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Community perception of heavy metal pollution and related risks in Lake Victoria Wetlands, Uganda

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Wetlands contributing a wide range of livelihoods to the riparian communities are progressively challenged with compounding heavy metals pollution. Controlling the negative impacts of the associated toxicants and adherence to policy implementation requires increased awareness among the local communities. This study investigated the socio-economic variables determining community risk perception of heavy metal pollution in the Lake Victoria wetlands associated with different land uses. A cross-sectional survey was conducted focusing on the wetlands' pollution status, sources and effects of toxicants on human health. Age, education and occupation were significant predictors of the community risk perception of the wetlands' heavy pollution. Individuals with at least secondary education were more likely to say a wetland was polluted or not. 68 % and 45 % of respondents agreed that industrial and commercial agricultural activities respectively, were the major sources of heavy metal pollution. Less than 25% of respondents identifying related implications of heavy metal contamination on human health was attributed to the low pollution risk awareness among the wetland dwellers. Therefore, there is a need to incorporate environmental pollution risk concepts at the different education levels using proper risk communication strategies to enable local communities to exploit wetlands resources from an informed point of view.

Key words: Community risk perception; heavy metal pollution; Lake Victoria wetlands.

INTRODUCTION

The release of heavy metal pollutants into the environment due to rapid population growth, industrialization, and agricultural technologies has posed a serious threat to human and wildlife health, as they are highly toxic, persistent, and capable of bioaccumulating in the various trophic levels of aquatic ecosystems (Ahmaed et al., 2016; Zaidi and Pal, 2017; Ali et al., 2019). The health hazards associated with this pollution have been known for ages, and the risks have been steadily increasing in many countries over the last century (Bhargava et al., 2017). This has led to increased research on food safety, specifically concerning health risks from the consumption of food contaminated with heavy metals (Mansour et al., 2009; Saha and Zaman, 2013). Recently, public health risks from exposure to intake of pollutants are now evident enough that the regulation topic due to the gradually higher values of toxic metals in the environment is very crucial (Ihedioha et al., 2016). In many developing countries where protein sources are limited, riparian communities depend on the wetland's fisheries for protein sources; however, these wetlands are increasingly contaminated with heavy

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metals pollution (Rahman et al., 2013), indicating a lack of awareness of the implications of such pollution to the among socio-economic factors that influence the heavy communicated to support local communities in making risk-based decisions established from a balanced judgment emerging from factual evidence about the imminent situation, their values and interests (Lahr and Kooistra, 2010). Earlier research done on the contamination of polychlorinated biphenyls pollution among the Rhone River inhabitants by Comby et al. (2014) revealed that many people got contaminated due to a lack of access to proper communication about the pollution level of the river. Thus, there is a need for effective risk communication involving the exchange of opinions and information between community members and institutions, discussing risk types and measures for dealing with risks (Lahr and Kooistra, 2010). To achieve this, it is important to apply coherent language to describe the magnitude of risk using scientific and policy perspectives to avoid public controversies (Leiss, 2004; Comby et al., 2014). Prior knowledge of community perception of pollution risk is important to consider before any formal communication exercise starts and this is influenced by many factors.

Geographical location, culture and many socio-economic factors influence community perception of environmental issues. But also, the mode of communication influences the outcome. Earlier studies have reported that community-related investigations (Jurg et al., 2009) and a person's exposure to the local pollution source (Grasmuck and Scholz, 2005) also influence local communities' responses to an environmental problem. Otherwise, a seemingly long-term environmental problem can turn into a pending disaster due to problem-damping and problem-amplifying with time and space by local communities with differing discourses (Comby et al., 2014).

Lake Victoria wetlands contribute considerably to rural income through the direct supply of ecosystem services. However, the wetlands are challenged with increased heavy metal pollution from different urban, industrial and commercial agriculture-associated activities (Bakyayita et al., 2019; Dietler et al., 2019). Recent assessment within Lake Victoria's Nakivubo channel recorded high levels of lead (Pb > 0.1 mg/L) and mercury (Hg > 0.01 mg/L) (Dietler et al., 2019). Other studies focusing on urban areas, particularly Kampala also confirm increased heavy metal pollution (Batbayar et al., 2017; Eliku and Leta, 2018; Zhen et al., 2016). Increased heavy metal contamination in wetlands has been postulated to result in negative health impacts on endangered communities with time (Abdel-Tawwab et al., 2017; Miebaka and Adiela, 2019). There is a need to effectively communicate with the wetland dwellers, based on how they perceive pollution aspects. The people's perceptions and attitudes are underlying factors influencing environmental management related decisions and an individual's behavior change is stimulated by these factors (Eck et al., 2019).

Therefore, this survey assessed the determinants among socio-economic factors that influence the heavy metal pollution risk perceptions of the wetland communities within the northern part of Lake Victoria. Based on the fact that as the contamination level differs substantially, the actual exposure and the associated potential risks will also vary in the different communities (Jiang et al., 2017). This wetlands community's perception of heavy metal pollution risk offers a foundation for the development of effective pollution risk communication approaches in the region.

MATERIALS AND METHODS

Study area

Situated along the equator at an elevation of approximately 1134 m a.s.l., Lake Victoria has many bays fringed with permanent wetlands, which are supported by its modified equatorial climate type with rainfall ranging from 1100 to 1600 mm occurring throughout the year. The riparian communities derive a wide range of livelihoods from these wetlands.

