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Health problems related to algal bloom among seaweed farmers in coastal areas of Tanzania

Aziza, H. Said[1, 2, 4*], Flower, E. Msuya[2], Margareth, S. Kyewalyanga[2], Aviti, J. Mmochi[2], Evalyn, W. Mwihia[1], Eystein Skjerve[1], Helena, A. Ngowi[3] and Jan, L. Lyche[1]

[1]Department of Food Safety and Infection Biology, Faculty of Veterinary Medicine, Norwegian University of Life Science, P.O. Box, 8146. Oslo, Norway.
[2]Institute of Marine Sciences, University of Dar es Salaam, P.O. Box 668, Zanzibar, Tanzania.
[3]Department of Veterinary Medicine and Public Health, Collage of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, P. O. Box 3021 Morogoro, Tanzania.
[4] Department of Biotechnology and Bioinformatics, Collage of Natural Sciences and Mathematics, School of Biological Sciences, The University of Dodoma, P.O. Box, 338, Dodoma, Tanzania.

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There is a scarcity of research-based data on the factors associated with skin irritation due to algal blooms in seaweed farming. Changes in temperature with an increase in nutrients levels lead to the growth of harmful algal blooms, which produce many active metabolites, some of which induce toxic responses in human including skin irritation. The objective of this study was to identify health problems experienced by seaweed farmers and the seasons when they occur, and how these are treated. A cross-sectional study design was used to gather data using structured questionnaire, focus group discussions and key informant interviews. The study was conducted between June and August 2015, in six villages, two from Mainland, and four from Zanzibar Islands, Tanzania. Study revealed that seaweed more than 50% of farmers experienced skin irritation problem, followed by 30.4% who had eye related problems, and only 19.6% had respiratory disorders as the most serious. Hot season, which is associated with algal blooms, was the period with the highest occurrence of skin irritation. No specific medication was used to treat the health problems reported. In some severely affected areas, farmers could not tend to their farms for months, a situation which affected their income. It is suggested that the findings from this study would reduce this knowledge gap and motivate stakeholders especially the policy makers to implement measures, which reduce the health problems observed due to algal blooms in the seaweed farmers.

Key words: Algal blooms, cyanobacteria, seaweed farming, seaweed farmers, skin irritation, Tanzania.

INTRODUCTION

Seaweeds are a group of photosynthetic non-flowering plant-like organisms (called macroalgae) that live in the sea. They are categories into three major groups based on their dominant pigmentation: red (Rhodophyta), brown

(Phaeophyta) and green (Chlorophyta). Seaweed is currently the most significant aquatic plant that has contributed to the development of an alternative aquaculture activity globally (FAO, 2010; Chipo et al, 2013).

Worldwide, its farming has been increasing from 19.9 million Metric Tons (MT) in 2010 to 23.8, 27 and 30.5 million MT in 2012 and 2013 and 2015 respectively (FAO 2015; 2013; Amosu et al., 2012). Seaweed industry provides a wide variety of products for human uses and it is estimated to have a total value of US$10 billion per year (Bixler and Porse, 2011; FAO, 2013). In addition, humans consume seaweeds directly as vegetables, Seaweed production for human consumption as food is estimated to constitute about 83% (Craigie, 2011). Seaweeds are eaten dried or fresh for its nutritional value or for flavouring (Kilinc et al., 2013). And the remaining is used as fertilizers, animal feed additives, medical applications ((Gilby et al., 2011). And biotechnological applications (McHugh, 2003). It has been reported that seaweed is among the best health food on the planet and it is very nutritious that contains vitamins and several minerals (Kim et al., 2017).

In Tanzania, seaweed farming started in Zanzibar in 1989 with two species namely *Eucheuma denticulatum* (Spinosum) and *Kappaphycus alvarezii* (Cottonii). In 1994 and 1995, seaweed farming spread to mainland Tanzania as an integrated coastal management project, in order to improve the socioeconomic status of coastal communities. In Zanzibar, seaweed farming is the third most important economic activity in terms of foreign exchange earnings after tourism and clove trade.

Furthermore, it has been contributing over 90% of Zanzibar's marine exports (Department of Fisheries and Marine Resources (DFMR) database 2015). United States of America, France, Denmark, Spain, China and Chile have been the main importers of seaweeds from Zanzibar (FAO, 2013). Available data from the Zanzibar Exporters Association show that, about 15,087 tons of dry weight seaweed were exported in 2012, followed by a drop to 11,000 tons in the preceding years (Neish and Msuya, 2015).

Cyanobacteria are photosynthetic bacteria that normally grow free in water or attached themselves on substrate such as macroalgae like seaweed, its rapid growth and spatial expansion is caused by change in climatic and environmental stimuli (such as increased water temperature or nutrient load) that can lead to the formation of extensive, monospecific blooms that dominate the benthic community (Paerl et al., 2011; Paerl and Otten, 2013). Cyanobacteria produce many active metabolites, some of which induce toxic responses,in human, fish, crabs, and other animals (Arthur et al., 2006; Ahern et al., 2007). These blooms, also have been linked to ecosystem and human health issues including smothered corals and seagrass, reduced grazing by fish and invertebrates, as well as dermatitis and breathing difficulties in humans who comes into contact with them (Panek, 2012).

