines

⁷⁰ The WHO uses a threshold of 10^{-6} disability adjusted life years as an acceptable level of risk for each regulated compound.

for Drinking Water Quality (WHO, 2011, 2017a) and adapted to the Senegalese context⁷¹. These guidelines prioritise elements that have a direct, measurable impact on human health. An emphasis on quantitative, measurable aspects of drinking water quality facilitates translation between different settings, for instance between the international, national and local levels. However, this quantitative emphasis also prevents other aspects of drinking water quality, for instance things like taste or temperature which may be important to consumers, from being included in a meaningful way.

In the WHO guidelines, the state foregrounds scientific knowledge and devalues other ways of knowing or perceiving drinking water quality. Consider the following statement from a chapter on acceptability in the WHO guidelines for Drinking Water Quality:

‘To a large extent, consumers have no means of judging the safety of their drinking-water themselves, but their attitude towards their drinking-water supply and their drinking-water suppliers will be affected to a considerable extent by the aspects of water quality that they are able to perceive with their own senses’ (WHO, 2017, p. 219, emphasis added).

The claim that consumers have no means of judging the safety of drinking water effectively diminishes the value of their knowledge and positions scientific measurement practices as the best way of determining quality. The WHO distinguishes between safety, which is knowable only through scientific means, as a privileged component of quality that consumers do not have access to, and other aspects of drinking water quality that consumers may be able to perceive with their own senses. The aspects consumers do have access to are portrayed as inadequate or even harmful, because consumers’ responses to unpleasant qualities of water may lead to consumption of less safe sources (WHO, 2017a). Such claims that relegate qualitative consumer knowledges to a less meaningful status are common in policies, documents and plans in the Senegalese State and Global Health

⁷¹ The Senegalese state is not a single unified entity, and drinking water quality is not its only priority. Drinking water quality is also distinct in the bureaucratic system from things like environmental water quality and sustainability for the most part (Interview Kaolack Ministry of Environment Office: SK-10-08-19).

Assemblages of drinking water quality. These sentiments were also echoed in interviews with national level actors, including at the DGPRE⁷².

The WHO guidelines do suggest that consumer acceptability is a factor that should be considered in assessing drinking water sources. Yet reports on drinking water in the Senegalese context assert a damaging relationship between consumers' dissatisfaction with taste, smell or appearance of tap water and their decision to reject "good" sources in favour of others which are more palatable but potentially less safe (DGPRE, 2016; Diop, 2014; Senagrosol-Consult, 2009). Other instances minimizing consumer knowledge in favour of quantitative measurement are found throughout reports on drinking water quality in Kaolack and elsewhere. For example, a DGPRE (2011) study of fluoride in the Kaolack region compared peoples' stated perceptions about drinking water quality to measured quantities of fluoride and concluded 'The fact that four out of five people support that the water is good even though more than half the boreholes have a quality of water unfit for consumption due to the abnormally high concentration of fluoride bears witness to their *ignorance*, and above all to a *misunderstanding of the risks they run*' (p. 25, emphasis added). This again explicitly devalues the way consumers perceive drinking water quality, equating their qualitative knowledges with ignorance and misunderstandings. Of course, there are substances in water that cannot be detected by organoleptic or other means open to water consumers in an immediate sense. However, in the case of fluoride consumers may be aware of the long-term connections between their water and fluorosis, or between certain sources of water and potential health impacts. Categorically labelling all consumers as ignorant implies that they do not have any potentially valuable knowledge about water and prevents any knowledges they may have from being included in State Assemblages of drinking water quality.

⁷² Interview DGPRE: FN-26-04-19; Interview Rural Hydraulic Office TH-07-05-19; Interview Hygiene Service: MSH-26-07-19.

Judging sources of drinking water

In the Global Health and Senegalese State Assemblages of drinking water quality, another way of assessing progress towards drinking water quality goals is determination of whether each household is primarily served by a safely-managed improved source. This is proposed as a supplement to the quantitative measurement practices I described in the previous section. In cases where there are shortages of equipment, manpower or expertise for monitoring the quantities of substances in water, the type of primary source of drinking water in each household represents a secondary indicator that facilitates monitoring progress towards goals of connectivity and access.

Safely managed drinking water is defined as the use of an ‘improved drinking water source located on premises, available when needed, and free of faecal and priority chemical contamination.’ The 2017 list of sources the WHO considers improved includes: piped household connections, public taps or standpipes, boreholes or tube wells, protected dug wells, protected springs, rainwater, tanker trucks and bottled water (WHO, 2017b). In Senegal, the DGPRES similarly links certain types of source to assumptions about their quality (DGPRES, 2016). Unlike the WHO, the DGPRES categorizes water from wells, bags and surface water as unclean, something consumers may turn to if they are not satisfied with the quality of tap water (DGPRES, 2016). The Senegalese water law also includes standards for characteristics of individual wells to prevent possible contamination, such as distance from latrines, waste dumps, cemeteries and so on (C. Faye, 2017).

The WHO acknowledges limitations to the improved versus not-improved indicator. They note that although improved sources are more likely to be free of contamination than unimproved, contamination is still very common. Despite this, there is an imperative to monitor progress towards realising the SDGs. Safely-managed improved sources make a notable appearance in SDG 6.1 (‘By 2030, achieve universal and equitable access to safe and affordable drinking water for all’), which tracks the ‘Proportion of population using safely managed drinking water services’. The improved versus non-improved dichotomy situates

the type of source as a more important indicator of drinking water quality than the properties of the water provided by that source (Bain et al., 2012).

For example, the WHO 2017 Drinking Water Quality guidelines are the first revision which accepts water delivered to the home (tanker trucks and so on) and also containerized water (sold in bottles or bags) as improved sources. The materiality of these sources did not have to change for their status to change. Instead, this change reflects shifting perceptions of those sources at the international level. Critics of the practice of prioritising access to specific categories of safely managed sources point to a disconnect between the materiality of specific sources and their expert-assigned status. They argue that such practices incentivise continuous increases in the number of households with access to tap water because it is safely managed, without prioritising improvements in the quality of that water (Pezon, 2018). Rather than focusing on access to water of sufficient quality and quantity as a unified goal, access remains independent of actual assessments of drinking water quality. Such a division allows narratives of successful increases in access to coexist with ongoing deficiencies in water quality. This presents a planning challenge which is not easily overcome. Humans cannot live without water and so it is necessary to facilitate access, however if the water is causing potential harm, it is difficult to justify bringing hazards into homes (Senagrosol-Consult, 2009).

Locating drinking water quality

The Senegalese State Assemblage of drinking water quality also limits where drinking water quality can or should be known. For example, SDE's contract for tap water provision only mandates measuring and monitoring drinking water quality within the confines of the piped water network. Therefore, SDE and the NGO laboratory which monitors tap water quality follow and ensure drinking water quality until the water has crossed property lines into homes. Though they are aware of the potential for change after water leaves the tap, their obligation is limited to drinking water quality before that moment. But after water leaves the tap it often continues to move and drinking water quality can subsequently change. After waiting in a barrel or a jug for hours or even days some amount of water may

be carried to a new destination for consumption or use. Households also share stores of water with their neighbours and family members during cut-offs, meaning that tap water continues to flow between homes even when pipes are empty⁷³. In addition, some companies that make bag water use tap water to fill their bags (either treated again in some way or not), and the kiosks for filtered water also predominantly use tap water as their raw material. Staff of SDE expressed concerns in interviews about their potential liability if someone were to get sick after consuming filtered water or bag water, and tried to distance themselves from changes in tap water quality after delivery⁷⁴.

Locating drinking water quality outside the boundaries of homes has implications for what consumers actually experience. The state and provider have obscured certain possibilities by assembling drinking water quality in ways that hide change after delivery. Furthermore, limiting the locations where drinking water quality can be known has clear effects on how the state identifies and responds to drinking water challenges. If drinking water quality is limited to the piped water network, where it is maintainable and knowable, then it is logical to improving drinking water security by connecting the maximum number of households possible. The repercussions of limiting the locations of drinking water quality will be discussed further in the following section.

Escapes from State Assemblages

Many elements can escape the state's rigid, bounded understanding of drinking water quality. These escapes are made possible in some sense by the limits the State Assemblage places on who can know drinking water quality, how they can know it and where it can be known. Although drinking water quality in State Assemblages includes many elements which allude to the multifunctional nature of quality, these elements are arranged into a hierarchy where some of the elements are more able to affect the assemblage than others. First, both devaluing of consumer knowledge and rendering technical through abstract notions of drinking water quality circumscribe the ability of consumers to make claims

⁷³ Household interview questions 13, 14 and 23 – “Where else can you obtain drinking water?”

⁷⁴ Interview SDE: YT-12-07-19

about drinking water quality or contest unsatisfactory conditions. These practices also obscure the normative and values-based nature of “quality” as an idea and hide the negotiations and political decision-making inherent in any definition of water quality (See for example Bouleau & Pont, 2015, discussed in Chapter 2).

The practices of measurement and assessment of drinking water quality can also obscure complexity and ongoing change. The Senegalese state mainly assesses households based on whether or not they are connected to the tap water network, with a secondary concern for other improved sources. Assessing households based on whether they are connected or not treats households as if they are internally homogeneous and primarily access water through a single source⁷⁵. Household interviews and observations in Kaolack showed that this is far from the case. About one third of interview participants stated that their household relies on a mix of sources of drinking water, with no consistent primary source. The majority also said that individuals and groups within the household do not all drink the same water. Elderly people in particular were more likely to avoid tap water, for reasons of health or preference. In addition, most individuals are not constantly at home and only drinking water there. So just because a household is served by an improved source does not mean everyone who lives there always drinks water that is safe. This heterogeneity escapes the boundaries of the State Assemblage of drinking water quality in its current form in Senegal.

Additionally, a household being connected to the tap water network does not mean it is forever served and that their water will always be acceptable, affordable and free from contamination. Households and individuals frequently shift between states of more or less water availability from particular sources. If a household is late on their bi-monthly payments for tap water they can be disconnected from the network. The fee to have a household’s water turned back on can be prohibitively expensive, leading to extended

⁷⁵ Household interviews row 17: “What is your primary source of drinking water?” – more than half of respondents named multiple sources; Row 19: “Do all people in the house drink the same water?” – approximately half of respondents said yes, but almost all proceeded to describe differences between individuals within the house in answers to subsequent questions.

periods without water in the tap⁷⁶. Once disconnected, households that are not able to pay their bills and fees quickly enough may have their meter removed. This removal can precipitate a significant delay because there are not enough meters for every household that wants one in Kaolack and a household that has paid off their debts can still be placed at the end of a months-long waiting list⁷⁷. Furthermore, tap water pressure is inconsistent and sometimes homes go for days without water in their taps. In areas where this is common households compensate by storing water in barrels (often treated with chlorine) where there is potential for contamination before the water is consumed⁷⁸. The physical characteristics of water and the things in and around a source of water are not frozen in time when they are measured or when water is delivered. Drinking water quality is always changing. Water flows, evaporates or stagnates; things in water dissolve, grow and settle out. So even households that are ostensibly connected to the network and subsequently considered served by an improved primary source can in practice experience a very different situation.

In summary, the Senegalese State Assemblage works to assemble drinking water quality into certain forms. This approach can obscure differences within and between households, hiding the fact that even in homes with piped network connections, people are not equally impacted by water scarcity, affordability or exposure to unsafe water. It can also make change after tap water delivery invisible to the state apparatus. Such blind spots allow the state to continue to prioritise connectivity over quality in their efforts to improve water access. They further make groups with less financial or social capital within households more vulnerable to exposure to harmful things in drinking water. All of these blind spots and escapes obscure the nuance and complexity in how water actually arrives to people where they consume it, and the diversity of drinking water quality in space and time.

⁷⁶ Field notes: AK-26-07-19

⁷⁷ Field notes: MN-04-10-19

⁷⁸ Household interview: SM-15-14-09-19

Blended Everyday Governing Assemblages

Everyday Governing Assemblages relate to, but are distinct from, the formalised Senegalese State Assemblage. As described in Chapter 6, in Kaolack there are two types of Everyday Governing Assemblages of drinking water quality. First, SDE and an independently contracted NGO regularly monitor the quality of tap water. Second, the Hygiene Service is concerned with drinking water quality of non-network water sold for human consumption. I described in the previous section how the State Assemblages arrange drinking water quality into a quantifiable, expert assessed entity tied to specific locations, allowing some things to escape. In practice implementation of the requirements laid out in the State Assemblage can be more blended with sensory and embodied ways of knowing quality. Actors in Everyday Governing Assemblages also have a more expansive understanding of where quality can be, although they maintain limits around who is able to know about drinking water quality. Therefore, in this section I discuss how both groups of everyday governing actors incorporate their own practical, embodied and experiential knowledges into their assemblages of drinking water quality but continue to devalue consumer knowledges. I show how the Hygiene Service assembles drinking water quality in ways that are generally more inclusive of a variety of material elements and locations, while the NGO laboratory and SDE stay closer to the requirements of the State Assemblage. This openness contributes to the flexibility of the Hygiene Service, while the other actors associated with monitoring tap water are more rigid and closed.

The NGO laboratory monitoring tap water quality formally only includes the exact things that the government has asked them to look for in their contract in the content of their drinking water quality assemblage. But there is room for some nuance here. The staff of this laboratory, who have university training and a high level of scientific expertise, still include more elements than the purely scientific in their personal assemblages of drinking water. For example, one staff member in the lab told me they buy filtered water for personal consumption, even though the tap water passes all of the laboratory tests for compliance. They have done the tests themselves and know filtered water is the most clean option and has the least things in it that are not “pure water”. Still, at home they usually mix in a small

amount of tap water before drinking the filtered water because it makes the taste more pleasant⁷⁹. This goes to show that the same actors can simultaneously participate in multiple assemblages. At work the laboratory staff are participating in Everyday Governing Assemblages, and at home they are a part of Consumer Assemblages and apply different logics in their consumption behaviours.

In a similar blending of expert and embodied knowledges, a member of the laboratory staff of the Hygiene Service presented their equipment to me and described the expertise required for drinking water quality analyses. The Hygiene Service staff produce and record data based on tests conducted with scientific equipment, for example in monthly reports that are sent to the national Ministry of Health in Dakar. Later that day I witnessed the same individual biting the corner off a bag of water to taste the contents before performing any tests on it⁸⁰. The Hygiene Service also acknowledges reports of changes in taste and smell from consumers, and staff make their own determinations about whether drinking water quality has potentially been compromised. So for both the Hygiene Service and NGO laboratory, determining drinking water quality includes more elements than only the quantifiable amounts of substances in water. The staff's experiential and embodied understandings of drinking water quality also become elements in their drinking water quality assemblages.

Another reason Everyday Governing Assemblages stretch to encompass more than the State Assemblages is because of limited availability of equipment, expertise and personnel⁸¹. While there are clear guidelines for what should be measured and when in urban settings in Senegal, often what the Hygiene Service measures is somewhat ad hoc, based on tips or complaints about possible issues⁸². The staff make systematic plans, but these plans tend to adapt and shift to the realities of each day. Staff frequently combine a variety of practices and elements to determine the quality of a source of water in a given moment. The Hygiene Service has simple tests for fluoride levels in water (Figure 8), but

⁷⁹ Interview NGO laboratory: ADC-05-09-19

⁸⁰ Interview Hygiene Service: LN-19-08-19

⁸¹ Interview Hygiene Service: MSH-26-07-19

⁸² Interview Hygiene Service: LN-19-08-19; Interview Hygiene Service: IM-19-09-19

they lack the proper expertise and equipment to test for changes in other possible contaminants⁸³. Bacterial contamination is considered the most serious potential problem with drinking water and falls most concretely into the Hygiene Service's purview. However, during my time in Kaolack, the Hygiene Service did not have any reagent available to test for E. coli. They had not had any for months and did not know when more would become available (UNICEF provides most of their equipment)⁸⁴. In part because of these constraints, agents of the Hygiene Service become quite inclusive in their assemblage, mobilising a range of elements to ascertain water quality: from laboratory tests and hygiene certificates to expiration dates, cleanliness of an area, taste, smell and appearance.

Hygiene Service agents evaluate sources in combination with their surroundings and reports from consumers. They observe whether wells are covered or a safe distance from septic tanks and other sanitation infrastructure. They may also ask whether people treat water with a disinfectant before drinking. For bag water or bottled water they check expiration dates on containers and also look through clear plastic packaging to check for discolouration, sediment or other visual indicators of compromised quality meriting further investigation. If a pile of water bags has been sitting in the sun the hygiene agents are more suspicious of bacteria, or that chemicals from the plastic will have leached into the water and altered the taste. Anyone who sells water or food requires a certificate from the Hygiene Service. This certificate requires the primary seller to go to the hospital once every six months for confirmation that they do not have any communicable diseases. The Hygiene Service also visits points of sale to make sure they are clean and well maintained. In the case of filtered water the company provides samples of their product to the same independent laboratory that tests tap water for confirmation that they meet applicable norms and standards. In concert, these combined elements are supposed to ensure the quality of water being sold.

⁸³ Interview Hygiene Service: LN-19-08-19

⁸⁴ Interview Hygiene Service: LN-19-08-19



Figure 8. Water Quality sampling equipment at the Hygiene Service: Top left – a fluoride test on filtered water from my bottle, indicating between 0 and 0.5 mg/L of fluoride; Top right – a fluoride test on tap water indicating more than 3 mg/L of fluoride; Bottom – collection of assorted water quality testing equipment (Photos 19-08-19)

While the Hygiene Service is broadly inclusive of alternative sources and interested in meeting people where they are, staff members do not engage with sources they do not consider drinkable, or that they do not have responsibility for. For example, I was told by an employee of the Hygiene Service that there is no point in measuring the quality of urban wells because no one drinks from them anyway. When I told him that I had seen and heard

about many people drinking well water he said ‘well they shouldn’t!’⁸⁵ In addition, the tap water network is outside their mandate for monitoring.

Furthermore, despite openness to a variety of elements in their drinking water quality assemblage, neither the Hygiene Service nor the NGO laboratory staff consider consumer knowledges to be as important as expert assessments. Employees of the Hygiene Service still claim a level of expertise relative to consumers. When I mentioned to the laboratory manager that I had been told by consumers that wells are becoming saltier in town he said ‘it is necessary to test that to be sure’, and expressed similar scepticism about claims people had made about improvements in the level of fluoride grounded in their experiences over time⁸⁶. Because of their deference to quantitative measurements, staff of the Hygiene Service will only accept that water is saltier if they are able to measure and collect relevant data. Consumer knowledges are prevented from meaningfully taking part in the Everyday Governing Assemblage.

At the same time as consumer knowledges are blocked from becoming meaningful elements in the Everyday Governing Assemblages, the knowledges produced in these assemblages is also generally unavailable to consumers. For instance, details of the NGO laboratory’s results are not allowed to be made public until ten years from the end of their contract. The only comment the laboratory manager would make about tap water quality in an interview emphasized that SDE has a strict regime of monitoring and treatment in place⁸⁷. Also, reports on drinking water quality by NGOs and the government are frequently written in French, which many people are unable to read. One would require an internet connection and a computer to download the documents, if you knew where to look for them. So the actors involved in governing drinking water quality both exclude alternative forms of knowledges from the possible content of Everyday Governing Assemblages and prevent their own knowledge from being available to other (Consumer) assemblages.

⁸⁵ Interview Hygiene Service IM-19-08-19

⁸⁶ Interview Hygiene Service: LN-19-08-19

⁸⁷ Interview NGO laboratory: ADC-05-09-19

In the Everyday Governing Assemblage the most important aspects of drinking water quality can vary based on the type of source, the time of year and where assessments are being conducted⁸⁸. There can also be different criteria for different sources. For instance, the expiration dates on bag water are considered a clear threshold, after which bags of water should be destroyed⁸⁹. However, even if the expiration date is in the future, bags left in the sun may no longer be deemed safe to drink. Well water, filtered water and tap water have no expiration date per se, but similarly, if they have been left uncovered or sat outside too long they are suspect⁹⁰. So the determination of whether water is drinkable involves a highly contextual assessment for which there are a set of criteria which vary in their applicability and level of importance. Drinking water quality in the Everyday Governing Assemblage depends on the surroundings, available resources and priorities of the person who is doing the assessment. The State Assemblage (including the NGO laboratory), on the other hand, is more rigid and static. The same substances and sources have stable status relative to drinking water quality within these assemblages.

The Everyday Governing Assemblages may also be more able to recognize continuity and relative change in practice than the State Assemblages. For instance, the local Hygiene Service uses and submits forms to the Ministry of Health where they record the quality of wells they visit. These reports include statements like 'eight of the ten wells tested this month met standards for drinking water quality'⁹¹. They do not typically take multiple samples of the same well on different days or conditions, and therefore at an institutional level cannot show whether an individual well is getting better or worse. But in practice the Hygiene Service staff evaluate sources of water in conversation with consumers who use it and are very aware of potential for change from one moment to the next.

The elements selected by the Hygiene Service and the non-network Everyday Governing Assemblage reflect their primary objective: to protect people from illness as best they can

⁸⁸ Interview Hygiene Service MSH-27-07-19 and IM-19-08-19

⁸⁹ Field notes – observation at the Hygiene Service; Interview Hygiene Service MSH-27-07-19 and IM-19-08-19

⁹⁰ Interview Hygiene Service LN-19-08-19 and IM-19-08-19

⁹¹ Field notes – observation and participation at the Hygiene Service

(related to their abstract machines from Chapter 6). In contrast to the State Assemblage, which considers drinking water quality up to the moment of delivery, Hygiene Service actors concern themselves with drinking water quality at both points of consumption and sale, and interact with flows of drinking water in a variety of locations. They contrasted their inclusiveness with the practices of SDE primarily who measure drinking water quality in water towers where it is stored⁹². The form of drinking water quality for Everyday Governing Assemblages at the local level can be seen in the practices of the Hygiene Service staff's day-to-day implementation of state-determined indicators and standards, along with pragmatic concerns about possible or immediate results. The human actors associated with the Everyday Governing Assemblage are inclusive of a variety of elements up to a point, while still remaining oriented towards measurement and expert knowledges as the primary way of knowing drinking water quality. What emerges is a mixture of the strict and limiting structures of the State Assemblage and more fluid realities of water quality in Kaolack. Some of the complexity that escapes from the Senegalese State Assemblage is recaptured and incorporated into the territory of the Everyday Governing Assemblage. In the next section I turn to Provision Assemblages, which blend these elements of drinking water quality in ways that are even more flexible and individual.