Indeed about 80% of the wetlands dwellers directly utilise the wetlands for food, household water and settlement (Kakuru et al., 2013). However, the increasing human populations, land uses and climatic variabilities are putting immense stress on the wetland resources, resulting in varying wetland pollution exposure levels. This study interviewed communities in different wetlands in the northern part of L. Victoria. Industrial wetlands were those highly affected by heavy metal pollution from urban and industrial activities within and neighbouring Kampala and Jinja cities (Batbayar et al., 2017; Dietler et al., 2019; Zhen et al., 2016), particularly Bulenga, Gabba, Mukono and Masese (Figure 1).

Agricultural wetlands were those associated with commercial agriculture, particularly Lutembe in Kampala, Lukaya in Mawokota and Wairaka in Kakira. And the natural wetland was Nabugabo wetland in Masaka due to the large coverage of intact natural wetland vegetation.

Survey design and tools

Data were collected with a cross-sectional design from adults living in the eight wetlands who had given consent to participate in the study. Everyone filled out a consent form which described the objectives of the study and the need for their consent to participate. The survey tool had questions for establishing the sources of heavy metal contamination and community risk perception of metal pollution within the wetlands. The questions included open-ended ones, some with categorical options of yes/no, multiple-choice ones, those with Likert scale (agree, do not know and disagree) and some with five–point ordinal scale options to measure the level of perception of pollution effect on the wetland water and general wetland system as exemplified in Table 1. The initial section of questions had the social and economic indicators adopted from Ondiek et al. (2020**)**, which included age, educational background, marital status and major occupation. Other social and economic factors included the location of the homestead in the wetlands, wetland fish species caught and the consumption of fish among others. A survey was also done to assess the possible recommendations for proper management of wetlands pollution. The number of households directly dependent on the wetlands for

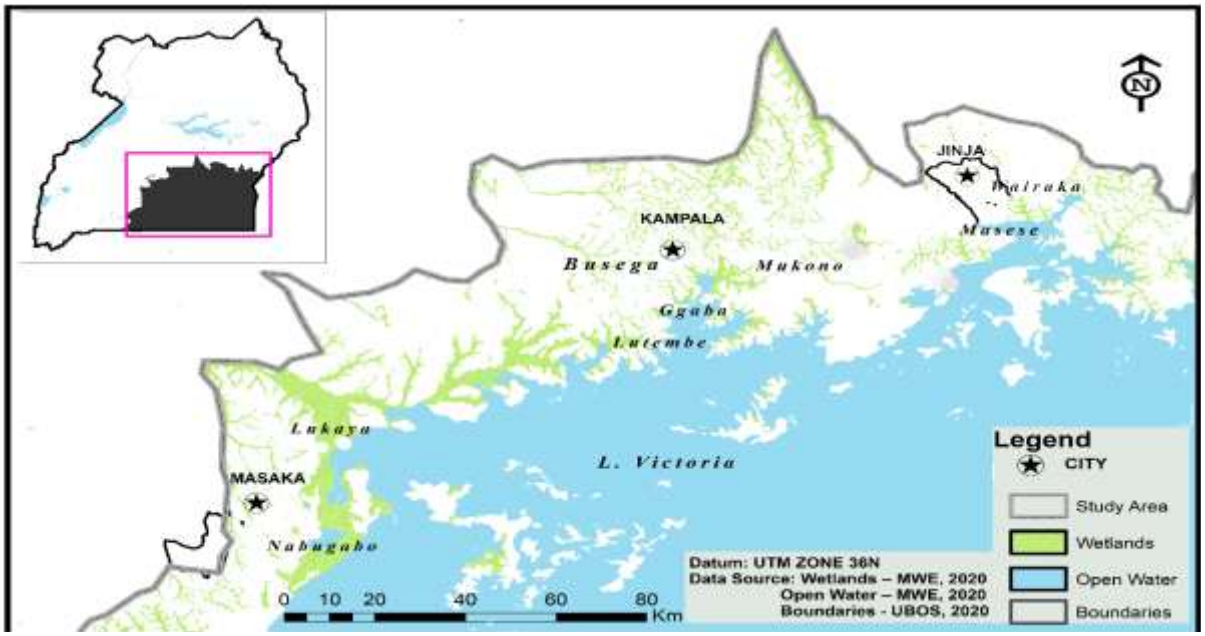

Figure 1. The different wetlands along the Lake Victoria shores.
Source: Authors

Table 1. Sample questions for community perception of heavy metal pollution risk.

Perception of heavy metal pollution problem, sources, and effects on wetland
Have you heard of heavy metal pollution in water bodies like wetlands, lakes, and rivers? (Yes, No, Don't know)
This land use activity ((industries, commercial agriculture, sand mining, fishing, and other activities) could be releasing heavy metal pollutants into the wetland. Do you…? (Agree, Do not know, Disagree)
How would you rate the effectiveness of these activities (industries, commercial agriculture, sand mining, fishing, and other activities) on the wetlands' structure and wetlands water quality? (5 - None/very low (None or not impacting on wetland); 4 - Low (Affect less than 25% of the wetland); 3 - Moderate (Affect 25-49% of the wetland); 2 - High (Affect 50-75% of the wetland); 1 - Very high (Dominate wetland (>75%)); 0 - Extreme (Totally dominated or affected by the land use activity)
Perception of heavy metal pollution risk
Do you use wetland water or eat wetland fish? (Yes, No)
Do you think heavy metal pollution affects fish? (Yes, No, Don't Know)
If yes, how do you think fish are affected by pollution? (habitat change/breeding, body physiology, migration to other areas, death, other, specify)
Do you think eating fish contaminated with heavy metal pollution may affect people's health? (Yes, No, Don't know)
If yes, could these (damage the kidneys, damage to the nervous system, skin cancer, liver damage, cause cancer, affect baby growth during pregnancy or affect brain development in children) be some of the effects? (Agree, Do not know, Disagree)

Source: Authors

agriculture, settlement, and water supply in the Lake Victoria wetlands was about 156,754 (UBOS, 2016).

