

Perception of health risks associated with the use of the water and fish from the River**Nyong, Cameroon****Abstract**

Objectives: Freshwater resources are essential to livelihoods because of the ecosystem services they provide. However rivers flowing through residential and agricultural areas are susceptible to contamination, affecting these services. It is essential to ascertain the level of confidence of residents in the use of the said river resources. The aim of this study was to assess the perceptions of the communities on the health risks associated with the use of the River Nyong in Cameroon

Methods: 140 semi-structured questionnaires were administered to users of the river in Akonolinga. Data were analysed in the SPSS version 21 statistical package at $\alpha = 0.05$.

Results: Some respondents (11.4%) do laundry in the River Nyong. Few (17.6%) bathe in the river while a majority (88.1%) consumes fish from it. A majority of respondents (78.6%) get sick and are hospitalised between 1 and 3 times annually. Food poisoning and waterborne diseases occur between 20 to 30 times annually in at least 22.2% of the respondents, and symptoms include stomach ache (54.8%), diarrhoea (41.9%) and rashes (17.2%). There is a strong association between the method of preparing fish before consumption and the number of annual hospital visits ($X^2 = 18.073$, $p = 0.006$).

Conclusion: While respondents' perceptions of the health risks associated with exposure to the water and fish from the river are strong, we did not find a causal association between the risk factors studied and the health risk indicators.

Keywords: Behavioral health risk; risk indicators; water use risk perception; food poisoning; River Nyong

1. Introduction

Water is essential to life and human development. Worldwide, freshwater resources are central to the lives and livelihoods of populations. According to Vari et al. [1], inland rivers and streams provide fish and other food resources, serve for irrigation, transport, laundry, recreation and other essential ecosystem and developmental services. This is even more so in the context of increasing global populations, declining freshwater resources through deforestation, climate change and other anthropogenic activities [2].

In developing countries, freshwater streams and rivers are essential to rural and peri-urban livelihoods because the sustenance they provide the users is often the only recourse for these inhabitants [3]. Fish caught from inland rivers in Cameroon as in most of West and Central Africa is pricy; in consequence, fishing in these freshwater streams and rivers has become a lucrative activity for the few capable fishermen. Roadside roasted fish is a delicacy in most Cameroonian towns, and the freshwater fish feeding this industry is often caught from the nearby rivers and streams, for example the exotic *Oreochromis niloticus* and *Heterotis niloticus* caught from the middle reaches of the Nyong river [4].

In addition, sand mining is another river-based lucrative employer of the riverine population, as the fast growing construction sector in the country demands increasingly more sand. The methods employed are often artisanal, requiring whole body submersion of the miners, but new technology has improved on the sector, thus increasing output. Moses [5] has reported that in the Tiko Estuary of the Mungo River alone, over 74,000 m³ of sand were extracted between 2008 and 2018 and over 100,000,000 frscfa paid in taxes to the government. The exposure sand miners face is similar to that when riverine inhabitants use the watercourse for laundry, bathing, recreational swimming etc. Moreover, the availability of fresh vegetables and fruits in most urban and peri urban areas in the tropical regions is often thanks to the

possibility of affordable irrigation water from these rivers [6]. Such irrigation especially in the offseason, ensures food security for the inhabitants, in addition to income generation for the farmers.

However, the effective use of urban and peri-urban rivers in developing countries is highly dependent on perceptions of the residents on the risk factors associated with the various uses [7, 8]. Urban freshwater systems are subject to various anthropogenic influences. They often flow through industrial areas, from which they receive various forms of effluent. Effluent discharging into river systems often includes sewage, as well as agricultural leachate or discharge waters [7]. These activities have the potential to influence the river water quality. In consequence, respondents' perception of the water quality or risk factors of exposure are essential in better adoption of river-supported livelihoods.