Provision Assemblages

Another example of a blending of state and alternative ways of knowing and making claims about drinking water quality is in Provision Assemblages. I divide these Provision Assemblages into tap water and non-network providers of drinking water, although as described previously there is some overlap between these categories. The tap water Provision Assemblage primarily relies on expert assessments and sees drinking water quality in ways that are compatible with the State Assemblages. Non-network Provision Assemblages in Kaolack, on the other hand, blend state-centred versions of quality and elements that concern consumers. To sell water, Provision Assemblages must incorporate the elements that are important to consumers, while also meeting the requirements of the

⁹² Interview Hygiene Service: LN-19-08-19

QUALITE DE L'EAU

- Eau certifiée selon normes OMS
- Traitement de tout type d'eau indépendamment des variations de qualité



Figure 9. Screenshot from Swiss Fresh Water website, "Certified according to the norms of the WHO; treatment of any type of water independent of variations in quality": <https://www.swissfreshwater.com/la-machine/> accessed 09-06-20

provider assemblages also vary based on what kind of water source is being sold.

Provision Assemblages in Kaolack are driven by a desire to maximise profits (Chapter 6). Therefore, those who sell water in Kaolack move between and relate to a blend of elements to optimise their ability to sell water. Actors who sell water in Kaolack need to both meet requirements imposed on them by the government and convince consumers that their products are worth spending money on. They try to appeal to consumers, sometimes by mobilising tools from the State Assemblages to convince people to buy their product. For instance, selective referencing of the WHO Guidelines for Drinking Water Quality can establish legitimacy and lend weight to arguments about the quality of a particular type of water. Both providers of tap water (SDE) and filtered water reference the WHO guidelines in their advertising materials. They mobilise the WHO guidelines as a component of their assemblage of drinking water quality because the guidelines can be persuasive. On the website of Swiss Fresh Water (Figure 9) and the walls of their locally franchised Diam'O kiosks (Figure 10) they proclaim that the water they provide is certified according to the norms of the WHO.

Senegalese state. In some cases, individual experience, feeling, taste and so on are the most important elements. In others knowledge of quality is second- or third-hand, based on trust, shared stories and elements like confirmation of meeting the WHO indicators or having a certificate from the Hygiene Service. The elements in

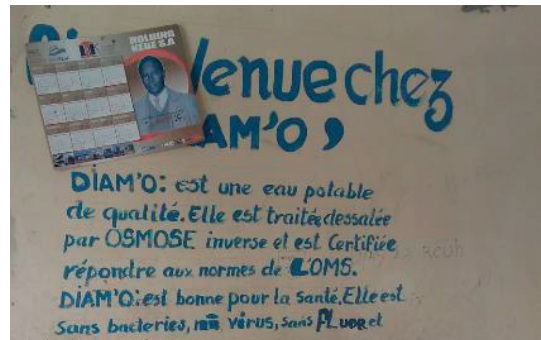


Figure 10. Photo Diam'O kiosk (11-11-19) "Diam'O: Is potable high quality water. It is treated and desalinated by reverse osmosis and is certified according to the norms of the WHO. Diam'O is good for health. It is without bacteria, viruses or fluoride and is low in salt. Your satisfaction is our reason to exist."

In a similar move, a representative of SDE asserted to me in an interview that the water they distribute and sell meets all important WHO guidelines, specifically in terms of microbiological quality and thus potability⁹³. If one considers the physio-chemical components of water this statement about tap water does not hold, but this SDE representative differentiated between microbiological quality as a key component of potability and physio-chemical status of water as separate from potability and thus outside their zone of responsibility. The WHO Guidelines for Drinking Water Quality state that water should 'not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages' (WHO, 2017a, p. 1). Both microbiological and physiochemical factors have the potential to directly cause health impacts, although the timeframe for impacts from physiochemical things in water may be relatively long-term compared to from microbiological contamination. This is why I refer to their referencing of the WHO guidelines as selective: because SDE in particular chooses to highlight their compliance in some areas, while declining to engage with others. Their staff delineate between water quality and potability based on a strategic practice of territorialisation rather than a clear delineation of those terms by the WHO.

In the same interview with the SDE representative they made it clear that the company aspires to improve the taste of their tap water to make their customers more comfortable, but also expressed frustration about the fact that consumers do not understand that the water is good enough already⁹⁴. Minimising the importance of consumer knowledges and preferences is another strategic side-step that allows SDE to make claims about the high quality of their drinking water in the face of consumer displeasure and evidence to the contrary. The WHO guidelines include acceptability by the majority of consumers as a criteria (2017, Ch. 10, p. 219-30), but this acknowledgement of acceptability runs parallel to the side-lining of consumer knowledge in other sections.

Another element in the tap water Provision Assemblage is labour and systematic monitoring as a proxy for drinking water quality. In an interview with an SDE staff member

⁹³ Interview SDE: YT-12-07-19

⁹⁴ Interview SDE: YT-12-07-19

I was told: ‘We do an enormous amount of sampling, hundreds of samples each month... the city of Kaolack, I believe it is the most sampled in all the country’⁹⁵. The implication was that my concerns about the quality of tap water should somehow be assuaged – how can the water be bad if it is constantly monitored? He also used SDE’s prolific monitoring as a way to contrast tap water with bag water or well water because ‘no one is checking to see if it is of good quality’⁹⁶. Furthermore, while SDE claims to meet all relevant standards and

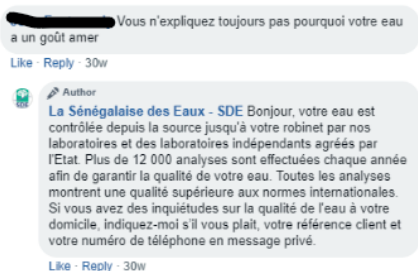


Figure 11. Screenshot of Facebook comments from 15-01-20

highlights their regular monitoring practices, neither SDE nor the NGO laboratory which conducts independent monitoring of their water quality share the details of their results with consumers. Though SDE likely possesses significant quantities of data about the quality of tap water in Kaolack, they do not make results

publicly available. So SDE uses their copious monitoring practices as a way to limit contestation without meaningful accountability⁹⁷. By foregrounding monitoring they are asserting a parallel between how frequently the water quality is monitored and quality. They are also making an implicit claim that their data and methods are valid and trustworthy (even though they are not public), and thus more convincing than a complaint from a customer about the taste of the water (Figure 11)⁹⁸.

I also noted patterns in how vendors of particular types of drinking water portray their products and try to position them relative to each other. One way vendors compete with each other is associating their products with ideas about health, lifestyles, modernity and

⁹⁵ Interview SDE: YT-12-07-19

⁹⁶ Interview SDE: YT-12-07-19

⁹⁷ Even though I am being quite critical here, I want to acknowledge that SDE does put a lot of effort into improving quality and providing a safe product to consumers. They regularly treat water with chlorine, wash out water towers and flush pipes, and they maintain a “ligne vert” where customers can call with concerns about leaks or other complaints.

⁹⁸ User: “You never explain why your water has a bitter taste”, SDE: “Hello, your water is controlled from the source to your tap by our laboratories and independent laboratories as agreed by the state. More than 12,000 analyses are carried out each year in order to guarantee the quality of your water. All of the analyses show a quality superior to international norms. If you have concerns about the quality of water in your home, please share with me your client reference number and telephone number in a private message.”

sustainability. For example, sellers of filtered water (Diam'O, Claire-Eau, Swiss Fresh Water, Pur-O) are fairly inclusive with regards to what elements of quality they mobilize in their assemblages. They assert that their business model promotes local ownership and employment, and draw on discourses of sustainability, hygiene and modernity. Not only does the water they sell meet WHO standards, but it is also filtered with cutting edge technology from Switzerland. Similarly, the two main bottled water companies (Casamançaise and Group Kirene) highlight convenience and healthy, happy lifestyles (Figure 12). The slogan of Kirene is 'Boire Kirene c'est engager à vivre mieux' (Drinking Kirene is to engage in living better). Clear plastic bags of water are often stamped with blue writing indicating that the water has been filtered in optimal hygiene conditions, or is the 'safest to trink (sic)' (Figure 13). Well water sellers assert that their water is the most natural option and point out that, contrary to tap water, it does not cause fluorosis. They also repeat that well water is the most historically and culturally familiar with claims about how their ancestors drank well water with no problems and so we can all trust that it is good for our health⁹⁹.



Figure 12. Bottled water companies mobilise a variety of elements to assert the desirability of their products (Quality, Professionalism, Proximity, Rigor, Beauty and Competitive Prices) Casamançaise website (accessed 09-06-20) <https://www.casamançaise.com/>

⁹⁹ Interviews well sellers: 1, 3, 4-20-11-19



Figure 13. Bag water making claims about hygiene and safety, 1) Back of a Karang bag of water (27-06-19) – ‘une eau filtrée et traitée dans les conditions d’hygiène optimales’ (Water filtered and treated in the optimal conditions for hygiene); 2) Front of a Senegambia Eau bag of water (27-06-19) – ‘Safest water to trink (sic) – Serve Cold’

In particular, managers of filtered water kiosks in Kaolack rely on a blend of ways of knowing drinking water quality. The reverse osmosis machines from Swiss Fresh Water have sensors inside which shut the machines down if they detect a problem and put up a code that can inform technicians about exactly what needs to be fixed. At the same time, many of the managers said their own tasting of water, visual checks of the filters and daily maintenance of machines makes them confident that they would notice right away if anything were to go wrong with the system¹⁰⁰. In addition, several of the kiosk managers told me that even though the machines are the same, the maintenance is not the same. They take pride in being conscientious about regularly flushing the machines and do not necessarily trust the staff of other kiosks to be equally as mindful of cleaning their equipment¹⁰¹. Several managers also emphasised that a benefit of filtered water is consistency, while the quality of tap water, well water and bag water is unpredictable. To prove the quality of their filtered water to potential clients several of the managers I spoke to said they keep a cup nearby and offer tastes of their water to sceptics¹⁰². They find that

¹⁰⁰ Filtration seller interviews, especially questions 13: “How do you know if the machine is functioning properly and the water is clean?” and 25: “Who else sells water in this neighbourhood and what is that like?”; Field notes: GF/GNT conversations, 5 visits for observation and participation at Diam’O 1-NT

¹⁰¹ Filtration seller interviews, especially questions 14, 25, 29.

¹⁰² Filtration seller interviews question 23: “What do you say to people who don’t trust your water?”

the personal experience of the pleasant taste of filtered water convinces many people of its quality.

For non-network Provision Assemblages transcendent ideals of what drinking water quality should be are less evident than in the Senegalese State Assemblage and the tap water Provision Assemblage. The elements included in assemblages continuously shift in relative importance. Drinking water quality can be what it needs to be for water to be acceptable and even desirable to consumers. Providers recognise that drinking water quality is a moving target and will not be the same for every potential customer, and so they experiment and adapt. For example, bag water costs more when the bags are cold. People will pay double the regular price for frozen water on a hot day¹⁰³. Temperature is not traditionally considered an element of drinking water quality in the State Assemblage of drinking water quality, but for consumers it can be central. Therefore, because ensuring water is cold is an important way for them to maximise their profit selling water, providers take temperature into account. Thus drinking water quality in non-network Provision Assemblages takes shape in an ongoing and immanent process.

In this section I have shown that providers of drinking water in Kaolack include an array of elements in their drinking water quality assemblages which are a blend of material and immaterial. For instance, the amount of labour and effort that is expended for monitoring and maintenance is often highlighted as an indicator of quality for both network and non-network sources. Ideals about modernity, naturalness and convenience are used to advertise products to customers. Different customers have different priorities, and the ways providers speak about their products reflect this. Unlike in the State Assemblages, taste and measurement seem to coexist in non-network Provision Assemblages, but their position relative to each other varies. Filtered water sellers, for example, use a combination of taste and indicators from their machines to ensure quality is consistent. On the other hand, the tap water provider minimises the importance of taste in relation to measurements of quality. Well water sellers rarely cite measurement as an element of

¹⁰³ Field notes – Dinner and regular time spent with AT (especially 09-09-19); Household interviews row 26; I certainly would pay an extra 25 xof for cold water when it is over 40 degrees Celsius outside.

quality, but rely heavily on taste as a way of ensuring their water is good to drink. Now, for the final of these four types of assemblages, I consider the elements of Consumer Assemblages of drinking water quality and how they relate to those which have come before.

Consumer drinking water quality assemblages

Of the assemblages of drinking water quality in Kaolack, Consumer Assemblages exhibit the strongest tendency towards flexibility and include the broadest range of elements. They take the form of what Deleuze and Guattari might refer to as a rhizome, in the sense that new connections are constantly being formed and re-formed between all possible elements (Deleuze & Guattari, 1987). For consumers a source of water does not arrive at a final state of good or bad quality, because there is always potential for more change. Consumers interact with drinking water quality in the place where they are drinking water, in ways that may escape the State Assemblages of drinking water quality.

Material elements in consumer assemblages

Consumers mobilise a broad range of material and social elements in their assemblages of drinking water quality¹⁰⁴. In household interviews consumers named a range of elements as factors in their decision making processes around drinking water. Some of these have to do directly with the materiality of the water they are presented with and others have to do with the surroundings and concerns about water's availability and accessibility. Elements include appearance, smell, taste and temperature of the water. Many people also specify particular things which are sometimes present in water which give sensory information about its suitability for drinking including bleach, sand or clay, microbes, iron from old pipes, bubbles, oil, honey, sugar, salt, sediment or soap. Concern for consistency and a keen

¹⁰⁴ The questions from the household interviews I associate most with content of assemblages of drinking water quality are question 31: "How do you know about or determine drinking water quality?" and questions 26-29: "What do you think about _ source of water?" (repeated for well water, bag water, tap water and filtered water). The answers and the types of things participants included are considered the content of the assemblage. I also tried to think about exclusions and anything the participants did not mention that came up in interviews with other groups.

awareness of subtle changes in the characteristics of drinking water sources are also common¹⁰⁵. Frequent cut-offs and variable taste, smell and appearance are a common complaint about tap water in Kaolack. Sometimes tap water in Kaolack tastes especially good or bad. Other times consumers notice that water has a funny smell or is oily, hard or soft, heavy or light¹⁰⁶. Sometimes the tap shuts off for hours at a time, and when it returns water is brown or red indicating dirt, clay or rust in the pipes¹⁰⁷. Other times the tap water tastes strongly of chlorine or is white with bubbles, indicating that SDE has been cleaning the water towers, often without informing users in advance¹⁰⁸.

Characteristics of a source can also send signals about drinking water quality to consumers. Customers take note of the cleanliness of the area around a potential source of drinking water, for example, whether wells have covers or filtration kiosks are kept tidy. People commented on the fact that sometimes the containers well water is delivered in can have mildew on the outside or appear dusty, indicating that the quality of water inside might be compromised¹⁰⁹. In addition, accessibility of a source is an element of quality, comprising the time, labour and financial resources required to obtain water¹¹⁰. Contextual elements including what temperature it is outside and time of year can influence drinking water quality assemblages¹¹¹. Unlike in the State Assemblages, there is minimal distance or abstraction of drinking water quality from the materiality of water, substances in water and

¹⁰⁵ Household interviews question 31

¹⁰⁶ I also documented a variety of non-drinking related complaints about tap water in Kaolack. For example: tap water feels oily and strange on your skin in the shower; using tap water to shower either makes your skin more black or more light depending on who you ask; tap water ruins your clothes when used for laundry; if you have a garden you have to buy well water because plants do not thrive in that much salt; and Kaolack tap water is bad for building because it corrodes the iron inside bricks so buildings in Kaolack do not last as long as elsewhere.

¹⁰⁷ Water cutting off regularly also has non-drinking consequences because it becomes difficult to keep your house and family clean and you have to seek out alternative sources that can be more expensive or inconvenient. (Household interviews question 16)

¹⁰⁸ Household interviews questions 26-29

¹⁰⁹ Household interviews questions 26-29

¹¹⁰ Household interviews questions 12: "Has your water ever cut off?"; 13: "Is it common for there not to be water in your tap?"; 14: "What alternative sources can you use?"; 15: "How long was your primary source of water unavailable?"; and 16: "What kind of problems and tiredness does lack of water cause?"

¹¹¹ Household interviews questions 26-29

sources. Quality is primarily expressed in terms of the embodied affects on individual bodies, not generalisations or numbers in the form of data.

Embodied perceptions like taste or smell are not the same for everyone, or even the same people at different times and under different conditions. For example, familiarity with sources of water plays a role in how comfortable people feel, and the unpleasant taste of tap water in Kaolack is something people adjust to over time. Several interview participants mentioned that people who grow up in Kaolack are able to drink tap water, while people who move into the area or live elsewhere for some years and return cannot¹¹². Elements like chlorine can also play multiple roles in Consumer Assemblages of drinking water quality. In some situations the presence of chlorine signals that water is safe to drink because it has been treated. When present in excess, chlorine is a reason to reject water because it may cause heartburn or an upset stomach, especially for children¹¹³. The taste of filtered water can also be mobilised as either a positive or negative factor. Several interview participants said filtered water tasted too good, like sugar, which they perceive as meaning some kind of product must have been added to the water which could cause diabetes or other health problems^{114,115}.

The individuality of these embodied impressions, perceptions and ideas about drinking water quality can make them difficult to capture verbally. To compensate in interviews, several people relied on non-linguistic indicators of drinking water quality to demonstrate qualities of a particular source. People pointed to containers of water, or brought out bottles and bags to show me sediment, clarity or colour¹¹⁶. Some asked me if I had tasted the water

¹¹² Household interviews questions 26-29

¹¹³ Household interviews questions 26-29; 36: "Has the water you drink ever done something to your body or the bodies of your family?"; 37: "Do you think water has ever made you sick?"; and 38: "What kind of sickness? How did you know it was from water? Which water?"

¹¹⁴ Household interviews question 28

¹¹⁵ The filtration businesses denied adding anything to water and two of them specifically noted that if they had to buy enough sugar to make the volume of water they sell sweet they would have gone bankrupt long ago.

¹¹⁶ Household interviews questions 26-29

for myself or offered me cups of water to experience their comments about drinking water quality first-hand¹¹⁷.

Personal experiences of a relationship between water quality and health can also be an important element. Many people I spoke to associated specific sources of water with experiences of illness or discomfort, for example claiming that filtered water or bag water gives them a cough or cold, or that water from a certain well had given them stomach problems¹¹⁸. Another common statement is that mixing waters, including during travel or using a variety of sources, is a cause of colds, so one aspect of water quality is your body's familiarity with it¹¹⁹. Not all consumers are confident that there is a relationship between their drinking water and health. In response to my question about whether water had ever made someone in their household sick, several interview respondents stated that sometimes people get sick, and this may or may not be related to water¹²⁰.

There was, however, widespread acknowledgement of a link between dental fluorosis and tap water, which could simply mean that fluorosis is seen as a cosmetic rather than a health issue. The element of fluoride was brought up by several interview participants in response to the question 'what do you think about tap water in Kaolack?'¹²¹. In response, people used visual aids like pointing to their own teeth or my research assistant's and saying things like: 'you grew up here and look at your teeth – do you have to ask if the water is good?' or 'Look at my teeth!' The teeth of the youngest generation of children, which do not yet show signs of dental fluorosis, were also referenced very frequently as a sign that the quality of tap water is improving¹²². Because many children do not have the discolouration, the claim is that tap water must be getting better. Several interview participants summoned groups of

¹¹⁷ Field notes MD/GA 25-07-19, Filtration seller interviews, Well seller interviews

¹¹⁸ Field notes CG 02-07-19; GMFB 11-07-19; NDM 27-08-19; BMK 30-10-19; Household interviews Rows 26-29; 36-38

¹¹⁹ Field notes MG/IT 08-07-19; ZS/MF 12-08-19; CD 27-08-19; BMK 30-10-19; 08-11-19 GNT; Household interviews questions 26-29; 36-38

¹²⁰ Field notes MD 06-07-19; MF/SF 10-07-19; Household interviews questions 26-29; 36-38

¹²¹ Household interviews question 26

¹²² SONES/SDE did add a new water tower recently which uses water from a part of the aquifer with less fluoride, so the amount of fluoride could be lower now than in the past, but also fluorosis does not manifest until children have had their second teeth for some time (WHO, 2004) so showing that all the youngest children do not have visible signs of fluorosis can be misleading.

children to show us their teeth as proof of their claims, saying that *beñu kadaam* [the condition of black or red teeth] used to be an identity card that showed you were from Kaolack, but this may be changing.

Social elements in consumer assemblages

Up to this point, the elements of Consumer Assemblages of drinking water quality I have presented are still somewhat amenable to the state's preference for measurable and quantifiable indicators. We can of course measure and set standards for number of hours of water service per day or week, distance from source to point of use and so on. Alongside these material or physical elements, elements having to do with relationships, labour and ideas play an equally important role. These immaterial and personal elements may elude measurement and quantification. For example, positive or negative experiences and relationships with a particular provider of water can inspire trust or distrust in the seller or their product¹²³. Experience has, in many cases, taught consumers who to trust, not necessarily aligned with the improved sources the WHO or Senegalese government have identified.

Also, some interview participants who consume filtered water regularly said that their relationship with their local provider and belief that the individuals are professional and conscientious is an important reason they believe in the quality of filtered water and feel it is safe to drink¹²⁴. Staff of many kiosks encourage this. Especially with Diam'O franchises, I observed that sellers were happy to explain the way the machines work and invite current or potential customers to examine their equipment. As the reverse osmosis technology is new (approximately six years since the first kiosk was established in Kaolack), explaining the process is a way of both building trust and convincing new customers there is value in paying for filtered water. Still, some consumers expressed deep scepticism about kiosks' ability to make water clean and healthy. Several participants commented that the process

¹²³ Field notes A 21-07-19; Household interviews questions 26-29

¹²⁴ Field notes A 21-07-19; Household interviews questions 26-29

is “dark” (*lendem*), indicating that they do not understand how it works and they feel it is not possible to be certain that the water produced is safe.

Similar claims were made about well water, bag water and anything that is delivered from an unfamiliar place. Participants reported concern about the fact that ‘you do not know what they are doing’ and ‘they do not want you to see the source or the process’¹²⁵. Several people, including my research assistant, shared their suspicions that bag water manufacturers pick up old used plastic bags off the ground, refill them and seal them shut again with a candle so they look new¹²⁶. On the other hand, customers who choose to have well water delivered to their homes expressed trust in the individual who delivers to them. Those consumers who have a long-standing relationship with the delivery person believe that person is doing what is necessary to keep the water clean. So for consumers one element of drinking water quality is their trust in the person or company selling it.

On the contrary, in the case of SDE and tap water many consumers described a lack of trust which includes suspicion about whether the company has more information than they are letting on and displeasure with their customer-client relationship. Some but not all of these complaints are directly related to the properties of the water. Doubts about whether SDE staff take the time to read meters accurately contribute to a general sense that they are not conducting their work in a way that is professional or fair. Furthermore, the chronic unwillingness of SDE to acknowledge or respond to peoples’ complaints about tap water quality arouses suspicion (Diop, 2014). I personally experienced a strong feeling of dissonance between being told that water quality is fine and the (in my opinion unpleasant) experience of drinking tap water in Kaolack.