Based on Krejcie and Morgen (1970) table of sample size, the target sample size for this study was 380 people at a 5% margin of error and 95% confidence interval. However, 313 valid qualitative data entries were made through face-to-face interviews using the questionnaire tool preloaded in the Kobo Collect application (CC-BY-NC-ND 4.0) installed on Android-based phones. Before the qualitative data collection, research assistants were trained for three days on the questionnaire tool and ethics. To ensure good quality data collection, the tool was designed with restrictions and skips to some questions. Pretesting of the tool was done and a satisfactory reliability check using Cronbach Alpha of 0.69 was attained. The key stakeholders including the wetlands farmers, fishermen, local community members, environment officers and local council chairpersons were interviewed.

Data analysis

Data were downloaded from the server into an excel sheet, cleaned, coded and then transferred to SPSS version 15 for

statistical analysis. Then it was summarized using descriptive statistics to derive the means and proportions of the responses. A binary regression analysis was used to determine the major predictors for community risk perception on whether the wetland was polluted or not and whether urban/industrial activity highly impacted the wetlands. In this analysis, the socio-economic and other identified perceptions such as knowledge of where industries dispose of their waste, and heavy metal effect on human and fish health represented the independent variables (predictors). Wetland being polluted was regarded as a dependent binary variable, assigning a value of 1 to polluted wetlands if a respondent said yes and a value of 0 for no. All predictors were also converted to binary values first. Later binary regression analysis with further categorical variables was done to identify specific categories that were significantly predicting the community risk perception model.

RESULTS

Socio-economic trends of the wetland community

Among the respondents, 31% were females and 69% were males. The majority belonged to the 26 – 45 years age group specifically, 59% were within the age group of 26 - 35 years and 34% were young within the age range of 15 to 25 years. The rest were above 35 years of age. 57% of respondents were married. 43% never attended school and 48 % had attained at least a secondary school education. Regarding the location of their homestead, 19% lived within the wetland area, 51 % lived at a distance of 1 Km from the permanent wetland areas and the rest lived more than 1 Km away from the permanent wetland area. The major economic activities done by communities varied among the different wetland groups (Figure 2). However generally the dominant activities varied from fisherman (37%), farmer (26%), animal husbandry (10 %) and, other activities like motorcyclists, traders, cleaners, teachers, and hairdressers.

Wetland fishery characteristics

The majority (43%) of the wetland fishermen had a 2- to 5- year experience in fishing. 37% had less than 2 years of fishing experience and 20% had more than 5 years of fishing experience. These wetland fishermen were catching fish using nets and hooks (43%), hooks only (36%) baskets (18%) and a combination of all three (3%). Although some could use more than 100 hooks, the average number of hooks was 38 ± 33 in all wetlands. The fishermen mainly caught *Protopterus aethiopicus* and *Clarias gariepinus* and the small *Clarias* species (Nsonzi) in all wetlands. Other fish species caught from wetlands included Tilapia and Haplochromine species. Comparing the wetland categories; urban/industrial affected, commercial agriculture associated and natural wetland, there were differences in fish commonly caught (Figure 3). 54% of fishermen in urban/industrial associated wetlands caught *Protopterus* sp all year round and *Clarias gariepinus* mostly in the wet season. While the commercial agriculture and natural wetland groups, fishermen caught *Protopterus* sp and *Clarias* sp more all year round. This small-scale fishery catch contributed to their livelihoods, earning 9000 to 350,000 Ug. X per day's fishing catch depends on the season and on average they earn 55000 Ug. X per day (Table 2). Question regarding the changes in wetland fishery production, 83% agreed that there was a reduction in the fish caught over the years. 72% of the respondents noted that the caught fish size had reduced to mainly medium-sized ones. There were differences in response to the question of what could be causing the fish catch decline among individuals from different wetlands (Figure 4). 45 % of respondents from the natural wetlands agreed that agriculture is main cause of fish decline while 46 % of those from urban/industrial affected wetlands agreed that industries are the major cause of fish catch changes in the wetlands. Overall, fishing, agriculture and industries were the major contributors to wetlands' fish catch decline at the response percentage of 26, 32 and 29% respectively.

Community perception of heavy metal pollution risk

Comparing awareness of how different land uses impact the wetlands among respondents from different land use-affected wetlands, there were notable differences. In the urban/industrial-affected wetlands, 44% of respondents agreed that industries had an extreme impact, mining had less than 25% impact, and 32% of them agreed that fishing had less than 25% impact on the wetlands. In the commercial agriculture-affected wetlands, 55% of respondents agreed that agriculture had impacted the wetlands to a high level of 50 to 75%. Nearly 25% of respondents agreed that industries/factories had a significant impact on wetlands, while respondents from natural wetlands agreed that industries had a less than 25% impact and agriculture had a moderate impact (Figure 5). Mining had a significant impact on the wetlands, with up to 70% of the natural wetland being used for sand mining sites. Regarding the awareness of heavy metal pollution problem in the wetlands, 83% of individuals in urban/industrial affected wetlands were aware of this problem. Majority of the respondents from all the wetland stated that industries polluted by releasing waste in the wetlands while commercial agriculture pollute via the use of fertilizer and pesticides (Figure 6). The consumption of wetlands' fish and the possible effects on human health in case there was any heavy metal contamination in the fish was assessed. While 24% of respondent stated that they eat wetland fish, 47% agreed that they eat *Protopterus* sp fish at least once a month. Comparing individuals from different wetland groups, 86% of respondents from natural wetlands eat whole fish while those from other wetlands eat pieces, half fish and