Based on the multiple uses of rivers and the resources they provide, freshwater health and quality is inextricably linked to human health. According to Lin et al. [9], contaminated or polluted rivers bring with them loads of toxins, heavy metals, bacteria of various genera etc. which can directly impact the health of the users. Sewage-enriched waters have high loads of nitrates which feed algal blooms, and the resulting noxious algae reduces river aesthetics. When blooms die out and decay, they deplete dissolved oxygen levels, which can result in massive fish kills and death of other freshwater biota. In addition, contaminated water serves as source of inoculum for pathogens of waterborne diseases like members of the *Salmonella* and *Enterococcus* genera [10]. Khan and Gupta[11] reported that *Escherichia coli*, when present in waterbodies, is indicative of vertebrate faecal contamination. All these pose significant challenges to human health if sufficient exposure occurs, as has been reported for freshwater systems in Europe [12] and for three river systems in Bangladesh [13] as well as in Douala, Cameroon [14]. Therefore how populations perceive the risk factors of exposure is essential in harnessing the ecosystem services that rivers provide. Cameroon has a dense

network of rivers. Of these, the most popular are the Rivers Wouri and Sanaga, which have received a lot of research attention. In the Southern part of the Country, the River Nyong, a typical blackwater river rich in several fish species including *Clariasgariepinus*, *Oreochromisniloticus* and *Heterotisniloticus* a major river and one of only two major national rivers that do not transcend international boundaries. Its approximated 430 miles long course traverses several rural, peri-urban and urban communities, including the towns of Mbalmayo, Akonolinga and AbongMbang. The river is partially navigable for 250 miles between Abong-Mbang and Mbalmayo. The river Nyong supports a population of about 1,179,200 people (Runge, 2012), and activities of these riverine populations include fishing, farming and few artisanal industries. Due to the long distance it travels between communities, potentials for contamination or pollution are high. Studies have shown a high correlation between freshwater contamination and human health, and those who first notice changes in aquatic ecosystems are those whose livelihoods depend on them. Therefore the aim of this study was to assess the perceptions of the riverine communities of the economic and behavioural risk factors associated with the use of this river, in relation to human health.

2. Materials and Methods

2.1 Study area

This study was carried out in Akonolinga, which is the divisional headquarters of the Nyong-et-Mfoumou Division, Centre Region of Cameroon. Akonolinga has a population of roughly 21300 inhabitants [15] and lies along the River Nyong, the second largest river in Cameroon, with a drainage basin of 27800 km² (Figure 1). The vegetation cover in the entire watershed is dominated by semi-deciduous forests on hill slopes and by raffia in the low-lying swampy zones. In the eastern-most portion of the basin, the River Nyong flows through permanent swamp forests and permanently and seasonally inundates grass swamps 2–3 km in width.

Downstream the basin is dominated by rounded hills covered in semi-deciduous forest (60%) and cropland (40%), predominantly tubers, cassava, palms and plantain. The climate of the region is of a Guinean type with four seasons: two rainy seasons, March to May and from September to November, separated by two dry seasons (June to August and December to February). The River Nyong is a typical "blackwater" river, with a mean p^H of 6.2, hardness of <10 mg/l (as $CaCO_2$) and electrical conductivity between 20 and 30 $\mu S/cm$. Water temperature is always between 20° and 24° C. The water is naturally clear and tea-coloured as a result of the low dissolved nutrient concentration, low light (due to narrowness of valleys and canopy cover) and high tannin concentrations leaching from the large amount of allochthonous vegetative matter that falls or flushes into the water from the surrounding forest [16]. Akonolinga being a riverine town, fishing is a mainstay of the economy, in addition to agriculture, services and commerce.