Consumers are aware that the tap water is being sampled and monitored by SDE, but they do not trust SDE to share accurate information or act promptly when there is a problem¹²⁷. This lack of transparency came up even in an interview with an employee of the local urban

¹²⁵ Field Notes P/EF 05-07-19; A 21-07-19; Household interviews questions 26-29

¹²⁶ Field notes NFI 12-07-19

¹²⁷ Household interview question 33: “If you want to know something about drinking water quality who can you ask?”

planning office¹²⁸. I was told that SDE has mountains of data about water quality but it is unlikely I would ever see it. Household interview participants echoed this and overwhelmingly said they did not have anyone in an official capacity they could ask about drinking water quality¹²⁹. Some also mentioned doubts about whether SDE would be willing to make their data public, or a lack of confidence in any information that SDE or SONES would provide. The combination of general feelings of distrust, frustration and suspicion that the quality of water they are purchasing may be substandard are all components of the Consumer Assemblage of drinking water quality in Kaolack.

Shared stories and narratives are another element mobilised by consumers in support of particular ways of assembling drinking water quality. In my observations and interviews, people constantly shared ideas, stories and perceptions about water quality with each other. When I was deciding what to do for my own drinking water needs in Kaolack, everyone I spoke to was more than happy to give me very insistent advice, although the recommendations were not consistent. For example, several respondents told me that doctors had cautioned them or someone they know to avoid certain sources of water, particularly during vulnerable life stages. Many people have specifically been counselled to avoid tap water when one is pregnant or over fifty years old because the salt can cause hypertension or diabetes¹³⁰. Doctors have an authoritative voice based on their health expertise, compared to if this advice came from someone else.

Perceptions, ideas and even suspicions about the history and origins of water are also potentially important elements of quality assemblages, such as if one believes that the water sold by filtration kiosks is clean now, but was originally waste water¹³¹. Well water, on the other hand, is considered the most natural option because it comes directly from the ground, with fewer steps in between removal and consumption. Also, because parents and

¹²⁸ Interview, Department of Urban Planning: LK-30-07-19

¹²⁹ Household interview question 33: 85 people answered this question. 72 people said they did not have anyone they could speak to about drinking water quality, 1 person said they were not sure, 5 people suggested speaking to their neighbours, 4 said they could ask the meter reader or technicians when they pass through the neighbourhood, 2 suggested talking to SDE directly via customer service channels, and one said 'You work with water, I would probably just ask you'.

¹³⁰ Household interviews questions 26 and 36-38

¹³¹ Household interviews question 28

grandparents drank well water for many years without negative effects, some people assume that it must be fine to drink¹³². Water from the town of Karang about forty kilometres from Kaolack has a widespread reputation for being of high quality, and bag water production there is a booming industry¹³³. In these case the history of the water is more of a concern than its current properties.

An additional element of consumer assemblages of quality is whether one has put their own labour into customising quality through practices of filtration, decanting or adding chlorine or other products to the water. While these practices are in some way a response to drinking water quality being assembled a certain way, they are also elements in assemblages. Human labour and the confidence that treatment has been done up to your personal standards are a way of ensuring that water is suitable for drinking¹³⁴. Conversely there can be distrust of sellers or providers to treat water appropriately. One well water seller told me that his clients had asked him to stop adding chlorine to the water he delivered to them because they think he sometimes adds too much and prefer to handle it themselves¹³⁵. Several consumers complained to me that SDE's level of chlorination is often excessive and can make the tap water temporarily undrinkable¹³⁶.

Another set of elements in Consumer Assemblages of drinking water quality are ideas about modernity, lifestyle and affluence in relation to particular types of drinking water. One interview respondent described how proud they would feel if the water in the tap improved and became drinkable, saying that she could then imagine she was in a modern city like Paris or New York¹³⁷. Also, in my experience people were shocked that I would consider filtering my own water or carry water for myself down the street instead of just relying on bottled water. This led to a lot of good natured teasing about how I am cheap and love money. In general it seems taken for granted that people with money and foreigners only drink bottled water, preferably delivered to them. This perception is more related to the

¹³² Household interviews question 27

¹³³ Field notes PCVN Karang 20-07-19; Household interviews row 29

¹³⁴ Household interviews rows 26-29

¹³⁵ Interview well sellers: 3 and 4: 20-11-19

¹³⁶ Household interviews question 26

¹³⁷ Interview MD-50-18-11-19

source or type of water and its reputation for links to a certain type of lifestyle (and financial resources) than the characteristics of the water in the bottle.

To sum up, Consumer Assemblages of drinking water quality are the most heterogeneous and flexible of the assemblages discussed in this chapter. They contain a mix of material and social elements which rise and fall in relative importance given the situation at hand. In the assumed absence of perfection, what factors are most important in an assemblage of drinking water quality can change from moment to moment. The relations between elements are not predetermined. What is satisfactory can be relative to what someone is accustomed to or expects, and expectations vary. Several people in household interviews said things like ‘This is the water that Allah gave us so we have to be fine with it’, or that tap water is acceptable if there is no other option¹³⁸. Consumers also recognize that drinking water quality is something that is different for different people and over time. It was also quite common in the household interviews for people to differentiate between the factors most important to elderly people, babies, pregnant women and so on¹³⁹. Consumers consider elements like labour, availability, history and preference alongside their concerns about health and well-being. These elements enter and depart assemblages, and vary in importance both between individuals and over time. Each Consumer Assemblage represents the epitome of the Deleuzoguattarian assertion that assemblages are always in the middle of an ongoing process of becoming (Deleuze & Guattari, 1987).

Summary of drinking water quality territories in Kaolack

In this chapter I have shown that each type of assemblage in Kaolack contains provisional collections of distinct elements, and also ascribes different weight and importance to those elements. The focus on elements and practices in this chapter emphasises that drinking water quality assemblages are made (and therefore could be made in different ways). There are therefore more places to consider the ethics of drinking water quality governance as

¹³⁸ Household interviews rows 26 and 27

¹³⁹ Household interviews rows 26-29; 36-38

they relate to immanence and positive affects in a Deleuzoguattarian ethical perspective than in traditional understandings of drinking water quality.

The territories of the assemblages of drinking water quality I identified in Kaolack are synthesised in Figure 14. The figure shows how assemblages of drinking water quality in Kaolack overlap in some ways but are distinct in others. Key elements in the Senegalese State Assemblage include expert knowledges and assessments, characteristics of sources, expected health effects and things in water. The Senegalese State Assemblage includes to some extent the knowledges and preferences of consumers, but these elements are largely blocked from meaningful inclusion in the assemblages. The Everyday Governing Assemblages include all of the same elements as the State Assemblages, combined with taste and the labour involved in monitoring, treating and ensuring a source of water is safe. Because the Everyday Governing Assemblages have limited access to some scientific monitoring tools they are more inclusive of consumer perspectives and also the Hygiene Service staff's own embodied perceptions of drinking water quality, especially taste. Consumer Assemblages of drinking water quality can potentially include any of the elements mentioned up to now, and more. Provision assemblages are also broadly inclusive of all of these potential elements, although providers strategically raise up certain elements as is useful to them. Furthermore, the importance of particular elements further varies within and between network and non-network providers. The tap water Provision Assemblage includes both consumer preferences and scientific expert assessments, but the mandates of the state in SDE's contract are their primary concern. SDE also habitually uses their own labour in monitoring and chlorinating the tap water network as a proxy indicating drinking water quality rather than directly referencing quantities of things in water. The non-network Provision Assemblages, on the other hand, are more directly oriented towards enticing consumers to purchase their products.

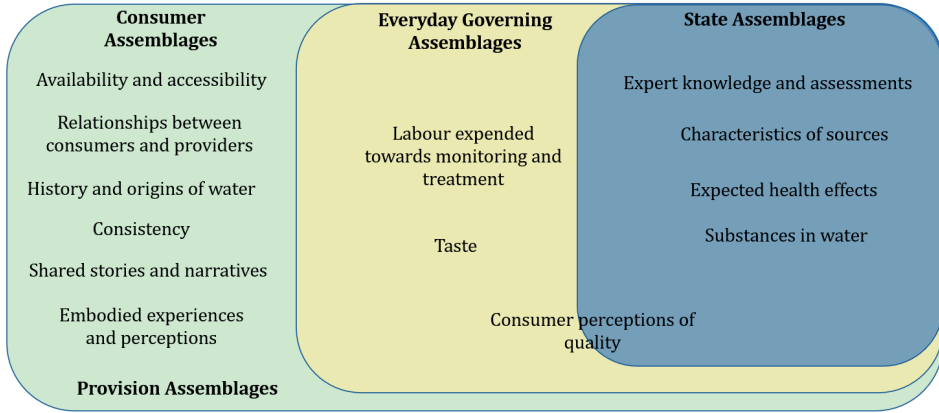


Figure 14. Elements in overlapping assemblages of drinking water quality. The largest green portion represents Consumer Assemblages, the middle yellow portion is Everyday Governing Assemblages and the small blue portion is State Assemblages. Provision Assemblages pull from each of these in a flexible manner.

The four main types of assemblages (State, Everyday Governing, Provision and Consumer) I identified in Kaolack are also presented in Table 9. Here I summarise by presenting where drinking water quality assemblages are forming in Kaolack, the content of these assemblages and their expressions.

As I described in the previous sections, knowledges are produced in assemblages. They are also elements in assemblages of drinking water quality. Thus knowledges can be both content and expression. Thinking about expression of drinking water quality assemblages in this way, as a cyclical process inextricable from content, also gives some insights into what a drinking water quality assemblage becomes. For example, experts and scientists make drinking water quality through their practices into the kind of object which can only be known through scientific measurement and data. This shapes the content of their assemblage; some material elements are naturally excluded because they cannot as easily be measured and abstracted into quantitative numerical forms.

Table 9. Content and expression of drinking water quality

Assemblages	Sites of formation	Content	Expression
Global Health Assemblage	WHO Guidelines for Drinking Water Quality, SDGs	Expert assessments of drinking water quality linked to human health	Data about quantities of things in water relative to pre-defined thresholds; number of households served by improved sources
Senegalese State Assemblage	National strategies, policies and legislation		
Everyday Governing Assemblage (local – tap water, NGO laboratory)	Reports to SONES (not publicly available)		
Everyday Governing Assemblage (non-network water, Hygiene Service)	Hygiene Service reports to Ministry of Health, assessment of drinking water sources	Combination of expert scientific assessments of drinking water quality and embodied experience	Mix of measurement of things in water (when possible) and situated qualitative assessments of sources
Provision assemblage (tap water)	Advertisements, prices, claims about tap water quality	Expert assessments of potability as distinct from quality (microbiological over physiochemical characteristics of water samples) – labour for protection, treatment and monitoring	Data, primarily about microbial composition of water; regular monitoring and cleaning of water towers
Provision assemblages (non-network water)	Advertisements, claims about the quality of various drinking water sources	Claims about hygiene, health, taste, history, modernity and lifestyles; certificates of cleanliness from the hygiene service and compliance with WHO guidelines	Prices, claims about acceptability, history – whatever is needed to sell their products
Consumer assemblages	Stated consumer perceptions and preferences about drinking water	Taste preferences; shared stories and narratives; embodied experiences of drinking water quality and links to health and well-being; price and accessibility; consistency; trust of providers; labour for protection and treatment	Deeply contextual and always changing – expressed in decisions about what water is safe and pleasant to drink in a moment

Despite some tendencies towards stability, the content of drinking water quality assemblages is always unique and context-specific because neither people nor the materiality of water are stable and constant. For instance, the Senegalese State and Global Health Assemblages of drinking water quality have more of a tendency towards stability than change but the realities they encounter are always in flux. So when well water is consumed by a particular human body it is sensed and perceived in concert with memories, ideas and knowledge that are unique to the individual. One form of drinking water quality assemblage emerges and the person responds accordingly. When filtered water meets an E. coli test being administered by a staff member of the Hygiene Service another assemblage

of drinking water quality emerges and data is recorded. Each element plays a role in what drinking water quality becomes at any given moment.

The temporalities of how elements in assemblages encounter each other and what sort of drinking water quality assemblage results matter. Consider fluoride, which is present in quantities exceeding the WHO recommended levels in Kaolack's tap water. Fluoride does not have an immediate smell, taste or appearance in water. To detect it in a particular sample of water requires some form of scientific equipment. Long-term exposure to large quantities of fluoride, however, causes a visible impact on human teeth – colouring them yellow, red or brown. So consumers become aware of the presence of fluoride in their drinking water, just over a much longer time scale than an expert performing a lab test with immediate results. Fluoride is also interesting in terms of how it fits into the WHO's scheme for determining acceptable quantities of certain contaminants in drinking water. These long-term and sometimes cosmetic effects do not align seamlessly with the disability adjusted life year paradigm. Impacts beyond health for the well-being of people with dental fluorosis, such as emotions of shame or sadness about their appearance¹⁴⁰, are invisible to the Senegalese State Assemblage with its focus on quantifiable and measurable indicators. These aspects of fluoride therefore play less meaningful roles in the State Assemblage of drinking water quality and their negative affects on consumers are likely to be allowed to persist.

Assemblages also vary in terms of their expression, or what kinds of patterns of relations comprise them. Figure 15 summarises the tendencies of drinking water quality assemblages in Kaolack. These tendencies are displayed here along a linear spectrum, but there is variation not only between but also within categories. For example, in State Assemblages drinking water quality is rigid and transcendent. For the state there are consistent sets of elements in drinking water quality assemblages and clear delineations between which elements are included and which are not. Senegalese State Assemblages tend to treat drinking water quality as a quantitative entity determined by experts. Drinking

¹⁴⁰ Household interviews questions 39 and 40; Field notes: NFI and interactions with people with fluorosis

water quality is assembled as an abstraction at the household or community level which is somewhat stable over time. Everyday Governing and Provision assemblages blend embodied, qualitative, individual understandings of quality that can be more flexible and open to uncertainty or change. Consumer Assemblages exhibit the greatest tendencies towards openness and inclusiveness of elements, and are also the most grounded in individual experiences. Which elements are included and how much weight they have is not the same for each consumer, nor does the relation between elements remain the same over time. Consumer Assemblages are flexible and open to uncertainty and change in a way that stands in contrast to the rigid and formal assemblages of drinking water quality in the Global Health and Senegalese State Assemblages. Thus consumer assemblages are closer to immanence than transcendence, as I will discuss in the concluding section of this chapter on the ethics of drinking water quality territories in Kaolack.

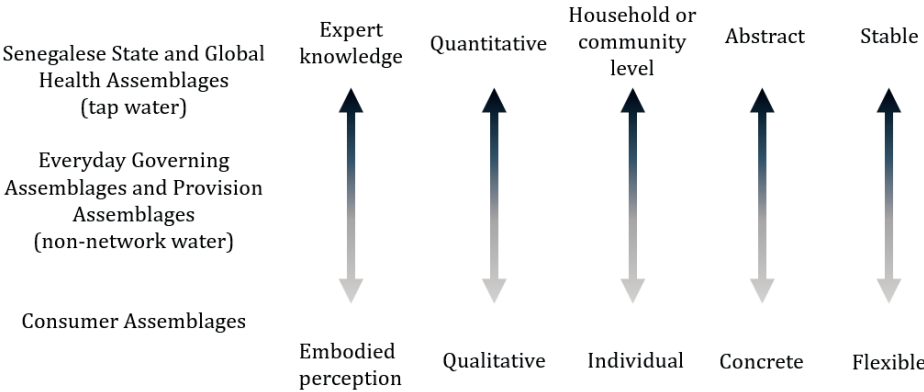


Figure 15. Tendencies of drinking water quality assemblages in Kaolack

Ethical articulations of drinking water quality assemblages

In a Deleuzoguattarian frame, ethics concerns two aspects: immanence versus transcendence and positive versus negative affective relations. Immanent relations are inherently more ethical because they allow for a greater range of possibilities (Frichot, 2012). For drinking water quality, one form of transcendence refers to external

assumptions about what elements are able to be included meaningfully in drinking water quality assemblages. Throughout this chapter I have shown that the State Assemblages of drinking water quality are the most limiting or transcendent, and these limitations can make some forms of exposure to hazards in drinking water more likely. Instead of trying to understand and communicate across difference, the state generally denies existence or value of other assemblages and says theirs is the only one that matters or should influence decision making. Opening up what we understand drinking water quality to be and continuously re-evaluating based on context, uncertainty and multiplicity could allow previously unforeseen becomings of drinking water quality to be possible.

The tendency in State Assemblages towards positioning consumer knowledges and preferences as subordinate to expert assessments prevents those knowledges and preferences from joining in affective relationships with elements in State Assemblages. Therefore, the arrangement and prioritisation of elements in the drinking water quality assemblages presented in this chapter can have implications for recognition and participation of consumers. Exclusion of elements which are not easily quantifiable has ethical implications because those elements are not able to participate in potentially positive affective relations. Preventing expert knowledge from State Assemblages from being available to consumers can also make it more difficult for them to make informed decisions about their drinking water, although, as described previously, consumers may not trust information from drinking water providers anyway. Blocking the development of affective relations between knowledges as elements in different drinking water quality assemblages is one way assemblages make certain things possible and not others. When it comes to distinguishing between consumer and state knowledges of drinking water quality, the point is not to reject scientific knowledge in favour of consumer perceptions, but to make that knowledge transparent and available to consumers while also taking into account their concerns about acceptability, affordability and so on.

Something I anticipated but did not encounter in Kaolack was any form of organised advocacy around drinking water quality. Perhaps one answer to why consumers do not protest and demand improvements in their drinking water is that the system limits

meaningful contestation. Consumers feel that their voices are not a part of the Senegalese State assemblage of drinking water quality. They therefore do not have an effective way to demand change. Transparency and inclusiveness from the State Assemblage would be more ethical because alternative knowledges of drinking water quality would be more able to speak to each other despite their differences. This would both allow consumers to make more informed decisions about drinking water quality and enable them to ask for improvements to drinking water quality in a language that the state would understand.

Furthermore, some of the elements the State Assemblage de-prioritises or excludes can make people more vulnerable to negative affects. Actors in the State Assemblage and those associated with the tap water network primarily measure water in pipes and storage tanks, which means they may end up missing changes in quality after delivery or where people actually consume water. The state practice of categorising households as either served or not served by an improved source can also obscure heterogeneity of user practices inside homes, along with inconsistency of access and quality of each source. The Senegalese State and Global Health Assemblages have also both been shown to conflate access and quality in their practices, leading to ongoing delivery of hazards into homes. In addition the hierarchies constructed by the state matter. If potability, framed in terms of microbiological quality, is the central element of drinking water quality, physio-chemical quality is less prioritised in policies and plans. Thus elements with the potential to impact on potential exposure of consumers to hazardous substances in their drinking water can be invisible or escape the state's practices of assembling drinking water quality.

Chapter 8. Findings III – Implications of drinking water quality assemblages

This chapter builds on explanations of the possibilities for and elements of drinking water quality assemblages in Chapters 6 and 7 to address the final part of research question 3: *What do drinking water quality assemblages do in Kaolack?* I showed in the previous chapter how drinking water quality assemblages form through combined social and material practices. These practices include or exclude certain elements from assemblages, and they structure relations between those elements. The resulting assemblages constitute evolving patterns of relations that vary in their tendency towards stability and change. Therefore, the purpose of this chapter is to explore how drinking water quality assemblages come to coproduce and inhabit territories of drinking water quality with implications for inequality, injustices and exclusions. I show that the ways drinking water quality is assembled matter and have implications for the health and well-being of people in Kaolack, including how they access drinking water or are exposed to potentially harmful things in drinking water.

Drinking water quality informs how people make decisions and act at different scales based on emergent and particular assemblages. These decisions and actions contribute to the formation of new connections and encounters in the urban environment of Kaolack, which in this chapter I categorise as patterns, relations and traces. These patterns, relations and traces emerged out of the data collection process as social and material products of assemblages which come to define the territory of drinking water quality in Kaolack, with particular affects. Considering these affects helps to understand the territories and ethics of drinking water quality assemblages. In line with the ontology of assemblage theory, these relationships are cyclical and mutually influencing rather than uni-directional (Figure 16). The territories I refer to in this chapter are both actual material places where drinking water quality is known and experienced and social, relational spaces¹⁴¹. The fact that

¹⁴¹ What I am describing as a territory in this chapter is akin to the concept of a “waterscape”. However, I find that concept to be too focused on water-society relations and circulation of water (Karpouzoglou & Vij, 2017) rather than expanding out to the whole range of relevant potential human and non-human relations. Waterscapes have been expanded to talk about wastewater-scapes and so on (Zimmer, 2011), but I did not consider introducing a new term for water quality-scapes or some such thing to be necessary.

drinking water quality assemblages act to organize material and social relations is an important part of what makes assemblage a useful analytic in this case.

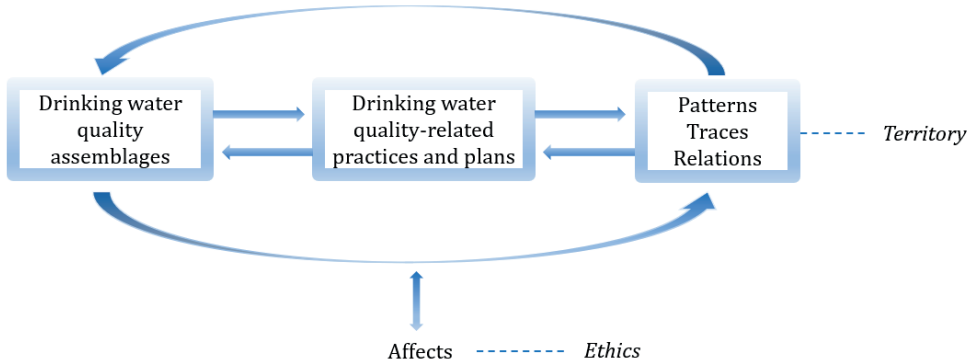


Figure 16. What do drinking water quality assemblages do?

Using the concepts of smooth and striated space, in this chapter I develop an account of drinking water quality assemblages that adds a spatial dimension to the entangled social and material topics in Chapters 6 and 7. Smooth and striated space are paired concepts developed in *A Thousand Plateaus* to encompass the links between assemblages and socio-material territories. Smooth space is heterogeneous and open-ended, while striated space is homogeneous and limited to repetitive patterns and segments. Deleuze and Guattari use several models in Plateau 14 to exemplify tendencies towards smoothing and striation, including sedentary and nomadic societies, different forms of music and math (Deleuze & Guattari, 1987). The concepts of smooth and striated space offer distinct analytical perspectives on what assemblages do by drawing attention to their tendencies to smooth or striate spaces. Another aspect of smoothing and striation is that they are processes. Therefore the emphasis is less on description (this space is striated and that space is smooth) and more on what assemblages do to territories around and within them. For instance, Deleuze and Guattari use these concepts to discuss the ways state assemblages work to control and capture territories by striating, although something always escapes in the form of smooth space (Deleuze & Guattari, 1987).

