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Quality of drinking water in Afghanistan

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Abstract

Norwegian peacekeeping operations abroad operate under different conditions than civil water supply in Norway. It may be poor access to drinking water of satisfactory quality, there is a greater daily intake of water and that the composition of personnel is not a cross-section of the population in Norway.

In the present work it is examined whether or not the groundwater in Maimanah and in Kabul, Afghanistan has a satisfactory water quality, as well as if the limits set in the Civil Norwegian Drinking Water Regulations is appropriate. Civilian Norwegian laws and regulations within the food area is not enforceable abroad, but the Norwegian Armed Forces (NAF) chooses to deal with the regulations governing.

The fieldwork related to this master consisted in withdrawal of water samples from wells in connection with military camps where there is deployed Norwegian military forces in Afghanistan. The water was analyzed for the determination of 59 different elements using ICP-MS (Agilent 8800 Triple quadrupole ICP-MS) to identify the content of inorganic elements in groundwater. Microbiological parameters were not considered in the present work.

Theoretical part of this thesis was a risk assessment in two parts. The first part was to calculate the inherent adaptive properties of Drinking Water Regulations when consuming 10 liters of drinking water per day, no time limit defined. Drinking water should have values corresponding limits in the regulations, as well as values corresponding limit value plus 50%.

The second part of the risk assessment was to use the results from the chemical analyses, and assess whether this water would pose a health risk when consuming 10 liters a day, no time limit.

Work shows that groundwater from KAIA, Kabu,l in an amount of 10 liters a day, may not be used as drinking water approved under the Drinking Water Regulations. However, groundwater from Maimanah, Faryab, in an amount of 10 liters a day, may be used as drinking water approved under Drinking Water Regulations.

Sammendrag

Norske fredsbevarende operasjoner i utlandet opererer under andre forutsetninger enn sivil vannforsyning i Norge. Det kan være dårlig tilgang på drikkevann av tilfredsstillende kvalitet, det er et større daglig inntak av drikkevann samt at sammensetningen av personell ikke er et tverrsnitt av populasjonen i Norge.

I denne masteroppgaven er det undersøkt om grunnvann i Maimanah og i Kabul, Afghanistan har en tilfredsstillende drikkevannskvalitet, samt om sivile norske grenseverdier ("Drikkevannsforskriften") er hensiktsmessig. Sivile norske lover og forskrifter innen næringsmiddelområdet er ikke rettskraftige i utlandet, men Forsvaret velger å forholde seg til regelverket som styrende.

Feltarbeidet i tilknytning til denne masteren bestod i uttak av vannprøver fra brønner i tilknytning til militær leire hvor det er deployert norske militære styrker i Afghanistan. Vannet ble analysert for bestemmelse av 59 ulike elementer ved bruk av ICP-MS (Agilent 8800 Triple Quadrupole ICP-MS), for å kartlegge innholdet av uorganiske grunnstoffer i grunnvannet. Vurderinger av mikrobiologiske parametre ligger utenfor denne oppgaven.

Teoretiske delen av oppgaven var en todelt risikovurdering. Første del var å regne på de iboende adaptive egenskapene til Drikkevannsforskriften ved et inntak på 10 liter drikkevann per dag, ingen tidsbegrensning definert. Drikkevannet skulle ha verdier tilsvarende grenseverdiene i forskriften, samt verdier tilsvarende grenseverdien pluss 50 %.

Den andre delen av risikovurderingen gikk ut på å benytte analyseresultatene fra feltarbeidet, og vurdere om dette vannet ville utgjøre en helserisiko ved et inntak på 10 liter om dagen, ingen tidsbegrensning.

Arbeidet viser at grunnvann fra KAIA, Kabul ikke vil kunne benyttes som drikkevann, i en mengde på 10 liter om dagen, godkjent i henhold til Drikkevannsforskriften. Grunnvann fra Maimanah, Faryab vil kunne benyttes som drikkevann i en mengde på 10 liter om dagen, godkjent i henhold til Drikkevannforskriften.

Abbreviation and Technical Terms

Aquifer: A rock formation, group of formations, or part of a formation that is water bearing. Commonly used synonyms are ground-water reservoir, water-bearing bed, and with water-bearing deposit.

Contaminant: Any substance that when added to water (or another substance) makes it impure and unfit for consumption or use.

DAACAR: Danish Committee for Aid to Afghan Refugees

DW: Dug Well

EC: Electrical Conductivity or Salinity.

Evaporation: The conversion of a liquid (water) into a vapour (a gaseous state) usually through the application of heat energy during the hydrologic cycle; the opposite of condensation

Groundwater Discharge: Groundwater discharges include, evaporation, transpiration and groundwater flow to the surface as drainage, springs, karezes and pumping for irrigation and water supply

Groundwater Level: Indicates the position where the atmospheric pressure and hydraulic head are at equilibrium (balance) in the aquifer

Groundwater Recharge: Groundwater recharge is defined as the downward flow of water recharging the water level forming an addition to the groundwater reservoir.

Hydrogeology: Hydrogeology deals with the area distribution and movement of groundwater in the soil and rocks of the Earth's crust.

Infiltration: The process whereby water enters the soil and moves downward toward the water table

mg/l: Milligram per liter

Precipitation: The part of the hydrologic cycle when water falls, in a liquid or solid state, from the atmosphere to Earth (rain, snow, sleet).

pH: defined as the negative decimal logarithm hydrogen ion activity(H^+). The pH value is indicated where the water is acid or alkaline. Neutral water pH=7. If the pH of water is less than 7 is acidic and more than 7 is alkaline

WHO: World Health Organization.

Sub Basin: water catchments larger than 40,000 km2

Water quality: The chemical, physical, and biological characteristics of water with respect to its suitability for a particular use.

Foreword

This master thesis is written at Department of Environmental Sciences at the Norwegian University for Life Sciences (NMBU). Specialization in Environmental Pollutants and Ecotoxicology with emphasis on toxicology. This thesis finalizes my master degree and comprises one semesters work.

In 2012 I was in Afghanistan as a veterinarian. The quality of the available ground water was of interest due to Force Health Protection. Looking into the availability and the quality of the ground water in Afghanistan, triggered an interest into alternative solutions to bottled drinking water.

I would like to thank my supervisors Associate Professor Elin Lovise Folven Gjengedal and Professor Lindis Skipperud, which has shown me extreme patience and understanding throughout these years. I would also like to thank my mother for the support throughout this masterprogramme.

NMBU, Ås 15.12.14

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Contents

1. Introduction and background

Political upheaval, military invasion, civil war, religious extremism, population displacement, and drought—Afghanistan has been overwhelmed with tragedy during recent decades. Mujahideen (Afghan opposition groups) initially rebelled against the government of the pro-Soviet Democratic Republic of Afghanistan (DRA) during the late 1970s. At the DRA's request, the Soviet Union brought forces into the country to aid the government from 1979. The mujahideen fought against Soviet and DRA troops during the Soviet War in Afghanistan (1979-1989); to which the United States provided assistance, aiding the mujahideen's cause. After the Soviet Union pulled out of the conflict in the late 1980s, the mujahideen fought each other for control in the subsequent Afghan Civil War. (Wikipedia, 2014-12-14) In their search for a peaceful future, the Afghan people face many difficulties. One of the country's most critical needs is to secure safe and reliable supplies of water.

Looking at historical groundwater level and water quality data in Kabul Basin reveals that the groundwater natural reserves are reduced and water quality has deteriorated due to over-exploitation. There is also increasing demand due to population growth, agricultural needs, industrialization and socio-economic improvement. (Broshears, 2005)

The province of Faryab is located in a very challenging area. At least seven districts in Faryab face serious problems related to obtaining potable water. Despite the fact that Afghanistan is rich in ground and surface water (from springs and rivers), a huge amount of this water is wasted or flows unused into the neighboring countries of Iran and Pakistan.

Norwegian Armed Forces (NAF) need the access to water, and obtaining drinking water that does not negatively influence health is optimal. Ground water of good quality is vital in obtaining that safe drinking water. In the future maybe NAF do not have to solely rely on bottled water as drinking water.

Hypothesis

1. Ground water at Maimanah and Kabul in Afghanistan does not possess a health risk provided a consumption of 10 liter per day per NAF personnel.
2. The Norwegian Drinking Water Directive ("Drikkevannsforskriften") can be used, in peacekeeping operations abroad, to determine that the ground water does not possess a health risk.

2. Theory

2.1. Afghanistan

Afghanistan is a mountainous country that borders to China, Pakistan, Iran, Turkmenistan, Uzbekistan and Tadzhikistan. The country is rich in natural gas, oil and coal. There is a shortage of drinking water and limited freshwater resources. Water and air pollution is also a problem in the urban areas. The soil is not particularly fertile and they have problems with deforestation and desertification.

In 2001, it was estimated that only 13 percent of the Afghan population had access to safe, potable water and by 2010 that number had risen to 27 percent. Both governmental and non-government organizations from around the world have worked tirelessly to improve this statistic. Coordinated efforts by the U.S. military and U.S. Geological Survey have provided detailed hydrogeological data to the Afghanistan Geological Survey (www.norplan.af). This information is important because in some areas the increased number of wells has led to competition for limited water resources and interference between wells. Additionally, ISAF military base camp wells are sampled regularly for a large number of potential contaminants in order to protect the health of deployed personnel. The military water quality data can augment other data sources and improve the understanding of local hydrogeology in order to increase access to safe drinking water for the Afghan people. By considering the potable water needs, the work being conducted has the ability to make a greater impact in improving the overall situation in Afghanistan and benefit the Afghan people.

2.2. Hydrogeology

Afghanistan is an arid country with limited surface water supplies. In many areas, water of sufficient quantity is available only by digging wells into unconsolidated alluvium aquifers located in mountain valleys. An understanding of hydrogeological conditions is required in order to minimize environmental health risks from both natural and anthropogenic sources of groundwater contamination.

Some published information on the hydrogeology of the Kabul Basin is available. The war between Afghanistan/Soviet union and Mujahedin was ongoing during the years 1979 to 1989. Some research was done during these years by the Soviet Union. Myslil et al. (1982) produced a water-table map of the Kabul area and briefly described the hydraulic properties and water quality of the aquifer. Transmissivity was reported to range from 10 to 8,000 m2/d. Based on a small number of chemical analyses; ground water in the basin was described as being variably mineralized. In zones of lower levels of mineralization, waters were of the calcium bicarbonate type. In more mineralized zones, waters were more enriched in sodium and chloride.

Shevchenko et al. (1983) described the hydrogeology of productive alluvial deposits along the Kabul River in the Darlaman area of southwest Kabul. Alluvium in this area consisted of gravels and conglomerates at least 55 m thick. Measures of hydraulic conductivity ranged from 46 to 105 m/d. Yields of as much as 70 L/s were accompanied by drawdowns of less than 10 m. Dissolved-solids concentrations were reported at less than 700 mg/L.

Figure 1 **River Basins in Afghanistan. Source** (artf.af/images/uploads/portfolio-gallery/Afgh_river_basin_map.jpg)

2.3. Kabul Basin

Kabul Basin is a plateau surrounded by mountains located in the eastern central part of the country, and is the site of Kabul, the Afghan capital.

Figure 2 **Kabul Basin in Afghanistan** (af.geoview.info)

The groundwater recharge mostly from riverbed exfiltration, possibly foothill infiltration and only a small portion recharges from rainwater.

Natural processes that have an effect on the quality of the groundwater are:

- Interaction of groundwater with carbonate rocks causing hardening of the water throughout the area: this hardness buffers acidic contaminants and gives rise to a high encrustation potential for wells, pipes and household appliances.
- Strong evaporation associated with the mainly negative hydrological balance in the Kabul Basin: evaporating water leaves behind dissolved salts that become concentrated. This raises the salt concentration as well as the concentrations of some problematic constituents, e.g. borates. The recent drought considerably worsens this problem. Considerable anthropogenic emissions are identifiable in the urban area which has a serious impact on the natural groundwater quality, e.g. through massive input of nutrients and bacteria from sewage and uncontrolled waste disposal.