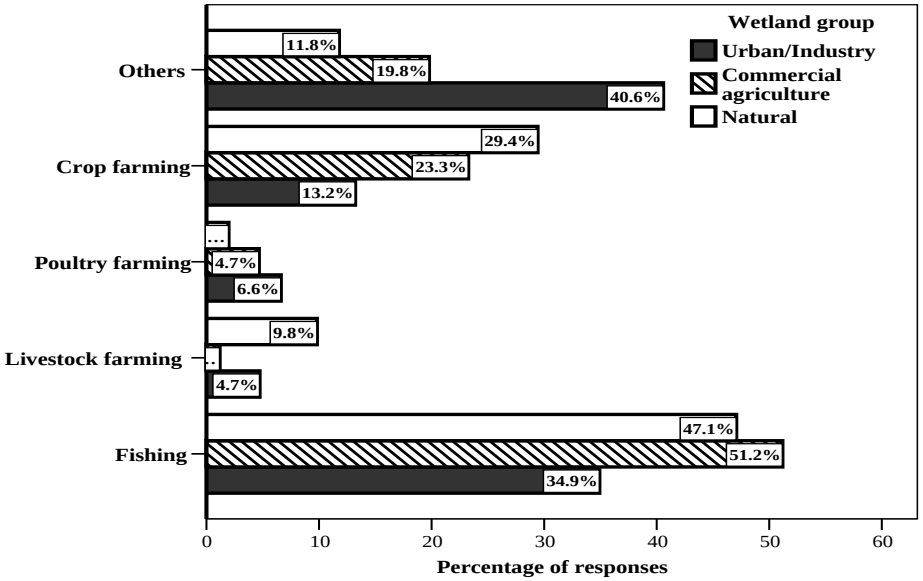

Figure 2. The major economic activities of the communities in the different.
Source: Authors

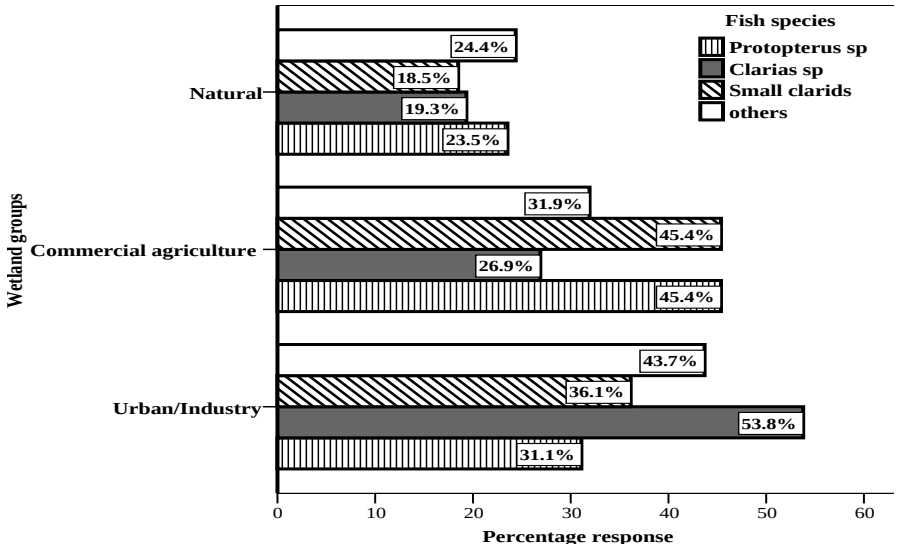

Figure 3. The dominant fish species caught from Lake Victoria wetlands.
Source: Authors

sometimes whole fish depending on availability and price. Many of the respondents agreed that fish get heavy metal contamination in the polluted wetlands (Figure 6). Despite that, 44 and 33% of respondents from urban/industrial and commercial agricultural affected wetlands, respectively, agreed that they eat fish from these wetlands (Figure 7). With respect to the question about the effect of consuming fish contaminated with heavy metals on human health, their responses varied a lot depending on which wetlands they were associated to. Generally, 71% agreed that this could affect human health (Table 3). But a low percentage of respondents could relate heavy metal contamination to specific human health issues. The identified health issues were kidneys dysfunction (27% of respondents), skin cancer (28%), liver damage (39%), cause other cancer types (26%) and effects on baby growth during pregnancy (22%). It was also realised that 75% of respondents perceived that even fish health can be affected by heavy metal pollution in the wetlands.

The binary linear regression for the perception that the wetland was polluted was performed. It revealed that six significant factors were influencing the opinion of the interviewed individuals (Table 4). These factors were

Table 2. Percentage responses on the wetland fishery (N = 115) and land use impact (N = 313) on the Lake Victoria wetlands.