In Tanzania, seaweeds are generally cultivated in shallow subtidal areas including lagoons or sheltered bays where fluctuations in temperature, salinity and sometimes nutrients contribute to eutrophication and algal blooms. Since 2012, skin irritation has been reported as the major health problem facing Tanzanian seaweed farmers (Msuya, 2013a) and it is suggested that algal blooms may cause these problems (Msuya, 2013b). This suggestion is supported by previous reports, which have associated exposure of humans to cyanobacteria with irritant contact dermatitis, as well as eye and respiratory problems (Osborne et al., 2001).

Similar problems such as swelling and reddening of the eyes, breathing difficulties and skin irritations have also been shown in Tanzanian seaweed farmers (Fröcklin et al., 2012). As the first of its kind in Tanzania, these problems were seen to be a barrier to some farmers to continue working on seaweed farms, reducing the production of seaweed and hence affecting people's livelihood. No study has ever been conducted to address these problems, therefore, the present study aimed at describing symptoms and diseases affecting seaweed farmers, and identifying possible factors associated with skin irritation and other related health problems to seaweed farmers in selected coastal villages of Tanzania.

MATERIALS AND METHODS

Study sites

Study sites included six villages, two from mainland Tanzania, namely; Kijiru in Tanga Region and Songosongo in Lindi Region, and four from Zanzibar Islands, namely Bweleo, Paje and Chwaka in Unguja Island and Tumbe in Pemba island. These villages were chosen based on reported high prevalence of skin irritation, which has negatively affected seaweed farmers (Msuya, 2013b).

Sample size and sampling technique

Epi tools (http://epitools.ausvet.com.au/) were used to calculate the

*Corresponding author. E-mail: azizahassan16@gmail.com.

sample size. The resources in the project were limited, and we tried to optimize design to enable us to present joint measures across villages, but also identify important differences between villages and mainland/ Zanzibar.

Basically, we estimated we could bring in approximately 250 farmers in these 6 villages. After consulting with an experienced epidemiologist, we took the following approach to decide on sample size: Given a total population of 11456 seaweed farmers (BSN 2012), a confidence level of 90%, the resources we had were sufficient to describe our population at a precision of +/- 5% at a prevalence of 50%, and at +/-2/ at a prevalence of 5%. We decided a sample size of 40 in each village, and a total sample size of 240. With this sample size, we would have limited power to detect differences between the villages. However, given specific factors would influence the pattern, we would be able to find variables of high importance to explain the variability. Due to this limited power, statistical models were established only for health problems with a frequency exceeding 10% in the whole population.

The study was a cross-sectional study conducted between June and August 2015. Forty seaweed farmers were randomly selected from each of the six villages, forming a total sample size of 240. The farmers were selected based on their experience in seaweed farming (above 5 years in seaweed farming) in order to get more information on disease history. Seaweed farmer identification was done with the help of the village leaders and seaweed group leaders in some areas. The selected seaweed farmers were interviewed in their farms, houses and market centres, where they normally sold their seaweed or attended meetings related to seaweed production. Two local fisheries officers from each study sites were used as enumerators to assist in conducting a survey, and Swahili language was used to translate the questions to ease understanding by farmers. Verbal consent was obtained from all the respondents before they were interviewed.

Data collection methods

Structured questionnaire

The questionnaire was composed by the demographic characteristics of the farmers, farming history, clinical signs or history of the farmers and the period when disease erupt as well as medical treatment. Prior to the actual data collection, a questionnaire was developed and reconnaissance visits were done to pre-test and check for accuracy of the questions to avoid ambiguity of the questions. This was then followed by conducting the actual survey in all study sites to get information on skin irritation and other related diseases that has been affecting seaweed farmers (occurrence, severity and treatments), as well as seaweed production trends. Apart from questionnaire testing, other activities done during this survey included meetings with the Village Executive Officers (VEO) or Shehas, elders and leaders of the key groups that were involved in seaweed farming activities to introduce the study, establish contacts, as well as familiarizing with the study sites.

Focus group discussions (FGDs)

Focus group discussions were done and information was recorded using a tape recorder. The discussions involved experienced seaweed farmers and cluster leaders who were chosen by the farmers themselves with the help of village leaders. A single group from each site comprised of 6 people of mixed ages and gender were participated in the discussion.

Direct observations

Direct observations of skin problems in farmers was done at seaweed farms and market centres, to observe the extent and to validate what was discussed during interviews and focus group discussions. However, we did not have a checklist for the observation because we had only two conditions to observe and that was skin rashes and eye problem on the open part of the hands and legs of the farmers from each study site.