In my analysis the relationship between assemblages and territories manifests as a link between drinking water quality assemblages and the actions or intentions of different actors that subsequently shape and are shaped by the territory of Kaolack. I use the concept of territory to refer both to the flexible boundaries around assemblages as entities and to the social and material spaces that assemblages are embedded in. Territories are therefore both physical and relational spaces.

In Chapter 7 I described how knowledges can be both content and expression of assemblages. As a social part of what assemblages do, knowledges can also play a role in the smoothing and striating of drinking water quality territories. For drinking water quality in Kaolack, there is a state way of knowing quality, and then something outside it. The state often tries to limit and control alternative ways of knowing in favour of their own way of thinking (Deleuze & Guattari, 1987). Knowledge produced by the state tends to be restricted to translatable forms of scientific assessments produced by experts. Thus knowledges produced by the state can be described as striated, in that they limit connections between alternative knowledges or cause certain material and social elements to be excluded or escape assemblages of drinking water quality (Chapter 7). The state strives to incorporate smooth space into the state assemblage through processes of striation: counting, measuring and controlling as tools of governing. In state forms of knowledge, numbers are a tool used to gain mastery of matter. Striated space is counted in order to occupy and control, whereas smooth space occupies without counting (Deleuze & Guattari, 1987). In opposition to striated forms of knowledge produced by State assemblages, the knowledges produced in and by Consumer Assemblages in particular can be described as smooth. The knowledges associated with Everyday Governing and Provision Assemblages vary in their tendencies towards smoothing or striation according to context. These aspects of smoothing and striation are entangled with material, relational and spatial affects. Therefore in the remainder of this chapter I will turn my attention to such affects and describe how assemblages of drinking water quality interact with particular territories in Kaolack.

I situate my contribution in this chapter relative to other work in the field with a discussion of how heterogeneous flows of water in cities have been discussed in the literature. I argue in favour of the assemblage theory concepts of smooth and striated space as one way of capturing the links between the social and material affects of drinking water quality assemblages. I further compare these concepts to other common conceptual metaphors used to describe the differences and relations between tap water and non-network drinking water, especially in the Global South. I argue that Deleuze and Guattari's concepts of smooth and striated space may help to understand the linked socio-material, spatial and ethical aspects of what drinking water quality assemblages do in Kaolack.

Assemblages and territories

This section begins from a simple premise: how people understand drinking water quality, and what they think about quality of particular sources, affects their decision-making and planning with regards to drinking water. In this way, drinking water quality assemblages shape how drinking water circulates through Kaolack. The scale and temporality of this influence varies among assemblages and actors. State Assemblages affect decisions made at the level of planning and governance, as the state works to ensure drinking water of adequate quantity and quality over the long term. Consumer Assemblages influence the decision making processes of individuals, which incrementally shift flows of drinking water and relations between people and places. Non-network Provision Assemblages result in provisional flows of drinking water to individuals and households. The link between these non-network flows and drinking water quality is that each source can be seen as a solution to particular drinking water quality problems (Chapter 6). Everyday Governing Assemblages respond to drinking water quality being problematic by stopping water sales or issuing fines to sellers. Thus the Hygiene Service, as representative of the Everyday Governing Assemblage in Kaolack, is more likely to interrupt flows of drinking water in Kaolack rather than starting or extending them. I expand on each of these examples in the following paragraphs.

For the Senegalese state, solutions to drinking water quality problems in Kaolack predominantly consist of long-term investments in large infrastructure including pipelines, treatment plants and construction of new deep bore wells in locations where water has less salt and fluoride¹⁴². At the time of my field work, the prospects of piping water to Kaolack from elsewhere or constructing treatment plants in Kaolack were still in the very early stages. No studies had been undertaken yet to assess the feasibility or cost of these plans¹⁴³. Two new deep bore wells have been constructed in the past decade, resulting in slight reductions in salt and fluoride in tap water across Kaolack. All of these plans are primarily focused on improving quality of tap water delivered into homes, which is considered the best option for achieving uniform and universal access to drinking water. These large investments in infrastructure take time to complete and can last for decades, with the exception of potential disrepair or breakdown. Such actions also fit within and must be compatible with frameworks for national improvements in access and quality. In the meantime, the NGO laboratory in Kaolack regularly tests tap water and SDE self-monitors and treats water with chlorine (Chapter 6). Responsibility for drinking water quality as it relates to hygiene remains with individuals and households, although their behaviour is also surveyed by the Hygiene Service.

The Hygiene Service, aligned with Everyday Governing Assemblages in Kaolack, sees drinking water quality problems and solutions in ways that are less oriented towards large-scale city-level change and more towards individual behaviour. Therefore, actors in this assemblage are not responsible for redirecting flows of water throughout the whole urban area. Generally the staff of the Hygiene Service goes to where people sell or consume water and investigates drinking water quality on site. The staff members attempt to be systematic about their monitoring practices, for instance planning to visit ten households in one neighbourhood each week for random sampling, but they also spontaneously respond to complaints or tips¹⁴⁴. Rather than creating or supplementing existing flows of water, the Hygiene Service is likely to go to a place where water has already been flowing and either

¹⁴² Interview DGPRE: FN-26-04-19

¹⁴³ Interview Mayor's office: AV-22-05-2019

¹⁴⁴ Interview Hygiene Service: IM-19-09-19; Field notes 29-08-2019

temporarily or permanently interrupt its flow if quality is compromised. For example, if a well is found to be uncovered or tests on the water from a well show the presence of *E. coli*, the Hygiene Service will issue a fine and stop the owner of the well from selling water until they can demonstrate it has been cleaned and quality is satisfactory. One day at the Hygiene Service office I also observed that they had confiscated hundreds of bags of water that had passed their expiration date. The officers intended to destroy the bags to prevent them from being sold or consumed later¹⁴⁵. So in this case the staff of the Hygiene Service interrupted a flow of bag water and stopped it before it reached consumers.

Consumers make individual decisions about where to source water or how to treat drinking water for themselves or their families in order to ensure adequate quality. Over time, consumers develop habits and patterns in their drinking water choices. However, they tend to maintain some flexibility in these patterns. For instance, all consumers I spoke to are aware of supplementary options in case their first choice for drinking water is compromised in some way¹⁴⁶. Consumers also commonly rely on multiple sources of water for different domestic, consumptive and productive uses. A household may rely on well water for drinking until their home is connected to the tap water network. If the tap is empty one day or the water coming out is murky, people in that household may decide to purchase a package of bag water, creating a temporary new flow of bag water into their home. Over time, if they come to trust bag water more than tap water they may get in the habit of regularly purchasing bag water, even if the tap is running normally. Conversely, if the price of bag water increases or someone in the household gets diarrhoea from drinking bag water, the household or individual may decide to avoid bag water in the future and return to drinking tap water primarily¹⁴⁷. The practices of individual consumers gradually shift larger flows and circulations of drinking water throughout the city (Furlong, 2010).

¹⁴⁵ Another part of the Hygiene Service officers' job is to visit shops and check that no items on the shelves have passed their expiry date. All expired products they encounter are burned. The officers are concerned that if expired products were simply dropped in informal dump areas with other waste, waste pickers and children on the street would end up collecting and consuming them and could make themselves sick.

¹⁴⁶ Household interviews question 14

¹⁴⁷ This is a generalisation based on household interviews and observation.

There is no final permanent destination for consumers; they remain aware of the possibility of water quality continuing to change¹⁴⁸.

These actions and plans are intimately connected to drinking water quality assemblages. The more rigid assemblages tend to result in more rigid, or striated, solutions and vice versa. In Chapters 6 and 7 I described how State Assemblages tend to be more fixed and inflexible than Consumer Assemblages. State Assemblages take longer to change and are assumed to be translatable across contexts. There is an implicit ideal of drinking water quality which comprises certain material or social elements and excludes others. The Senegalese state's planned activities to improve drinking water quality in Kaolack reflect this stable understanding of quality. They involve long-term investments based on one version of quality that is not expected to change. Conversely, I presented how Consumer Assemblages are flexible and open-ended. The responses of consumers reflect this flexibility as well. If consumers encounter a new material reality – in the form of changes to quantities of substances in water or characteristics of water sources – or learn new information, they may also change their behaviour. Even if Consumer Assemblages are not actively changing in a certain moment, the point is that they have a greater tendency towards smoothness and change than State Assemblages.

The relationship between assemblages and actions is mutually constitutive. Changing drinking water quality assemblages precipitate changing responses. Novel responses shift the form of assemblages. The state decides to build a treatment plant because tap water, which is their preferred method of providing water to the largest number of people, is understood to be problematic in Kaolack. They consider bacterial contamination to be the first priority, followed by physio-chemical substances. Taste is not positioned as a meaningful element in State Assemblages. So, when the state builds a treatment plant, the results reflect these priorities. The treatment process changes the quality of tap water by removing fluoride and salt, which potentially changes how people perceive and respond to the water delivered to their homes. There might be some inertia here because the long-

¹⁴⁸ Household interviews questions 26-29; field notes

standing reputation of tap water in Kaolack and lack of trust could mean that consumers continue to use tap water for domestic tasks but avoid it for drinking. In any case, in assemblage theory human intentionality is one among several causal actors (Chapter 3). Thus drinking water quality assemblages are part of complex webs of causation, resulting in people gaining access to water they feel safe and comfortable with, or potentially being exposed to harmful things in drinking water. The outcomes are always unpredictable.

Each drinking water quality assemblage can therefore be linked to the unfolding of different territories in Kaolack. Drinking water quality assemblages are entangled with how water (and water quality) circulates in the city, the development of human and non-human relationships and traces left behind by drinking water access practices. Building on this idea in the following sections I will show that just as different assemblages exhibit tendencies towards stability or change, so do the resultant socio-material territories they give rise to. Whereas up to now I have discussed the assemblages one at a time, in the subsequent sections I will organise the discussion around the sources which are entangled with and result from drinking water quality assemblages. This will better enable me to explore the socio-material and spatial affects of these sources, as each source may be linked to multiple assemblages.

Patterns

Water circulates through the city in numerous coexisting flows associated with tap water, bag water, bottled water, well water and filtered water¹⁴⁹. Each of these types of sources move through and interact with the city in interconnected ways. While tap water circulates in a grid pattern defined by pipes, non-network sources are typically more flexible, varied and independent. Tap water flows are contained in the network and associated with household-level service, while alternative sources are distributed heterogeneously throughout households, neighbourhoods and the city at large. In this section I will present

¹⁴⁹ Water also escapes and exceeds the tap water network, for instance through leaks, overflows or floods, but here I focus on intentional flows of drinking water.

these sources one at a time and describe how they relate to certain patterns in how water of different qualities flows and circulates through Kaolack.

Overlapping relationships between sources of water can make it challenging to clearly distinguish between them. Tap water is the substrate used to make most reverse osmosis filtered water, and the same goes for some locally produced bag water. Provision of drinking water typically involves multiple overlapping processes that blur the distinctions between formal and informal, legal and illegal and so on (C. McFarlane, 2012; Schwartz, Tutusaus Luque, Rusca, & Ahlers, 2015). However, for the purpose of simplifying and disentangling the relations in Kaolack I present sources separately here.

The sources of water I present diverge in multiple respects. For instance, not all sources of water are primarily used for drinking water. Tap water and well water are sometimes drunk, but they are also used for domestic tasks, urban agriculture and construction. Bag water, bottled water and filtered water are primarily produced and marketed for consumption – although I observed taxi drivers buying filtered water to pour into their engines because the tap water has too many minerals in it and does not run as cleanly¹⁵⁰. Nevertheless, I continue to emphasise the characteristics of sources as they pertain to drinking water quality as that is the focus of my research questions¹⁵¹. I briefly discuss the implications of varied sources with multiple uses in the conclusion of this chapter.

The piped water network forms a grid throughout Kaolack. Naturally present groundwater, primarily from the Maastrichtien Aquifer, is pumped into water towers and redistributed systematically. Though the network extends to every neighbourhood in the city (UN Habitat, 2009), there are limits to its reach. Some households lack connections, primarily in the expanding urban periphery, and at the margins of Kaolack water pressure decreases

¹⁵⁰ Field notes GNT 08-11-19

¹⁵¹ This means I leave out the river, for instance, which flows from East to West along the southern edge of the city. The river water is broadly assumed to be too salty for drinking, and may be contaminated with solid and liquid waste. However, the river has important productive uses including: collection and production of salt for export, fishing, and transport of goods through the port of Kaolack.

and cut-offs increase¹⁵². In addition, households that struggle to pay their water bills on time face threats of being disconnected by SDE¹⁵³. Still, generally speaking, a grid underlies and striates the urban area of Kaolack (Figure 17). The tap water network shapes flows of water in a long-term way because it is expensive to expand connections into new areas or change the form of the network once it is established. Some of the original connections in the city centre date back to the early days of Kaolack (Badiane, 2004). While some of the pipes are dilapidated, water still flows through the older areas of the city in more or less the same patterns it did when those neighbourhoods were first constructed.

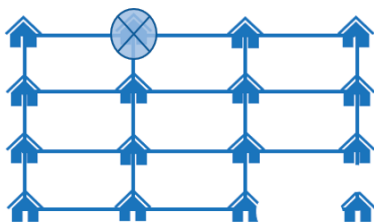


Figure 17. Tap water's grid pattern of space. Water flows to connected households. Some houses are cut off temporarily if they do not pay their bills or the pressure in the network drops (the x through one house), and others are not connected (the house without connections on the bottom right).

Some of the state's planned or proposed interventions to improve drinking water quality in Kaolack would have implications for the way water circulates within and beyond the existing tap water system. For example, building desalination plants to treat groundwater would continue the current vertical movement of water up out of the aquifers. However, instead of going directly from the aquifer to water towers and finally households, such a plan would require all tap water to pass through treatment plants. Therefore water would travel further and undergo a qualitative transformation before arriving at households and businesses throughout the city. This plan would extend but not supplant the existing tap water network. The plan to construct pipelines to transport water with less salt and fluoride into Kaolack would create significant new flows of water into the city, over even larger

¹⁵² Field notes AM 04-05-19 and 30-05-19; Interview with Kaolack Urban Planning Directorate, DBU-30-07-19

¹⁵³ Field notes: AK-26-07-19; Field notes: MN-04-10-19

distances. Again, once treated and stored the water would flow through the existing pipes into households. So the network would not be replaced, but Kaolack would be bound more closely to surrounding rural areas. These connections already exist on a smaller scale through the importing of bag water from towns like Karang, forty kilometres to the south of Kaolack. A pipeline would reinforce and stabilise this link.

Alongside the tap water network, non-network sources of water also have patterns that shape the territory of the city. First I address bag water, the plastic packages of four hundred millilitres of drinking water sold and consumed all over Kaolack (Figure 18)¹⁵⁴. Relations between consumers and sellers of bag water arise and disperse as needed in provisional and shifting patterns. The people who sell bags of water are often on the move, travelling from house to house, business to business or busy areas around the market and main roads in search of customers. In other cases bags of water are stored in a refrigerator or shady spot in a shop or house and consumers come to pick up one or several bags. Larger packages of fifty to one-hundred bags are delivered to central hubs by trucks and then distributed throughout the city by motorcycles, on foot, in cars and so on. Some brands of water collect tap water or well water in Kaolack and filter (or do not filter depending on who you ask) it before sealing it in bags for sale. Other brands are based in regions considered to have better quality drinking water, which are then distributed in Kaolack. Many of these brands come from south of Kaolack, especially the town of Karang. However, I collected empty bags of over one hundred and twenty different brands of water while walking through town. Producers typically stamp their bags with information about the origin of the water, and I found bags from as far away as Ghana to the South and Mali to the East¹⁵⁵.

¹⁵⁴ Sometimes in the literature bag water and bottled water are described together as containerised water, but I consider their patterns to be distinct. In this section I will not directly address bottled water because it is far less prevalent in Kaolack than bag water. Some of the claims I am making about how bag water flows through the city and connects Kaolack to other regions would hold for bottled water, although bottled water is sold more from sedentary spaces like restaurants or shops instead of being carried through the streets.

¹⁵⁵ These extreme cases may have been tossed out the windows of truckers passing through Kaolack on the national highway. The majority of bags were from central Senegal.

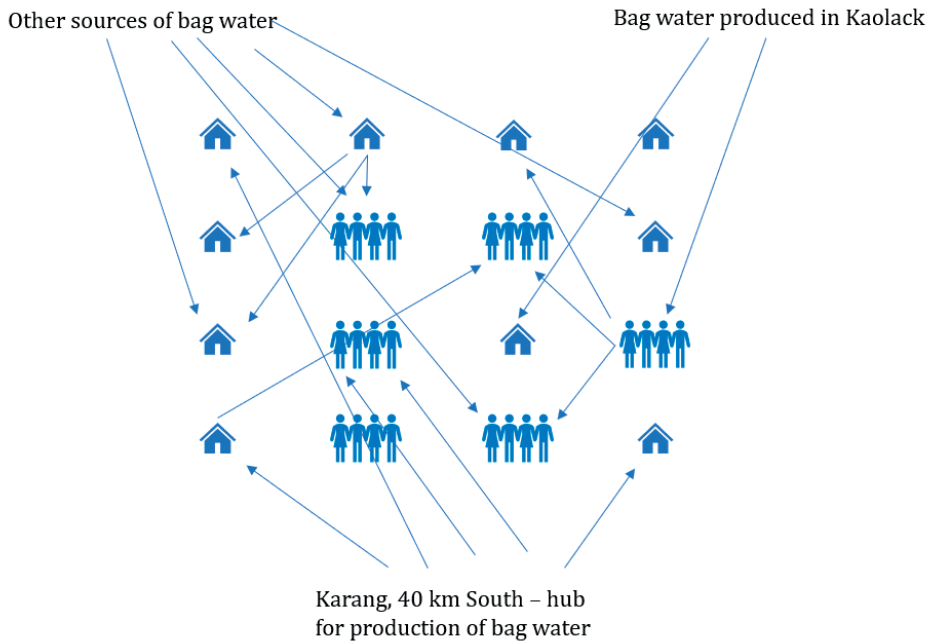


Figure 18. Bag water travels into and through Kaolack in a variety of provisional and temporary patterns.

Unlike tap water, which can serve entire households, the quantity of water in a bag is just enough for a single serving for one person. People may consume bags of water immediately after buying them or take a large package of several bags home to freeze for later. It is also common to buy large quantities of bag water to distribute to guests at a party or meeting. I experienced that large buckets of water bags are present at most social events to hand out to guests¹⁵⁶. Several people told me they never drink bag water at home but if it is given to them when they are a guest or if they are thirsty at the market they will accept¹⁵⁷.

Much like bag water, well water flows through the city in ephemeral and flexible ways (Figure 19). In Kaolack, most well water is not used or consumed on site, but delivered to

¹⁵⁶ This is different from events I attended in other regions where there would simply be a reservoir of water that people can dip cups into.

¹⁵⁷ Repeated statements in field notes and household interviews

households throughout the city. Historically there have been wells spread across Kaolack, but gradually salinity is increasing northward from the river and so wells have either been covered and closed or are now only used for certain tasks for which salinity is not an issue. Well water sellers for the most part use carts pulled by donkeys to go where they are called or where they perceive a need. The sellers I spoke with said they do not have set neighbourhoods or routes they always visit¹⁵⁸. Most days they simply head south from the wells where they fill their jerry cans and proceed until the reserves are empty. When the weather is hot or there are cut-offs in the tap water network, they finish selling earlier in the day and do not cover as much ground.

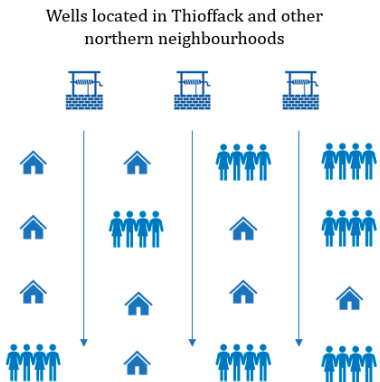


Figure 19. Well water flows from North to South in Kaolack into most neighbourhoods, primarily to individuals or groups within households.

Unlike bag water, well water is entirely local rather than imported from other cities and regions. Well water generally proceeds in one direction, North to South. Wells with water considered drinkable are located in the northern parts of the city, far from the encroaching salinity of the river. Some may be outside of the formal municipal boundaries, but they are still woven into the urban (or perhaps peri-urban) fabric. Ongoing flows of water and people tightly link the livelihoods and resource use of the centre to the periphery. Well water is also not typically a primary source for drinking water at the household level.

¹⁵⁸ Interviews with well sellers: 1, 3, 4-20-11-19

Elderly people are the most likely to rely on well water as their primary source of drinking water, because for them it is familiar and therefore the most trusted¹⁵⁹.

A third source of drinking water in Kaolack is filtered water. Reverse osmosis kiosks are proliferating quickly around Kaolack. The first filtered water business opened in 2012, and by the end of my field work there were at least thirty kiosks operating and several others planning to open soon. The largest company in Kaolack, Diam'O, does not allow franchise locations to be within a one kilometre radius of each other¹⁶⁰. The kiosks are therefore spaced out so they do not compete for customers in an area. As consumers become more familiar with the technology and local businesses, the networks of users associated with each kiosk are growing. However, not all consumers are convinced that filtered water is of good quality and so reliance on kiosks for drinking water still varies within and between households. Even in the immediate surroundings of kiosks there are consumers who do not engage with filtered water. In one household interview the home shared a wall with a reverse osmosis kiosk but the interview respondent had never been inside the kiosk. They were not aware of the details of the business and not interested in learning more, even though they were responsible for drinking water in the household¹⁶¹. The filtered water kiosks are connected to the tap water network, but they alter the composition of water and then redistribute it throughout their surroundings. Therefore, filtered water kiosks create a kind of hub-and-spoke pattern in their neighbourhood where flows are not constant or ubiquitous (Figure 20). These flows are reminiscent of Karen Bakker's (2003) metaphor of archipelagos of drinking water access, but in this case they are archipelagos of drinking water quality.

¹⁵⁹ Household interviews question 27

¹⁶⁰ I observed that the kiosk closest to my house was shut down and their machine taken back by the company. Another kiosk owner, who opened their business first, had filed a complaint and was successful in arguing that they should not both be allowed to operate in such close proximity (Field notes NF-24-07-19, several conversations with GF and Diam'O managers including NF).