The depth of the water table in the Kabul Aquifer ranges from 2 to 12 meter. Fluctuations up to 5 meter or more occur. Shallow groundwater is currently the most important drinking water resource for the inhabitants of Kabul. The water is pumped up by countless hand-pumped wells throughout the city and accounts for 85 % of the total supply. Because there is no systematic sewage treatment or refuse collection, the shallow groundwater is affected by considerable contamination and the associated hygiene problems.

Figure 3 Kabul **River runs dry shortly after the snow has melted, wadi. (**rodneylovell.com)

2.4. Northern Afghanistan Artesian Basins

The groundwater level is around 30 m below ground level and appears to be below the elevation of the Maimana River, suggesting:

1) There is a degree of discontinuity between river and aquifer
2) The River is likely to be infiltrating water into the ground.

However, the sediments in the vicinity of the river are generally clayey, so the degree of river infiltration to the aquifer is likely to be rather limited.

Lack of good terrain elevation data renders the following observation very tentative, but it appears there is a slight slope of the groundwater level surface away from the Maimana River over much of the section, again suggesting an infiltrating river regime.

Much of the locally available groundwater has become saline and can only be used for irrigation and as drinking water for animals. The locals frequently have to walk 30 to 40 kilometers to collect drinking water for themselves.

Figure 4 **Faryab topography with riverbed.** (www.mil.no)

2.5. Climate

The Afghan climate has large fluctuations in temperature day-night both summer and winter. Wintertime the temperature may be -10 degrees Celsius, whilst during summertime the temperature may reach 50 degrees Celsius. The annual precipitation ranges from less than 50mm/year in the south-west to 1000mm/year in the northeastern highland. (Houben, G., 2009)

3. Risk assessment

Water-availability is of crucial importance to human beings. Providing drinking water that possesses no threat to human welfare is the objective of any water-supplier. The Norwegian Armed Forces has to provide its soldiers with drinking water the meets NOR civilian standards. The drinking water should be of good quality and safe for the soldier both in the short- and long-term. However, what is considered safe differs among different countries and military organizations with regards to what is analyzed and what levels are considered risk levels. There is work being done in North Atlantic Treaty Organization (NATO), in order to harmonize the understanding of safe potable water.

The Norwegian Armed Forces are now contributing troops and equipment worldwide. Soldiers in international operations are provided with bottled drinking water; both due to less than optimal quality of local water and from an operational safety aspect. Ideally having a local well in camp, providing quality drinking water, would increase operational security as well as quality control of the water. This is where the problem arises; the drinking water directive ("Drikkevannforskriften") might not be adaptive enough. So the terms of the guidelines could be better suited for international operations (INTOPS) for military personnel.

3.1. Problem formulation

In INTOPS there may be a Norwegian well-drilling team that set up one secure well within the temporary camp perimeter. This water is used to supply showers, toilets and other water-needs, but not as drinking water. This water is analysed according to the Norwegian Drinking Water Directive ("Drikkevannsforskriften"), but even though the water is concluded to be safe according to the Norwegian Directive, military personnel in INTOPS are supplied with bottled drinking water, which are produced by an international approved manufacturer. Theoretically one could use the water pumped out of the ground for drinking water as well. There are three issues preventing this today:

- Infrastructure in camp. A system that can ensure that the water maintains drinking water quality from well, to taps placed at different locations in camp.
- Analyses of the ground water. Research of local geology and area is necessary to decide which tests should be performed.
- Water-treatment. After the analyses have revealed the chemical composition of the water, are techniques available and present on site to remove the necessary contaminants?

The decisions on "safe water" are based on the criteria established in the Norwegian Drinking Water Directive, which consider a standard citizen to consume 2 litres of drinking water a day for 70 years and a subject weight of 70kg. This scenario does not resemble the situation in international operations. The terrain, climate and activity vary depending on the mission. The level of activity varies amongst different groups of soldiers. There may be a difference of 2 to 20 liters a day, depending on these factors.

3.2. Analysis

Soldiers sign up for six months at a time. Some may also do another six months within a three year period. I am going to look into what soldiers may be exposed to, if they use local water from wells as drinking water. The scenario parameters and variables are as follows:

- Water-quality: A chosen set of chemical parameters within the recommended values and exceeding the values set in "Drikkevannsforskriften" by 50%.
- The water is immediately bottled and consumed within a short period of time
- The bottle is of good quality and does not leach chemicals into the bottled water
- A six to 12 month period ("not a lifetime")
- Water-intake per day is set to ten liter per soldier
- Male soldier is 23 years and 85 kilo
- Female soldier is 23 years and 65 kilo

Risk levels are the levels set in the Norwegian "Drikkevannsforskriften". The levels are based on 2 L/day for 70 years, 70kg person.

The **Tolerable daily intake/ Acceptable daily intake (TDI/ADI)** is an estimate of the amount of a substance, expressed on a body weight basis that can be ingested daily over a lifetime without appreciable risk, mg/kg. Reference: World Health Organization, WHO.

The **no-observed-adverse-effect-level (NOAEL)** is defined as the highest dose or concentration of a chemical in a single study, found by experiment or observation, that causes no detectable adverse health effect. Wherever possible, the NOAEL is based on long-term studies, preferably of ingestion in drinking-water.

The **lowest-observed-adverse-effect level (LOAEL)** is the lowest concentration or amount of a substance found by experiment or observation which causes an adverse alteration of morphology, function, capacity, growth, development or life span of a target organism distinguished from normal organisms of the same species under defined conditions of exposure. Federal agencies use set approval standards below this level.

Uncertainty factor (UF) is normally applied when a LOAEL is used instead of a NOAEL. The derivation of these factors requires expert judgment and careful consideration of the available scientific evidence. Sources of uncertainty:

Intraspecies variation (individual variations within species, e.g. humans) UF = 1–10

Adequacy of studies or database UF= 1–10

Nature and severity of effect UF= 1–10

For most kinds of toxicity, it is believed that there is a dose below which no adverse effect will occur. For chemicals that give rise to such toxic effects, a tolerable daily intake (TDI) should be derived as follows, using the most sensitive end-point in the most relevant study, preferably involving administration in drinking-water:

TDI = (NOAEL or LOAEL)/ UF

The reason for choosing these metals/chemicals for this risk evaluation is the result of two factors:

1. These metals/chemicals are parameters most likely to be found in the ground water in Afghanistan. The metals are a result of geology in that area and may subsequently vary according to composition of the rocks the water passes. The chemicals are a result of more anthropogenic sources.

2. These metals/chemicals have adverse health effects when ingested in toxic levels. Some health effects are minor (nausea, skin rash), others are more serious (renal failure, cancer)

Antimony-

Elemental antimony forms very hard alloys with copper, lead and tin. Daily oral uptake of antimony appears to be significantly higher than exposure by inhalation, although total exposure from environmental sources, food and drinking-water is very low compared with occupational exposure.

Arsenic-

Arsenic is widely distributed through the earth`s crust, for instance as metal arsenates. Arsenic is introduced into ground water through the dissolution of naturally occurring minerals and ores. Arsenic in drinking.-water is a significant cause of health effects in some areas, and arsenic is considered to be a high priority substance for screening.

Lead-

Lead is used principally in the production of lead-acid batteries, ammunition, petrol, solder and alloys. Due to decreasing use, concentrations in air and food are declining, and intake from drinking-water constitutes a greater proportion of total intake.

Boron-

Boron is used in various manufacturing industries, e.g. glass, detergents and as flame retardants. Naturally occurring boron leaches to ground water from rocks and soils containing borates and borosilicate.

Cyanide-

Cyanide is occasionally found in drinking water, but usually at very low concentrations. However there may be spills from industry, and these can give rise to very high concentrations in drinking water sources.

Iron-

Iron is one of the most abundant metals in the Earth`s crust. It is found in natural fresh waters at levels up to 50 mg/L.

Cadmium-

Cadmium metal is used in the steel industry and in plastics and batteries. Cadmium is released to the environment in wastewater and by contamination from fertilizers.

Copper-

Copper is both an essential nutrient and a drinking-water contaminant. It has many uses in commercial industry, and may contaminate the ground locally.

Magnesium-

Magnesium is the fourth most abundant cation in the body and the second most abundant cation in intracellular fluid. Magnesium is naturally occurring in soils and rocks containing dolomite

Manganese-

Manganese is an essential element for humans, and one of the most abundant metals in the Earth`s crust. It is naturally occurring in many groundwater sources, particularly in anaerobic or low oxidation conditions.

Nitrate/Nitrite-

Nitrate and nitrite are naturally occurring ions in the nitrogen cycle. The nitrate concentration in ground water can increase as a result of runoff from agricultural land or contamination from human waste. The formation of nitrite is a consequence of anaerobic microbial activity and may be intermittent.

Selenium-

Selenium is an essential trace element, and present in the Earth`s crust.

Sodium-

Sodium salts are found in virtually all food and drinking-water. Contributing to sodium salts in ground water are areas close to sea-water and with the sodium-containing geology.

Table 1. **Chemical parameters most likely to be found in the ground water in Afghanistan**.

Parameter	***Risk level* mg/L**	***Risk level* +50% mg/L**	***Tolerable daily intake /Acceptable daily intake*** **mg/kg per day (85 kg/65kg) mg per day**	***LOAEL*** **mg/kg per day (85kg/65kg) mg per day**	***Total mg intake with 10 L intake per day***		***Total volume of liters per day, at risk level, in order to reach LOAEL/ADI***
					Water w/risk level content	***Water w/risk level +50% content***	
Antimony (Sb)	0,005	0,0075	0,006 (0,51/0,39)	0,35 (29,8/22,8)	0,05	0,075	65 kg: 1380/78 85 kg: 1800/102
Arsen (As)	0,01	0,015	0,002 (0,17/0,13)	0,014 (1,2/0,9)	0,1	0,15	65 kg: 90/13 85 kg: 120/17
Lead (Pb)	0,01	0,015	0,0035 (0,30/0,23)	0,2 (17/13)	0,1	0,15	65 kg: 1300/23 85 kg: 1700/30
Boron (B)	1,0	1,50	**0,16 (13,60/10,40)**	Not set. But 72 mg gives adverse effect	10	15	65 kg: 72/10,4 85 kg: 72/13,6
Cyanide (CN)	0,01	0,015	0,012 (1,02/0,78)	1,2 (102/78)	0,1	0,15	65 kg: 7800/78 85 kg: 10200/102
Iron (Fe)	0,2	0,30	Men: 9 mg/day Women: 15mg/day	100mg/day	2	3	65 kg: 500/75 85 kg: 500/45
Cadmium (Cd)	0,005	0,0075	**0,001 (0,085/ 0,065)**	**0,001 (some ref. to 0,0002) (0,085/0,065)**	0,05	0,075	65 kg: 13/13 85 kg: 17/17
Copper (Cu)	0,1	0,15	**0,9mg/day**	5,3 mg per day	1	1,50	65 kg: 53/9 85 kg: 53/9
Manganese (Mn)	0,05	0,075	0,06 (5,1/3,9)	15 mg per day	0,5	0,75	65 kg: 300/78 85 kg: 300/102
Magnesium (Mg)	125 (EU)	187,5	250 mg per day	360 mg per day	1250	1875	65 kg: 3/- 85 kg: 3/-

Parameter	***Risk level* mg/L**	***Risk level* +50% mg/L**	***Tolerable daily intake /Acceptable daily intake*** **mg/kg per day** **(85 kg/65kg)** **mg per day**	***LOAEL*** **mg/kg per day** **(85kg/65kg)** **mg per day**	***Total mg intake with 10 L intake per day***		***Total volume of liters per day, at risk level, in order to reach LOAEL/ADI***
					Water w/risk level content	***Water w/risk level +50% content***	
Nitrate (NO_3 - N)	10	15	0-3,7 (314,5/240,5)	***1,8-3,2*** ***(153/117)***	100	150	65 kg: 11,7/24 85 kg: 15,3/31,5
Nitrite (NO_2 - N)	0,05	0,075	0,07 (5,95/4,55)	0,37 (31,5/24)	0,5	0,75	65 kg: 480/91 85 kg: 630/119
Selenium	0,01	0,015	Men: 0,05mg/day Women: 0,04mg/day	0,91 mg per day	0,1	0,15	65 kg: 91/4 85 kg: 91/5
Sodium (Na)	200	300	2400mg per day	Not set	2000	3000	65 kg: ?/12 85 kg:?/12

Looking at Table 1, one can see which chemicals will exceed LOAEL, at a daily water intake of 10 liters.