Secondary data

Secondary information on seaweed production trend was obtained from different sources (websites, books and articles) as well as fisheries officers at each fisheries department in all study sites. These were reviewed and sorted to give information on general and specific issues related to seaweed production, and the problems that seaweed farmers faced. This secondary information was used in validating and improving the reliability of information gathered from the interview.

Data management and analysis

The questionnaire was coded and data entered in a database using Microsoft Excel®. After cleaning and removing errors, the data were transferred to the statistical package for social sciences (SPSS) statistical package (version 20, IBM Analytics, Armonk, NY). Data were coded, and quantitative data as age was coded into categories to enable a simple statistical comparison. The data was examined using tables and graphs while Chi square test was used to compare the variables across the six villages. We also examined the health problem profile of each village using a radar plot in Microsoft Excel. Then we attempted to link individual health problems to explanatory factors using a logistic regression platform. Before the logistic regression, variables were recoded to enable large enough groups for statistical comparison. Notably, farming stage participation was recoded into three groups (farming, harvesting and other). Statistical models were established only for health problems with a frequency exceeding 10% in the whole population (skin irritation, body itching, skin sores, eye irritation, eye swelling, headache, vomiting) while the rest (stomach problems, respiration failure, vomiting) were not followed up. In modelling we focused on geographical (village), demographic (age, education, marital status) and exposure (farming stage participation) variables. A backward selection strategy was used in model building, with a Likelihood Ratio test at $p<0.005$ as inclusion criteria in models.

The qualitative data was analysed manually using thematic content analysis. In this case, components of the verbal discussions held with the key informants and focus groups were analysed in an objective and systematic manner. The recorded dialogue with group participants was then broken down into small and meaningful units of information of themes and tendencies, which helped in establishing values and attitudes of the respondents.

RESULTS

Socio-demographic characteristics of seaweed farmers

According to Table 1, the majority of the seaweed farmers were females aged between 31 to 40 years old, although 45% of farmers in Tumbe village were aged

Table 1. Socio - demographic characteristics of seaweed farmers in the study villages.

Varriable		Number (%) of respondents						p-value
		Songosongo (n=40)	Tumbe (n=40)	Kijiru (n=40)	Paje (n=40)	Bweleo (n=40)	Chwaka (n=40)	
Age	20–30 (n =63)	9 (22.5)	18 (45.0)	9 (22.5)	8 (20.0)	9 (22.5)	10 (25.0)	*p* <0.01*
	31 -40 (n=88)	18 (45.0)	13 (32.5)	16 (40.0)	9 (22.5)	2 (30.0)	20 (50.0)	
	41– 50 (n= 69)	11 (27.5)	8 (20.0)	10 (25.0)	14 (35.0)	17 (42.5)	9 (22.5)	
	51-60 (n=20)	2 (5.0)	1 (2.5)	5 (12.5)	9 (22.5)	2 (5.0)	1 (2.5)	
Gender	Male (n=53)	6 (15.0)	14 (35.0)	12 (30.0)	8 (20.0)	3 (7.5)	10 (25.0)	*p* <0.05*
	Female (n=187)	34 (85.0)	26 (65.0)	28 (70.0)	32 (80.0)	37 (92.5)	30 (75.0)	
Marital status	Married (n=164)	24 (60.0)	34 (85.0)	33 (82.5)	23 (57.5)	24 (60.0)	26 (65.0)	*p* >0.05
	Single(n=10)	2 (5.0)	2 (5.0)	0 (0.0)	1 (2.5)	2 (5.0)	3 (7.50)	
	Divorced (n=26)	7 (17.5)	2 (5.0)	2 (5.0)	6 (15.0)	5 (12.5)	4 (10.0)	
	Widowed (n=40)	7 (17.5)	2 (5.0)	5 (12.5)	10 (25.0)	9 (22.5)	7 (17.5)	
Education level	Not educated (n=98)	12 (30.0)	29(72.5)	17 (42.5)	15 (37.5)	16 (40.0)	9 (22.5)	*p* <0.001*
	Educated (n=142)	28 (70.0)	11(27.5)	23 (57.5)	25 (62.5)	24(60.0)	31 (77.5)	
Main livelihood activity	Seaweed farming (n=194)	37(92.5)	32 (80.0)	24 (60.0)	31 (77.5)	35 (87.5)	35 (87.5)	*p* <0.001*
	Seaweed sellers (n=5)	1(2.5)	3(7.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.5)	
	Fishing (n=10)	2 (5.0)	0(0.0)	3 (7.5)	3 (7.5)	0 (0.0)	2 (5.0)	
	Agriculture (n=10)	0 (0.0)	5(12.5)	2 (5.0)	1 (2.5)	1 (2.5)	1(2.5)	
	small business (n=18)	0 (0.0)	0(0.0)	11(27.5)	3 (7.5)	3 (7.5)	1(2.5)	
	Animal husbandry (n=3)	0 (0.0)	0(0.0)	0 (0.0)	2 (5.0)	1(2.5)	0 (0.0)	