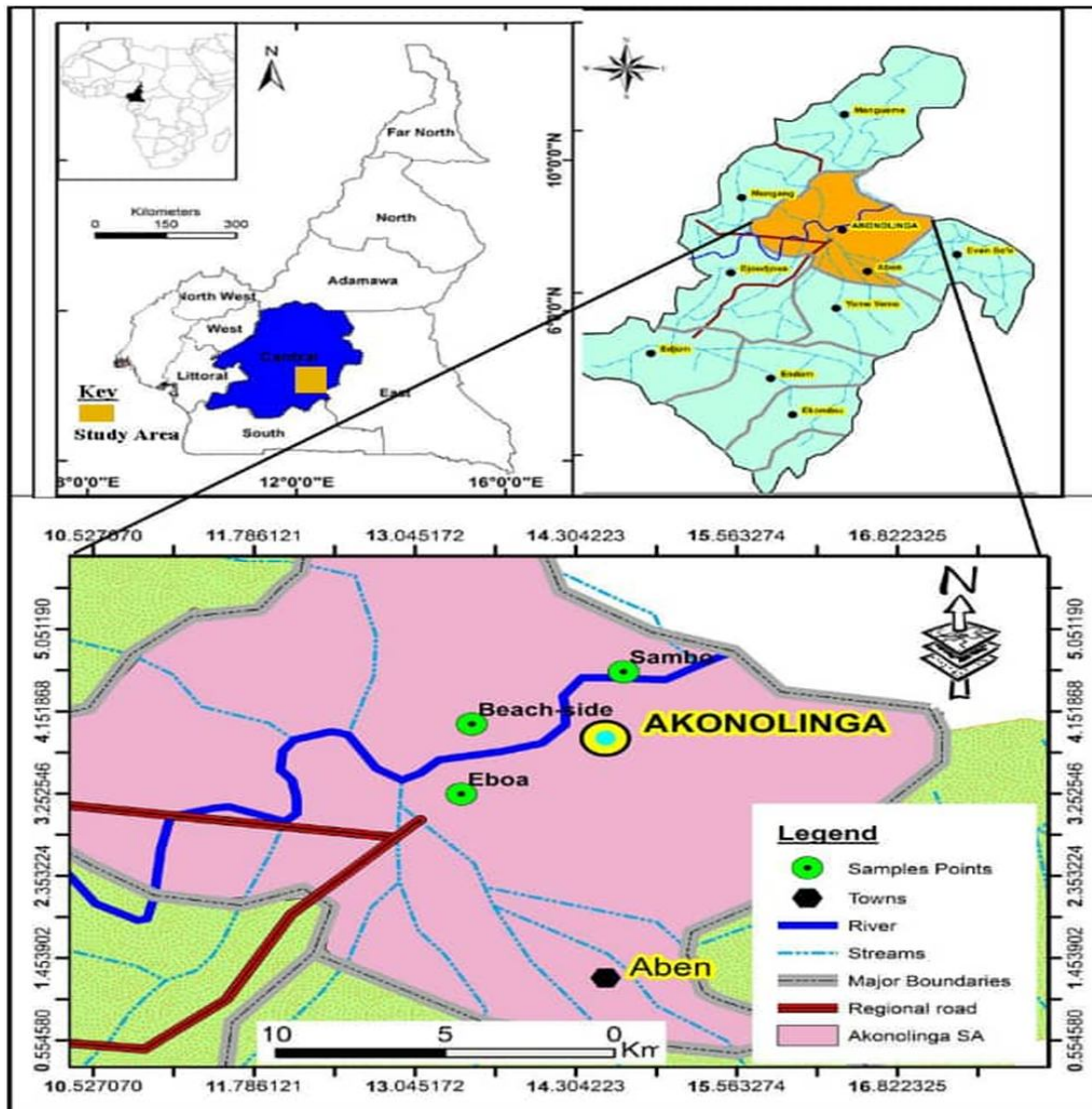


Figure 1: Map of Akonolinga showing collection sites of fish samples from River Nyong

2.2 Study design

This research was conducted through surveys, using semi-structured questionnaires. The method employed was a stratified random sampling design. Semi-structured questionnaires were designed to cover the main themes of socio-demographic characteristics, uses of the water and fish of the River Nyong and disease/health related information.

2.3 Study population and sample size

The population of the area is about 21300 inhabitants. The sample size was determined using Krejcie and Morgan [17] table. For a population of 21300 inhabitants, the expected sample size was 377 respondents. However, due to taboos relating to divulging health and income information, only 140 questionnaires were returned. Prior to the study, ethical clearance was obtained from the Institutional Animal Care and Use Committee (UBIACUC) of the University of Buea, Cameroon. Informed consent was sought from the respondents prior to questionnaire administration. The questionnaire was administered in person.

2.4 Data analysis

Data were coded into SPSS version 21 and analysed for frequency distribution and χ^2 test of association between risk factors and risk indicators. All analyses were conducted at $\alpha = 0.05$.

3. Results

3.1 Socio-demographic characteristics of the respondents

A majority of the respondents (56.9%) were male, and aged between 21 to 40 years old (64.2%). Almost all respondents have attained post-primary education (74.4%). They are all employed in various fields; specifically, farming (2.3%) and fishing (3.8%) constitute the least occupation. About half of the respondents (50.4%) are married mainly in monogamous marriages (90.3%). A majority of the families surveyed typically have up to 5 children (78.2%) and 3 to 8 dependents (63.2%) (Table 1).