Variable	Responses %		
Fish caught from the wetland	*Protopterus* sp	92	
	Clarias sp	72	
	Small clarids	29	
	Others	8	
Mean number of fishing gear (hooks) used per day		38 ± 33	
Average price of 1 kg of *Protopterus* sp (Ug. X)		7500 ± 4500	
Average price of 1 kg of *Clarias* sp (Ug. X)		6400 ± 2500	
Fishing income per day (Ug. X.)		55600 ± 9500	
Consumption of wetland fish	***Protopterus* sp**	**%**	**% *Clarias gariepinus***
	Everyday	2	13
	Twice a week	12	8
	Once a week	15	15
	Once a month	46	27
	N/A	24	37
To what extent has the quantity of fish caught changed?	Increased	4	
	Decreased	72	
	Same	5	
	Don't know	19	
Cause of the change in fish catch	Fishing	26	
	Agriculture	32	
	Mining	6	
	Industries	29	
	Others	7	
	Don’t know	5	

Source: Authors

age, education, occupation, wetland, best fishing season and knowledge of where industries dispose of their waste. Using the odds ratio values, it was three times ($p = 0.003$) more likely that respondents in one age group would consider that a particular wetland was more severely polluted than another age group. From further regression of age categories, the 15 to 25 years age group was the only significant category at $p = 0.021$ and these respondents were most likely to respond that a wetland was polluted. Regarding education, it was two times more likely that respondents in one education category would say that a wetland was polluted than those in another education category. On further regression of the education level categories, the secondary school category was the only significant ($p = 0.003$) category. Therefore, those with secondary education were more likely to say that wetlands were polluted than those with other education categories. The occupation was also a significant predictor at $p = 0.006$ and further categorical analysis identified that respondents with other occupations which included motorcyclists, traders, cleaners, teachers, and others were more likely to say that a wetland was polluted. The wetland location variable was also a significant predictor and it was further realised that respondents from Wairaka, Masese, Bulenga and Lukaya were more likely to say that the wetland was polluted all at $p < 0.05$. The knowledge of where the industries disposed of their waste was also a significant predictor.

Those who responded that industries disposed of waste in the wetlands, were more likely at $p < 0.05$ to say that wetlands were polluted than those who responded differently.

An open question tool was used to gather potential management options to ensure proper management of heavy metal pollution and four major categories of possible options to improve heavy metal waste management within the wetlands were identified (Table 5). Implementation of environmental laws and land use management was highly suggested with about 28% of respondents. Strict environmental monitoring and sensitization were also suggested. 37% suggested that government should have restrictions on industries and farming within the wetland and ensure regular monitoring

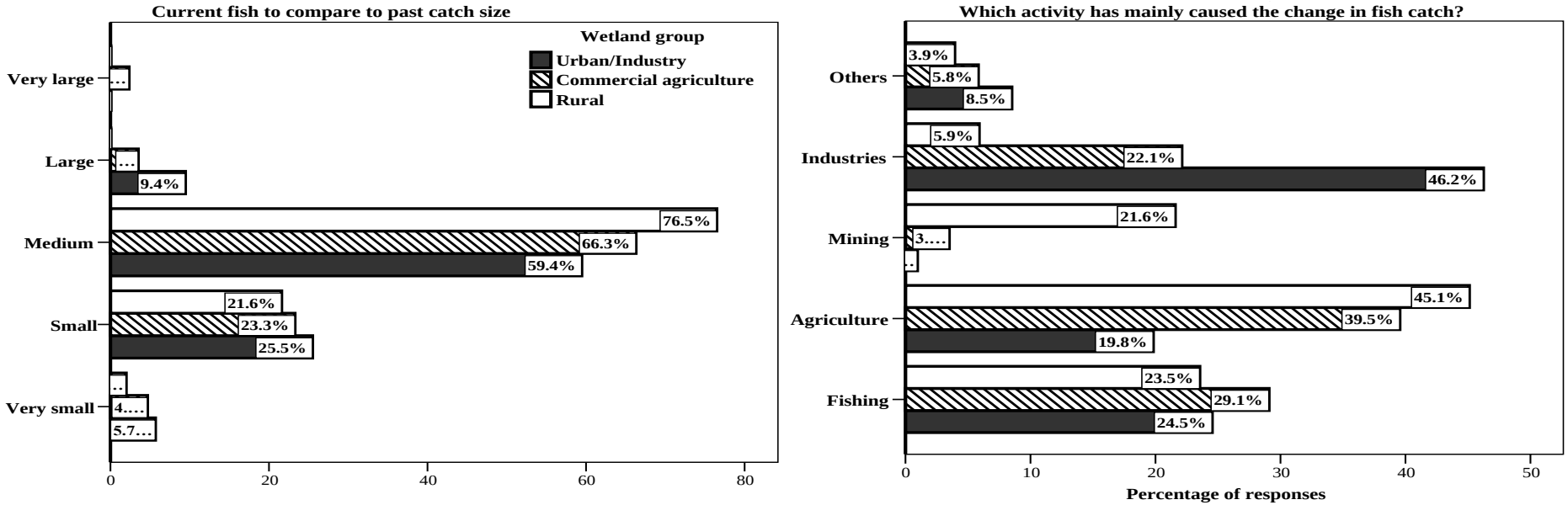

Figure 4. The community perception of the current fish sizes and what land use activity has mainly caused the changes in fish catch (N=115).
Source: Authors

of industrial activities. They also suggested that there should be proper disposal of wastes, monitoring of the extent of pollutants toxicity, relocation of polluting industries and commercial farmers dealing in floriculture from wetlands. Government should put more effort in sensitising wetlands dwellers on how to sustainably use the wetland.