between 20 to 30 years old. Most of the farmers were married (>80 %) with a few widowed (25%) especially in Paje village. Moreover, there was significance difference in education levels (p<0.05) between seaweed farmers across the villages. However, more than 50% of farmers were educated (from primary to secondary level of education). Additionally, more women than men significantly performed seaweed farming activities across the villages (p< 0.05). More than 60% of the famers depend on seaweed farming as the main livelihood activity, most expressed in Songosongo village (92.5%). Small businesses (27.5%) were least observed in Kijiru village followed by agriculture (12.5%) and fishing activities (7.5%). There were very few cases of animal husbandry (5%) and seaweed value addition and trading (7.5%) observed in all study sites. Seaweed farming was the main livelihood activity to the farmers (80.8%) across the villages. Also, statistical analysis showed highly significant differences between these parameters and the study population.

Health problems

Results for health problems faced by seaweed farmers (Table 2) showed that a majority of the farmers (>50%) in all study sites reported having skin irritation problems. The highest occurrences were reported in Kijiru (80%), Songosongo (70%), and Paje (65%) and the least in Bweleo (25%). Body itching was frequently reported in all villages, especially in Kijiru (67.5%) and Songosongo villages (62.5%), followed by skin sores. Eye irritation problems (30.4%) were the second most frequently reported together with swelling of face and eyes as well as headache. Very few cases on digestive problems such as vomiting and diarrhoea (2.5%) were reported in Paje and Chwaka villages, while death was only reported by 3 (7.5%) farmers in Paje village. There were significant differences in health problems such as skin irritation, eyes and respiratory problems across the villages (p<0.05). Body itching (p<0.05), skin sores (p<0.05) and swelling of eyes (p<0.05) were among health problems which showed significant difference across the villages.

Season and stage of farming when skin irritation and other problems occur

Results on the seasons when the health problems occur and the time of occurrence during the whole farming process are indicated in Table 3. Health problems during the hot season (January to February) was frequently

Table 2. Analysis of reported health problems in the study villages.

Health problems	Diseases		(%) of respondents per village n=240 Songosongo (n=40)	Tumbe (n=40)	Kijiru (n=40)	Paje (n=40)	Bweleo (n=40)	Chwaka (n=40)	p-value
Skin	Irritation	P (n=135)	28 (70.0)	21 (52.5)	32 (80.0)	26 (65.0)	10 (25.0)	18 (45.0)	$p<0.001$*
		A (n=105)	12 (30.0)	19 (47.5)	8 (20.0)	14 (35.0)	30 (75.0)	22 (55.0)	
	Itching	P (n=119)	25 (62.5)	17 (42.5)	27 (67.5)	22 (55.0)	8 (20.0)	20 (50.0)	$p<0.001$*
		A (n=121)	15 (37.5)	23 (57.5)	13 (32.5)	18 (45.0)	32 (80.0)	20 (50.0)	
	Skin sores	P (n=80)	16 (40.0)	9 (22.5)	12 (30.0)	21 (52.5)	7 (17.5)	15 (37.5)	$p<0.01$*
		A (n=160)	24(60.0)	31(77.5)	28 (70.0)	19 (47.5)	33 (82.5)	25 (62.5)	
Eye	Irritations	P (n=73)	19 (47.5)	2 (5.0)	20 (50.0)	12 (30.0)	6 (15.0)	14 (35.0)	$p<0.001$*
		A (n=167)	21(52.5)	38 (95.0)	20 (50.0)	28 (70.0)	33 (82.5)	26 (65.0)	
	Swelling of face/eye	P (n=61)	17(42.5)	1 (2.5)	14 (35.0)	10 (25.0)	7 (17.5)	12 (30.0)	$p<0.001$*
		A (n=179)	23 (57.5)	39 (97.5)	26 (65.0)	30 (75.0)	33 (82.5)	28 (70.0)	
Digestive	Vomiting and diarhea	P (n=7)	4 (10.0)	0 (0.0)	1 (2.5)	0 (0.0)	1(2.5)	1(2.5)	$p>0.05$
		A (n=233)	36 (90.0)	40 (100.)	39 (97.5)	40 (100.0)	39 (97.5)	39 (97.5)	
	Stomach ache	P (n=8)	3 (7.5)	2.50 (1)	2 (5.0)	0 (0.0)	1(2.5)	1(2.5)	$p>0.05$
		A (n=232)	37 (92.5)	97.5 (39)	38 (95.0)	40 (100.0)	39 (97.5)	39 (97.5)	
	Death	P (n=3)	0(0.0)	0 (0.0)	0 (0.0)	3 (7.5)	0 (0.0)	0 (0.0)	$p<0.01$*
		A (n=237)	40 (100.0)	40 (100.0)	40 (100.0)	40 (100.0)	40 (100.0)	40 (100.0)	
Respiratory	Failure to breath	P(n=14)	4 (10.0)	3 (7.50)	1 (2.5)	0 (0.0)	1 (2.5)	5 (12.5)	$p<0.001$*
		A (n=226)	36 (90.0)	37 (92.5)	39 (97.5)	40 (100)	39 (97.5)	35 (87.5)	
Fever	Headache	P(n=42)	12 (30.0)	4 (10.0)	6 (15.0)	6 (15.0)	8 (20.0)	6 (15.0)	$p>0.05$
		A (n=198)	28 (70.0)	36 (90.0)	34 (85.0)	34 (85.0)	32 (80.0)	34 (85.0)	