Exceeding LOAEL: A soldier drinking 10 liters of water, with levels within the limits set by "Drikkevannsforskriften", will still exceed LOAEL by drinking water alone for the metal cadmium and the polyatomic ion nitrate.

The metal cadmium has a TDI/ADI of 0,001mg/kg, whilst LOAEL varies in literature between 0,001 to 0,0002mg/kg. The 0,0002mg/kg level is connected to long term exposure, and since this is for 6 month to one year, the LOAEL is set to 0,001mg/kg this risk assessment.

Nitrate exceed LOAEL when the level are more than 50% than the risk level, and then only for the 65 kg female.

Exceeding TDI/ADI: The metals arsenic, boron, cadmium, copper and selenium all exceed tolerable/acceptable daily intake.

The metal that exceeds TDI/ADI with 10 L per day of drinking water that is of acceptable quality according to "Drikkevannsforskriften" is copper. This is an essential nutrient for humans. The risk level + 50% are the metals arsenic, boron, cadmium, selenium and nitrate.

3.3. Risk characterization

The drinking water should be of good quality, safe for the soldier both in the short- and long-term. However, parameters measured and risk levels vary between the organisations.

Table 2. **Comparison of risk levels inorganic chemicals**

Parameter	Unit Max level or TT.	**WHO** 60 kg, 2 L per day for 70 years.	**Norway** 70 kg, 2 L per day for 70 years.	**EU** 70 kg, 2L per day for 70 years.	**USA** 70 kg, 2 L per day for 70 years.	**NATO**	
						Annex A 5L/15L per day, max 7	Annex B 5L per day, routine
Aluminum (Al)	mg/L	***	0.2*	0.2*	--	--	28
Ammonium (NH4+)	mg/L	***	0.5*	0.5*	--	--	4.2
Antimony (Sb)	mg/L	0.02	0.005*	0.005*	0.006	--	0.02
Arsenic (As)	mg/L	0.01**	0.01*	0.01	0.01	0.3/0.1	0.010
Asbestos	Mill. fibers per L	***	--	--	7	--	--
Barium (Ba)	mg/L	0.7	--	--	2	--	--
Beryllium (Be)	mg/L	--	--	--	0.004	--	--
Boron (B)	mg/L	0.5**	1.0*	1.0*	--	--	1.3
Cadmium (Cd)	mg/L	0.003	0.005*	0.005*	0.005	--	0.007
Chloride (Cl-)	mg/L	***	200*	250*	--	600/600	600
Chromium (Cr)	mg/L	0.05**	0.05*	0.05*	0.1	--	0.3

Parameter	Unit	WHO	Norway	EU	USA	NATO	
Copper (Cu)	mg/L	2.0	0.1 w.plant1.0 tap*	2.0*	1,3=action, TT	--	2.0
Cyanide, free (CN)	mg/L	0.07	0.01*	0.05*	0.2	6/2	0.28
Fluoride (F)	mg/L	1.5	1.5*	1.5*	4.0	--	1.7
Iodine (I)	mg/L	1	--	--	--	--	--
Iron (Fe)	mg/L	***	0.2*	0.2*	--	--	4.2
Lead (Pb)	mg/L	0.01	0.01*	0.01*	0.015= action, TT	--	0.015
Magnesium (Mg)	mg/L	--	--	125	175	100/30	--
Manganese (Mn)	mg/L	0.4	0.05*	0.05*	--	--	2.0
Mercury (Hg)	mg/L	0.006	0.0005*	0.001*	0.002	0.003/ 0.001	0.002
Molybdenu m (Mo)	mg/L	0,07	--	--	--	--	--
Nickel (Ni)	mg/L	0.07	0.02*	0.02*	--	--	0.28
Nitrate (NO3-)	mg/L	50	10*	50*	10	--	97
Nitrite (NO2-)	mg/L	0.2	0.05*	0.5*	1	--	--
Selenium(Se)	mg/L	0.01	0.01*	0.01*	0.05	--	0.07
Silver (Ag)	mg/L	***	--	--	--	--	--
Sulfate SO4-	mg/L	***	100	250*	--	300/100	300
Sodium (Na)	mg/L	***	200*	200*	--	--	--

Thallium (Tl)	mg/L	--	--	--	0.002	--	--
Zinc (Zn)	mg/L	***	--	--	--	--	--

* Quality requirements
** Provisional guideline
*** Risk evaluation concludes with no guideline value needed
TT= treatment technique
mg/L= milligrams per liter
Bq/L= Bequerel per liter (emittance)
MRDL= maximum residual disinfectant level
Tbd= To be decided

A soldier drinking water containing metals at levels exceeding the LOAEL will have a probability of experiencing unwanted adverse effects as a consequence of the quality and quantity of water intake.

Potential health effects

The potential health effects of the different metals are ref.: Table 1. Chemical parameters most likely to be found in the ground water in Afghanistan; WHO (2009); (who.int/water_sanitation_health/dwq/chemicals/en); (epa.gov/iris/).

Arsenic-

Arsenic is one of the few substances shown to cause cancer in humans through consumption of drinking-water. This is causally related to development of cancer at skin, bladder and lung.

WHO has set a provisional guideline value of 0,01mg/l, which is the same as the Norwegian limit.

Probability- In this assessment the female would have to drink 90 liters a day, of acceptable water, in order to reach LOAEL. But in order to reach TDI, only 13 liters is necessary. There is also uncertainty over the contribution of arsenic in food – a higher intake of inorganic arsenic from food would lead to a lower risk estimate for water – and the impact of factors such as variation in the metabolism of arsenic and nutritional status.

Consequence- Arsenic has been, as mentioned, shown to cause cancer. This potential consequence is severe, and needs to be addressed.

Boron-

Short- and long-term oral exposures to boric acid or borax in laboratory animals have demonstrated that the male reproductive tract is a consistent target of toxicity. Negative results in a large number of mutagenicity assays indicate that boric acid and borax are not genotoxic.

WHO has set a provisional guideline value of 0,5mg/l, which is half of the Norwegian limit (1.0 mg/l).

Probability- In this assessment the LOAEL value is not a probability since it requires drinking 72 liters per day. Water with boron-level within risk level will bring the female at 65 kg up to ADI level, whilst the man will exceed the ADI at risk level + 50%.

Consequence- The potential of toxicity on the male reproductive tract is very relevant since young male soldiers are the primary consumers of this water.

Cadmium-

Absorption of cadmium compounds is dependent on the solubility of the compounds. Cadmium accumulates primarily in the kidneys and has a long biological half-life in humans of 10–35 years. The kidney is the main target organ for cadmium toxicity. However, there is no evidence of carcinogenicity by the oral route and no clear evidence for the genotoxicity of cadmium.

WHO has set a guideline value of 0,003mg/l, which are lower than the Norwegian risk level.

Probability- LOAEL and TDI are defined to be equal in this assessment. Only level 50% above risk level result in LOAEL/TDI for the female soldier, 0,075mg per day, equals 0,0012mg/kg. The critical cadmium concentration in the renal cortex that would produce a 10% prevalence of low-molecular-weight proteinuria in the general population is about 200 mg/kg and would be reached after a daily dietary intake of about 175mg per person for 50 years. But at the same time the female soldier would only have to consume 13 liters and the male 17 liters of water in order to reach LOAEL/TDI in this assessment.

Consequence- The consequences are somewhat uncertain. The LOAEL are easily obtainable within permissible risk levels, but documentation of the consequences at this level are difficult to find.

Copper-

This assessment was based on studies of gastrointestinal effects of copper-contaminated drinking-water. Recent studies have delineated the threshold for the effects of copper in drinking-water on the gastrointestinal tract, but there is still some uncertainty regarding the long-term effects of copper on sensitive populations, such as carriers of the gene for Wilson disease and other metabolic disorders of copper homeostasis. Chronic (long-term exposure) effects of copper exposure can damage the liver and kidneys. I addition to copper being an essential nutrient, mammals have efficient mechanisms to regulate copper stores such that they are generally protected from excess dietary copper levels.

WHO has a guideline value of 2mg/l, which is 20 times higher than the Norwegian limit.

Probability- It takes 53 liters to reach LOAEL for Copper, but only 9 liters to reach ADI. The likelihood of soldier`s intake of copper exceeding ADI is high.

Consequence- The potential consequence of drinking 10 liters a day of this water is small. It would contribute to ADI of copper, but at the same time WHO has set the limit 20 times higher.

Nitrate-

The primary health concern regarding nitrate and nitrite is the formation of methemoglobinemia, so-called “blue-baby syndrome.” Nitrate is reduced to nitrite in the stomach of infants, and nitrite is able to oxidize hemoglobin (Hb) to methemoglobin (metHb), which is unable to transport oxygen around the body. The weight of evidence is strongly against there being an association between nitrite and nitrate exposure in humans and the risk of cancer. LOAEL (ref. USEPA) varies according to different studies between 1,8-3,2 mg/kg/day. TDI varies between 0 to 3,7mg/kg/day, which may actually be higher mg/kg/day than LOAEL!

WHO have set a guideline value for nitrate at 50mg/ liter.

Probability- Lowest value of LOAEL is reached with risk level +50% for male and female soldiers.

Consequence- The variation in LOAEL and TDI values between US EPA, WHO and “Drikkevannsforskriften”, and the fact that infants are most at risk, makes the potential methemoglobinaemia consequence for soldiers low. Guidelines concluded that extensive epidemiological data support the current guideline value for nitrate-nitrogen of 10 mg/liter, but stated that this value should be expressed not on the basis of nitrate-nitrogen but on the basis of nitrate itself, which is the chemical entity of concern to health. The guideline value for nitrate is set to 50 mg/ liter.

Magnesium-

Osmotic diarrhea was chosen as the most sensitive toxic manifestation of excess magnesium intake as a result of excessive dietary intakes. The critical effect is osmotic diarrhea; other effects include nausea, abdominal cramping, and serious neurological and cardiac symptoms. No adverse effects have been associated with the ingestion of magnesium from food sources.

Since WHO have not set an official guideline level for magnesium, the upper level (UL) used will be UL approved by the European Union (EU) “Upper levels for calcium and magnesium intake, by national/regional authority” (adapted from FAO/WHO Technical Workshop on Nutrient Risk Assessment 2006)

EU have an upper level value for magnesium at 250mg/ day; hence 125mg/l (since 2L/day).

Probability- LOAEL magnesium set by the Food and Nutrition Board (FNB) (1997) is 360 mg.

Consequence- Healthy human kidneys are capable of excreting 40-60 magnesium per day without side effects when there is persistent infusion. Elevated serum levels may occur if drugs containing magnesium are taken in excess of 15 grams per day on a chronic basis. Moderate increase in serum plasma levels may induce symptoms such as nausea, vomiting and hypertension. (Hathcock. J.N., 2004)

Selenium-

Selenium is an essential element for humans, with a recommended daily intake of about 1mg/kg of body weight for adults. The toxic effects of long-term selenium exposure are manifested in nails, hair and liver. Data from China indicate that clinical and biochemical signs occur at a daily intake above 0.8mg. No clinical or biochemical signs of selenium toxicity were reported in a group of 142 persons with a mean daily intake of 0.24mg from food.