DISCUSSION

This study focused mainly on examining the community perception of heavy metal pollution concerning the socio-economic characteristics of the wetland dwellers considering the spatial variation of the wetlands. It was realised that age group, educational background, occupation and the particular wetland where one lives were important determinants of one's response to whether a wetland was polluted or not. Pollution risk perception is a general belief derived from a variety of risk attitudes and conclusions determined by the characteristics of different citizen groups (Grasmuck and Scholz, 2005). Respondents in the 15 – 25 years age group and those with secondary education were more likely to say that a wetland was polluted based on what they observed in their surroundings. This compares with the research done in Kenya by Egondi et al. (2013) who realised that individuals who perceived higher levels of air pollution had at least a primary education level unlike those with no or less than a primary education level. Therefore, the knowledge attained in a particular level of education of respondents could have enabled them to spot the basic characteristics of a polluted area. According to Jurg et al. (2009), there is a general observation that educated people are more concerned about environmental pollution. Therefore, formal education could have increased their understanding of the characteristics of a polluted and non-polluted wetland and could even suggest the main source of pollution in their locality. The occupation was also a significant predictor that respondents with other occupations such as motorcyclists, traders, cleaners, teachers and others were likely to say

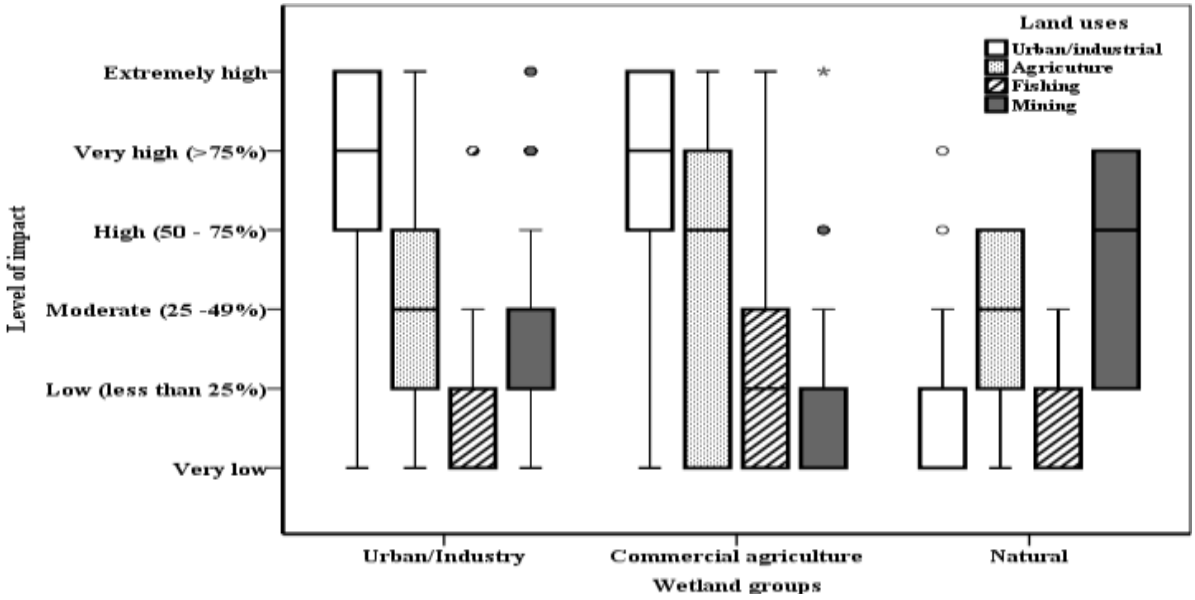

Figure 5. Wetland communities' perception of the impact of different land uses on the wetland (N = 313).
Source: Authors

that a wetland was polluted. It have been reported that the involvement in different kinds of occupation by respondents associated significantly with the varying perception of pollution (Egondi et al., 2013).

The exposure to better environments could have influenced the respondents with other occupations to say that the wetlands were polluted. The type of risk (voluntary or involuntary imposed risks, known or unknown risks); social dimensions and individual behavioral and personality attitudes towards the hazards are some of the factors that influence the community pollution risk perception (Lahr and Kooistra, 2010).

There were different responses about the sources of wetland pollution among individuals from different wetlands. For instance, those engaged in fishery-related activities reported that industry substantially impacted wetlands and this was attributed to their belief that their fishing activity had a less negative impact on the wetlands. According to Comby et al. (2014), the response gathered depended on the oral history (personal thoughts about the pollution causes and consequences) and life history (his whole life experiences). On the other hand, a high percentage of respondents agreed that industries were major polluters and that industries released their waste into the wetlands. This was attributed to their education level which ensured that they could characterize the effects of industrial activities on the environment. But many respondents also hinted on acquiring information from different media. Mass media such as newspapers, radio and TV are recognized as sources of information about pollution, influencing citizen perspectives (Cisneros and Schweizer, 2018).

More respondents from the natural wetland agreed to eating wetland fish than those from other wetlands. The determinant factors like availability and low prices of fish, the perception of fish as a healthy and nutritious food and limited protein alternatives, increase the consumption rate of fish (Ilibezova et al., 2013). Fish was readily available in the natural wetlands and respondent considered it good for consumption. Since large natural water resources are ecologically active that the pollution dilution capacity is high (Sarkar and Das, 2022). This background could have encouraged those with environment management awareness to consume the fish from natural wetland without reservations. People living in urban/industrial affected wetlands consumed less fish and this was attributed low acceptability of fish coming from the visibly polluted wetlands. In many developing economies, the pollution from industries and municipal uses result in various problems like poor waste disposal and cases of stagnating polluted waters in the environment (Zaidi and Pal, 2017). These sights directly discourage people in their right minds from eating fish coming from the nearby wetlands. There were differences in fish size consumed among the wetland groups. This was attributed to the variation in the fish prices, that any increased prices lead to low capita fish consumption (Ilibezova et al., 2013). Fish prices in urban areas were high which could have led to consumption of pieces of fish rather whole fish.