"P= present" "A=absence" *p- value in Pearson Chi Square test.

reported in Songosongo (83.3%) and Paje villages (95%), followed by Bweleo (90%), Kijiru (85%) and Tumbe (82.582.5%), while fewer cases were reported during long rains season (March to May), 4.2%.

Regarding the stages of the seaweed farming when the problems were experienced, farmers reported to have high occurrence (37.5%) during the actual farming time itself (planting). About 32% of farmers from Songosongo village indicated that they got the problems during harvesting. However, majority of the farmers in Bweleo village (60%) could not specify exactly at which stage of farming they experienced health problems. There was a significant difference ($p<0.05$), between seasons when health problems occurred and farming stages across the villages.

The response of interviewees on what farmers did when they got health problems are shown in Table 4. There were differences between villages regarding what the farmers did when they get the seaweed farming related health problems. A majority of farmers either went to nearby hospitals or dispensaries for medical treatment or did nothing while waiting for natural recovery (Figure 3).The highest percentage of those who went to nearby hospitals was observed in Songosongo (60.0%) while the least was observed in Bweleo. Very few cases of farmers (12%) reported to seaweed experts when they experience health problems, all of them were from Kijiru.

The logistic regression models showed a stable pattern for the most common health problems. As shown in Table 3, participation in farming was a factor for all health problems. Village was important for skin problems, while age was more important for eye problems. Farmers (44%) reported that no medication they got when they visited hospitals/dispensaries were only given painkillers,

Table 3. Results from the multivariable logistic regression analyses for associations between the most common health problems and potential risk factors. Results shown as Odds ratio (OR) with 95% Confidence intervals and corresponding p-values. For each model, the area of the Receiver Operating Curve is also shown.

Participating in culturing vs. not	Skin irritation (ROC=0.75)	Body itching (ROC=0.77)	Skin sores (ROC=0.68	Eye irritation (ROC=0.78)	Eye swelling (ROC=0.75)	Haedache (ROC=0.71)
	OR=6.31 (3.0-13.4); *p*<0.001	**OR=6.5 (3.3-13.1); *p*<0.001**	**OR=2.4 (1.3-4.5); *p*<0.01**	**OR=2.8 (1.5-5.4); *p*<0.001**	**OR=2.3 (1.2-4.5); *p*<0.01**	**OR=4.3 (2.0-8.9); *p*<0.001**
Bweleo	OR=1.00	OR= 1.00	OR= 1.00	OR= 1.00	OR= 1.00	OR= 1.00
Chwaka	OR=1.9 (0.65-5.3); *p*>0.05	3.4 (1.15-10.2); *p*<0.05	OR=2.5 (0.87-7.4); *p*>0.05	OR=2.9 (0.92-9.1); *p*>0.05	OR=1.7 (0.56-5.1); *p*>0.05	OR=0.51 (0.15-1.8); *p*>0.05
Kijiru	OR=11.0 (3.5-34.0); *p*<0.001	OR=7.9 (2.6-23.9); *p*<0.001	OR=1.7 (0.56-5.0); p>0.05	OR=5.8 (1.9-17.8); *p*< 0.001	OR=2.1 (0.72-6.3); *p*>0.05	OR=0.50 (0.14-1.7); *p*>0.05
Paje	OR=5.6 (1.72-13.9); *p*<0.001	OR=5.4 (1.8-16.1); *p*<0.005	OR=4.8 (1.6-13.8); *p*<0.005	OR=2.6 (0.82-8.3); *p*>0.05	OR=1.5 (0.5-4.5); *p*>0.05	OR=0.59 (0.17-2.0); *p*>0.05
Tumbe	OR=4.9 (1.7-13.9); *p*<0.005	OR=4.3 (1.4-12.9); *p*<0.01	OR=1.6 (0.53-5.1); *p*>0.05	OR=0.40 (0.07-2.2); *p*>0.05	OR=0.14 (0.015-1.2); *p*>0.05	OR=0.54 (0.14-4.2); *p*>0.05
Songosongo	OR=6.5 (2.2-18.7); *p*<0.001	OR=6.3 (2.1-18.9); *p*<0.001	OR=2.8 (0.97-8.1); p>0.05	OR=5.1 (1.7-15.6); *p*< 0.001	OR=3.1 (1.05-8.9); *p*<0.05	OR=1.4 (0.46-4.2); *p*>0.05
20-30 years	OR= 1.00	OR= 1.00	OR= 1.00	OR= 1.00	OR= 1.00	OR= 1.00
31-40 years	OR=2.1 (0.99-4.7); *p*≤0.05	OR=1.6 (0.73-3.3); *p*>0.05	OR=1.5 (0.7-3.1); *p*>0.05	OR=2.6 (1.08-6.1); *p*<0.05	OR=2.7 (1.1-6.7); *p*<0.05	OR=1.4 (0.56-3.6); *p*>0.05
41-50 years	OR=1.4 (0.64-3.2); *p*>0.05	OR=1.4 (0.61-3.0); *p*>0.05	OR=1.5 (0.68-3.4); *p*>0.05	OR=3.4 (1.4-8.5); *p*<0.01	OR=2.1 (0.81-5.4); *p*>0.05	OR=1.6 (0.61-4.4); *p*>0.05
51-60 years	OR=1.8 (0.55-5.9); *p*>0.05	OR=0.87 (0.26-2.9); *p*>0.05	OR=1.7 (0.52-5.3); *p*>0.05	OR=1.1 (0.28-4.5); *p*>0.05	OR=2.0 (0.53-8.6); *p*>0.05	OR=0.93 (0.17-5.3); *p*>0.05