Table 1 Socio-demographic characteristics of the respondents

Variable	Frequency	Valid Percent	Variable	Frequency	Valid Percent
Gender			Marital status		

Male	78	56.9	Married	63	50.4
Female	59	43.1	Single	62	49.6
Age Group			Marriage Type		
10 to 20	19	14.2	Monogamy	37	90.3
21 - 30	51	38.1	Polygamy	4	9.7
31 - 40	35	26.1	Number of children		
41 - 50	19	14.2	1 to 2	43	42.6
>50	10	7.4	3 to 5	36	35.6
Level of education			6 to 8	13	12.9
Primary	27	20.3	9 to 11	6	5.9
Secondary	76	57.1	>15	3	3
University	14	10.5	Number of dependents		
Professional	9	6.8	1 to 2	16	15.1
None	7	5.3	3 to 5	36	34
Occupation			6 to 8	31	29.2
Civil Servant	8	6	9 to 11	14	13.2
Private sector	56	42.1	12 to 15	6	5.7
Farming	3	2.3	>15	3	2.8
Fishing	5	3.8			
Others	61	45.9			

Values in the table represent frequencies and percentages of responses. Responses based on valid respondents. The Sample size was 150, but only those who responded to each question are considered

3.2. Economic characteristics of the fishing sector

Fish caught in the river serves both domestic needs of the fishermen, and for marketing (Figure 2). A majority of the catch is sold at the River beach (37.93%) and in the open market (31.03%). Hawkers who move around town with the catch also account for a significant proportion of sales (24.14%)(Figure 2A). The monthly income from sales of fish caught in the river goes up to 60,000 frscfa and above. A majority (55.65%) of the fishermen earn

20,000 frs and below. However, a significant proportion earns from 41,000 frs and above (44.4%) (Figure 2B).