¹⁶¹ Household interview NZ-54-23-11-19

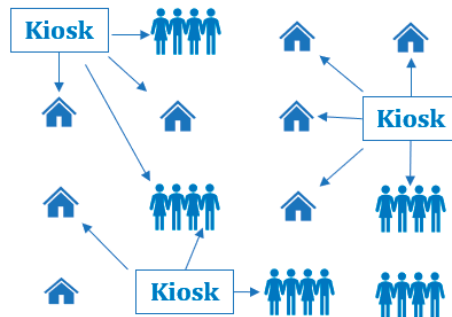


Figure 20. Filtered water kiosks form archipelagos of drinking water quality in Kaolack that branch out from individual network connections

Kiosks are established in semi-permanent locations. Managers of kiosk businesses often paint the walls blue and white and set up special connections to electricity and tap water. The machines themselves are actually quite portable and easy to move. Multiple managers of kiosks noted that if a large-scale treatment plant were to be built in Kaolack which made filtration unnecessary they would simply relocate their business to another area where people still needed filtered water¹⁶². So while these filtered water kiosks constitute a growing flow of drinking water through Kaolack, they represent a response to a specific set of drinking water quality problems. If the problems went away, the solution would no longer be necessary and the flows would shift elsewhere.

This section focused on physical patterns regarding flows of water in Kaolack. Straightforward associations exist between the smooth and striated concepts and flows of water in Kaolack. Tap water begins from a source and flows outward through pipes to its point of consumption. In Kaolack, this process begins with groundwater extraction and continues into water towers, through pipes, to households. Tap water is limited in its range by the existing network of infrastructure and can only flow through repetitive and segmented patterns contained within a grid-patterned network of pipes. Conversely, non-network sources of water tend towards smoothness in the sense that they can travel anywhere and everywhere through heterogeneous and always shifting patterns associated

¹⁶² Filtered water seller interviews questions 25, 27 and 29

with smooth space. Sources are spread throughout the city and beyond, and the destination is not predetermined. If a flow of one brand of bag water is interrupted, other varieties will appear or some other form of water will fill the gap. There are some exceptions to this, for instance because filtered water is anchored to a specific location linked to the tap water network. However, flows of filtered water are more complicated and potentially varied because they encompass a mix of delivery options and self supply which emerge and dissipate according to consumer needs and preferences. The stability of these patterns depends on the actions of people and also the characteristics of the infrastructures involved. Next I will turn to social patterns, or the relations that emerge around certain drinking water quality assemblages and access practices.

Relations

The peculiar conditions regarding drinking water quality in Kaolack encourage certain kinds of behaviours to customise, protect and ensure access to drinking water of adequate quality. These practices of drinking water access and provision in Kaolack facilitate particular relations between human and non-human actors. Relations resulting from situated practices of drinking water access are linked to certain kinds of encounters between consumers, producers, water, sources of water and so on. Some of the social elements in assemblages I described in Chapter 7 also emerge out of these encounters. For instance, trust as an element in drinking water quality assemblages has to do with what kinds of relationships exist between consumers and providers of drinking water. Knowledges about drinking water quality emerge out of the meeting of social and material elements, and then those knowledges themselves become elements in drinking water quality assemblages. These knowledges can also reflect processes of smoothing and striation as discussed in the beginning of this chapter.

The first relations I describe are those around tap water provisioning in Kaolack. SDE and SONES are the main actors in the public private partnership for urban water provisioning in Senegal, and their contract defines the terms of a particular form of producer-consumer relationship. Customers of SDE are households or businesses with tap water connections.

To a lesser extent, public standpipes provide a way for customers without connections to access tap water by paying an attendant for specific volumes of water. Each connected household pays an initial connection fee to direct water to their property and then receives subsequent bi-monthly bills for water. To get a tap installed in one's home requires navigating layers of bureaucracy involving the Urban Planning Directorate of Kaolack, the mayor's office and SDE. The cost of installation can be prohibitively expensive for many households. A program exists to offer subsidised connections to low-income households, but the people I interviewed who live in houses without connections were not aware of this option¹⁶³. Some individuals without connections also described limitations for renters, because the landlord needs to be the one to apply for the connection and if they do not live on the property they do not have much incentive to do so.

Until a household receives a connection, their relationship with SDE is naturally limited in scope. Once connected, each household has a customer number for communicating with SDE about any complaints using their customer service phone line¹⁶⁴. In Kaolack, though, most consumers (connected or not) I spoke to did not feel they had clear channels to contact SDE. They had not seen representatives of SDE in their neighbourhoods aside from meter readers, who are not considered to have expert knowledge about water quality or consistency issues¹⁶⁵. Consumers also encounter staff of SDE at the office when they go to pay bills, although increasingly people pay utility bills electronically through Orange Money which allows people to put money on an account and send it via SMS. One final point to note about these relations between SDE and consumers is that they are not at all limited to households which rely on tap water for drinking. Regardless, of whether or not one drinks the water, if there is a tap in a house this customer-client relationship exists. If residents

¹⁶³ Household interviews, specifically with disconnected households; this is in line with the findings of the UN Special Rapporteur on the human right to water that found that most subsidies and other programmes primarily end up serving only households that are already connected to the tap water network (Human Rights Council, 2015).

¹⁶⁴ Some customers complain publicly on Facebook as well, and receive canned responses encouraging them to call the customer service phone line.

¹⁶⁵ Household interview question 35: "Have you ever met a representative of SDE in your neighbourhood? If so, what was that like?"

obtain drinking water or supplementary water elsewhere, they then participate in multiple relations, such as the ones I will describe for well water, bag water and filtered water.

Well water delivery drivers have a less formal and structured relationship with consumers than SDE does for consumers of tap water. The drivers I interviewed did not seem to have consistent relationships with many of their customers¹⁶⁶. I asked consumers as well, and some people who drink well water had phone numbers for their preferred delivery person and others did not. Wells themselves are considered far away from most neighbourhoods and the circumstances of the wells are not really known to consumers¹⁶⁷. Distance and lack of visibility can pose a barrier to trust, with some consumers noting their lack of knowledge about where the water was coming from as a reason not to drink it¹⁶⁸. Furthermore, because delivery people and consumers do not have consistent relationships there is not much opportunity for recourse or consequences if water quality is problematic. On the other hand, the well water delivery drivers I spoke with maintain close relationships with the owner of the land where the wells are located. The owner of the wells I visited said he charges only a small daily fee to collect water because all the sellers are slightly older heads of households and need the income for their families¹⁶⁹. He also takes responsibility for regularly cleaning and adding bleach to the well to maintain drinkable quality.

Bag water also mediates temporary relations with varying degrees of distance between producers and consumers. Though consumers may have regular relationships with the person who sells their bags of water, this is not always the case. Bag water sellers are often in motion, carrying their wares through the market or busy areas where they make anonymous sales. Also, the bags may change hands several times before arriving at their final destination. They start at the point of production, frequently outside of Kaolack. Bags are then transported into Kaolack and distributed to shops or individuals for resale. Some consumers associate quality with certain brands of bag water or source locations, but others seemed surprised when I pointed out that there is contact information or addresses

¹⁶⁶ Interviews with well sellers: 1, 3, 4-20-11-19

¹⁶⁷ Household interviews question 27

¹⁶⁸ Household interviews question 27

¹⁶⁹ Interviews with well sellers: 1, 3, 4-20-11-19

on the bags¹⁷⁰. Responsibility for drinking water quality, can be attributed either to the person one purchases bag water from or the original source¹⁷¹.

The growing presence of filtered water kiosks in Kaolack encourages and sustains a new set of relations between customers and sellers. Some kiosks offer delivery services for a price, while others serve primarily their immediate surroundings and customers arrive on foot. For my own water needs I occasionally walked to a kiosk about one kilometre from my apartment, but then I established a relationship with a motorcycle taxi driver who would collect my bottles and deliver water weekly. This was a practice recommended by my neighbours who had a similar arrangement. Many customers stay to talk with the managers of kiosks for several minutes while waiting for their water, while others drop off their containers and come back later in the day to collect them and pay. In this way the kiosk becomes a site of socializing and community as well as a source of drinking water¹⁷². This is in line with literatures in development studies that describe how changing sources of drinking water in communities can have unexpected (not always positive) impacts on people who collect water. For instance, some projects change who is responsible for collecting water or fail because women reject new sources in favour of old sources that allow them time and space for socialising outside their homes (Mateer, 2017).

In Kaolack, customers visit the kiosks whenever they need to refill their containers, but not on a regular schedule. Household interview respondents who rely on filtered water largely said they purchase it if and when they have enough money, and that not everyone within their household drinks filtered water. Contrary to SDE with their customer numbers and records, the transactions at filtered water kiosks are not well documented. None of the kiosk managers I spoke to kept a list of their customers, but many did write down how much money they received for each transaction¹⁷³.

¹⁷⁰ Household interviews question 29

¹⁷¹ Household interviews questions 26-29

¹⁷² Field notes, especially day observing GNT-08-11-19

¹⁷³ Filtered water seller interviews

Filtered water kiosks are also related to several off-site entities. The machines themselves are connected to the internet and banking systems for the managers to add credits whenever needed and to report if there is a change in the functioning of the equipment. The Senegalese branch of the company has international relationships with the Swiss social enterprise that provides the machines, there is a national Diam'O office in Fatick where the maintenance staff are based and the thirty or so Diam'O franchise locations in Kaolack have relationships with each other. Many of the kiosks also have owners that live outside of Kaolack.

In general, providers involved with different types of non-network sources claim to not view each other as competitive, but rather complementary. For instance, filtered water kiosk sellers said they do not see well water as competition because the product is entirely different¹⁷⁴. They noted that different people use water for different things or for different reasons, and so they are not taking business from each other. A similar sentiment was expressed by well water sellers¹⁷⁵. In addition, non-network water does not interfere with or interrupt flows of tap water. Most households with a connection to the tap water network continue to use that water for some things, so flows of water for different needs coexist. I have asserted in Chapter 6 that each of these sources and flows of water fills a specific niche around drinking water quality. Different kinds of drinking water sources exist in parallel and consumers utilise and connect to them as needed according to their requirements and preferences. So the relationships between sources are often of coexistence and complementarity.

The relations between the tap water provider and consumers can be defined as striated, in that they produce a certain kind of social space where relations are unidirectional, highly structured and limited to certain places. Non-network sources of drinking water vary in the extent to which their relations with consumers and others are striated or smooth, although in Kaolack I found that they tend towards smoothness. Filtered water, bag water and well

¹⁷⁴ Filtered water seller interview DTG-2-06-11-19 – 'Ku nekk ak wersekam' loosely translated to 'everyone has their own luck'.

¹⁷⁵ Well seller interviews WNA-1-20-11-19; WDM-2-20-11-19; WDM-3/4-20-11-19

water are sold incrementally without necessitating a formal or structured relationship between consumers, producers and sellers. Anyone can purchase these sources of water whenever they want or need to, without contracts or stable infrastructure networks; thus non-network drinking water sources encourage a smooth relational space between actors.

Traces

In this section I present some noteworthy impacts of drinking water quality assemblages on the territory of Kaolack. Drinking water quality assemblages are entangled with actions and plans that leave traces in the urban environment. These traces take the form of consequences and externalities linked to the presence of drinking water sources that fill different needs for drinking water quality.

The Senegalese state prioritises extension and improvement of the tap water network in their drinking water quality planning. This strategy has implications for Kaolack which exceed the pipes of the tap water system. Even though much of the piped water infrastructure is underground, its imprint is visible on houses and roads up to and even outside the borders of the city. One might expect to see a grid pattern in planned social housing areas¹⁷⁶ or the historic city centre, but in fact they extend almost everywhere. This grid is quite visible from above or on Google Earth (Figure 21). In part, construction happens in such a way to meet criteria for eligibility to connect to the tap water network. Qualifying for a connection requires adequate width of access roads, sufficient distance from sanitation infrastructure (at least 15 metres) and enough space between buildings¹⁷⁷. These requirements make connections in low-income or unplanned areas more challenging to obtain for consumers¹⁷⁸. Houses and streets are therefore constructed along wide perpendicular streets that reflect the needs of the infrastructure networks. New construction on the urban fringe is not yet served by the tap water network. However, beyond the boundary of where the network currently extends, several household interview

¹⁷⁶ Kaolack has two main neighbourhoods that were originally constructed as "Habitation à loyer modéré" (HLM) or public housing units for low-income residents. These are Bongré and HLM Sara.

¹⁷⁷ Law regarding the code of sanitation [Loi n° 2009-24 du 8 juillet 2009 portant Code de l'Assainissement].

¹⁷⁸ Interview, Department of Urban Planning: LK-30-07-19

respondents indicated that they are aware of these requirements for eventual connection and have constructed their homes accordingly¹⁷⁹. The owners of newly built houses even install pipes and spigots in anticipation of eventually being connected. So the state's emphasis on networked water shapes both patterns of flows and the very shape of the city as it grows.



Figure 21. Image of Kaolack from Google Earth (January 2021).

Although this grid pattern is quite visible, the existing piped water system is typically invisible unless there is a problem because the majority of water infrastructure is underground. Some authors working in infrastructure studies have identified this common pattern; infrastructure is largely invisible to most people until it breaks down (Graham, 2010). In Kaolack this invisibility extends to the maintenance access points of the tap water network. I was told that only the oldest and longest-employed staff members of SDE know where the access points are, and that current maps are missing important information.

¹⁷⁹ Household interview DM-20-11-19

Because of these gaps in institutional memory, when pipes need to be replaced or repaired this often requires digging up large portions of the street¹⁸⁰.

In contrast to the limited visibility of pipes, water towers are several stories tall, and are a distinctive feature of the urban landscape. Because most homes are a single story, it was possible to stand on the roof of the five storey apartment building where I lived and see each of the seven water towers spread across the city (Figure 22). These water towers are a visible extension of the underground infrastructure for water service provision.



Figure 22. Top image: View from the roof of my apartment building (Left arrow - water tower in Thioffack, Right arrow - water tower in Kasnack). Bottom image: View from third floor of a guest house along the national highway (Arrow - water tower in Kasnack neighbourhood). Note in both pictures the straight wide streets laid out in a grid pattern.

¹⁸⁰ Household interview MB-27-16-09-19

Planned future interventions to alter the quality of tap water in Kaolack also have the potential to impact the urban environment in multiple ways. The suggestion to build a pipeline to carry water from rural areas with better water quality into Kaolack is one example of this. Water governance and planning choices that rely on moving water from one place to another have complex implications for equity between rural and urban areas (Torio, Harris, & Angeles, 2019). For instance, water pipeline projects have been shown to be problematic because they may bypass the people living in urban hinterlands so those communities live next to a pipeline or other big infrastructure project but still experience scarcity (Hommes & Boelens, 2017; Hommes et al., 2020). In the case of large-scale treatment plants, there are also some important, as yet unanswered, questions about depletion of groundwater resources in Kaolack and elsewhere (C. Faye, 2017). It is not clear, for instance, what increased rates of extraction could mean for salinisation. Furthermore, large-scale desalination systems have been known to discharge hot salty water into nearby water bodies, causing die-offs of local flora and fauna (Boden & Subban, 2018; March, 2015). There are also concerns about the large quantities of energy needed for desalination and its environmental impact and costs (Al-Karaghoulis & Kazmerski, 2013).

Non-network sources of drinking water can also leave traces on the urban environment, though they may not be as obvious at first glance. For example, the filtration process used by reverse osmosis kiosks to improve drinking water quality produces significant volumes of briny wastewater which must be disposed of somehow. In some cases in Kaolack, wastewater from reverse osmosis enters the sanitation system and is mixed with other flows of wastewater, while in others it is dumped in the streets or even gifted to neighbours without tap water connections to use for household cleaning or flushing of toilets¹⁸¹. The Hygiene Service and Ministry of Environment worry about the potential for wastewater from filtration to contaminate tap water flows or shallow groundwater, and issue citations to filtered water sellers that do not find safe solutions for management of their waste¹⁸².

¹⁸¹ Field notes: GF/GNT conversations, 5 visits for observation and participation at Diam'O 1-NT; Multiple interviews with filtered water sellers

¹⁸² Field notes – observation at the Hygiene Service/ visit to OCAS Diam'O; Interview Hygiene Service MSH-27-07-19 and IM-19-08-19; Interview Ministry of Environment SK-01-08-19

Another source which marks Kaolack in highly visible ways is bag water. Bag water is convenient, cold and affordable, and it is also considered by many consumers to be more clean, pleasant tasting and trustworthy than tap water¹⁸³. These qualities of bag water contribute to its widespread consumption in Kaolack. Unfortunately, waste management for the large volumes of plastic associated with bag water is lacking. Consumers typically bite off a corner of the package, drink the water and drop the empty bag onto the ground. No area of Kaolack is immune to the constant presence of empty plastic bags blowing in the wind and blocking drainage canals (Figure 23). So even though bag water flows through the city in provisional and always changing ways, it leaves marks on the urban landscape in the form of the empty bags that are left behind.



Figure 23. Empty plastic bags blocking a drain after heavy rains in Kaolack

Some sources of drinking water leave traces that striate the space of the city while the traces of others can be heterogenous, unevenly distributed and smooth. For example, tap water modulates space into a long-lasting grid pattern, striating the space of the city in long-term and stable ways dating back to the colonial period. It also shapes the broader patterns of

¹⁸³ Household interview question 29 – with exceptions, some people do not trust bag water at all due to suspicions about its origins and hygiene

the city into wide streets set at right angles, and visible water towers dominate the urban landscape. Even the more flexible non-network flows of drinking water in Kaolack leave some traces behind. Though the water itself passes through a smooth space of ephemeral networks and channels that shift as needs and relations change, these flows leave traces. The patterns, relations and traces I have presented thus far have affects within and beyond the socio-material territory of Kaolack. They impact on inequality of access to water and exposure to harm, thereby entangling drinking water quality assemblages and access practices in ethical matters.

Ethics, affects and inequalities

In this section I describe the ethical implications of what drinking water quality assemblages do. As I have shown in this chapter, drinking water quality assemblages are mutually imbricated with patterns, relations and traces in the territory of Kaolack in ways that contribute to its smoothing and striation. Drinking water assemblages occupy and are formative of physical and social territories, with implications for how people access drinking water or are exposed to harmful things in water. These affects associated with drinking water quality assemblages are unevenly distributed across the urban landscape. Some affects are positive for involved parties, while others are negative. In line with the definition of ethics in assemblage theory, it is therefore possible to assess the ethical dimensions of drinking water quality assemblages. Ideally, ethical planning and governance of drinking water quality would take note of these dimensions associated with the diverse and changeable assemblages in a territory and work to maximise the positive affects.

The physical patterns of drinking water circulating through Kaolack mean that each type of water naturally reaches some people and excludes others. In the case of tap water, the patterns of water flows are quite limited to the grid pattern laid out by the state, a clear example of striation. The tap water network stops at the edge of the city and people who live outside the municipal boundaries do not have a chance to receive in-home access to

water¹⁸⁴. In areas that are covered, only those with adequate financial resources are able to exit the piped water network or customise their drinking water. Thus the state's decision to prioritise access to tap water over other sources of water – in its current condition - can lead to ongoing exposure to fluoride and excessive quantities of salt for the most vulnerable people in Kaolack. In the future if plans to improve tap water are successful this may no longer be the case. In the meantime, perhaps an ethical action to improve such a situation would be to support the capabilities of all residents to afford drinking water of their choosing, through price subsidies or financial assistance. The negative affects of harmful things in drinking water often land on those who are already marginalised, as do the costs and burdens of knowing about drinking water quality and adapting.

In addition, the lasting impacts drinking water quality assemblages and their associated actions (or intended actions) have on a territory include the physical traces they leave behind on space via infrastructure and also waste. The burdens from water treatment and transport tend to accumulate around the periphery of Kaolack, where many people dump their solid and liquid waste. The same can be said for the plastic bag waste from bag water, which is both visually unappealing and can block drainage canals, encouraging flooding and providing an ideal breeding ground for malaria-transmitting mosquitos. Here again, the negative impacts of responses to drinking water quality assemblages typically impact people who are already living on the margins of society.

Drinking water quality assemblages also affect people emotionally. This accords with growing awareness in geography and political ecology of the uneven distribution of emotional challenges associated with water insecurity (Sultana, 2011, 2015; Wutich, Brewis, & Tsai, 2020; Wutich & Ragsdale, 2008). Household interview participants described a range of emotions relating to drinking water quality. Several people referred to feelings of embarrassment if they had to offer tap water to guests, and disappointment

¹⁸⁴ This issue is most present at the northern edge of the city. To the East is a small village named Kahone that is gradually merging with Kaolack as both grow. Similarly to the West there is a village called Koundam which is now essentially a neighbourhood of Kaolack, and then the salty tannes which are not suitable for houses. The southern border of Kaolack is the river.

about Kaolack's reputation for unpleasant drinking water¹⁸⁵. Others felt shame about their dental fluorosis or the state of their children's teeth. In a few cases interview participants pointed at my research assistant's teeth to illustrate their points about tap water quality, making her visibly uncomfortable¹⁸⁶. Some consumers described feeling frustrated about the rising cost of tap water which has not been accompanied by improvements in quality or consistency. I also discussed with a few acquaintances that other cities in Senegal have treatment plants, and that the technology exists to remove salt and fluoride from Kaolack's tap water. These people became upset because they had not realised that water treatment at that scale was possible and felt misled by the government¹⁸⁷. Much like the financial and time costs of seeking out alternative drinking water or illness caused by hazards in drinking water (Rusca et al, 2017), emotional costs of poor water quality are not evenly distributed across the population.

Shifting relations between people and things also change who and what is drawn into drinking water quality assemblages, with implications for ethics. Rural areas may profit from selling their water in bags, but may not be compensated for water extracted by the state in a pipeline project. The ecosystems of these rural areas may also experience falling aquifer levels due to the rapid extraction of groundwater. Therefore, what began as a net positive relation for those communities can be changed into a negative affective relation by the actions the state takes to improve urban drinking water quality. The particular drinking water quality challenges that face Kaolack exacerbate these issues and inevitably impact people and environments.

Another drinking water relation with implications for ethics is the one between consumers and providers. The distributional impacts of commodification and privatisation of drinking water services have been discussed at length elsewhere and will not be my focus here (See Bakker, 2003 for a seminal example). However, I will point out that commodification of water has been linked to shifting positions of individuals relative to the state, as people are

¹⁸⁵ Field notes TB-11-05-19; Field notes MD, MNB, FB, MF

¹⁸⁶ Household interview notes, usually question 39

¹⁸⁷ Field notes AN-26-06-19; TD-19-11-19

transformed in the eyes of their water provider from citizens into customers (Jepson & Brown, 2014). This shift can have implications for who are seen as citizens bearing the right to water and how it may be possible to exclude or decline to serve some people – usually the poor or people who live on the margins of society (Anand, 2017). Budds & McGranahan (2003) note these debates on privatisation might be “missing the point” in the face of the diverse ways people actually access drinking water.

Debates on privatisation often assert that privatisation may be incompatible with the human right to water, but this is not necessarily the case (Bakker, 2007). The UN special rapporteur on the human right to water takes the position that paying for water is not problematic in terms of realising the human right to water (de Albuquerque & Roaf, 2012; J. Grönwall & Danert, 2020). Also in their view, direct provision of water by the state to citizens is a last resort when individuals or communities are reasonably unable to meet their domestic and consumptive water needs for themselves (de Albuquerque & Roaf, 2012). The first responsibility of the state is not to disrupt or interfere with existing flows, including traditional or customary service arrangements (J. Grönwall & Danert, 2020).