WHO has set a guideline value 0, 01 mg/liter.

Probability- ADI is reached with only 4 to 5 liters of drinking water. But in order to reach LOAEL 91 liters of drinking water is required, and highly unobtainable.

Consequence- There seems to be unlikely with any health effects with levels up to 0,15mg Se per day, based on previously mentioned study.

3.4. Adaptability of "Drikkevannsforskriften"

The Norwegian "Drikkevannsforskriften" would provide safe drinking water for male and female soldiers consuming 10 liters a day, for most of the parameters in this assessment. The fact that the drinking water that qualifies at 2L/day, fails at some of the parameters when the volume increases to 10L/day, suggests that the Directive has not the inherent ability to adapt to larger amounts of consumed water.

There are four parameters which need further assessment whether or not we need different risk levels in INTOPS, than in Norway.

Boron-

WHO contributes 2 liters of drinking water a day to contribute to 40% of total boron uptake. With 10 liters this would be even higher, and would require more monitoring. WHO has also a lower guideline value, 0,5 mg/liter, against Norway`s 1,0 mg/l. Standard water treatment does not remove boron, and with the male reproductive tract a consistent target of toxicity, risk level should possibly be adjusted.

Cadmium-

WHO contributes 2L of drinking water a day to contribute to 10% of total cadmium uptake. The main sources are food and tobacco, especially in underdeveloped countries. WHO also has a lower guideline value, 0,003mg/l, against Norway`s 0,005mg/l. With a LOAEL value ranging from 0,0002 mg/kg/day to 0,001mg/kg/day, there is reason to do more research about total cadmium uptake for soldiers. This includes total volume of water per day, quality of water, cadmium-content in food and tobacco content.

Magnesium-

This element is of vital importance in many biochemical and physiological processes. Hypomagnesaemia is considered a larger problem than the relative mild toxic effects of hypomagnesaemia. It is only when supplements reach more than 10 mg/kg/day that plasma levels may become elevated. (Hathcock, J. N., 2004)

Nitrate-

WHO emphasizes the connection between nitrate and nitrite. Nitrite is 10 times more potent in causing methaemoglobinaemia than nitrate. Chloramination may give rise to the formation of nitrite within the distribution system if the formation of chloramine is not sufficiently controlled. The formation of nitrite is as a consequence of microbial activity and may be intermittent. All water systems that practice chloramination should closely and regularly monitor their systems to verify disinfectant levels, microbiological quality and nitrite levels. There is reason to do more research, including nitrate vs. nitrite levels, chlorination procedures and microbial quality.

4. Method and materials

4.1. Site description

The groundwater was sampled from wells in Kabul and in Maimanah, two locations where ISAF had established military bases.

In Kabul the wells were located securely inside camp and operated by a civilian contractor. They were responsible for providing enough water of a given quality, to the entire camp. The human usage of this water was for personal hygiene and preparation of food. Drinking water was bottled water delivered to camp.

In Maimanah the wells were located securely inside camp and operated by the Norwegian Armed Forces (NAF). Due to periodical ground water shortages, there was sometimes the need to restrict water usage in camp. The human usage of this water was for personal hygiene and preparation of food. Drinking water was bottled water delivered to camp.

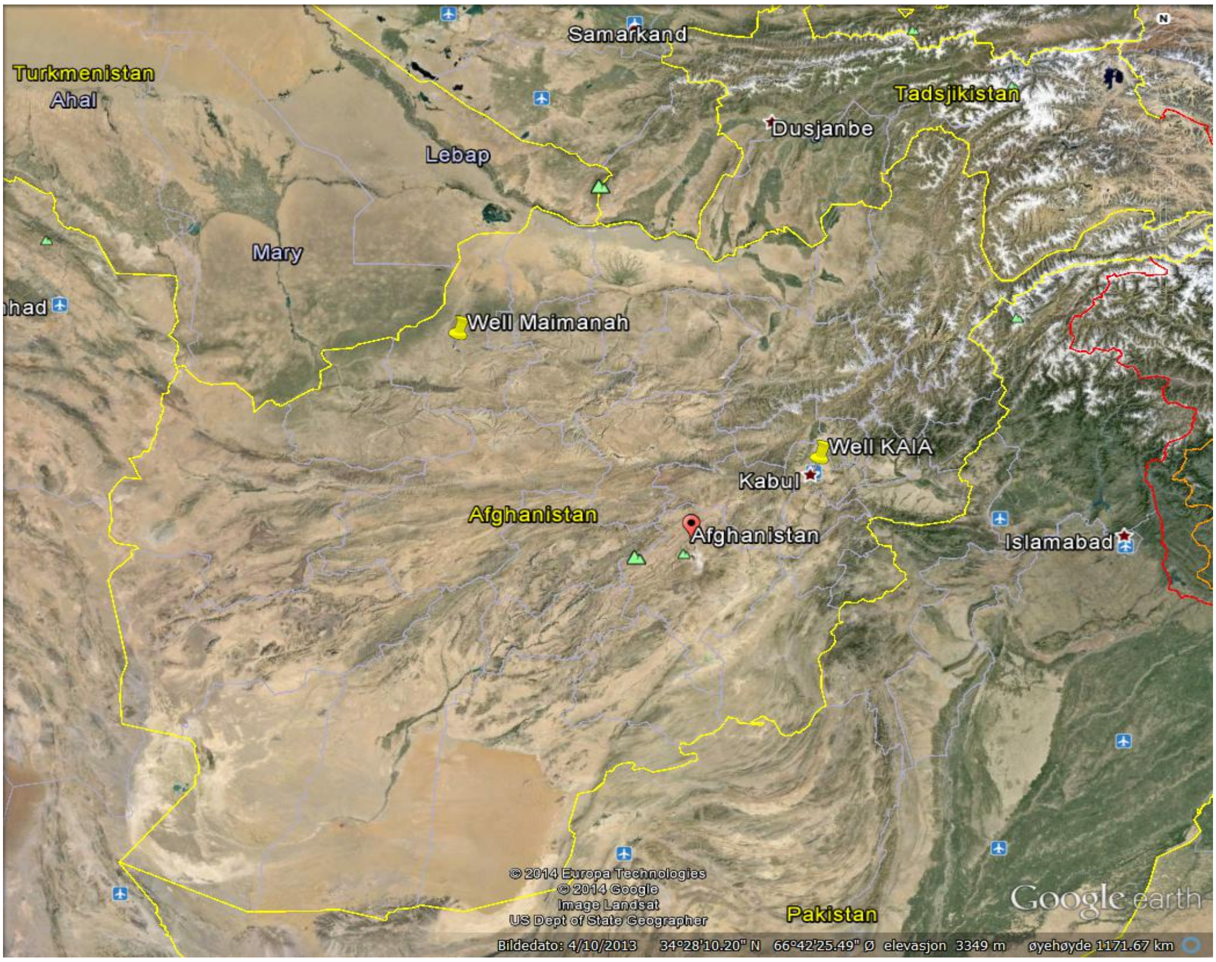

Figure 4 **Afghanistan and location of Maimanah and Kabul.** (google.com/earth/)

Figure 5 **Location of well in ISAF camp Maimanah.** (google.com/earth/)

Figure 6 **Location of well at KAIA, Kabul International Airport.** (google.com/earth/)

4.2. Fieldwork

The water was sampled in June and July 2012. The samples were then stored in Afghanistan for 7 months prior to being transported to Norway and the NMBU. They kept being stored in the lab at NMBU for another 13 months. Analysis of the samples was performed in March/April 2014.

4.3. Analyses

The sampling and analyzing procedure was executed according to Appendix B.

Laboratory personnel at the research laboratory at NMBU-IMV conducted the analyses. Instrument used was Agilent 8800 Triple Quadrupole ICP-MS, and the content of 59 different elements was determined.

5. Results and discussion

5.1. Quality of the measurements

The **limit of quantification** (LOQ) is the lowest amount of element which can be quantitatively determined with suitable precision and accuracy.

The **limit of detection** (LOD) is the lowest amount of element that is possible (by this method) to detect, but not necessarily quantified as an exact value.

The **mean** (x) is calculated by the sum of the numbers, divided by the number of samples.

The **standard deviation** (SD, σ) is calculated to measure the amount of variation from the mean. A low standard deviation indicates that the data points tend to be very close to the mean, whilst a high standard deviation indicates that the data points are spread out over a large range of values. When the determined result are below limit of quantification (<LQ), there are no valid data to calculate standard deviation (SD)

The **median ($\dot{x}$)** is determined by arranging all the 3 parallels from lowest value to highest value and picking the middle one.

The **relative deviation** (RD, %) is determined by $[(x_{max} - \dot{x})/ \dot{x}] * 100$ (%). A high RD indicates that there is a large variation between the measured parallels, relative to the mean. This means that the mean value is associated with large uncertainty.

The results presented in this study are most likely associated with relatively large uncertainties. The number of collected samples (3) are simply too few in order to ensure full statistical validity. Therefore, in future analyses one should ideally retrieve more samples (> 10) evenly distributed both time of year and time of day. This would significantly decrease the uncertainty of the analyses. Despite the limitation associated with only a few samples, this study provides valuable results that can be used as a guideline concerning the water quality in this particular region of Afghanistan. ,

The most straightforward way to ensure safe drinking water would be to only trust drinking water with all three of the parameters below limit of detection (LD). If more samples are to be included, this criterion might be refined.

5.2. Results of the water analyses

The selection of parameters and the results of the analyses of the water samples are described in Table 3. The unit of the measured value varies according to the parameter determined.

The high number (59) of elements are due to the history of Afghanistan. As mentioned in the introduction, Afghanistan has endured a lot of military activity, and there is of interest to see if one would encounter only natural occurring elements.

Table 3. **Results of the analyses**

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul
Li 0,300	Mean value µg/L	167	0,4	330	<LD	167	0,4	347	0,5
	Median, µg/L	170	<0,3	320	<LD	170	<0,30	350	0,60
	SD,µg/L	5,8	0,29	17	-	5,8	0,36	5,8	0,17
	RD (%)	1,8	35	6	-	1,8	51	0,86	30
	No samples,n	3	3	3	3	3	3	3	3
Be 0,013	Mean value µg/L	<LD	<LD	0,013	<LD	0,013	<LD	0,013	<LD
	Median, µg/L	<LD	<LD	<0,013	<LD	<LD	<LD	<LD	<LD
	SD, µg/L	-	-	-	-	-	-	-	-
	RD (%)	-	-	-	-	-	-	-	-
	No samples,n	3	3	3	3	3	3	3	3
B 0,008	Mean value mg/L	**5,0**	0,10	**9,0**	0,039	**5,2**	0,070	**9,8**	0,087
	Median, mg/L	5,1	0,055	8,7	0,040	5,2	0,058	9,8	0,076
	SD, mg/L	3,5	0,70	0,4	0,0060	0,2	0,035	0,15	0,039
	RD (%)	6	40	8,9	13	3,8	57	1,0	49
	No samples,n	3	3	3	3	3	3	3	3
Na 0,35	Mean value mg/L	**740**	0,86	**1400**	<0,35	**750**	0,47	**1400**	0,98
	Median, mg/L	740	0,66	1400	<0,35	760	0,40	1400	0,84
	SD, mg/L	15	0,57	58	0	17	0,33	0	0,67
	RD (%)	2,7	74	0	0	1,3	40	0	74
	No samples,n	3	3	3	3	3	3	3	3
Mg 0,013	Mean value mg/L	**150**	0,042	**310**	0,013	**160**	0,014	**310**	0,051
	Median, mg/L	150	0,042	310	<0,013	160	<0,013	310	0,039
	SD, mg/L	5,8	0,023	5,8	0	0	0,009	5,8	0,050
	RD (%)	6,7	0	3,2	0	0	7,1	3,2	96
	No samples,n	3	3	3	3	3	3	3	3
Al 1,7µg/L	Mean value mg/L	0,0017	0,0025	0,0220	0,0017	0,026	0,0017	0,016	0,0022
	Median, mg/L	<0,0017	0,0025	0,02	<LD	0,018	<LD	0,017	0,0022