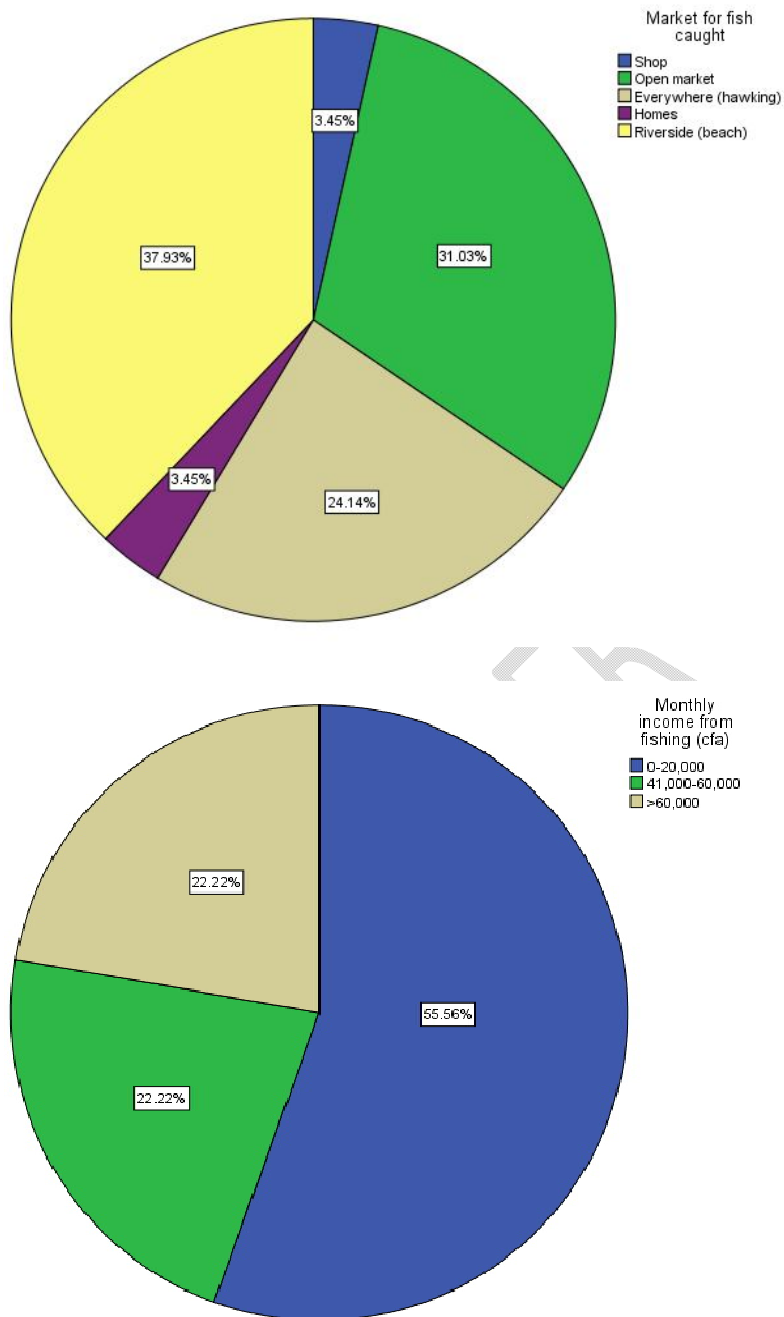


Figure 2 Markets for, and income from fish caught from the River Nyong, Cameroon

3.3 Perception of Behavioral risks factors by respondents

Behavioral risk factors associated with the use of water and consumption of fish from the River Nyong are presented on Table 2. A majority (52.6%) of the respondents use pipe borne water for drinking, followed by boreholes (28.1%). However, 3.7% of the respondents use water from the River Nyong for drinking. For the most part, the water fetched for drinking from the river or nearby streams is not treated (84.6%). Another risk factor associated with human health is the type of toilet facilities. A large majority (65.4%) of the respondents still uses open pit latrines, with just 33.8% having access to water closets. Domestic waste is mostly disposed of in open community dumps or landfills (68.9%). Some respondents (11.4%) do their laundry in the River Nyong, although a majority does laundry at home (84.1%). Few respondents (17.6%) bathe in the river while a significant majority (88.1%) consumes fish from the River Nyong.

Table 2 Behavioral risk factors associated with the use of water and fish from the River Nyong

Factor	Frequenc y	Valid Percent	Factor	Frequenc y	Valid Percent
Source of Drinking Water			Waste disposal system		
Pipeborne water	71	52.6	Community dumping	91	68.9
River	5	3.7	Private dumping	37	28
Stream	7	5.2	Others	4	3
Borehole	38	28.1	Laundry point		
spring	11	8.1	River	15	11.4
All	3	2.2	Stream	6	4.5
Treatment of river or stream water			Home	111	84.1
Yes	8	15.4	Bathing in the river		

No	44	84.6	Yes	22	17.6
Type of toilets			No	103	82.4
Water closet	45	33.8	Consumption of fish from river		
Pit latrine	87	65.4	Yes	118	88.1
Others	1	0.8	No	18	10.4

Values in the table represent frequencies and percentages of responses. Responses based on valid respondents. The Sample size was 150, but only those who responded to each question are considered

3.4 Perception of risk indicators associated with the use of the River Nyong

Indicators of risk associated with the use of water from the River Nyong as well as consumption of fish therefrom, include number of hospital visits, rate of food poisoning per year and annual rate of water borne diseases (Table 3). A majority of respondents (78.6%) get sick and are hospitalised between 1 and 3 times annually. This is followed by 19% of respondents who are hospitalised between 4 and 6 times annually. Most respondents reported that they suffer from food poisoning between 1 and 10 times annually (44.4%). This is similar to the rate of waterborne diseases. Food poisoning and waterborne diseases occur at a significant rate of between 20 to 30 times a year in at least 22.2% of the respondents (Table 3).

Table 3 Indicators of risk associated with use of water and fish from the River Nyong

Factor	Frequency	Valid Percent
Number of annual hospital visits		
0-3	33	78.6
4 to 6	8	19
>9	1	2.4
Rate of food poisoning		
1 to 10	4	44.4
11 to 20	3	33.3
21-30	2	22.2
Rate of waterborne diseases		

1 to 10	4	44.4
11 to 20	3	33.3
21-30	2	22.2

Values in the table represent frequencies and percentages of responses. Responses based on valid respondents. The Sample size was 150, but only those who responded to each question are considered

A majority of the respondents who drink river water reported symptoms such as stomach ache (54.8%) and Diarrhoea (41.9%). Among respondents who use the river for bathing, 17.2% reported that they suffer from rashes afterwards while 6.9% reported that they suffered from body itches. Nine percent of the respondents who eat fish report symptoms of stomach ache, although a majority (88.3%) reported no symptoms (Table 4). Kruskal-Wallis non-parametric ANOVA shows that there is no significant difference in symptoms of those drinking river water with respect to the source of drinking water ($p = 0.404$). Also, symptoms associated with bathing in the river do not show a statistical significance when compared with the different bathing options ($p = 0.095$). Similarly, symptoms reported from eating fish are statistically similar when the different options on fish consumption are considered ($p = 0.458$).