This interpretation of the human right to water indicates that the state has specific obligations regarding water quality. The state first has a responsibility to facilitate laws and regulations that protect water quality. The state should also promote awareness and education with regards to drinking water quality (J. Grönwall & Danert, 2020). This duty can refer to helping people differentiate between potable and non-potable water, capacity building and sharing of information, because most people do not reasonably have the ability to determine all aspects of drinking water quality that are relevant for health without assistance (J. Grönwall & Danert, 2020). In addition, the human right to water does not only refer to water for drinking, but also domestic use (it excludes productive use in its current form) (de Albuquerque & Roaf, 2012).

Focusing exclusively on drinking water quality is a moment of transcendence which can obscure the importance of multiple uses of water, with important implications. For example, I described earlier in this chapter how the Hygiene Service might decide to block

people from using a well because bacteriological contamination has been detected. They then stop all use of water from that well, even though not all of the well's water would have been used for drinking. As a result, the people who rely on that water have an increased burden of finding water for other domestic uses (which often falls on women). Additionally, studies have shown that in terms of public health, handwashing is the most effective intervention to prevent diarrhoeal disease so in some cases having enough poor quality water is better than having good quality water but not enough (Grönwall et al., 2010). Stopping access to a well can counterproductively make household hygiene practices more difficult and increase risk of exposure to diarrhoeal disease instead of protecting citizens.

As shown throughout this chapter, drinking water quality assemblages do quite a lot, some of which is negative and some of which is positive. Assemblages of drinking water quality make it possible for the state or others to assess water and decide what kind of use it would be appropriate for. The state's planned activities are intended to improve water access and quality for citizens, and though these actions can be critiqued for their limitations they are likely better than nothing. However, we should not lose sight of the fact that there is potential for drinking water quality assemblages to do things that are harmful or promote inequalities. I return to some limitations of immanent perspectives on drinking water quality in Chapter 9 when I turn in a speculative direction and discuss some potential ways to strive for more ethical drinking water quality governance.

Concepts for heterogeneous drinking water access

Thus far in this chapter I have described the heterogeneity of how people access water in Kaolack, how this heterogeneity relates to drinking water quality assemblages and what the implications are for ethical drinking water quality governance and planning in Kaolack. Specifically, I describe each method of water provisioning as processes that are always in a process of becoming and I consider drinking water quality assemblages among many immanently causal actors that potentially influence peoples' ability to access water or exposure to harmful things in water. Descriptions of coexistence of multiple drinking water provisioning modalities, such as I have described in this chapter, are not new to studies of

everyday urbanism and critical infrastructure studies. A proliferation of studies have reacted against a longstanding focus on piped water in geographical literature wherein other ways of accessing water were seen as aberrations (Jaglin, 2004). This focus masked the fact that in many cities piped water access is limited, and only analysing tap water (or its absence) hides the extent of diversity of how people meet their needs (Jaglin, 2004). Calls for decentring or worlding analyses of water access and supply have grown out of a growing acknowledgement of the multiplicity of everyday access practices of water users, especially in the Global South (Furlong & Kooy, 2017). Scholars engaging with the actually existing heterogeneity of how consumers access resources, in the Global South and elsewhere, have named and discussed such multiplicity in a variety of ways.

Several common concepts or terms are used to describe the ongoing coexistence of different modes of accessing water. These include: splinters (Graham & Marvin, 2002), fragments (C. McFarlane, 2018), archipelagos (Bakker, 2003), meshworks (C. McFarlane, 2012; Schwartz et al., 2015) and grey spaces (Truelove, 2019). Graham and Marvin (2002) coined the term “splintering urbanism” to refer to how infrastructure reaches into and fragments the city in different ways. The idea of splintering urbanism opened new pathways for research in urban studies on the impacts of infrastructural failure and the alternative service modalities that fill the gaps. For instance, McFarlane later considered the fragments themselves (products of the fragmentation Graham and Marvin describe). He describes the ways diverse residents of cities gather together the pieces they need to make provisional wholes and meet their needs (C. McFarlane, 2018). Residents can also create fragments themselves, or even act as extensions of the infrastructure network (Simone, 2004).

However, there are important critiques of the splintering urbanism concept, not least as it pertains to infrastructures in the Global South. For one, the metaphor of splintering implies a directional fragmentation of infrastructure from a whole into parts. In many cities in the Global South, there has never been a uniform network of infrastructure from which to splinter (Coutard & Rutherford, 2015; Furlong, 2014). In addition, splintering also conjures up images of sharp, hard edges and clear separations between spaces that are or are not covered by networks of infrastructure. Schwartz and others (2015) raised similar concerns

about Bakker's (2003) archipelago concept. They argued that archipelagos portray a clear boundary between islands of network access and the sea of everything else. What I encountered in Kaolack was also more flexible, overlapping and shifting than either the metaphors of splintering or archipelagos.

In addition, concepts like splintering and fragmenting seem to express a normative inclination towards tap water as the proper way to achieve universal access to good quality water. An associated critique has emerged of the "modern infrastructure ideal". Critics argue that uniformity and universality should not necessarily be the goal considering the prevalence of existing heterogeneous infrastructure configurations (Budds & McGranahan, 2003; Coutard & Rutherford, 2015; Lawhon, Nilsson, Silver, Ernstson, & Lwasa, 2018; Truelove & Cornea, 2020). Heterogeneity's purported benefits include redundancy and mitigation of risk (Lawhon et al., 2018). However, serving different populations with varied service modalities can perpetuate existing inequalities in access and exposure (Boakye-Ansah et al., 2021). There are concerns that heterogeneity leads to lower income households paying more for lower quality water (Robak & Bjornlund, 2018) and it can be difficult to coordinate and regulate a heterogeneous mix of delivery configurations (Coutard & Rutherford, 2015; Jaglin, 2014). Providers of tap water tend to be the most organised and therefore have the most power to channel resources to themselves, while alternative service modalities do not have coalitions representing and advocating for them (Jaglin, 2014). Policy is changing in many cases to be more inclusive and pragmatic about what is already there, for example with the WHO recognising bag water and delivery of water from safely managed sources as adequate forms of access (WHO, 2017b; WHO & UNICEF, 2017). And yet, recognising or formalising multiple modalities does not always or inherently improve the situations of the most marginal members of society in terms of their access to water or exposure to water of poor quality.

Categorising sources as either formal or informal is another widespread way of approaching differences between types of service provision. Informality is often used as if it were synonymous with non-network sources of water, or with a connotation of poverty or lack of development associated with particular spatial locations like slums or peri-urban

areas (Kooy, 2014). The label of informality is also sometimes extended out to include things like water storage, rainwater collection and water sharing (Burt & Ray, 2014; Zug & Graefe, 2014). Two streams of literature on informality can be identified (Ahlers, Cleaver, Rusca, & Schwartz, 2014). The first assumes a strong dichotomy between formal and informal defined in relation to the state and legality (Ahlers et al., 2014). Formal is inherently understood to be more desirable in this stream. The second stream represents a more critical approach, where informality is seen as a fluid, normative and relative position that can be mobilised by the state to delegitimise practices outside their bureaucratic purview (Ahlers et al., 2014).

Empirical analyses have also shown that non-network sources of water are not only responses to the network failing to do what it is supposed to do. Service modalities are entangled along a spectrum of formal and informal and at different instances can incorporate aspects of both (Ahlers et al., 2014; Jaglin, 2014). Formality and informality may actually be considered different moments in the same supply chain (Schwartz et al., 2015). Even high-income households may use a mix of formal and informal processes to get what they need (Schwartz et al., 2015). Demand to extend capabilities beyond the central infrastructure system comes both from the rich, with resources to improve mediocre services for themselves, or from the very poor, who are not connected and have no choice but to seek out alternative sources (Jaglin, 2014).

Formal and informal sources of water continue to coexist, even within households and regardless of whether or not there is a functioning system of piped water (Burt & Ray, 2014). Use of non-network water does not automatically disappear when taps are installed (Meehan, 2013). In addition, contrary to perception of informal networks as chaotic or unstructured, they can be very organised (Bakker, 2003; Myers, 2011). The quality and potability of formal sources is also not inherently superior to informal sources. Therefore, scholars increasingly argue against the ubiquity of the dichotomy between formal and informal, instead highlighting the characteristics of water provisioning systems as meshworks (C. McFarlane, 2012; Schwartz et al., 2015), hybrids (Furlong, 2014) or grey zones of overlapping legal and illegal sources of water (Truelove, 2019). In Kaolack, non-

network sources fall under a different framework and monitoring regime than tap water, but they are not illegal. This further challenges the positioning of informality as synonymous with illegality and the applicability of such binaries in Kaolack.

Each of these terms contains assumptions including normative orientations towards what kinds of access are preferable and ideal solutions. In addition, the majority of these concepts for infrastructural heterogeneity include some kind of binary: formal and informal, fragments and wholes, connected or disconnected. Formal and informal especially are accompanied by normative assumptions and preferences for state-mediated access to water as legal, safe and potentially more affordable. Such notions further include biases about who is considered deserving of access to formal infrastructure (Kooy & Bakker, 2008a, 2008b). Analyses highlight that urban water supply is neither characterised solely by the centralized piped network nor the absence of pipes; it is a system comprised of a range of practices and different waters including wastewater, flood waters, drinking water and more (Furlong & Kooy, 2017).

One recent concept that takes the focus off the piped water network is heterogeneous infrastructure configurations (Lawhon et al., 2018). Heterogeneous infrastructure configurations as a conceptual framing highlights the materiality and vitality of diverse socio-technical configurations through which services are delivered (Lawhon et al., 2018). This approach further distances itself from normative centring of piped water networks to open up consideration of the viability of alternative service modalities. Advances from such perspectives have led to a growing number of studies grounded in thick description of the everyday practices of water users (Lawhon et al., 2018). This brings some nuance to the conversation about drinking water access beyond and in addition to piped water by showing how consumers navigate changing flows of water in their surroundings (Peloso & Morinville, 2014).

I have now shown that there are multiple concepts available to discuss heterogeneity in drinking water access practices, each with their own strengths and oversights. Though theoretical engagements have begun to explore the socio-material complexity of how

people obtain water, I argue that there are still some normative assumptions and gaps that limit their broader applicability. Furthermore, as I demonstrated in Chapter 2, for the most part drinking water quality is underrepresented in these debates. Also, while many of these concepts from the literature are descriptive, the concepts of smoothing and striation are more analytical.

Smoothing and striating: alternative spatial concepts from assemblage theory

I conclude by returning to the concepts of smoothing and striation that I have applied in this chapter. I argue that these concepts could potentially offer new insights to the crowded field of concepts representing heterogeneous access practices for drinking water in the Global South by conceptualising what drinking water quality assemblages do in relation to territories of drinking water access. Smoothing and striation offer a way to consider links between the social, material and spatial aspects of drinking water quality assemblages, providing space to understand what drinking water quality assemblages do, more than simply what they are.

First, parallels between striation and the modern infrastructure ideal are evident. The modern infrastructure ideal represents a transcendent interpretation of what is good and right external to the realities of a situation. The assumptions of the modern infrastructure ideal thus block creativity and experimentation by making it appear that expanding the tap water network is logically the correct answer in all cases (Nilsson, 2016). As established in Chapter 3, Deleuze and Guattari promote an ethics of immanence wherein solutions are assessed based on individual situations. The metaphors of smooth and striated space therefore draw attention to the ethics of planning for drinking water systems.

Smoothing and striation are also tendencies, not types. This distinction is important because Deleuze and Guattari are not asserting a binary between two different kinds of spaces. Therefore smoothing and striation are more similar to the ideas of meshworks or grey spaces than to the more rigid boundaries between formal and informal or fragments

and wholes. Such a perspective also impacts on analysis. For instance, Ranganathan (2015) attributes flow to some things (stormwater, capital) and fixity to others (social order, infrastructure). The continuity between smooth and striated spaces challenge this assessment and maintains that all entities are in motion, just motion that is itself more free or constrained. So the tap water network may have a greater tendency towards stability than non-network sources, but disrepair, changes in water quality and disrupted flows all demonstrate that pipes are still not entirely fixed.

Finally, agency is located differently in various conceptual understandings of infrastructure, which shapes the way analysis happens and the kinds of conclusions that are drawn. In some interpretations agency seems to belong to the state, and heterogeneous forms of access are a result of state failure. In others the technologies themselves are agents of change. In still others agency comes from “below” through practices of consumer adaptation and compensation. In assemblage theory agency can potentially come from anywhere or anything. Agency emerges through assemblages and must be discovered and mapped contextually.

While existing concepts for understanding the complexity of how people actually access water in the Global South each offer something different to analysis, many of these concepts are what Lawhon and others (2018) refer to as performative descriptions of what is there. An assemblage theory approach pushes analysis past asking what heterogeneous infrastructures are (fragments, splinters, fixed, flowing) and adds sensitivity to what they do. Accessing and provisioning water are processes, and in my analysis, drinking water quality is an assemblage which is made and remade through practices. One of the benefits of seeing all these processes as ontologically equivalent in assemblage theory is that we can ask how assemblages interact as they are articulated and produced in different sites and scales (DeLanda, 2006).

Considering the capacities and tendencies of drinking water quality assemblages towards smoothing or striation during analysis thereby provides insights into the connection between assemblages and their associated traces, relations and patterns in material and

social space. These insights go beyond the fact that the metaphor of striation fits well with the grid patterns associated with piped water networks. Thinking of these sources as varying in their tendencies keeps analysis open to ongoing potential for change. Further, rather than focusing on one type of source or another, it can be helpful to consider these sources as belonging to multiple overlapping systematising networks. Such a focus highlights that sources of water are inextricable from assemblages of drinking water quality, as are their impacts. Therefore instead of fixating on tap water or its absence, I considered how alongside striated state spaces, smooth space continues to exist and proliferate, changing patterns of relations and possibilities for drinking water quality and access in the city.

Deleuze and Guattari encourage us to explore the limits of smoothness but warn not to cast off striation all at once. As they repeatedly emphasise, there is nothing inherently preferable about smoothness over striation (Deleuze & Guattari, 1987, p. 581). The implications have to do with how people tasked with planning and governance of drinking water resources respond. For drinking water quality and access I have identified benefits to both ends of the spectrum. There is nothing inherently wrong with tap water, just as there is nothing inherently right about bag water. The question is: what are they causing to happen in context and is this overall better or worse? For example, heterogeneity has benefits for choice, customisation and redundancy. However, if too many people exit the tap water network it may become unprofitable and defunct. Therefore water may not arrive to the vulnerable people who need it because the utility does not have enough money to continue.

As I have now established through these findings chapters, drinking water quality assemblages are fluid and always have the potential to change. Therefore, responses may need to reflect shifting territories of access and exposure. An open ended approach to governance and planning of drinking water resources which asks “what works here?” instead of applying ideals of best practice complements this understanding of quality. I will expand on the ways an immanent ethics of drinking water quality changes how planning and governance could potentially respond to drinking water challenges in the concluding chapter.

Chapter 9. Conclusion

Throughout this dissertation I have established that drinking water quality is a complicated socio-material phenomenon which challenges theoretical frameworks and relatedly poses distinct problems for governance of both water quality and supply. Over the course of this chapter I elaborate the main conclusions that emerged from my research and situate these in terms of their contributions to current debates. I reflect on what turning my gaze to as yet understudied topics, places, concepts and perspectives has contributed to understanding the complexity and multiplicity of drinking water quality. I also point ahead to future avenues of research in light of my findings. To close, I build on the empirical and ethical discussions in the findings chapters to further consider the implications of drinking water quality assemblages for ethical drinking water quality governance. This discussion of the potential for an immanent ethical evaluation of drinking water quality governance represents the final main contribution of the thesis.

Three entangled strands of inquiry: theoretical, empirical and philosophical

The questions I laid out at the beginning of the thesis were framed as theoretical, empirical and philosophical. While these three strands of inquiry are distinct in some ways, they are axiomatically deeply entwined parts of the thesis. The theoretical framework of assemblage theory influenced analysis of the empirical findings and produced distinct insights. The empirical uniqueness of Kaolack pushed me to develop the theoretical framework to uncover what parts of the ontology and which concepts were most applicable for drinking water quality. At the end of each findings chapter, I explore what ethical implications assemblage theory analysis has made visible and reflect on the potential for more ethical drinking water quality governance. These reflections are rooted in the ontology of Deleuze and Guattari. In the following sections I present the principal theoretical and empirical contributions of the findings chapters. Building on these contributions, the thesis concludes with a return to the final research question and philosophical consideration of the implications and importance of my findings for ethical drinking water quality governance.

Empirical contributions: topic, methodology and case study site

The three empirical contributions of this dissertation pertain to the selection of the topic, methodology and case study site. First, this thesis has contributed to addressing the dearth of social science research on drinking water quality relative to access and scarcity (see Chapters 1 & 2). I place the topic of drinking water quality at the centre of my enquiry and contribute a unique perspective on drinking water quality as an emergent more-than-physical and more-than-social phenomenon. Drinking water quality appears in my research as a multifaceted core aspect of water security distinct from access in ways that have escaped much of the existing literature on urban drinking water systems, particularly those that assume some level of homogeneity within and between networked households. An assemblage theory perspective encourages asking how it became possible for a certain form of drinking water quality assemblage to be dominant, thus perpetuating distributive and representational inequalities.

Second, I rely on multiple methods and scales of investigation to explore how drinking water quality is assembled both within and outside the state. Social constructivist approaches to water quality at the level of laws and policies (Bouleau, 2006; Bouleau & Pont, 2015) may under-represent the degree of difference between the state and consumers. Interfaces between rationalities of actors focused on governing and those focused on survival are an understudied but potentially fruitful area of inquiry (Watson, 2009). Assemblage theory brings difference and the interfaces between assemblages to the foreground and encourages us to consider multi-scalar relations which are more “rhizomatic” than top-down or bottom-up. There are constant interactions and transformations occurring between assemblages and between elements in those assemblages. Thus my use of a range of methods including ethnographic-inspired observation and participation, interviews and document analysis allowed for sensitivity to how drinking water quality is relationally assembled by human and non-human actors and emerges out of practices. I was further able to consider drinking water quality at multiple scales within the city and follow interesting leads wherever they took me. While perhaps some depth of understanding was lost by not honing in on one area or level of assemblage,

this grounded approach allowed me to develop a broad perspective on the dynamics of drinking water quality assemblages throughout the city.

Third, my research is situated in a medium sized African city which is a context that has received limited attention from social science researchers. In Africa, the majority of population growth is predicted in small and medium sized urban centres, which are so far underrepresented in much research on cities (Satterthwaite, 2021). Furthermore, there is a long history of theory being developed in Europe and North America and used to explain phenomena elsewhere rather than attending to the specificity of non-Western contexts (Lawhon et al., 2014). Thus there are calls to recognise existing knowledge traditions and to ground theoretical engagements in ordinary cities of the Global South (Robinson, 2013). My thesis contributes to addressing these gaps by basing development of theory in a secondary city. I show how even within Senegal, Kaolack is not just a smaller version of Dakar, but a unique social and hydrological context. This degree of difference can disrupt ideas of best-practice solutions to drinking water quality as a technical problem.

Application of an assemblage ontology

One strength of this study is its strong parallel engagement with empirical and theoretical angles. In this section I present the core contributions and conclusions from each of the findings chapters and reflect on how the empirical and theoretical components of the research drove each other forward. I drew on extensive and detailed empirical data to inform analytical perspectives on drinking water as both more than social and more than material. Using a range of ethnographic-inspired qualitative methods, I investigated how drinking water quality assemblages take shape and explored the implications of those assemblages for distribution of and access to safe and sufficient drinking water. For the theoretical framework of the dissertation I engaged with assemblage theory ontologies to foreground the heterogeneity, multiplicity and ongoing becoming of drinking water quality. I also selected concepts from assemblage theory that can potentially help to understand the complex relationships between social and material elements of drinking water quality. The encounter between these empirical and theoretical projects both helped me to understand

and explain what drinking water quality is and does in Kaolack, and to advance the practical applicability of my chosen interpretation of assemblage theory.

Recognition of the extent to which certain social elements are interwoven with the materialities of drinking water quality is an important contribution from an assemblage perspective which sets it apart from social constructivism, ANT, the natural sciences and urban political ecology (See Figure 2, Chapter 2). The assemblage approach I develop in this dissertation provides one way to address some of the gaps in each of these perspectives by showing that drinking water quality emerges from many different directions (Chapters 2 and 3). There are therefore multiple possible angles from which to approach drinking water quality problems. This multiplicity and potential is a recurring theme throughout the findings chapters.

In Chapter 6, I use the concept of abstract machines to show how, given the same set of possible components, different assemblages can lead to divergent understandings of drinking water quality that may be in tension. Abstract machines comprise the drivers and problem framings of multiple actors in coexisting assemblages and can help to explain their similarities and differences. Therefore, assemblages can be driven by variable understandings of what kind of problem drinking water quality can be, what exactly is problematic about drinking water quality and who is responsible for knowing about and responding to drinking water quality problems. The value added from an assemblage theory approach is that the focus remains on multiplicity, transformation and multi-level interaction.

In addition, the concept of abstract machines allows analysts to consider multiple actors and perspectives on social problems. For instance, state actors, service providers and consumers encounter the same physical environment in Kaolack. Despite this, the Senegalese government and SDE consider tap water to be adequate while consumers find it unsatisfactory and in some cases undrinkable. This is possible because the abstract machines of the State Assemblage and Consumer Assemblages of drinking water quality are driven by diverging principles and understandings of drinking water quality. In Kaolack the

Global Health and Senegalese State assemblages construct drinking water quality as a technical, solvable problem primarily limited to measurable quantities of substances in water with direct impacts on human health. This implicates experts in the knowing of drinking water quality and necessitates particular kinds of large-scale, long-term and uniform solutions. On the other hand, Provision Assemblages and Consumer Assemblages view drinking water quality as a problem with immediate consequences particular to individual circumstances.

Considering the abstract machines of multiple assemblages, rather than just focusing on the problematisations of the state, highlights how drinking water quality is not a monolithic or straightforward entity. It also draws our attention to the labour and power required to maintain a certain view of drinking water quality problems and solutions. Finally, describing the abstract machines of multiple assemblages that may be in tension reopens the question of how drinking water quality could be different, as could responses to drinking water quality problems.

In Chapter 7, I show how heterogeneous material and social elements are variously enrolled in drinking water quality assemblages. The content of assemblages is always context-specific because drinking water quality varies spatially, temporally and amongst actors. I also describe how the inclusion and exclusion of various elements in drinking water quality assemblages can allow certain potential elements to escape from the State Assemblage of drinking water quality. The state practice of locating drinking water quality in pipes, at or before the point of sale, can obscure heterogeneity within households or over time. Conflation of access and quality can draw attention towards connectivity to networked sources and away from the embodied experiences of consumers. Similarly, the somewhat arbitrary distinction between potability and quality can create a hierarchy between microbiological and physiochemical substances in water that deprioritises certain long-term health impacts. For example in Kaolack, I found that the distinction between potability and quality made by SDE facilitates claims about drinking water quality which give precedence to short-term affects from microbiological contamination and minimises the long-term consequences of exposure to fluoride and salt in drinking water.