A LOQ	Sample	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
Li 0,300	Mean value µg/L	23	0,3	0,1	0,1	<LD	<LD	<LD	<LD
	Median, µg/L	22	0,3	<LD	<LD	<LD	<LD	<LD	<LD
	SD,µg/L	1,2	0,0	-	-	-	-	-	-
	RD (%)	4,3	0,0	-	-	-	-	-	-
	No samples,n	3	3	3	3	3	3	3	3
Be 0,013	Mean value µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg/L	-	-	-	-	-	-	-	-
	RD (%)	-	-	-	-	-	-	-	-
	No samples,n	3	3	3	3	3	3	3	3
B 0,008	Mean value mg/L	0,20	0,030	0,022	0,030	0,022	0,016	0,020	0,015
	Median, mg/L	0,19	0,027	0,022	0,030	0,022	0,016	0,021	0,015
	SD, mg/L	0,016	0,0046	0,0020	0,0035	0,0030	0,0015	0,0060	0,0015
	RD (%)	5	17	9,1	13	14	13	30	13
	No samples,n	3	3	3	3	3	3	3	3
Na 0,35	Mean value mg/L	78	0,35	<LD	<LD	<LD	<LD	<LD	<LD
	Median, mg/L	78	<0,35	<LD	><LD	<LD	<LD	<LD	<LD
	SD, mg/L	0	0	-	-	-	-	-	-
	RD (%)	0	0	-	-	-	-	-	-
	No samples,n	3	3	3	3	3	3	3	3
Mg 0,013	Mean value mg/L	43	0,015	0,018	0,013	<LD	<LD	0,0040	<LD
	Median, mg/L	43	<0,013	<LD	<LD	<LD	<LD	<LD	<LD
	SD, mg/L	0,58	0,010	-	-	-	-	-	-
	RD (%)	2,3	20	-	-	0	0	225	0
	No samples,n	3	3	3	3	3	3	3	3
Al 1,7µg/L	Mean value mg/L	0,0017	0,0017	0,0064	<0,0017	<0,001	<LD	<0,0017	<0,0017
	Median, mg/L	0,0017	0,0017	<LD	<LD	<LD	<LD	<LD	<LD

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
	SD, mg/L	0	0,0042	0,0060	-	0,011	-	0,002	-	0	0,0	-	-	-	0	-	-
	RD (%)	0	12	32	-	31	-	13	-	0	-	-	-	-	0	-	-
	No samples,n	3	2	3	3	2	3	3	1	3	2	3	3	3	3	3	3
Si 0,009	Mean value mg/L	9,2	0,020	9,6	0,010	8,9	0,009	9,73	0,013	5,23	0,011	0,009	0,009	0,009	0,009	0,012	0,009
	Median, mg/L	9,2	0,020	9,6	0,011	8,9	<0,009	9,7	0,013	5,2	0,011	<0,009	<0,009	<0,009	<0,009	<0,009	<0,009
	SD, mg/L	0,153	0,0021	0,15	0,001	0,058	0,0050	0,058	0,054	0,15	0,0014	0,0	0,0050	0,0	0,0	0,010	0,0050
	RD (%)	1,1	5	1,4	10	1,1	5,6	0,72	31	3,3	9,1	-	5,6	-	-	50	4,4
	No samples,n	3	2	3	3	3	3	3	2	3	2	2	3	3	3	3	3
P 2,0	Mean value µg/L	13,7	2,1	16	2,0	14	2,0	10	2,0	4,6	2,0	2,0	200	2,0	2,0	130	2,0
	Median, µg/L	13	<2	17	<2	13	<2	16	<2	4,6	<2	<2	<2	<2	<2	<2	<2
	SD	1,155	1,328	1,2	0	3,2	0	1,5	0	0,20	0	0	0	0	0	220	0
	RD (%)	9,5	9,5	4,1	0	29	0	70	0	4,3	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3
S 0,09	Mean value mg/L	370	0,32	720	0,20	380	0,18	750	0,27	57	0,10	0,090	0,090	0,090	0,090	0,090	0,060
	Median, mg/L	370	0,30	720	0,20	380	0,17	750	0,29	56	0,10	<0,090	<0,090	<0,090	<0,090	<0,090	<0,090
	SD,	5,8	0,068	15	0,030	0	0,037	5,8	0,070	2,3	0,014	0	0	0	0	0	0,0
	RD (%)	2,7	3,3	2,4	15	0	22	1,3	14	5,3	20	0	0	0	0	0	50
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
K 0,010	Mean value mg/L	9,7	<LD	14	<LD	9,8	<LD	14	<LD	4,0	<LD	<LD	<LD	<LD	<LD	0,037	0,048
	Median, mg/L	9,7	<LD	14	<LD	9,9	<LD	14	<LD	4,0	<LD	<LD	<LD	<LD	<LD	0,037	0,048
	SD	0,25	0	0	0	0,32	0	0	0	0	0	0	0	0	0	0,010	0,0070
	RD (%)	3,1	0	0	0	2,0	0	0	0	0	0	0	0	0	0	19	15
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
Ca 0,06	Mean value mg/L	100	<LD	150	<LD	100	<LD	140	<LD	83	<LD	<LD	<LD	<LD	<LD	0,29	<LD
	Median, mg/L	100	<LD	150	<LD	100	<LD	140	<LD	83	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	5,8	0	0	0	5,8	0	1,0	0	0	0	0	0	0,50	0
	RD (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	196	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

A LOQ	Sample / Location	1,2,3 KAIA, well A Kabul	7,8,9 BLANK KAIA, well A Kabul	4,5,6 KAIA, tank A Kabul	10,11,12 BLANK KAIA, tank A Kabul	13,14,15 KAIA, well B Kabul	16,17,18 BLANK KAIA, well B Kabul	19,20,21 KAIA, tank B Kabul	22,23,24 BLANK KAIA, tank B Kabul	25,26,27 Maimanah well 1	28,29,30 BLANK Maimanah, well 1	31,32,33 Maimanah, well 2	34,35,36 BLANK Maimanah, well 2	37,38,39 Maimanah, well 3	40,41,42 BLANK Maimanah, well 3	43,44,45 Maimanah, well 4	46,47,48 BLANK Maimanah, well 4
Sc 0,03	**Mean value µg/L**	0,030	<LD	0,042	<LD	0,030	<LD	0,034	<LD	0,030	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	0,03	<LD	0,042	<LD	<0,030	<LD	0,035	<LD	<0,030	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0,0020	0	0,017	0	0,0030	0	0	0	0	0	0	0	0	0
	RD (%)	0	0	4,8	0	0	0	8,8	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
V 0,007	**Mean value µg/L**	15	0,013	13	<LD	14	<LD	12	0,015	1,5	<LD	<LD	<LD	<LD	<LD	0,045	<LD
	Median, µg/L	15	<0,0065	13	<LD	14	<LD	12	0,015	1,5	<LD	<LD	<LD	<LD	<LD	0,045	<LD
	SD, µg /L	0,58	0	0,58	0	0,58	0	0,58	0,0	0,058	0	0	0	0	0	0,0	0
	RD (%)	0	50	0	0	0	0	0	-	0	0	0	0	0	0	-	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0
Cr 0,3	**Mean value µg/L**	0,64	<LD	2,4	<LD	0,66	<LD	2,3	<LD	2,7	<LD	<LD	<LD	<LD	<LD	<LD	0,3
	Median, µg/L	0,64	<LD	2,3	<LD	0,57	<LD	2,4	<LD	2,5	<LD	<LD	<LD	<LD	<LD	<LD	0,3
	SD, µg /L	0,010	0	0,23	0	0,17	0	0,12	0	0	0	0	0	0	0	0	0,0
	RD (%)	1,6	0	13	0	29	0	4,3	0	19	0	0	0	0	0	0	-
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1
Mn 0,04	**Mean value µg/L**	**50**	0,036	16	<LD	**68**	<LD	6,9	0,036	0,078	0,024	0,036	<LD	<LD	<LD	0,10	0,036
	Median, µg/L	50	<0,036	15	<LD	55	<LD	7,0	0,036	0,063	<0,036	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	1	0,0	1,7	0	24	0	0,50	0,0	0,020	0,021	0,0	0	0	0	0,0	0,0
	RD (%)	2	-	13	0	40	0	7,2	-	28	50	-	0	0	0	-	-
	No samples,n	3	2	3	3	3	3	3	1	3	3	1	3	3	3	1	1
Fe 1,1	**Mean value µg/L**	41	3,1	50	0,73	**250**	1,1	47	2,2	1,2	1,3	3,0	1,1	1,1	<LD	1,6	1,4
	Median, µg/L	40	3,1	51	<1,1	250	<1,1	42	2,2	1,2	1,3	<LD	<1,1	<LD	<LD	<LD	<LD
	SD, µg /L	2,1	0,50	9,5	0	28,0	0,0	15	0,0	0,070	0,21	0,0	0,0	0,0	-	0,64	0,42
	RD (%)	4,9	9,7	18	50	8	-	36	-	8,3	7,7	-	-	-	-	25	21
	No samples,n	3	2	3	3	2	2	3	1	2	2	1	2	1	3	2	2
Co 0,15	**Mean value µg/L**	0,46	0,15	0,43	<LD	0,62	<LD	0,38	0,10	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	0,46	<LD	0,43	<LD	0,50	<LD	0,38	<0,15	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
	SD, µg /L	0,0060	0,0	0,015	0	0,25	0	0,020	0	0	0	0	0	0	0	0	0
	RD (%)	0	-	0	0	47	0	5,3	50	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ni 0,023	Mean value µg/L	3,9	0,063	7,3	0,023	160	0,034	4,5	0,031	0,19	0,015	0,039	0,027	0,028	0,015	0,015	0,034
	Median, µg/L	4,0	<LD	6,5	<0,023	11	<0,023	4,5	<0,023	0,12	<0,023	0,033	<0,023	0,028	<0,023	<0,023	<0,023
	SD, µg /L	0,12	0,0	1,6	0	250	0,032	0,15	0,040	0,14	0	0,016	0,020	0,018	0	0	0,033
	RD (%)	2,6	-	26	0	180	65	4,4	120	84	53	46	26	21	53	53	68
	No samples,n	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Cu 0,15	Mean value µg/L	0,30	<LD	5,3	<LD	7,8	<LD	3,8	0,090	0,48	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	0,30	<LD	4,6	<LD	1,2	<LD	4,0	<LD	0,49	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,020	0	1,8	0	12	0	2,1	0,16	0,021	0	0	0	0	0	0	0
	RD (%)	3,3	0	40	0	180	0	50	200	4,2	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Zn 0,12	Mean value µg/L	6,3	0,12	290	0,040	26	0,040	1200	0,30	130	0,080	0,073	<LD	0,040	0,040	0,040	0,107
	Median, µg/L	6,2	<0,12	260	<LD	25	<LD	590	0,15	130	<0,12	<LD	<LD	<LD	<LD	<LD	<0,12
	SD, µg /L	0,23	0,075	180	0	20	0	1400	0,40	0	0	0,13	0	0	0	0	0,115
	RD (%)	4,8	8,3	100	200	81	200	130	150	0	50	200	0	200	200	200	9,3
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ga 0,006	Mean value µg/L	0,0070	0,0040	0,0080	<LD	0,010	0,040	0,010	0,0020	0,013	0,0030	<LD	0,0020	<LD	<LD	0,16	<LD
	Median, µg/L	<0,0060	<0,0060	0,0076	<LD	0,0091	<LD	0,011	<LD	0,014	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,0050	0	0,0060	0	0,011	0	0,0010	0	0,0030	0,0050	0	0	0	0	0,28	0
	RD (%)	36	50	38	0	120	0	10	200	15	170	0	200	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ge 0,031	Mean value µg/L	0,10	<LD	0,079	<LD	0,15	<LD	0,081	<LD	0,031	<LD	<LD	<LD	<LD	<LD	0,12	<LD
	Median, µg/L	0,11	<LD	0,069	<LD	0,11	<LD	0,070	<LD	<0,031	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,019	0	0,020	0	0,080	0	0,025	0	0	0	0	0	0	0	0,21	0
	RD (%)	20	0	27	0	60	0	36	0	0	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
As 0,009	**Mean value µg/L**	1,4	<LD	1,8	0,0030	1,4	<LD	1,8	<LD	0,40	0,0030	0,0030	0,0060	0,0030	0,0030	0,0060	<LD
	Median, µg/L	1,4	<LD	1,8	<LD	1,4	<LD	1,8	<LD	0,44	<LD	<LD	<0,009	<LD	<LD	<0,009	<LD
	SD, µg /L	0	0	0,058	0	0,058	0	0,153	0	0,015	0	0	0	0	0	0,006	0
	RD (%)	0	0	5,6	200	0	0	5,6	0	13	200	200	50	200	200	60	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Se 0,009	**Mean value µg/L**	0,41	<LD	2,3	0,012	0,34	<LD	2,3	0,022	1,7	0,028	0,016	0,0030	0,039	0,0090	0,054	0,028
	Median, µg/L	0,46	<LD	2,4	0,013	0,38	<LD	2,4	0,029	1,8	0,020	0,024	<LD	0,023	<LD	0,062	<LD
	SD, µg /L	0,10	0	0,36	0,012	0,13	0	0,12	0,019	0,12	0,032	0,014	0	0,048	0,016	0,039	0,048
	RD (%)	15	0	13	92	29	0	4,3	68	5,9	125	56	200	139	200	63	196
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Rb 0,025	**Mean value µg/L**	1,6	0,086	1,6	<LD	1,6	<LD	1,7	0,14	0,95	0,012	<LD	0,0080	<LD	<LD	0,0080	0,0080
	Median, µg/L	1,6	0,041	1,6	<LD	1,6	<LD	1,7	<0,025	0,95	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,058	0,090	0,058	0	0,1	0	0,10	0,22	0,031	0,021	0	0	0	0	0	0
	RD (%)	6,3	120	6,3	0	6,3	0	5,9	170	4,2	200	0	210	0	0	210	210
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sr 0,28	**Mean value µg/L**	3000	0,35	5100	<LD	2900	0,19	5000	0,33	2300	0,19	<LD	<LD	<LD	<LD	2,8	<LD
	Median, µg/L	3000	<0,28	5100	<LD	2900	<0,28	5000	0,28	2300	<0,28	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,29	100	0	58	0	100	0,21	58	0	0	0	0	0	4,9	0
	RD (%)	0	43	2,0	0	3,4	47	2	27	0	47	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Y 0,005	**Mean value µg/L**	0,0080	0,0020	0,018	<LD	0,044	<LD	0,023	<LD	0,0020	<LD	<LD	<LD	<LD	<LD	0,27	<LD
	Median, µg/L	0,0071	<LD	0,019	<LD	0,0063	<LD	0,019	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,0010	0	0,0020	0	0,066	0	0,0080	0	0	0	0	0	0	0	0,47	0
	RD (%)	19	150	5,6	0	170	0	43	0	150	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Zr 0,006	**Mean value µg/L**	0,017	<LD	0,019	<LD	0,020	<LD	0,012	<LD	0,0040	<LD	<LD	<LD	<LD	<LD	0,0020	<LD
	Median, µg/L	0,018	<LD	0,020	<LD	0,014	<LD	0,015	<LD	<0,0060	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,0020	0	0,0030	0	0,015	0	0,0050	0	0	0	0	0	0	0	0,0040	0