Table 4 Symptoms presented by respondents in relation to their use of the River Nyong waters and fish

Factor	Frequency	Valid Percent	Kruskal Wallis Test
			Source of Drinking Water
Symptoms from drinking river water			
Stomach ache	17	54.8	P = 0.404, Not significant
Diarrhoea	13	41.9	
Not sure	1	3.2	
			Bathing in the river
Symptoms for those bathing in the river			
None	22	75.9	P = 0.095, Not significant
Rashes	5	17.2	
Itching	2	6.9	
			Fish consumption
Symptoms from eating fish			
None	98	88.3	P = 0.458, Not significant
Stomach ache	10	9	
Vomiting	1	0.9	
Allergy	2	1.8	

Values in the table represent frequencies and percentages of responses. Responses based on valid respondents. The Sample size was 150, but only those who responded to each question are considered

Table 5 shows the relationship between risk factors and associated risk indicators as a result of the use of water and fish from the River Nyong by the communities. There is no significant association between demographic variables and the risk indicator chosen ($p > 0.05$ for all χ^2 interactions). Similarly, there is no significant association between economic variables and associated risk indicators. With respect to behavioral risk factors, there is a strong association between the method of preparing fish before consumption and the number of annual hospital visits ($\chi^2 = 18.073$, $p = 0.006$).

Table 5 Test of association of respondents' perceptions on risk factors associated with the use of water and fish from the River Nyong, and associated Risk indicators.

Risk factors	Risk indicators	
	X ²	p-value
Demographic variables		
Gender	1.180	0.554
Age group	2.696	0.988
Level of Education	2.070	0.913
Occupation	3.858	0.870
Marital Status	1.404	0.496
Marriage type	2.176	0.140
Number of children	6.745	0.564
Number of dependents	13.601	0.093
Economic variables		
Market for fish caught	3.273	0.351
Annual income from fishing	1.875	0.392
Behavioral risk factors		
Source of drinking water	12.353	0.136
Type of toilets	2.584	0.630
Waste disposal system	1.223	0.543
Laundry point	1.670	0.796
Bathing in the river	1.869	0.393

Consumption of fish from the river	7.892	0.096
Method of fish preparation	18.073	0.006

Values in the table represent Pearson Chi Square values and the associated levels of significance

4. Discussion

Results on demographic characteristics of the respondents in the current study are in line with findings by NIS Cameroon and CIF [18] who reported that households in Cameroon typically have an average of five members, with almost half of the population under 15 years old; a majority of Cameroonians though literate, have not studied beyond the secondary school. The high rates of literacy suggests that the sample was reliable enough in the responses given during the survey for appropriate conclusions to be done. Significantly, most of the respondents are employed in various fields and at least half are married indicating sufficient levels of maturity and stability. Incorporation of demographic information in the survey thus improves results reliability as reported by Ziegenfus et al. [19].

Artisanal fishing in the River Nyong represents a livelihood safety net and source of both food and income for the riverine community. Sonjiwe et al. [20] have shown the significant contribution of artisanal fishing to communities' livelihoods. In West and Central Africa, artisanal fishing has historical roots and has been a mainstay of nourishment, employment and income generation. Similar findings have been reported by Campredon and Cuq [21]. Communities along the River Nyong use traditional fishing methods including cast nets, hooks and dugout boats for fishing. The income earned is typically low, especially considering the high cost of living. Levels of income of fishermen are usually low compared to other rural community groups and this varies depending on gender, as reported by Amadu et al. [22].

The Cameroon health and population survey reported that in rural areas only 57% of households have an improved water source and 57% of rural households do not have improved toilet facilities [18]. Our findings corroborate this position, and show that only 52% have pipeborne water and 65.4% still use pit latrines. These conditions pre-dispose the population to diseases. Behavioural activities in and around the River Nyong, including the use of water for bathing, fishing and drinking have the potential to expose the community to health issues. Mora et al. [23] in their study of the Atoyac River, a peri urban river in Mexico, showed that urban area waters are highly contaminated, with coliforms, metals, microplastics and these were reflected in high levels of cancer biomarkers in humans. Literature suggests that open defecation or defecation in non-standard sanitary facilities has a strong correlation with contamination of water sources. Okullo et al. [24] reported that there was strong evidence of contamination of waterways with faecal matter from non-standard sanitary facilities, with high levels of *Escherichia coli*, faecal streptococci, *Salmonella typhi*, and total coliform in the surrounding waterways. The high levels of pit latrines in our study site therefore indicates significant river contamination potential. Why most households lack water closets in the study area remains to be studied, but in a similar study in Eastern Zambia, cultural taboos contributed most to the reluctance to build and use better toilet facilities [25].