In addition, the exclusion of certain knowledges from drinking water quality assemblages can impact on participation and representation of actors. Prioritisation of expert over lay knowledge prevents consumer voices from being heard in assemblages of drinking water quality. In Kaolack the Senegalese State, Global Health and Everyday Governing Assemblages are all strategically arranged in ways that block consumers from meaningful contestation by positioning their knowledges and perceptions as less valuable or true than expert knowledge. This position is supported by the emphasis on measurement by the state. In contrast, outside of the state, and even for actors in the Everyday Governing Assemblages, qualitative indicators like taste are key factors in decision making.

One could perhaps do similar analytical work by considering drinking water quality as a “black box”. Black boxing is an idea prevalent in STS wherein a shared understanding of a concept becomes so ubiquitous that the components making it up are essentially invisible (Latour, 1999). Assemblage theory relatedly unpacks the components in an assemblage (or network), while further encouraging questions about how relations came to be structured this way, who benefits from them being stabilised in such a way and how things could be different (C. McFarlane, 2011a). This approach therefore brings to the foreground considerations of inequality and power.

In the third empirical chapter, Chapter 8, I consider how drinking water quality assemblages constitute and interact with material and social territories in Kaolack. I show how drinking water quality assemblages affect residents of Kaolack in terms of their access to safe water and exposure to harmful substances in drinking water. Throughout this chapter I describe the processes by which the negative affects of drinking water quality assemblages tend to fall on already marginalised groups in the form of costs and burdens of knowing and adapting to drinking water quality problems.

I further link the drinking water choices of consumers, providers and the state to patterns, relations and traces within the socio-material territory of Kaolack. The actions and intentions of these actors shape flows of water through the city that are more or less structured, and the broader morphology of the city reflects these flows. This is in line with

some arguments in critical infrastructure studies that show that recipients of urban services are not passive recipients of water, but rather active agents that shape their surroundings according to their needs (Furlong, 2010). The wide grid patterned streets of Kaolack, even in informal areas, reflect the requirements of (planned or existing) networked drinking water infrastructure. Additionally, drinking water quality assemblages can structure and be structured by patterns of relations within and beyond the city, for instance by increasing flows of water from areas of “good” quality to those with “bad” quality or connecting households within neighbourhoods in archipelagos of high quality filtered water.

To analyse the ways drinking water quality assemblages act on and interact with social and material territories in Kaolack I employ the Deleuzoguattarian concepts of smooth and striated space. I argue that these concepts draw attention to the complex relations between social and material elements in ways that escape other current frameworks for understanding heterogenous ways of accessing drinking water. For instance, I show how the Senegalese state uses striated space, in the form of networked water and rigid assemblages of drinking water quality, as a tool of governing. In the meantime, smooth spaces associated with non-network flows of drinking water continuously escape and exceed the State Assemblage. Even though Deleuze and Guattari express concern that striated space can be oppressive, they also acknowledge that going too far into deterritorialization can have negative consequences (Deleuze & Guattari, 1987). Similarly, the point of describing smooth and striated spaces in Chapter 8 is not to vilify striated space and advocate for smooth space, but to show that something always that escapes the striating processes of the state. As with Chapters 6 and 7, in this chapter assemblage theory provides makes visible more moments to consider the ethics of drinking water quality governance.

Immanent ethics and drinking water quality governance

Throughout the thesis, I consider an often-overlooked and potentially powerful aspect of Deleuze and Guattari’s philosophy, that of the ethical (Buchanan, 2011; Frichot, 2012). In

my thesis the third research question turns to the implications of drinking water quality assemblages for governance. In this section I continue to draw out key findings from my current work. I also consider the normative and ethical implications of my findings and assume a more speculative stance, asking, what might these conclusions mean going forward?

In Chapter 3 I established that immanence and positive affects are two entangled parts of a Deleuzoguattarian ethics. We can therefore evaluate a particular action based on whether it encourages positive affects and relations within a system. An immanent approach to drinking water quality governance encourages positive affects through experimental and open-ended responses to problems, while transcendence orients our actions towards an arguably unreachable destination thereby limiting our options. Through my engagement with literature on drinking water quality and experience collecting and analysing data about drinking water quality in Kaolack, I have identified three core moments of transcendence which seep into drinking water quality planning and governance. The first moment of transcendence concerns the concept of drinking water quality. In Chapters 6 and 7 I showed how drinking water quality is a complex multiplicity assembled through practices, and yet in many cases is treated as if it were a transcendent, externally determined ideal. The second moment is the positioning of water for drinking as the central water quality problem, and the third refers to assumptions about how drinking water quality can or should be achieved. I identified and discussed the second two moments in Chapter 8. In this section I return to each of these three transcendent moments, describe their links to affects and speculate about how drinking water quality governance could become more accommodating of plural perspectives to promote an ethics of immanence.

Drinking water quality as transcendent ideal

The first moment of transcendence in much drinking water quality governance is the reification of drinking water quality as a transcendental ideal. An objective or perfect version of water quality is widely assumed to exist in the form of a most clean and pure state of water achievable by technical means (Berry et al., 2018). In actuality, drinking

water quality is something that is negotiated based on politics, finances and availability of certain kinds of equipment as much as human health and well-being (Cisneros, 2018). Determinations about drinking water quality include multiple knowledges and perceptions, trust in providers, taste, smell and appearance of water, alongside aspects like price, distance from point of use and consistency (de França Doria et al., 2009). While the goal of maximizing positive affects means striving for a situation where the things in water are only those which do good things in your body, what constitutes a positive affect will not be the same for all people, and may mean different things for the same person over time. Therefore, drinking water quality is anything but a universal transcendent ideal that can be ascertained simply from the essential characteristics of things in water. Drinking water quality is an idiosyncratic and ambiguous multiplicity made up of heterogeneous elements and relations. I demonstrate this in Chapters 6 and 7 by showing that multiple coexisting assemblages of drinking water quality are driven by different abstract machines and made up of always shifting patterns of relations between social and material elements.

The transcendence of drinking water quality as an ideal includes assumptions about how quality may be known and by whom. While there can be overlaps between what would be included in a transcendent or immanent understanding of drinking water quality, one is generally rigid and closed while the other is flexible and open. Politics and power shape what becomes a transcendent understanding of drinking water quality. The idea that drinking water quality is objective and knowable solely by experts obscures nuance and struggles over what is included or excluded from drinking water quality governance (Berry et al., 2018). Uncertainty permeates decision making about where thresholds should be set, whether impacts are acute or chronic and what the range of impacts can be from exposure to particular things in water (Damania et al., 2019). Furthermore, state actors and experts commonly exclude or minimize consumer knowledge about drinking water quality. This disparaging of non-expert knowledge prevents consumers' claims about their drinking water from being considered legitimate. Thus consumers have a limited ability to influence discourses about the quality of their drinking water, possibly contributing to many people being exposed to harmful substances for years. I showed in Chapter 7 that such processes are at play in Kaolack, and in the WHO Guidelines for Drinking Water Quality (2011).

Leaving aspects of water quality that are relevant to consumer acceptability, like taste, smell and appearance, out of drinking water quality assessments (or including them but in a subordinate role) can also cause negative affects in the form of feelings of marginalisation and lack of recognition.

Rejecting this form of transcendence in favour of what could be termed immanent ethical drinking water quality governance would maximize the potential for all participants to positively affect and be affected by drinking water assemblages. An understanding of drinking water quality as a multiplicity open to transformation could facilitate better communication between the state and consumers by allowing consumers a meaningful role in affecting the state drinking water quality assemblage. As I have shown in this thesis, in Kaolack the state participates in a rigid assemblage of drinking water quality which is associated with similarly rigid material and social spaces and exclusion of consumer knowledges. Consumers on the other hand are associated with embodied and experiential assemblages of drinking water quality which exceed and escape the processes of the state. All actors should have equivalent and transparent access to knowledges about drinking water quality, and perspectives and desires of a broad range of actors should be included. In moments where there are conflicting perspectives about drinking water quality the best case scenario would involve reaching a consensus without demeaning anyone's point of view. Given the challenges of reaching consensus in a world of deep difference, if there cannot be agreement there should at least be space for recognition and coexistence (Bignall, 2010; Watson, 2006).

Understanding that there can be multiple ways of knowing about drinking water quality can improve governance and planning by preparing practitioners for the likelihood of unanticipated responses to actions based on alternative (ie. non-scientific) perspectives. For instance, consumers have been known to surprise planners by exiting the piped water network because they do not agree with the assertion that tap water is better than other alternatives (Kjellén, 2006). Similarly, in Kaolack the staff of SDE expresses frustration

about consumers rejecting tap water despite their efforts to keep it clean and safe¹⁸⁸. In an immanent ethical approach to drinking water quality governance this difference would not be seen as a roadblock or source of frustration, but rather an opportunity for expanding the assemblage. An immanent perspective here means acknowledging that drinking water quality is more complex and normative than it first appears, and that we cannot know exactly what that complexity will look like in advance.

Drinking water quality as inherently most valuable

The second moment of transcendence I identified is the assumption that drinking water is the most valuable and therefore highest-priority intended use. Such a normative perspective drives planning and governance towards the assumption that all water should be potable and puts human needs, often in the immediate term, above all others in pursuit of universal and uniform access to drinking water (Hall et al., 2014). A primary focus on water for human consumption blinds us to the interconnectedness of drinking water quality and environmental or ecological water quality. It also obscures the importance of productive use of water and makes an unnecessary distinction between issues of access and supply, and quality (Hall et al., 2014; Mehta, Allouche, Nicol, & Walnycki, 2014).

To counter an over emphasis on drinking water in an immanent ethic, we can consider a range of affects from certain actions taken to change water's qualities, or to provide water of a certain quality to consumers. Humans and our needs can be seen as one part of a larger water quality entity within which the goal is to maximize overall positive affects. So we can focus on drinking water quality in a specific situation but should attempt not to lose sight of the bigger picture. We should also think about water in terms of its potential for positive affects across the board so the things we have some control over (human actions) should not make water quality more likely to harm the environment or people.

The immanence of drinking water quality planning could perhaps then be evaluated in terms of how readily the drinking water quality assemblage affects and is affected by other

¹⁸⁸ Interview SDE: YT-12-07-19

water quality areas. A more transcendent approach would have silos for different types of quality, independent from or even in competition with each other. I am guilty of this transcendent attitude towards drinking water quality in my research, as I have chosen to focus primarily on drinking water quality rather than an integrated perspective including environmental, agricultural or other forms of quality. I prioritise water for human consumption above other uses because it is necessary for life. Regardless, I discuss some practical implications of assuming drinking water quality to be the most urgent and central water quality problem in Chapter 8.

Transcendent drinking water quality solutions

A third example of transcendence saturating drinking water quality planning and governance is the application of externally determined best-practice solutions to drinking water quality problems. For instance, the World Bank asserts that ‘Only three options are available to address the water quality problem: prevention, treatment and information provision’ (Damania et al., 2019, p. 93). But recognition of the multiplicity of water quality calls this claim into question. Another transcendent solution to drinking water challenges has been identified by researchers working on critical infrastructure studies. These researchers note that what they refer to as the modern infrastructure ideal imposes external (transcendent) conceptions of the proper way to deliver drinking water to urban populations onto a heterogeneous reality (See for example Coutard & Rutherford, 2015; Furlong & Kooy, 2017; Graham & McFarlane, 2014; Lawhon et al., 2018). While they do not necessarily reject central piped networks as an option for delivering water in some contexts, they demonstrate that in many situations there are alternatives which are swept aside by the assumptions of the modern infrastructure ideal. In this view informal systems should not be seen as a failure to achieve universal access; the multiplicity of ways people access drinking water in the Global South can actually be a sign of vitality and flexibility within a system (Jaglin, 2014). In particular when it comes to drinking water quality, a universal piped network is not inherently better than any other way of delivering water. Where low water pressure or cut-offs are frequent, tap water quality can rapidly become

problematic (Satterthwaite, 2016; UNICEF & WHO, 2015). The modern infrastructure ideal is also discussed in Chapter 8.

Current debates about infrastructure in the urban Global South note that small-scale, private and informal ways of accessing drinking water are pervasive in many cities and persist even in areas connected to piped water (Furlong & Kooy, 2017; Kooy & Bakker, 2008a; Meehan, 2013). Alternatives to tap water provide flexibility and security to households, and displacing or replacing them may in fact do more harm than good (Peloso & Morinville, 2014). Arguments in favour of decentralisation of drinking water services are plentiful (Leigh & Lee, 2019). Decentralising, or at least changing the scale and scope of drinking water quality and treatment, can entail supporting small sources of potable water instead of treating all water or creating multiple flows of drinkable and non-drinkable water in cities (Boakye-Ansah et al., 2021). This can be complicated, however, because if decentralisation is not done carefully there can be a lack of oversight, and new systems can preserve old inequalities or create two-tiered systems where some groups are more entitled to safe and good quality drinking water than others (K. McFarlane & Harris, 2018).

Aspirations towards universal connectivity to a network may blind planners to the potential for other opportunities. Such a closed perspective on the correct way to solve drinking water quality problems limits positive affects and possibilities and is therefore considered less ethical in an immanent framing. An immanent approach would say that one should not assume that there is one correct and knowable solution that applies to all situations. Defining the end in advance closes off still unidentified spaces of becoming and possibility (Hillier & Abrams, 2013), and focusing on failure to achieve an ideal distracts from what is really present (Furlong & Kooy, 2017; Jaglin, 2014). The tendency of governments to continue with business as usual has led some to speculate that they are more interested in a particular image of development than delivering services adapted to socio-economic realities (Nilsson, 2017). Critical scholars therefore ask: 'Is poor infrastructure really the problem in African cities? Or is it our inability to see and think about technology in new ways that keeps millions of people from having access to safe water and decent sanitation systems?' (Nilsson, 2017, p. 482). An immanent perspective

which is open to uncertainty and unanticipated outcomes could potentially facilitate providing more people with consistently safe and secure drinking water, even if such forms of access may not be synonymous with connection as defined in current frameworks.

These three general moments of transcendence could provide some guidance for evaluating specific situations in terms of their ethics. A particular drinking water quality planning or governance system could be evaluated based on how specifically adapted it is to the socio-environmental context and whether governance promotes positive affects and relations. Actions could be assessed based on whether actors unquestioningly implement best practice solutions or seriously consider the situation at hand and plan accordingly. A more immanent ethical approach to drinking water quality governance and planning would be humble about its shortcomings, inclusive of difference and open to adapting to the unexpected. But such an approach has both general limitations and limitations specific to drinking water quality, as I will discuss in the following section.

Limitations to immanent drinking water quality

The elements of transcendence I have outlined for drinking water quality governance and planning are ubiquitous and enduring for a reason. The suggestions I have made for an immanent drinking water quality ethic are challenging, and in some ways problematic. I cannot solve all of the problems, but for the purposes of this discussion about immanent drinking water quality ethics I will acknowledge them, address them to the extent I am able and then move on. First, Deleuze and Guattari prefer that we abstain from moral judgement, but when it comes to drinking water quality there is such a thing as water that can cause negative affects for certain human bodies. The water is not inherently bad, but what it does when it encounters people is bad. Thus there may be a need to rely on externally determined assessments of water's safety for consumption, but in an immanent perspective these assessments should include some level of sensitivity to context and the characteristics of the people and place in question.

Further, the idea that drinking water quality is a technical thing that can be known scientifically – and only through science – is particularly pervasive and it can seem counterintuitive or uncomfortable to cast it off. The materiality of water and drinking water quality seems to challenge calls for immanence, because there are many aspects of drinking water quality that are undetectable without scientific equipment and expertise. But this does not have to be a problem. The claim that planners and policy makers should acknowledge and include the perceptions and knowledges of consumers does not mean they should simultaneously reject the state or experts. A regulatory body associated with the state plays an important role in monitoring drinking water quality and protecting citizens. The point is to allow those same citizens an opportunity to affect this assemblage, and to allow them to be affected by it as well (sharing information for instance). It is also to challenge the assumption that anyone can know exactly what will be most important about drinking water quality for everyone at all times. Instead it should be accepted that while there can be patterns in how drinking water quality knowledge-making unfolds, difference is the rule not the exception.

Similarly, acknowledging that there can be multiple forms of drinking water quality that are not the same for everyone or all the time can be problematic if it allows for inequality of access and exposure. For example, Dunn, Bakker and Harris (2014) found that flexibility in drinking water quality standards across Canada meant that rural and First Nations communities are more likely to have lower standards which increase their risk of exposure to harmful things in their drinking water. The variation in thresholds and requirements was intended to accommodate the financial and technical challenges of smaller municipalities. But cases such as these raise questions about whether allowing drinking water quality to mean different things for different people can make it too easy to justify inequality. On the other hand, current standardised global indicators and thresholds as they are operationalised now are not effectively contributing to improving peoples' lives (Bain et al., 2012; Satterthwaite, 2016), so a middle ground may need to be found.

Another challenge to an immanent perspective on drinking water quality confronts the idea that current human consumption should not automatically be the highest priority, relative

to productive use, sustainability or environmental quality. Such a claim can be contested on moral grounds because access to safe and sufficient drinking water is fundamental to the survival and well-being of all people. The immediacy of this requirement means that elevating drinking water quality within a hierarchy of needs may be justifiable. Claims about the human right to water acknowledge the importance of long-term availability, ecological requirements and productive use alongside drinking water (Miroso & Harris, 2012). In light of these competing needs, progressive realisation of rights to domestic and productive use can follow after the immediate need for drinking water of adequate quantity and quality (Hall et al., 2014). Thus an ethical approach to drinking water quality should strive for a balance which maximises positive affects for all of these purposes, in acknowledgement of the fact that one may have to come first. This may not be so different from the water justice paradigm, however it is more open ended. Planning and governance of drinking water quality can strive for equitable distribution of resources and participation, while still acknowledging that it may be unacheivable. An immanent ethics alters how actors relate to drinking water quality challenges, while still allowing a normative position within their own assemblages.

An additional question to consider in advocating for an immanent drinking water quality ethic is about the role of the state in this vision of drinking water quality governance and planning. What kinds of claims can or should we make on the state in an immanent drinking water quality world? For instance, current interpretations of the human right to water assert that the state is only responsible for providing water as a last resort in cases when citizens are reasonable incapable of obtaining enough safe water on their own (Grönwall, et. al, 2010). Should the state be expected to determine and improve the quality of all drinking water, or only in cases where consumers are reasonably unable to do so on their own? These sorts of questions do not have clear answers.

Future avenues for research

In the previous section I suggested some potential pathways for ethical governance of drinking water quality in light of my findings. That section was focused on the implications

of my findings for practice. The results of this thesis also raise further questions for research. The limitations of time and resources available for a doctoral study mean that I could not pursue every possible line of inquiry. With that in mind, in the future this research could be productively extended in several ways.

In this thesis I worked across multiple levels of assemblages, including consumers, formal and informal providers and the Senegalese state. In future research there could be benefits to extending analysis to both finer and broader scales. For instance, Consumer Assemblages could be disaggregated to a greater degree. Considering gender, ethnicity, disability, socio-economic status or other intersectional aspects of identity as they pertain to assemblages of drinking water quality might provide insights into how drinking water quality is experienced and understood by diverse groups. A strand of assemblage theory research focused on deconstructing identity perhaps could productively be brought into this conversation (Saldanha, 2012). Additionally, future research could consider international assemblages of water quality in greater detail. In this thesis I focused on differences and tensions between the state and local levels and examined how the national scale interacts with implementation of standards and the experiences of consumers in Senegal. The creation and adoption of international policy standards for drinking water quality effect change on local and global scales, and also have implications for capital and political economy that were not addressed in my dissertation. It could be insightful to explore how the local level interacts with the global, for example by considering the relations between activist movements and international organisations.

Furthermore, in future research it would be productive if assemblage theory perspectives on drinking water quality were brought into conversation with other debates on water (in)security. For instance, combining assemblage approaches with current trends towards studying emotional geographies of water security (Sultana, 2011; Wutich & Ragsdale, 2008) could draw attention to relationships between drinking water quality, emotions and actions. It would also be of interest to explore the links between drinking water quality and migration in ways that have already begun to be considered for water scarcity and uncertainty about livelihood impacts of water insecurity (Stoler et al., 2021).

Using assemblage theory I have contributed to bridging material and social perspectives on drinking water quality. Such approaches in research could make space for interdisciplinary work engaging the knowledges of, amongst others, hydrologists, public health specialists, geographers, cultural and anthropological researchers and scholars interested in planning and governance. Multi- or inter-disciplinary collaborations that apply an assemblage ontology would complement existing work in socio-hydrology (Rusca & Di Baldassarre, 2019; Sivapalan et al., 2014) and other interdisciplinary approaches to include many perspectives without privileging any one way of knowing about drinking water quality. These approaches could productively be applied to other environmental governance challenges including air quality.

In addition, some understudied areas in the existing geography and environmental studies literatures were raised in this thesis and merit further study. More research is needed that engages with issues of water quality in addition to supply, and with multiple uses of water and access to water for needs beyond consumption (Van Koppen & Smits, 2010). There would also be value in more work that explicitly engages with the contributions of Southern urban theory (Ernstson et al., 2014). My dissertation has provided one example of a study that considers cities in the Global South as a site of knowledge production not just extraction. Such studies are vital given that growing portions of the world's population reside in cities which are inadequately represented in the paradigms of Northern or Western theory (Satterthwaite, 2021). Future research on drinking water quality assemblages could also include some "experimental comparison" (Lancione & McFarlane, 2016) between sites of theorization in both Northern and Southern contexts.

Finally, the changing global climate will have significant implications for water security in Senegal (Mbaye, Sylla, & Tall, 2019; World Meteorological Organization, 2020). An urgent need exists to consider how the quality and availability of drinking water supplies will be impacted by shifting weather patterns which in Senegal are expected to include more intense variability of temperature and precipitation (Mbaye et al., 2019). Assemblage theory approaches, such as the one presented in this thesis, provide a coherent ontological

framework well suited to the uncertainty and multi-scalar problems of current and future global environmental governance.