	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
A LOQ	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
	RD (%)	12	0	11	0	85	0	25	0	50	0	0	0	0	0	230	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Nb 0,025	Mean value µg/L	<LD	<LD	0,008	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RD (%)	0	0	210	0	0	0	0	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mo 0,021	Mean value µg/L	82	0,052	56	<LD	76	0,027	56	0,047	0,74	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	81	0,040	56	<LD	76	<0,021	56	<0,021	0,74	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	1,5	0,048	1,53	0	0,58	0,035	0,577	0,058	0,040	0	0	0	0	0	0	0
	RD (%)	0	83	3,6	0	1,3	120	0	110	5,4	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ag 0,013	Mean value µg/L	0,015	<LD	0,029	<LD	0,016	<LD	0,038	0,0050	0,0040	<LD	<LD	0,0040	<LD	<LD	<LD	<LD
	Median, µg/L	0,015	<LD	0,028	<LD	0,017	<LD	0,021	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,0090	0	0,0040	0	0,010	0	0,030	0,0080	<0,013	0	0	0	0	0	0	0
	RD (%)	6,7	0	14	0	13	0	90	180	230	0	0	230	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Cd 0,003	Mean value µg/L	0,0040	0,0010	0,0060	<LD	0,14	0,0010	0,044	<LD	<LD	0,001	<LD	<LD	0,0010	<LD	0,0010	<LD
	Median, µg/L	0,0050	<LD	0,0075	<LD	0,0071	<LD	0,0075	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,0030	0	0,0050	0	0,23	0	0,066	0	0	0	0	0	0	0	0	0
	RD (%)	25	190	35	0	190	190	170	0	0	190	0	0	190	0	190	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
In 0,020	Mean value µg/L	0,020	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RD (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sn	Mean value µg/L	0,018	<LD	0,018	<LD	0,015	<LD	0,016	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
0,018	Median, µg/L	<0,018	<LD	<0,018	<LD	<LD	<LD	<0,018	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0,026	0	0,018	0	0	0	0	0	0	0	0	0
	RD (%)	0	0	0	0	200	0	94	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sb 0,030	Mean value µg/L	0,035	<LD	0,051	<LD	0,087	<LD	0,052	<LD	0,067	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	0,033	<LD	0,053	<LD	0,039	<LD	0,044	<LD	0,066	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,0030	0	0,0050	0	0,090	0	0,021	0	0,0060	0	0	0	0	0	0	0
	RD (%)	11	0	7,8	0	120	0	46	0	9,0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3
Te 0,030	Mean value µg/L	<LD	0,018	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,031	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RD (%)	0	190	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Cs 0,020	Mean value µg/L	0,020	<LD	0,034	<LD	0,020	<LD	0,023	0,0070	<LD	<LD	<LD	0,26	<LD	<LD	<LD	<LD
	Median, µg/L	<0,020	<LD	0,034	<LD	<0,020	<LD	0,020	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0,0040	0	0	0	0,014	0	0	0	0	0,45	0	0	0	0
	RD (%)	0	0	8,9	0	0	0	22	190	0	0	0	200	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ba 0,122	Mean value µg/L	15	0,13	14	<LD	14	<LD	15	0,50	51	0,11	<LD	<LD	<LD	1,5	0,083	0,040
	Median, µg/L	15	<0,12	14	<LD	14	<LD	15	<LD	52	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,16	0	0	0	1,0	0,58	0,87	1,2	0,19	0	0	0	2,6	0,14	0
	RD (%)	0	110	0	0	7,1	0	0	200	2,0	200	0	0	0	200	200	200
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
La 0,005	Mean value µg/L	0,0050	0,0030	0,012	<LD	0,09	<LD	0,021	0,0020	<LD	<LD	<LD	<LD	<LD	<LD	1,2	<LD
	Median, µg/L	<0,0050	<LD	0,012	<LD	<0,0050	<LD	0,0057	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,0040	0,0030	0	0,15	0	0,026	0	0	0	0	0	0	0	2,1	0
	RD (%)	0	150	25	0	190	0	140	150	0	0	0	0	0	0	200	0

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ce 0,005	Mean value µg/L	0,0050	0,0070	0,023	<LD	0,14	<LD	0,039	0,0020	<LD	<LD	<LD	<LD	<LD	<LD	3,07	<LD
	Median, µg/L	<0,0050	<LD	0,023	<LD	<0,0050	<LD	0,013	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,012	0,0050	0	0,24	0	0,050	0,0030	0	0	0	0	0	0	5,3	0
	RD (%)	0	200	22	0	200	0	150	200	0	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Pr 0,003	Mean value µg/L	<LD	0,0010	0,0030	<LD	0,019	<LD	0,0060	0,0010	0,0030	<LD	<LD	<LD	<LD	<LD	0,43	<LD
	Median, µg/L	<LD	<LD	0,0033	<LD	<LD	<LD	<0,0030	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,0020	0,0020	0	0,032	0	0,0080	0	0	0	0	0	0	0	0,75	0
	RD (%)	0	220	23	0	200	0	120	200	0	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Nd 0,002	Mean value µg/L	0,0020	0,0050	0,012	0,0010	0,065	<LD	0,020	0,0010	0,0010	<LD	0,0010	<LD	<LD	0,0010	2,0	<LD
	Median, µg/L	<0,0021	<0,0021	0,012	<LD	<0,0021	<LD	0,0091	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,0080	0,0020	0,0010	0,11	0	0,023	0,0020	0	0	0	0	0	0	3,4	0
	RD (%)	5	180	17	120	190	0	130	220	110	0	0	0	0	0	195	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sm 0,004	Mean value µg/L	<LD	0,0020	0,0030	<LD	0,012	<LD	0,007	<LD	<LD	0,0010	<LD	<LD	<LD	<LD	0,40	<LD
	Median, µg/L	<LD	<LD	<0,0040	<LD	<LD	<LD	<0,004	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0,0030	0	0	0,020	0	0,010	0	0	0	0	0	0	0	0,69	0
	RD (%)	0	130	33	0	190	0	160	0	0	300	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Eu 0,003	Mean value µg/L	0,0030	<LD	<LD	<LD	0,0020	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	0,077	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<0,0030	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0,0020	0	0	0	0	0	0	0	0	0	0,13	0
	RD (%)	0	0	0	0	75	0	0	0	0	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Yb	Mean value µg/L	<LD	<LD	0,0030	<LD	0,0030	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	0,0080	<LD