Another risk factor identified in the study site is the practice of communal or private waste disposal in open dumps or landfills. Such dump sites become breeding grounds for mosquitoes, bacteria and other pathogens, with potential for contamination of soils and waterways through leaching as has been reported by Fonge et al. [26] in Buea, Cameroon. In Mamfe, a strong correlation was found between open dumping of waste and prevalence of diseases such as malaria, diarrhoea, bilharzia and intestinal worms [27]. Illegal open dumping in peri-urban areas might be a result of factors such as social status and accessibility to the

different alternatives, as has been reported by Sotamenou et al. [28] for the city of Yaounde, Cameroon, as families tend to use the least cost alternative for waste disposal.

Peri-urban rivers are often associated with discharge of industrial and domestic effluents and other pollutants/contaminants that may be detrimental to human health. In particular, faecal indicator organisms such as *Escherichia coli* may be present in the water and these indicate faecal contamination of the water. King et al. [12] have reported strong correlation between the levels of faecal Indicator organisms and gastrointestinal infections in humans. In the current study, the high proportion of the sample bathing in the River Nyong may thus represent a significant exposure risk. The route to illness from bathing is through ingestion of contaminated water. Islam and Islam [13] reported significantly high risk of disease from single bathing events in three rivers in Bangladesh, with infection rates higher than the USEPA threshold of 3 to 6 illnesses per hundred bathing events.

Variables of exposure to the waters of the river Nyong were also in line with respondents' reports of high rates of hospital visits, high rates of waterborne diseases and food poisoning diseases. This reflects repeated exposure to the source of contamination. Urban and peri-urban rivers in Cameroon have been shown to exhibit varying levels of contamination with various contaminants. In the Abiete-Toko gold district of Southern Cameroon, the river system has been shown to have relatively high levels of heavy metal contamination [29]. In the West Region of Cameroon, Biguioh et al. [30] reported a 90.9% faecal coliform contamination rate of samples obtained from various inland sources including springs, wells and rivers. High rates of industrial and anthropogenic pollution of the Wouri and Dibamba rivers have resulted in very high levels of nitrates and ammonia at some sites, rendering these rivers unsafe for domestic use [31]. Being a peri-urban river that flows through major residential and agricultural areas, it is safe to assume that the River Nyong would equally be suffering from such anthropogenic impacts (study ongoing). This would explain the apparent

coincidence of exposure through bathing and laundry with rates of hospital visits and foodborne diseases.

Indeed, a vast majority of respondents consume fish from the river Nyong. Popular fish consumed from this river include various species of *Clarias* and *Clariallabes*, typically roasted. If the river is contaminated, such fish would in turn serve as inoculum sources for foodborne diseases. It is not unusual for fish to be contaminated and in turn serve as inoculum sources. Fonge et al. [32] reported high rates of heavy metal bioaccumulation in *Arius heudelotii* from the Wouri River, and advised that such fish were not fit for consumption. However, it has also been shown that food handlers of 'ready-to-consume' foods such as roadside roasted fish popular in Cameroon, also play a key role in the spread of food-borne pathogens especially *Salmonella* [33]. *Salmonella* infections would cause several of the symptoms reported in the ten medical centres in the current study.

We found strong association between the method of fish preparation and the respondent-reported number of annual hospital visits, suggesting that more appropriate preparation methods could reduce the rate of human contamination. Statistically however, no strong associations were found between the number of annual hospital visits (risk indicator) and the demographic, economic and other behavioural risk factors, suggesting that other factors may be contributing to the reported rates of hospitalization.

5. Conclusion

The current study shows that respondents dependent on the peri-urban River Nyong, display economic and behavioral risk characteristics in the use of the river water and fish. As perceived by the respondents, such characteristics can influence their health. While respondents' perceptions of the health risks associated with exposure to the water and fish

from the river are strong, we did not find a causal association between the risk factors studied and the health risk indicators. Further studies are thus needed to identify more sources of contamination, determine the water and fish quality and hence link that to public health.

Ethical Clearance

Ethical clearance was obtained from the Institutional Animal Care and Use committee (UBIACUC) of the University of Buea, Cameroon.

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