Bolded p-values are significant.

vitamins and injections to supress irritation pains (Figure 4). However, most farmers (25%) reported to only using traditional treatments for instance coconut oil mixed with natural herbs such as mangrove roots to reduce irritations.

We were not able to reach any stable logistic regression model explaining the individual health problems and potential explanatory variables.

Thus, it seems like the difference observed is not explained by factors we have included in this study, notably the large variability of health problems across villages.

DISCUSSION

In the current study, majority of seaweed farmers were relatively young (31 to 40 years old), and hence the potential to make the seaweed industry grow bigger. Among those, majority were women who have little alternative livelihood and currently enjoying better economic positions and respect in the society while reducing dependency on family income usually brought by men (Msuya, 2011a). In some villages, such as Tumbe village in Pemba, quite a good number of men were observed to participate in seaweed farming after seeing the benefits in terms of income made by their wives.

According to Msuya (2011) and Zamroni and Yamao (2011), some men on Unguja started participating in seaweed farming as an alternative livelihood activity after failing in their main livelihood activities like fishing. Contrary to the men from Pemba Island, Zanzibar Island has fewer alternative income generating activities. Nevertheless, most of respondents reported that seaweed farming was their main income generating activity for their livelihood in all the study sites. This is probably due to the fact that fishing activity has now become a problem for the coastal people and they are turning into seaweed farming as the alternative livelihood activity especially in Songosongo (Msuya and Porter, 2014) and Zanzibar Islands.

Fisheries in coastal areas of Tanzania are artisanal. With the increasing human populations, the areas are overfished and the fishing per unit effort has been decreasing continuously (Media, 2015) leading to problems such as fishing juveniles and other destructive fishing methods. Further to that, population density in Zanzibar is 530 per km^2 (URT, 2013) compared to the overall Tanzania's density which was projected to be 62.3 per km^2 by 2016 (http://data.un.org/CountryProfile.aspx). Seaweed farming has proven to be an important livelihood to the people living in Songosongo as their area is too small for other economic activities such as agriculture (Tobisson, 2014). According to Msuya

Table 4. Analysis on the time (season) when seaweed farmers experiencing health problems.

Variable	(%) of respondents per village n=240						
	Songosongo (n=40)	Tumbe (n=40)	Kijiru (n=40)	Paje (n=40)	Bweleo (n=40)	Chwaka (n=40)	*p*-Value
Seasons (Months) when health problems occur							
Hot (Jan-Feb) n = 200	38 (95.0)	33 (82.5)	36 (85.0)	38 (95.0)	36 (90.0)	21 (52.5)	
Windy/Dry (Jun-Sept) n=21	1 (2.5)	6 (15.0)	0 (0.0)	1 (2.5)	2 (5.0)	13 (32.5)	
Longrains (March-May) n=10	1 (2.5)	0 (0.0)	1 (2.5)	0 (0.0)	2 (5.0)	5 (12.5)	$p < 0.001$*
Shortrains (cold) (Oct-Dec) n= 4	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.5)	0 (0.0)	0 (0.0)	
None (n=5)	4 (10.0)	1 (2.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Stages in Seaweed farming processes when problems were experienced							
Farming (n=73)	15 (37.5)	5 (12.5)	17 (42.5)	13 (32.5)	8 (20.0)	15 (37.5)	
Harvesting (n=42)	13 (32.5)	11 (27.5)	4 (10.0)	7 (17.5)	2 (5.0)	5 (12.5)	
Drying (n=2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.0)	$p< 0.0001$
Wholefarm period (n = 44)	3 (7.5)	8 (20.0)	12 (30.0)	8 (20.0)	6 (15.0)	7 (17.5)	
None (n=79)	9 (22.5)	16 (40.0)	7 (17.5)	12(30.0)	24(60.0)	11 (27.5)	