Environmental exposure to heavy metal pollution posed serious health threats to human well-being because these metals interfere with the basic metabolic processes leading to fatal diseases among humans (Bhargava et al., 2017).

Metal bioaccumulation by fish also affects the long-term

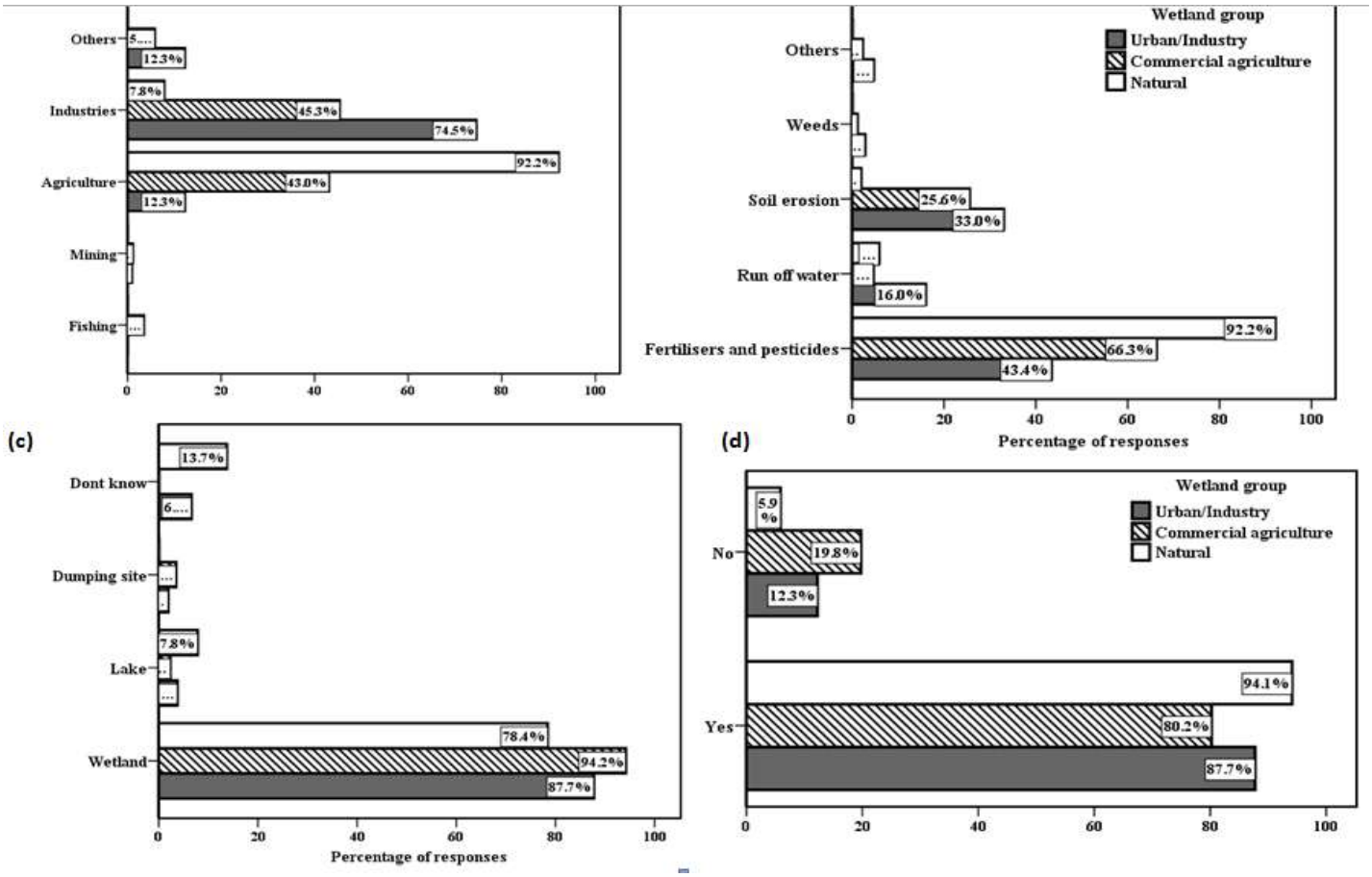

Figure 6. Awareness of Heavy metal pollution: (a) the dominant land use releasing heavy metals in the wetlands is. (b) commercial agricultural activities are affecting the wetlands through ... (c) industrial activities affect wetlands by releasing wastes in … and (d) do you think fish can get heavy metal contamination in these wetlands?
Source: Authors