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
0,010	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,013	0
	RD (%)	0	0	230	0	230	0	0	0	0	0	0	0	0	0	190	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Gd 0,004	Mean value µg/L	0,0014	0,0014	0,0014	<LD	0,014	<LD	0,0060	<LD	<LD	0,0010	<LD	<LD	<LD	<LD	0,26	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<0,0041	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0,025	0	0,0060	0	0	0	0	0	0	0	0,45	0
	RD (%)	190	190	190	0	67	0	83	0	0	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Tb 0,003	Mean value µg/L	<LD	<LD	0,0010	<LD	0,0020	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	0,023	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0,0030	0	0	0	0	0	0	0	0	0	0,039	0
	RD (%)	0	0	210	0	120	0	0	0	0	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Dy 0,003	Mean value µg/L	<LD	<LD	0,0030	<LD	0,0090	<LD	0,0040	<LD	<LD	<LD	<LD	<LD	<LD	<LD	0,090	<LD
	Median, µg/L	<LD	<LD	0,0049	<LD	<0,0033	<LD	<0,0033	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0,0030	0	0,014	0	0,0040	0	0	0	0	0	0	0	0,16	0
	RD (%)	0	0	160	0	180	0	53	0	0	0	0	0	0	0	200	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ho 0,004	Mean value µg/L	<LD	<LD	0,0010	<LD	0,0020	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	0,011	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0,0030	0	0	0	0	0	0	0	0	0	0,018	0
	RD (%)	0	0	300	0	155	0	0	0	0	0	0	0	0	0	190	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Er 0,005	Mean value µg/L	<LD	<LD	0,0030	<LD	0,0020	<LD	0,0020	<LD	<LD	<LD	<LD	<LD	<LD	<LD	0,018	<LD
	Median, µg/L	<LD	<LD	<0,0045	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0,0040	0	0	0	0	0	0	0	0	0	0,031	0
	RD (%)	0	0	50	0	160	0	0	0	0	0	0	0	0	0	78	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
Tm 0,003	**Mean value µg/L**	<LD	<LD	<LD	<LD	0,0020	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	0,0020	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<0,0027	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0030	0
	RD (%)	0	0	0	0	160	0	0	0	0	0	0	0	0	0	180	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Yb 0,003	**Mean value µg/L**	0,0011	<LD	0,0011	<LD	0,0010	<LD	<LD	<LD	0,0010	<LD	<LD	0,0010	<LD	<LD	0,0070	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0,0030	0	0	0	0	0	0	0	0	0	0	0	0,013	0
	RD (%)	200	0	370	0	220	0	0	0	220	0	0	220	0	0	20	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
Lu 0,004	**Mean value µg/L**	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RD (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Hf 0,003	**Mean value µg/L**	0,0080	0,0020	0,010	<LD	0,025	<LD	0,0050	0,0010	0,0030	<LD	<LD	0,0010	0,0010	<LD	<LD	<LD
	Median, µg/L	0,0089	<0,0030	0,011	<LD	0,015	<LD	0,0047	<LD	<0,0030	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,0030	0	0,0020	0	0,022	0	0,0040	0	0	0	0	0	0	0	0	0
	RD (%)	23	50	10	0	100	0	70	200	0	0	0	200	200	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Ta 0,006	**Mean value µg/L**	0,0040	0,0040	0,0020	0,0040	0,0040	0,0040	0,0040	0,0020	0,0020	<LD	0,0040	0,0050	0,0020	0,0020	0,0060	0,0020
	Median, µg/L	<0,0060	<0,0060	<LD	<0,0060	<0,0060	<0,0060	<0,0060	<LD	<LD	<LD	<0,0060	<0,0060	<LD	<LD	<0,0060	<LD
	SD, µg /L	0	0	0	0	0	0	0,0040	0	0,0040	0	0	0,0060	0	0	0,0040	0
	RD (%)	50	50	200	50	50	50	50	200	265	0	50	98	200	200	18	200
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
W 0,05	**Mean value µg/L**	0,072	<LD	0,077	<LD	0,083	<LD	0,077	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	0,067	<LD	0,072	<LD	0,070	<LD	0,074	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0,014	0	0,010	0	0,033	0	0,0090	0	0	0	0	0	0	0	0	0

A LOQ	Sample	1,2,3	7,8,9	4,5,6	10,11,12	13,14,15	16,17,18	19,20,21	22,23,24	25,26,27	28,29,30	31,32,33	34,35,36	37,38,39	40,41,42	43,44,45	46,47,48
	Location	KAIA, well A Kabul	BLANK KAIA, well A Kabul	KAIA, tank A Kabul	BLANK KAIA, tank A Kabul	KAIA, well B Kabul	BLANK KAIA, well B Kabul	KAIA, tank B Kabul	BLANK KAIA, tank B Kabul	Maimanah well 1	BLANK Maimanah, well 1	Maimanah, well 2	BLANK Maimanah, well 2	Maimanah, well 3	BLANK Maimanah, well 3	Maimanah, well 4	BLANK Maimanah, well 4
	RD (%)	22	0	16	0	45	0	13	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Tl 0,013	Mean value µg/L	0,013	<LD	0,013	<LD	0,009	<LD	0,009	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	<0,013	<LD	<0,013	<LD	<0,013	<LD	<0,013	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RD (%)	0	0	0	0	44	0	44	0	0	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Pb 0,6	Mean value µg/L	<LD	<LD	0,60	<LD	4,3	<LD	1,3	<LD	0,88	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	<LD	<LD	<0,6	<LD	1,0	<LD	<0,60	<LD	0,88	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	0	0,69	0	6,7	0	1,9	0	0,080	0	0	0	0	0	0	0
	RD (%)	0	0	100	0	180	0	150	0	9,1	0	0	0	0	0	0	0
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Bi 0,016	Mean value µg/L	0,028	<LD	0,055	<LD	0,016	<LD	0,025	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	Median, µg/L	0,028	<LD	0,044	<LD	<0,016	<LD	0,023	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD	<LD
	SD, µg /L	0	-	0	-	0	-	0,018	-	-	-	-	-	-	-	-	-
	RD (%)	25	-	53	-	0	-	40	-	-	-	-	-	-	-	-	-
	No samples,n	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

RED DIGITS- Measured level (mean) are higher than the levels set in the Norwegian "Drikkevannsforskriften". These levels are based on 2 L/day for 70 years, 70kg person. This means that the water fails the criteria at just 2 L/day.

Green- All 3 water sample parallels are below limit of detection (<LD). These samples are not contaminated.
Yellow – The BLANK may be contaminated. If the value is low as compared to the mean, it does not influence the mean of the identical water sample.
Blue- The numbers of water sample parallels are 3, but only one parameter is determined. This leads to increased uncertainty of the mean.
Orange- As the results show, some of the samples were contaminated and must be disregarded. This is based upon relative deviation, RD > 50%. If there is 1 outlier which is the reason for a high % RD, one removes this outlier and calculates a new mean.

5.3. Water Quality

Water analysis varies depending upon the water-source available, geology in that area, number of recipients and what country/organization is responsible for the water-quality. There are five different directives of interest to consider for reference, they are:

- WHO, World Health Organization
- Guidelines for drinking-water quality, third edition‖. First edition 2004. Third edition 2006.
- Norway
- Drikkevannsforskriften. Implemented 2002.01.01.Edited 2010.01.01
- EU, European Union
- The Drinking Water Directive 98/83/EEC. Implemented 1998.11.03
- USA
- Safe Drinking Water Act‖. Implemented 1974. Edited 1996.
- NATO, North Atlantic Treaty Organization
- STANAG 2885, Emergency Supply of water in war‖. Edited 2004.02.18
- STANAG 2136, Minimum Standards of Water Potability During Field Operations And in Emergency Situations. Edited 2002.04.10

5.4. Risk assessment

The result of the analyses of the water from KAIA, Kabul and Maimanah, Faryab revealed that there are four parameters which need further assessment whether or not we need different risk levels in INTOPS, than in Norway.

Looking at "Drikkevannsforskriften" (2L/day), the water from KAIA, Kabul contained too high levels of boron, magnesium, manganese, iron, and sodium. Of these there is inconsistency with regards to iron, being high in only one sample. Soil being high in iron may be the cause of the contamination. This result will be rejected based upon being only one sample (KAIA, well B) and the fact that the water is collected onto KAIA, tank B that has iron levels below the risk level.

Population at Risk

The Norwegian soldiers consuming 10 liters a day of the water from well A and well B in KAIA, would be exposed to levels higher than the risk levels that already are too high at 2 liters a day. These elements are boron, magnesium, manganese and sodium.

The parameters that are exceeding risk levels only by increasing the intake from 2 L per day to 10 L per day, due to the inherent lack of adaptability of "Drikkevannsforskriften", are boron, magnesium, cadmium and nitrate.

Cadmium in the sampled water was measured but not at high enough levels to exceed the risk levels even by consuming 10 liters a day. Nitrate was not measured, but cannot be ruled out as a potential health risk.

The elements that are higher than the risk levels defined in "Drikkevannsforskriften" are boron, magnesium, manganese and sodium.

Toxic Effects

Boron-

High boron content in drinking water affects the testes and sperm of males, and causes birth defects in the offspring of pregnant females. Some research has suggested that small amounts of boron in drinking water may actually offer a beneficial effect for certain conditions, such as arthritis.

Magnesium-

Drinking water in which both magnesium and sulfate are present in high concentrations can have a laxative effect, although data suggest that consumers adapt to these levels as exposures continue. Increased seldom causes hypermagnesaemia in persons with normal kidney function. Studies do show a negative association (i.e. protective effect) between cardiovascular mortality and drinking-water magnesium. Statistically significant benefits (where observed) generally occurred at magnesium concentrations of about 10mg/l and greater. (WHO, 2009) It is only when supplements reach more than 10 mg/kg/day that plasma levels may become elevated. (Hathcock, J. N., 2004)

Manganese-

Thus any quantitative risk assessment for manganese must take into account aspects of both the essentiality and the toxicity of manganese. In humans, many data are available providing information about the range of essentiality for manganese. In addition, there are many reports of toxicity to humans exposed to manganese by inhalation; much less is known, however, about oral intakes resulting in toxicity. There are concerns about possible adverse neurological effects at doses not far from the range of essentially. (www.epa.gov/iris)

Sodium-

High levels of sodium in drinking water would often lead to a not appealing taste of the water, which often would limit the consummation of the water. This offset taste sets inn at about 200 mg/l. When this does not happen, a large amount of sodium would dehydrate the body by exerting an osmotic pull from the interstitial fluid to the intestines, and to some degree to the blood vessels.

6. Conclusion

Drinking-water supply has a primary objective of protecting human health, including ensuring access to adequate quantities of safe water. The quantity per day for a limited time is important in order to assess a drinking water`s potential to be a health risk. There is a need to differentiate between chronic and acute health effects, combined with an increasing volume per day.

Hypothesis 1: Ground water in Afghanistan does not possess a health risk.

The sampled water from Maimanah, Faryab DO NOT constitute a health risk, from the elements tested, if consumed at 10 liter per day.

The sampled water from KAIA, Kabul DO constitute a potential health risk from boron, magnesium, manganese and sodium.

Hypothesis 2: The Norwegian Drinking Water Directive ("Drikkevannsforskriften") can be used, in peacekeeping operations abroad, to determine that the drinking water does not possess a health risk.

In order to assess potential health risk from drinking water that is consumed of more than 2 liters a day, for less than 70 years, "Drikkevannsforskriften" do not have the adaptability to be used to determine if the drinking water do not possess a health risk.

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Appendix A

Prosedyre for prøvetaking av drikkevatn

- Brønnvatn Afghanistan

Forfatter: Elin Lovise Folven Gjengedal

1 Representativ prøvetaking

1.1 Krav til dokumentasjon

Krav til dokumentasjon av vasskvalitet er gitt i " Forskrift om vannforsyning og drikkevann" (SHD, 2001). "Veiledningen til drikkevannsforskriften" (http://www.mattilsynet.no/mattilsynet/multimedia/archive/00021/Pr_vetakingsprogramm_21843a.pdf) utdjupar forhold som er omtalt i forskrifta. Det finns ein god del informasjon om korleis prøvetaking av drikkevatn skal skje og korleis prøvene dernest skal handterast; til dømes NS-ISO 5667-5 og NS 4789 som omhandlar prøvetaking av drikkevatn og vatn som brukast til næringsmiddelproduksjon (Standard Norge, 1990, 2001).

1.2 Kva faktorar påverkar kvaliteten av drikkevatn?

Ei prøve som ikkje er representativ kan føre til feil tolking av data og feil konklusjon på vasskvalitet. Kvaliteten på drikkevatnet blir bestemt av samansetning av ubehandla råvatn, av bidrag frå rørmaterialet og koplingar fram til tappekran. Kvaliteten av vatnet kan også variere over tid avhengig av til dømes forbruk og klimatiske forhold.

1.3 Planlegging av prøvetakingsstrategi

Viktige moment ved planlegging av strategi for prøvetaking:

- Kontaminering av utstyr
  - Unngå forureining av kork og opning av sentrifugerøret. Hald derfor nedst på røret. Ikkje ta på opninga av røret eller innsida av korken. Prøv å unngå å legg frå deg korken. Dersom du må legge korken frå deg, legg den med innsida opp.
- Konservering av prøve
  - Sentrifugerøra er på førehand tilsett syre for konservering. Lik syrekonsentrasjon i prøver og standardløysingar er viktig ved analyse på ICPMS. Fyll røret sakte slik at vatnet ikkje renn over!
- Tidsvariasjon (døgn, sesong)
  - Råvassprøva bør takast så nær kjelda som muleg og helst frå vatn i bevegelse (ikkje stagnert vatn). Dersom råvatn er brønnvatn blir det sjølvsagt vanskeleg å ta ut prøve frå vatn i bevegelse – Då blir det viktig å ta ut fleire stikkprøver over tid.