*p- Value in Pearson Chi square test. Significant values at < 0.05.

and Porter (2014), in small island like Songosongo, the farmers have few economic alternatives and eagerly adopted seaweed farming from the beginning when it was first introduced to Songosongo Island in 1996. Therefore, if problems that interfere with this activity such as the health problems reported persist, most of the livelihood will be affected. It should be noted here that the industry employs 26,000 farmers whose livelihood will be affected, Also, the study showed majority of seaweed famers were educated by completing primary level of education and most of them were married, this is typical for coastal societies were they normally have low education level and higher rate of marriages, as reported by other researchers (Sahu et al., 2011).

Literature on health problems associated with seaweed farming is scanty. Seaweed farmers in Zanzibar have shown to have more incidences of allergies, respiratory problems and eye related problems as reported by Stockholm Resilience Centre (2012), Fröcklin et al. (2012) and Msuya (2013c). Undesirable skin conditions including itching, scarring and marking, darkening of colour, skin that shrinks and changes in its firmness or condition and skin irritations were reported by Msuya (2012).

Furthermore, according to Msuya (2015) toxic algal blooms of cynobacterium (*Lyngbya*) have been observed in Zanzibar and were suggested as a potential etiological factor for these dermatological and other health problems among seaweed farmers. Among the health problems that affect seaweed farmers, skin irritation showed high prevalence in all study sites, although significant differences were found across the villages for all health problems except for stomach problems. Incidences of body itching and skin sores were common among the farmers, and the symptoms could be so severe that the workers were not able to work in the farms. Other health problems were respiratory and eye problems. According to Rzymski and Poniedziałek (2012), cyanobacteria in the genus *Lyngbya* produce lyngbyatoxins, which are indole alkaloids causing skin problems such as itching, redness, burning, blistering and swelling of genital, perineum and perianal areas, ears (sores, discharge) and eyes (sores). Other health problems farmers faced included headache due to high fever as well as digestive problems which includes stomach ache, nausea, vomiting and diarrhoea and sometimes death cases due to eating the sea turtle that was contaminated by some cyanotoxins. The onset of the symptoms ranges from few minutes to hours after exposure and may last for more than 10 days as reported by Jiang et al. (2014).

Skin problems and other condition may also be attributed to exposure to the algae toxins during storage, because the farmers reported that the children, who do not do the actual seaweed farming, showed symptoms like coughing and fever when the seaweed were stored at home (Torre-Castro, 2006; Stefan Fors, 2010). Sores eyes (Moorea et al., 2010) and skin problems may also be related to strong sunlight and its reflection in the water. However, the normal skin and eye lesions from excess sunlight exposure differ significantly from those lesions observed in seaweed farmers (Torre-Castro, 2006; Fröcklin et al., 2012). Therefore, health problems raised a concern from the farmers through the Department of Fisheries of the Ministry of Agriculture,

Figure 1. Skin lesions on seaweed farmers in Songosongo, Tanzania (permission for display was obtained from the filmed farmer).

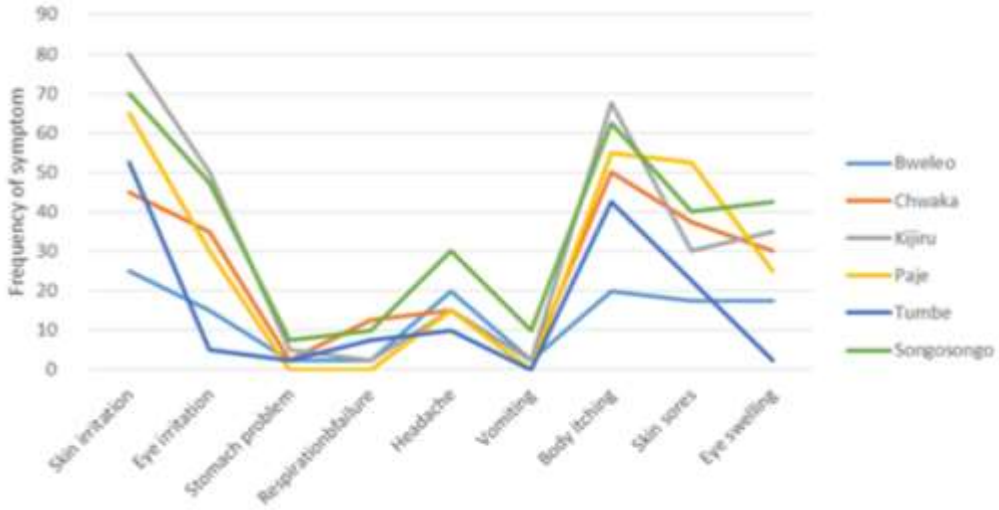

Figure 2. The frequencies of health problems at each study site.