Final reflections – An approach not an answer

When I first began considering the implications of an immanent drinking water quality ethic my inclination was to structure the discussion around archetypal ethical problems that might face planners or managers of drinking water quality systems. I thought it would be interesting to outline a Deleuzian ethical perspective and then see how it could help to evaluate possible actions and decide what is the right thing to do in such cases. I also considered describing a particular ethical challenge for drinking water quality in Kaolack, and then generalising out from that case. However, over the course of writing I have begun to question whether that activity is compatible with Deleuze and Guattari's philosophy. Selecting an ideal type of drinking water quality problem and then speculating about how to solve it ethically *in general* would be contrary to an immanent understanding of ethics. In an assemblage theory ontology there is no "this type of situation", there are only situated particular events which must be experimentally approached and learned from each time. While at first I found this a concerning limitation of a Deleuzian ethics, I now regard it as a challenging but worthwhile provocation to reconsider the way we think about drinking water quality governance. Instead of universal versions of water problems with correct answers, we should try to understand individual situations in all their peculiarity. In a practical sense, this could entail more participatory approaches where the planner or manager of a drinking water system is themselves affected by other members of assemblages. The ethics of drinking water quality planning and governance is less about helping make decisions on concrete cases (this action would be more/less ethical than another) and more about the entire approach.

Given the diversity of social and hydrological situations practitioners may be faced with, it may not be possible - or desirable - to define a universal water ethic. Such universality would always be leaning towards transcendence. In each moment of transcendence the fact that some aspect of drinking water quality is decided in advance, maybe by an external

body, has the potential to make negative affects happen and prevent positive relationships that help people thrive. The goal of planning in a Deleuzian view is locally specific, ethically situated processes that maximise the power of each actor (human and non-human) to engage in positive affects (Tedeschi, 2016). Conversely, in theoretical debates which assume there is a best or most fair solution to every problem the 'complex multiplicity of events is reduced to its simplified interpretation, while potentially relevant features, which may enhance the chance for change, are dismissed' (Ansaloni & Tedeschi, 2016, p. 317). An ethical evaluation of possibilities and potentials is more open to the unexpected. So ethical forms of planning and governance are an approach not an answer (Hillier, 2015, p. 103). Strictly following laws and rules, and expecting the world to also behave according to these rules, minimizes space for experimentation and creativity – exactly the things we need to cope with ambiguity and change. Planners have an ethical responsibility to recognize the uniqueness of each situation instead of falling into the trap of letting the solution define the problem (Hillier & Abrahams, 2013) because 'General solutions for abstract territories are not only boring, but also testify to a lack of regard and empathy for people's relationship with the territory' (Banville & Torres, 2017, p. 270). The extent of social (and in my case hydrological) complexity means openness to different perspectives and responsiveness to uncertainty and unpredictability could be more useful.

Furthermore, implicit judgements about risk and value should be recognised and made explicit as elements in assemblages. Rather than hiding behind expert knowledge, there should be open discussion about how knowledge has been made, where thresholds are and who has the power to decide. There should also be transparent examination of potential trade-offs between risks, uncertainties and measures taken so that affected parties have the opportunity to contest decisions. Without this transparency people may not be aware of the potential impacts of drinking water quality governance decisions and can thus be exposed to harmful things in water without their consent.

Despite the limitations I outlined previously, an immanent drinking water quality ethic is not as distant as it first appears. For instance, Brown and Schmidt (2010a) claim an ethical imperative to foreground situated practical knowledge of water to allow us to adapt and

handle uncertainty. They further emphasize that there is much we do not, and perhaps cannot, know about water systems and as such we should not act as if we have all the cards (Brown & Schmidt, 2010a). The world is too complicated for single or inflexible principles which prevent managers from adapting and limit their options, a perspective which seems quite well aligned with Deleuze and Guattari's immanent view of ethics. In this combined view, ethical drinking water quality governance and planning emerge as a mode of being which is oriented more towards evaluation than judgement and 'not a directive as to what to do, but an orientation as to how people cope with the contingencies one faces' (Hillier, 2015, p. 103). This approach encourages us to experiment, avoid prescriptive models or universal solutions and rules and look at the world through a lens of becoming. Plans or actions regarding drinking water quality can thus be evaluated in terms of their flexibility, openness to connectivity and perhaps even humility.

When we recognize drinking water quality as a multiplicity and a becoming, it is even more clear that applying repetitive solutions to diverse water problems does not make sense. It is not my intention to obscure the fact that some people are more at risk from poor water quality than others - far from it. Instead I argue that whether a particular instance of water is good or bad is a normative judgement which must be negotiated, constructed and assembled, and that in some cases this process allows water quality to become elusive and slippery, potentially creating ambiguities and allowing further inequalities. Engagement with Deleuzian immanent ethics provides a philosophical foundation from which to mount a further critique of such an approach. Immanent water ethics also emphasize that there cannot be a final moment where planning goals have been achieved and everything is solved; climate patterns shift, people move in and out of cities, groundwater dries up or is replenished by rain. Water quality changes. There are elements of uncertainty everywhere and our ethical imperative is to continue to adapt. Exploring a Deleuzian-inspired assemblage theory perspective on ethics could help us look forward towards the possibilities and potentials of a more ethical drinking water quality world.

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Appendix 1. Research authorisation Ministry of Higher Education, Research and Innovation, Senegal



N° 00000314 /MESRI/DGRI/JSD/jam

Dakar, le 22 FEB. 2019

LE MINISTRE,

Objet : Autorisation de recherche.

Référence : V/I du 30 janvier 2019

Monsieur le Directeur,

Par lettre susmentionnée en référence, vous avez bien voulu solliciter mon avis sur la demande d'autorisation de recherche au Sénégal au profit du Dr Elisabeth Ann MAC AFEE, chercheuse au Norwegian University of Life Sciences en Norvège. Dr MAC AFEE, compte mener au Sénégal une recherche sur la gouvernance des eaux souterraines de la zone urbaine de Kaolack sur la période allant d'avril à décembre 2019. Cette recherche sociale vise à comprendre le contexte environnemental et les facteurs sociaux qui influencent la gestion des eaux souterraines à Kaolack.

Cette étude fournira de plus amples informations nécessaire à l'amélioration de la gestion des eaux souterraines. Par conséquent, j'autorise Dr MAC AFEE à réaliser la recherche susmentionnée, sous les auspices du Professeur Seynabou CISSE FAYE au Département de géologie Laboratoire d'Hydrochimie et d'Hydrogéologie de l'Université Cheikh Anta Diop de Dakar sur la période demandée. Les coordonnées du Pr FAYE sont les suivantes : 77 202 35 01 email: seynaboucisse.faye@ucad.edu.sn.

Dr MAC AFEE devra donc prendre contact avec le Professeur FAYE à son arrivée avant le démarrage des travaux de recherche et me faire parvenir les résultats de ses recherches mais aussi le rapport final et les publications scientifiques issues de ces travaux, conformément à l'engagement pris.

La présente autorisation peut être suspendue ou révoquée en cas de non-respect des conditions susmentionnées.

Je vous prie d'agréer, **Monsieur le Directeur**, l'expression de ma considération distinguée.

Au
Professeur Ousmane SENE
Directeur du Centre de Recherche Ouest Africain
(CROA/WARC)
DAKAR



Appendix 2. Affiliation Letter, WARC



West African Research Center / Centre de Recherche Ouest-Africain

Rue E x Lon G. Damas – Fann-Residence- Dakar, SENEGAL
☎ 5456 Dakar-Fann ☎ 33 865 22 77 Fax 33 824 20 58 NINEA 0271198
Email : warccroa@gmail.com - Web : www.warc-croa.org

Dakar, January 16th, 2019

To: **Elisabeth MACAFEE**
Norwegian University of Life Sciences , Urban & Regional Planning
2227 Peach Tree Lane , San Jose ,
CA 95128
Email: elisabeth.macafee@nmbu.no

From: Professor Ousmane SENE,
WARC Director
PO Box: 5456 Dakar, Fann
Dakar, Senegal

Object: **Affiliation.**

We are more than pleased to extend the offer of the West African Research Center to serve as your host institution during the period (April 21st, 2019 – December 31st, 2019) of your research in Senegal. You would like to conduct a research project on Groundwater Governance in the Urban Waterscape. In this research project you will attempt to describe mechanisms by which constellations of groundwater access and control are co-produced by a mix of purposive and planned management efforts, everyday practices, and the physical and material characteristics of groundwater. Using an ethnographic case study of Kaolack, Senegal, you will aim to inductively develop theory about the challenges and opportunities for effective and sustainable governance of groundwater resources. You will further supplement qualitative interviews and observation data.

As you may know the Center's broad mandate is to promote research on West Africa and the Diaspora and to foster collaboration between American and West African Institutions and researchers. We would appreciate a finished or draft copy of your work for the Center's library at the end of your researches. The Center will provide the necessary environment for your research to the best of our ability.

Our best wishes for a productive stay in Senegal.

Professor Ousmane SENE
WARC Director

WARC/CROA
Centre de Recherche Ouest Africain
West African Research Center
Rue Erlon G. Damas, Fann Residence
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Siège de l'Association de Recherche Ouest Africaine (WARA/AROA)

Appendix 3. NSD Project Approval



NSD's assessment

Project title

Social constructions of urban groundwater quality in Kaolack, Senegal

Reference number

752599

Registered

01.04.2019 av Elizabeth MacAfee - elizabeth.macafee@nmbu.no

Data controller (institution responsible for the project)

Norges miljø- og biovitenskapelige universitet / Fakultet for landskap og samfunn / Institutt for by- og regionplanlegging

Project leader (academic employee/supervisor or PhD candidate)

Elizabeth MacAfee, elizabeth.macafee@nmbu.no, tlf. 46938426

Type of project

Research Project

Project period

01.05.2019 - 01.09.2021

Status

02.04.2019 - Assessed with conditions

Assessment (1)

02.04.2019 - Assessed with conditions

SIMPLIFIED ASSESSMENT WITH CONDITIONS Having reviewed the information registered in the Notification Form with attachments, we find that this project presents a low risk to the rights and freedoms of data subjects. This assessment is based on the project not processing special categories of personal data or personal data relating to criminal convictions and offences,

and not including vulnerable groups. The duration of the project is reasonable and the processing of personal data is based on consent. We have therefore given a simplified assessment with conditions. You have an independent responsibility to meet the conditions and follow the guidance given in this assessment. If you meet the conditions and the project is carried out in line with what is documented in the Notification Form, the processing of personal data will comply with data protection legislation. **CONDITIONS** Our assessment presupposes: 1. That you carry out the project in line with the requirements of informed consent 2. That you do not collect special categories of personal data or personal data relating to criminal convictions and offences 3. That you follow the guidelines for information security as set out by the institution responsible for the project (i.e. the institution where you are studying/carrying out research) 4. That you upload the revised information letter(s) for each sample in the Notification Form and select "Bekreft innsending" (Confirm submission) so that documentation is correct. NSD will not carry out a new assessment of the revised information letter(s). **1. REQUIREMENTS FOR INFORMED CONSENT** The data subject should receive written and/or oral information about the project and consent to participation. You must ensure that the information at least includes the following: - The purpose of the project and what the collected personal data will be used for - Which institution is responsible for the project (the data controller) - What types of data will be collected and how the data will be collected - That participation is voluntary and that participants may withdraw their consent, without giving a reason, as long as their personal data are being processed - The end date of the project and what will happen with the collected personal data; whether it will be erased, anonymised or stored for further use - That you will be processing personal data based on the consent of the data subject - The right to request access, correction, deletion, limitation and data portability - The right to send a complaint to The Norwegian Data Protection Authority (Datatilsynet) - Contact information for the project leader (or supervisor and student) - Contact information for the Data Protection Officer (Personvernombudet) at the institution responsible for the project On our website you will find more information and a template for the information letter:

http://www.nsd.uib.no/personvernombud/en/help/information_consent/information_requirements.html

It is your responsibility to ensure that the information given in the information letter corresponds to what is documented in the Notification Form. **2. TYPE OF DATA AND DURATION OF PROJECT** The project will be processing general categories of personal data until 01.09.2021. **3. FOLLOW YOUR INSTITUTION'S GUIDELINES** NSD presupposes that the project will meet the requirements of accuracy (art. 5.1 d), integrity and confidentiality (art. 5.1 f) and security (art. 32) when processing personal data. If you will be using a data processor in the project, the processing of personal data must meet the legal requirements for use of a data processor, cf. arts. 28 and 29. To ensure that these requirements are met you must follow your institution's internal guidelines and/or consult with your institution (i.e. the institution responsible for the project). **NSD's ASSESSMENT** Our assessment of the legal basis for processing personal data, of the principles relating to this processing and of the rights of data subjects, follows below, but presupposes that the conditions stated above are met. **LEGAL BASIS** The project will gain consent from data subjects to

process their personal data. Presupposing that conditions 1 and 4 are met, we find that consent will meet the necessary requirements under art. 4 (11) and 7, in that it will be a freely given, specific, informed and unambiguous statement or action, which will be documented and can be withdrawn. The legal basis for processing personal data is therefore consent given by the data subject, cf. the General Data Protection Regulation art. 6.1 a). **PRINCIPLES RELATING TO PROCESSING PERSONAL DATA** Presupposing that conditions 1-4 are met, NSD finds that the planned processing of personal data will be in accordance with the principles under the General Data Protection Regulation regarding: - lawfulness, fairness and transparency (art. 5.1 a), in that data subjects will receive sufficient information about the processing and will give their consent - purpose limitation (art. 5.1 b), in that personal data will be collected for specified, explicit and legitimate purposes, and will not be processed for new, incompatible purposes - data minimisation (art. 5.1 c), in that only personal data which are adequate, relevant and necessary for the purpose of the project will be processed - storage limitation (art. 5.1 e), in that personal data will not be stored for longer than is necessary to fulfil the purpose of the project **THE RIGHTS OF DATA SUBJECTS** So long as data subjects can be identified in the collected data, they will have the following rights: transparency (art. 12), information (art. 13), access (art. 15), rectification (art. 16), erasure (art. 17), restriction of processing (art. 18), notification (art. 19), data portability (art. 20). Presupposing that the information meets the requirements in condition 1, NSD finds that the information given to data subjects about the processing of their personal data will meet the legal requirements for form and content, cf. art. 12.1 and art. 13. We remind you that if a data subject contacts you about their rights, the data controller has a duty to reply within a month. **NOTIFY CHANGES** If you intend to make changes to the processing of personal data in this project it may be necessary to notify NSD. This is done by updating the information registered in the Notification Form. On our website we explain which changes must be notified. Wait until you receive an answer from us before you carry out the changes. **FOLLOW-UP OF THE PROJECT** NSD will follow up the progress of the project at the planned end date in order to determine whether the processing of personal data has been concluded. Good luck with the project! Data Protection Services for Research: +47 55 58 21 17 (press 1)

Appendix 4. Interview guides

Interviews were conducted in Wolof or (to a lesser extent) French. Interviews with key informants were tailored to their specific role and area of expertise with regards to drinking water quality.

Household interviews

Reading of informed consent script and confirmation of consent to participate.

1. Were you born here in Kaolack?
2. If you were born elsewhere, how many years have you lived in Kaolack?
3. What is your primary work?
4. Did you study, and if so to what level?
5. Does your home have a connection to piped water?
6. If yes, for how many years have you been connected to piped water?
7. Has your water ever been cut off for non-payment?
8. Does the water ever cut off in your tap? Why?
9. How much do you pay each month for water? What do you think about this price?
10. What do you do if the tap water cuts off?
11. Where can you obtain other water?
12. How long does the water cut off at a time? (days)
13. What is the experience of being without water like?
14. What type/source of water do you most frequently drink?
15. Where do you obtain drinking water?
16. Do you typically obtain water from one place or several?
17. Do you have a relationship with the person who sells you water?
18. Are there other places you can obtain drinking water?
19. Is/Are the place(s) you obtain water far away? How much time do you spend obtaining water?
20. Does everyone in your household drink the same water? Why or why not?
21. Do you do something to your water before drinking it?
22. Why or why not?
23. *What do you think about tap water in Kaolack?*
 24. Is it clean? Is it good? How does it taste? Do you think it is safe?
 25. Do you trust this water? Why or why not?
 26. What do you think about the work of the water company (SDE)?
27. *What do you think about well water in Kaolack?*
 28. Is it clean? Is it good? How does it taste? Do you think it is safe?
 29. Do you trust this water? Why or why not?
30. *What do you think about filtered water in Kaolack?*
 31. Is it clean? Is it good? How does it taste? Do you think it is safe?
 32. Do you trust this water? Why or why not?

33. What do you think about the work of the people who make and sell filtered water? Is the amount they charge for water reasonable?
34. *What do you think about sachet water in Kaolack?*
 35. Is it clean? Is it good? How does it taste? Do you think it is safe?
 36. Do you trust this water? Why or why not?
 37. What do you think about the work of the people who make and sell sachet water? Is the amount they charge for water reasonable?
38. If you drink bag water or filtered water, for how many years have you done so?
39. Why did you start to drink bag water or filtered water?
40. Who should take care of drinking water quality?
41. How can you know whether water is clean? How can you know whether water is safe?
42. If you want to know something about drinking water quality, who can you ask?
43. Has the water you drink ever done something to your health or the health of someone in your household?
44. Do you think drinking water has ever made you sick?
 45. What kind of sickness? How did you know? What water caused sickness?
46. Does anyone in your house have fluorosis (discoloured teeth)? What causes this?
 47. Is the frequency of fluorosis changing? Why?
48. Do you think there is variation in water quality in Kaolack? Why? Where is it better or worse?
49. If one wanted to improve drinking water quality in Kaolack, what could they do? Who should do this?
50. Is there anything else you would like to share about drinking water quality in Kaolack?

Filtered water vendor interviews

1. Please explain what your job is here. What kind of business is this and how does it function?
2. How long has this business been open? How long have you worked here?
3. Who owns this business? Where are they located?
4. How many people work here?
5. Why is this business (selling water) good in Kaolack?
6. What is the difference between filtered water and tap water?
7. What kind of filtration process do you use?
8. Where did the machine come from? Where did you buy this equipment?
9. If the machine is from Swiss Fresh Water, what is your contract with them like? What is your relationship with them like? Do they come here often?
10. What does this machine take out of water? How do you know it is functioning properly?
11. In your opinion are all filtration machines the same?
12. Do you discuss with clients how to preserve drinking water quality after they buy it?
13. Has the Hygiene Service ever come here to check the quality of your water?
14. If so, how often do they come? Have they ever had any issues with your water?

15. What kind of permit do you need to sell water here?
16. How do you know if the machine breaks down? Has it ever broken?
17. Does the source of water (if tap water) ever cut off? If so, what do you do?
18. What can you tell me about your clients? Do they buy a lot or a little water at a time?
Do they come here or purchase delivery services?
19. Do you have relationships with your clients?
20. Are the clients mostly the same people regularly or does it vary?
21. In your opinion, why do people buy this water?
22. Do you know how many people or litres of water you sell here each day?
23. How much does the filtered water you sell cost? Has the price ever changed (increased or decreased)?
24. After paying for rent and electricity, do you make a profit?
25. What is the difference between filtered water and sachet water?
26. The slogan of Diam-O is “not just water, more than water”, what does this mean?
27. Where does the waste from your filtration go?
28. Do you have any struggles or problems in your work here?
29. We (NFI and I) have been doing household interviews and several people have told us this water has sugar or some other product added to it, or that it gives people colds.
They said they do not trust the procedure. Have people said this to you as well? How do you respond to those claims?
30. Has anyone come here and asked you to explain the filtration process?
31. Are there other businesses that sell water in this neighbourhood? How far away?
32. Would you like to say anything else about water in Kaolack?

Well water seller interviews

1. Please explain what your job is with regards to well water.
2. Do you filter the water you sell?
3. What do you do to insure the water you sell is good?
4. Why do people in Kaolack buy well water?
5. What is the difference between well water and other water in Kaolack?
6. Is all well water the same or is some better or worse?
7. Does the quality of well water change throughout the year or by season?
8. Has well water changed over time? Was it better or worse in the past? Will it change in the future?
9. Is well water good/bad for health? Why?
10. Do you have to pay for the water you obtain from wells to sell?
11. Do you need some kind of permission to sell well water in Kaolack?
12. In your opinion, if the tap water in Kaolack improved, would people still buy well water from you?
13. What water do you and your household drink?
14. Have you ever observed health problems related to water?

15. Do many people buy well water in Kaolack? Where do you go to sell water?
16. Do you go to the same people each day? Are some neighbourhoods more likely to buy well water than others?
17. Would you like to share anything else about well water or water in Kaolack in general?

Appendix 5. Lists of interviews

Table 10. Key informant interviews and dates

	Date	Position	Office
1	26/04/2019	Leader of the planning division	DGPRES- Dakar
2	7/5/2019	Chef de division	Rural Hydraulic Office of the Kaolack Region
3	22/05/2019	Agent Voyer	Mayor's Office
4	23/05/2019	Director	Urban Planning Office of Kaolack
5	28/05/2019	Director	Organisation for Sanitation (Kaolack office)
6	12/7/2019	Adjunct technical leader	SDE - Kaolack
7	15/07/2019	Professor and head of department of hydrology	UCAD
8	26/07/2019	Division Leader (city)	Hygiene Service
9	30/07/2019	Director	Urban Planning Office of Kaolack
10	30/07/2019	Adjunct Director	Urban Planning of Kaolack
11	1/8/2019	Assistant to the director	Regional Ministry of Environment Office
12	19/08/2019	Laboratory head	Hygiene Service
13	19/08/2019	Officer	Hygiene Service
14	26/08/2019	Adjunct to the Prefect	Prefecture de Kaolack
15	29/08/2019	Division Leader (region)	Hygiene Service
16	5/9/2019	Laboratory head	Caritas
17	4/11/2019	Administrative and Financial Leader	Sen-Op, Diam-O (Fatick)

Table 11. List of household and provider interviews

Number of interviews	Date	Interview participant group	Location (s)
9	13-Sep	Household users	Thioffack (along border of Saam and Medina)
11	14-Sep	Household users	Thioffack
10	16-Sep	Household users	Border between Saam and Medina
6	2-Oct	Household users	Leona
6	3-Oct	Household users	Ndar bu ndaw/Dialegne
6	4-Nov	Household users	Near OCAS Market in Touba Kaolack
4	6-Nov	Filtration sellers	Diam-O Ñaari Talli, Tabangoye, Ngane Alassane, Leona
5	11-Nov	Filtration sellers	Parcelles 1, Parcelles 2, Sara Ndougary, Kasnack, Kassaville
4	13-Nov	Filtration sellers	Dialegne, Medina Sud, Thioffack, Fass Chiekh Tidiane
3	18-Nov	Filtration sellers	Kasnack Sud, Couer de Ville, Leona
3	18-Nov	Household users	Medina Baye
4	20-Nov	Well Sellers	Ngane Alassane, Darou Mina
2	20-Nov	Household users	Ngane Alassane, Darou Mina
2	23-Nov	Filtration sellers	Ndorong, Nimzat
3	23-Nov	Household users	Nimzat
9	26-Nov	Household users	Samm
10	10-Dec	Household users	Gawane
9	12-Dec	Household users	Kasnack
Total households		84	
Total filtration sellers		18	
Total well sellers		4	

ISBN: 978-82-575-1864-6

ISSN: 1894-6402



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