    - Kvaliteten av vatnet kan variere over tid avhengig av vassforbruk. Er det muleg å estimere vassforbruk?
    - Kvaliteten av vatnet kan variere over tid avhengig av geologi og klimatiske forhold.
        - Fins det informasjon om klimatiske forhold tilgjengeleg (temperatur, nedbør)?
        - Fins det informasjon om lokal geologi tilgjengeleg?
- Antropogen aktivitet
    - Er det mistanke om forureining frå
        - Industri?
        - Annan menneskeskapt aktivitet (eksisterande eller tidligare aktivitet) som til dømes avfallsdeponi eller nedgravd avfall?
        - Landbruk?
- Er det grunnvatn med pH *i nettvatnet* under 7,0?
    - Leiingsevne (konduktivitet) er relativt enkelt å måle, og elektroden krev mindre vedlikehald enn det som er tilfelle med glaselektroden som blir brukt til bestemming av pH.
    - pH-strips kan gi ein indikativ verdi for pH
    - Jern (Fe) kan vere aktuell parameter for å påvise korrosjon, i staden for pH.
- Inntrenging av overflatevatn
    - Temperatur i grunnvatn kan brukast som indikator på inntrenging av overflatevatn, men det er viktig å hugse på at ein kan ha inntrenging av overflatevatn i ein brønn utan at dette gjev utslag på temperaturen.
- Utlekk frå vassrør/ slangar
    - Dersom det ikkje har vore tappa vatn over lengre tid (til dømes over natta) er det viktig å skylje godt igjennom ledningsnettet før prøvetaking. La vatnet renne frå kranen i 3 minutt før uttak av prøve.
- Utlekk frå emballasje for lagring
    - Utlekk frå emballasje for lagring av drikkevatn kan vere avhengig av temperatur.

1.4 Val av prøvepunkt

Uttak av vatn i ulik avstand frå drikkevasskjelda blir viktig for å identifisere kjelder for ulike grunnstoff:

- Råvatn
    - Brønnvatn – Stagnert vatn
    - Borevatn – Vatn i bevegelse
- Springvatn
- Springvatn lagra på kanner, drikkepose eller flasker

2 Utstyr og konservering av prøve

Leiingsevne(konduktivitets)måler; fabrikat?
Kalibreringsløysing 0,0100 M KCl.
50 mL polypropylen (PP) sentrifugerør med blå kork, merka ”Ledningsevne 1-2-3”.

Colour-fixed indicator sticks. Prolabo paper dosatest® pH 4,5 – 10,0 (3 zones) per 0,5 pH units, kode 35311.604.

Emballasje til drikkevassprøver er graderte polypropylen (PP) sentrifugerør med kvit skrukork. Sarstedt 50 mL, 115x28 mm, kode 62.559.010).
PP-røret er på førehand tilsett 1,0 mL 10% (V/V) HNO_3 fortynna frå 65% (w/w) ultrapure salpetersyre. Syra er tilsett for å konservere vassprøva. Volumet utgjer ein fortynningsfeil på 2% - dette ser vi bort i frå! **Bruk vernebriller** (VWR vernebriller er vedlagt).

Før analyse må vassprøvene konserverast med sterkare syre. Sluttkonsentrasjon HNO_3 i 50 mL prøve bør vere 5 % (v/v) av konsentrert syre. Dette blir utført etter at prøvene kjem tilbake til Norge.

Bruk av hanskar er omdiskutert. Her treng du ikkje bruke hanskar for å beskytte deg sjølv. Den beste måten å unngå kontaminering av prøven er å arbeide utan hanskar. Då vil du merke om du blir våt på fingrane, du merkar ikkje om hansken blir våt! Sjå dessutan avsnitt 1.3 Kontaminering av utstyr.

3 Prøvemerking

Sporbarhet av prøver er viktig. Prøvene må merkast med vassfast tusj. Noter dato, klokkeslett og prøvetakingspunkt. I tillegg skal alle prøvene (også blanke prøver) merkast med ein unik talkode. Vær nøye med å loggføre dato, klokkeslett, lokalitet for prøveuttak og talkode i eit rekneark. Ta back-up!

4 Framgangsmåte for uttak av vassprøver

Dersom det ikkje er muleg å ta prøvene etter denne framgangsmåten er det viktig at tillegg eller avvik blir dokumentert i logboka.

1. **Uttak av råvatn så nær kjelda som muleg (brønn eller pumpestasjon)**
   a. Brønnvatn – Stagnert vatn
      Senk ned ei rein drikkeflaske tynga av eit lodd. Overfør vatn frå denne flaska til 50 mL-merket på sentrifugerøret. Følg der etter pkt. 1b ii-iii.
   b. Borevatn – Vatn i bevegelse
      i. Opne korken og hald prøverøret kontrollert delvis inn under rennande vatn. Fyll sakte opp til 50 mL-merket.
      ii. Skru på korken.
      iii. Skru av og på korken på rør merka BLANK; dette for at blankløysing og innvendige flater i rør og kork også bli eksponert for luft og eventuelt partiklar i lufta. Eksponeringstid skal vere like lang som ved prøvetaking av vatnet.

2. **Springvatn**
   a. Ta først ei prøve av vatn som har stått i tapperøret/ slangen over tid; dette for å undersøkje utlekking av metall frå rør og tappearmatur.

b. Opne krana og la vatnet renne i 3 minutt. Du skal ikkje regulere vasstraumen under tapping og prøvetaking.
c. Opne korken og hald sentrifugerøret under vasstraumen. Fyll sakte opp til 50 mL-merket og skru fast korken.
d. Skru av og på korken på røret merka BLANK.

3. **Springvatn lagra på kanner, drikkepose eller flasker**
   a. Fersk tappa vatn: Overfør vatn frå kanne eller flaske til 50 mL-merket på sentrifugerøret. Følg der etter pkt. 1b ii-iii.
   b. Lagra vatn på kanne eller flaske ved høy temperatur (>40 °C): Overfør vatn frå kanne eller flaske til 50 mL-merket på sentrifugerøret. Følg der etter pkt. 1b ii-iii.
   c. Lagra vatn på kanne eller flaske ved låg temperatur (< 10 °C): Overfør vatn frå kanne eller flaske til 50 mL-merket på sentrifugerøret. Følg der etter pkt. 1b ii-iii.

5 Lagring

Eg veit ikkje kva bufferevne drikkevatnet har. Ein tilsats på 1,0 mL 10% (V/V) HNO_3 kan vere for lite til å senke pH tilstrekkeleg for å hindre mikrobiell vekst. Det beste vil vere å lagre prøvene mørkt og kjølig. Unngå frost (då kan røra sprekke!)
Plasser prøvene i isoporstativ og stable i transportkassa. Husk å merke kassa godt!

6 Referansar

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Appendix B

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Prøve				BrønnVann	TankVann	Vann-beh. System					Lagring Prøver
Parallell sett	Journalnr	Dato/tid	Lokasjon				Temp./ Celsius	pH	Konduktivitet	Div.	
1	1	11.06 .2012 Tid: 16.15	KAIA 1	Tappet 5 sek.	-	Multimedia-, kull-og resinfilter, klor	22,5	7,58	4,4 4	Rennende vann fra pumpehu s	Rom temp
	2	11.06 .2012 Tid: 16.15	KAIA 1	Tappet 5 sek.	-		22,5	7,58	4,8	"	Rom temp
	3	11.06 .2012 Tid: 16.15	KAIA 1	Tappet 5 sek.	-		22,5	7,58	4,4 4	"	Rom temp
2	4	11.06 .2012 Tid 16.26	KAIA 2	-	Tappet 20 sek.		21,6	8	7,9 4	Vann ferdigbeh. Og klar for lagring tank	Rom temp
	5	11.06 .2012 Tid 16.26	KAIA 2	-	Tappet 20 sek.		21,6	8	7,9 4	"	Romt emp.
	6	11.06 .2012 Tid 16.26	KAIA 2	-	Tappet 20 sek.		21,6	8	7,9 4	"	Romt emp.

3	7	11.06.2012 Tid 16.15	KAIA 1	BLANK åpen 5 sek.	-		-	-	-	Tilhører sett 1	Romt emp.
	8	11.06.2012 Tid 16.15	KAIA 1	BLANK åpen 5 sek.	-		-	-	-	Tilhører sett 1	Romt emp.
	9	11.06.2012 Tid 16.15	KAIA 1	BLANK åpen 5 sek.	-		-	-	-	Tilhører sett 1	Romt emp.
4	10	11.06.2012 Tid 16.26	KAIA 2	-	BLANK åpen 20 sek.		-	-	-	Tilhører sett 2	Romt emp.
	11	11.06.2012 Tid 16.26	KAIA 2	-	BLANK åpen 20 sek.		-	-	-	Tilhører sett 2	Romt emp.
	12	11.06.2012 Tid 16.26	KAIA 2	-	BLANK åpen 20 sek.		-	-	-	Tilhører sett 2	Romt emp.
5	13	27.06.2012 Tid 15.45	KAIA 1	Tappet 5 sek.	-		21,2	Feil	Feil	pH- og konduktivitetmeter fungerte ikke	Romt emp.
	14	27.06.2012 Tid 15.45	KAIA 1	Tappet 5 sek.	-		21,2	Feil	Feil	"	Romt emp.
	15	27.06.2012 Tid 15.45	KAIA 1	Tappet 5 sek.	-		21,2	Feil	Feil	"	Romt emp.
6	16	27.06.2012 Tid 15.45	KAIA 1	BLANK åpen 5 sek.	-		-	-	-	Tilhører sett 5	Romt emp.

	17	27.06.2012 Tid 15.45	KAIA 1	BLANK åpen 5 sek.	-		-	-	-	Tilhører sett 5	Romtemp.
	18	27.06.2012 Tid 15.45	KAIA 1	BLANK åpen 5 sek.	-		-	-	-	Tilhører sett 5	Romtemp.
7	19	27.06.2012 Tid 15.50	KAIA 2	-	Tappet 20 sek.		-	Feil	Feil	pH- og konduktivitetmeter fungerte ikke	Romtemp.
	20	27.06.2012 Tid 15.50	KAIA 2	-	Tappet 20 sek.		-	Feil	Feil	"	Romtemp.
	21	27.06.2012 Tid 15.50	KAIA 2	-	Tappet 20 sek.		-	Feil	Feil	"	Romtemp.
8	22	27.06.2012 Tid 15.50	KAIA 2	-	BLANK åpen 20 sek.		-	-	-	Tilhører sett 7	Romtemp.
	23	27.06.2012 Tid 15.50	KAIA 2	-	BLANK åpen 20 sek.		-	-	-	Tilhører sett 7	Romtemp.
	24	27.06.2012 Tid 15.50	KAIA 2	-	BLANK åpen 20 sek.		-	-	-	Tilhører sett 7	Romtemp.
9	25	09.07.2012 Tid 15.10	Maimanah	Tappet 5 sek.	-	-	-	26,5	7,2	Lokalt pH- og konduktivitet sett	Romtemp.

	26	09.07 .2012 Tid 15.10	Maimanah	Tappet 5 sek.	-	-	-	26,5	7,2	"	Romt emp.
	27	09.07 .2012 Tid 15.10	Maimanah	Tappet 5 sek.	-	-	-	26,5	7,2	"	Romt emp.
10	28	09.07 .2012 Tid 15.15	Maimanah	BLANK åpen 5 sek.	-	-	-	-	-	Tilhører sett 9	Romt emp.
	29	09.07 .2012 Tid 15.15	Maimanah	BLANK åpen 5 sek.	-	-	-	-	-	Tilhører sett 9	Romt emp.
	30	09.07 .2012 Tid 15.15	Maimanah	BLANK åpen 5 sek.	-	-	-	-	-	Tilhører sett 9	Romt emp.

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