Natural Resources, Livestock and Fisheries who put the issue to scientists at Institute of Marine Sciences to be investigated in 2013.

The first identification of *Lyngbya* toxin as a potential etiological factor for the skin and eye problem among seaweed farmers was first reported in 2012 (Msuya, 2013b; Msuya, 2015), while the farming has been going on since the late 1980s. The adverse health effects among the seaweed farmers (Figure 1) are different than the common water itch and most common water reflection eye sores, stomach ailments and skin irritations resulting from common microbes and irritations due to ultra violet light (Leventhal and Tlougan 2012).

The results from the present study showed that the hot season is the period when people experience skin irritation. This could be due to farmers tending to spend more time in water and expose themselves to direct sunlight, higher salinity and temperature. According to Belsito (2005) and Jöhnk et al. (2008), a combination of hot weather and wet working conditions may led to maceration of the skin, which increase the ability for toxins to penetrate the dermal barriers and cause skin diseases. During the hot dry season, which is December to February, there is an increase in sea surface water temperature, salinity and the nutrients concentration due to evaporation thereby increasing the environmental condition supporting blooms of the harmful cyanobacteria. In addition, direct sun burning and the time spent in salt water may reduce the protection barrier of skin, which may further increase the susceptibility of cyanobacteria toxins materials.

The farmers reported the uses of traditional medication that is, applied virgin coconut oil, charcoal ashes to the areas with skin irritation problems or reported to the

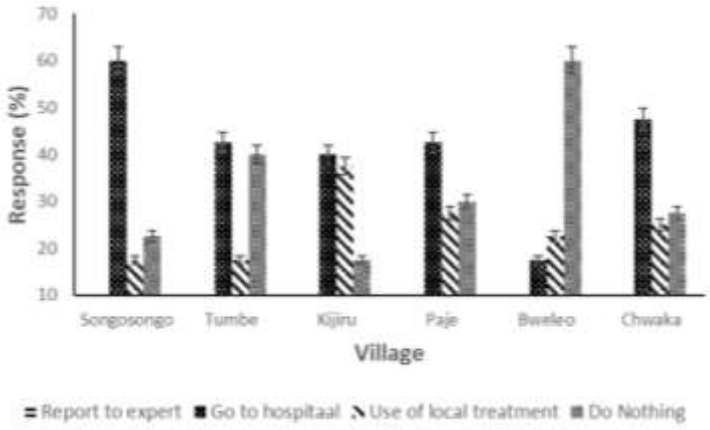

Figure 3. Action taken by farmers when experiencing health problems across study sites.

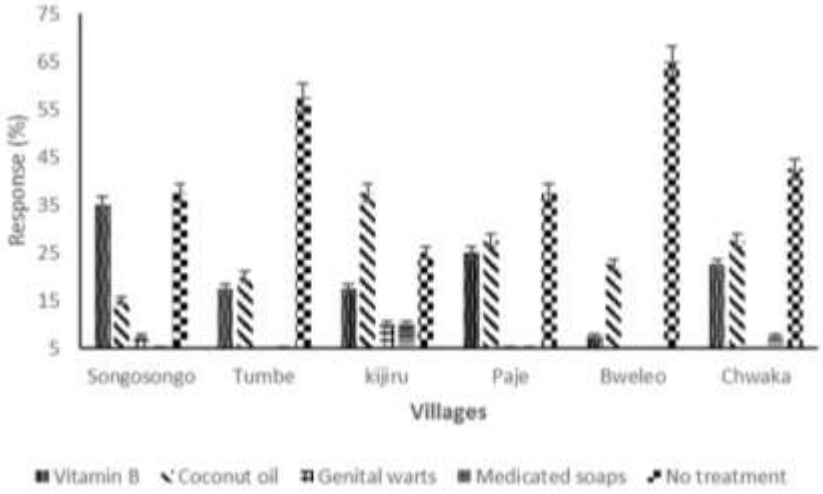

Figure 4. Types of medication used by farmers when experiencing health problems across study sites.

nearby dispensaries where they are treated with pain killers, vitamin, and injections B probably because they do not know the cause of the rashes. Further studies are needed to increase awareness of skin irritation related cause in health personnel and propose the medication for it.

Conclusion

Skin irritation is the main health problem faced by the seaweed farmers in the study sites. In terms of direct effects to farmers this study indicated that during the hot season, the farmers and seaweed farms are affected by the algal blooms and stakeholders should develop management/mitigation measures against the problems. Furthermore, the study indicated that there is no proper treatment for the ailments but with identification of the causative agents it is now time to start working on proper treatment of the illnesses. There is an obvious need to carry out further scientific investigation, on the main causes of skin irritations and the related health problems faced by seaweed farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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