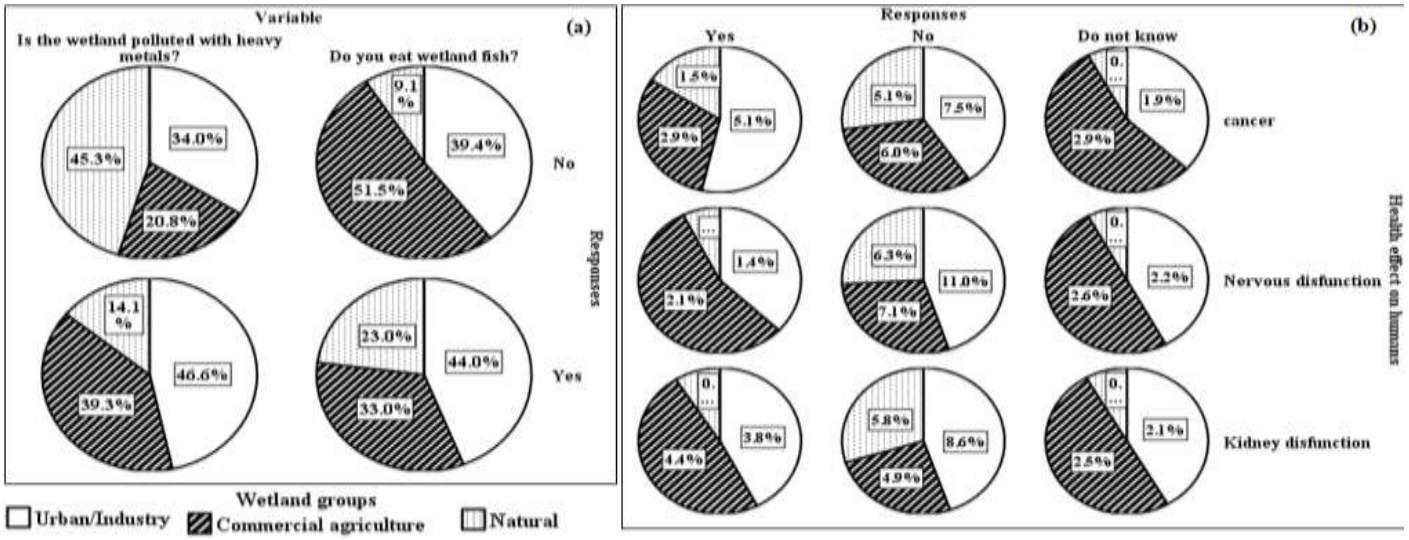

Figure 7. Community perception of whether wetlands are polluted with heavy metals (a) and the effects of eating contaminated fish over time to the human health (b) among responded from different wetlands groups.
Source: Authors

Table 3. Wetlands' heavy metal pollution sources and effects on the human and fish health perceptions (N=313).

Subject		% Response		
		Agree	Do not know	Disagree
Eating fish contaminated with heavy metals can affect people's health.		71	16	13
Land use activity mainly releasing heavy metals into the wetlands	Fishing	5	70	25
	Agriculture	45	45	10
	Mining	23	70	7
	Industries	68	31	1
	Other activities such as	5	86	9
Heavy metal pollution effect on human health	Damage to Kidney	27	15	58
	Damage to the nervous system	11	16	73
	Skin cancer	28	16	56
	Liver damage	39	14	47
	Cause cancer	26	15	59
	Affect baby growth during pregnancy	22	14	64
	Affect brain development in children	10	17	73
Do you think heavy metal pollution affects fish?		75	15	10
Heavy metal pollution effect on fish health	Change breeding habitat	62	28	10
	Body physiology	13	75	11
	Migrate to other areas	23	64	13
	Death	61	29	10
	Others, specify (reduced size and number of eggs)	4	83	16

Source: Authors

Table 4. Predictors on the perception of polluted wetlands and if urban/industrial activities highly impact wetlands.

Perception model	Predictors	B	*p*	Odds ratios
Wetland is polluted	Age	1.070	0.003	2.916
	Education	0.561	0.028	1.753
	Occupation	0.352	0.006	1.422
	Distance of homestead from wetland	0.506	0.096	1.658
	Sources of Income	-0.173	0.312	0.841
	Wetland location	-1.204	0.000	0.300
	Best fishing season for wetland fish	0.042	0.026	1.043
	Industrial disposal of waste knowledge	0.890	0.001	0.411
	Constant (intercept)	-2.624	0.006	0.073
Urban/industries were highly impacting wetlands	Age	0.293	0.475	1.340
	Education	0.022	0.930	1.022
	Occupation	0.321	0.041	1.005
	Wetland location	-0.722	0.000	0.486
	Distance of homestead	-0.772	0.077	0.462
	Sources of Income	-0.509	0.147	0.601
	Constant	1.119	0.012	3.712

Source: Authors

Table 5. Responses about potential management options to reduce heavy metal pollution in the wetlands (N=313).

Suggestions category	Emphasized suggestions
Implementation of environmental laws	Restrictions on industries and farming activities in the wetlands
	Ban the use of illegal fishing gear
	Gazette for wetland buffer zones
	Reduce corruption among law enforcers
	Strengthen punishments for wetlands management law violators
Strict monitoring of activities	Develop teams through responsible ministries to monitor activities of industries in terms of disposal of their wastes, the extent of waste toxicity, nature of the water quality and wetlands' fishery, and emerging land use within the wetlands
Improve waste management	Create garbage sites away from wetlands for industrial and other human activity waste
	Reclaim the wetland cover and detoxify wetland areas
	Construct latrines for the wetland dwellers
	Ensure that industries have proper waste management
Land use management	Relocate industries and commercial farming activities from wetlands
	Gazette-specific areas for industries away from wetlands
	Stop licensing industrial activities in the wetlands
Sensitization	Sensitize wetlands dwellers on how to sustainably use the wetland
	Increase awareness and empower fishermen to use better fishing methods
	Wetlands people reduce the consumption of food or fish coming from contaminated areas.

Source: Authors

fish physiology leading to early death and a reduction in their reproduction capacity (Bawuro et al., 2018). In this study, it has been found that individuals were aware of the negative effects of pollutants on the wetlands; given the high percentage response that heavy metal contamination can affect human well-being. However, a few could relate heavy metal contamination to specific health issues in humans and fish.

According to Grasmuck and Scholz (2005), individual pollution risk perception and acceptance are greatly determined by the person's exposure (or not) to the local pollution hazard source. Many respondents could have had insufficient knowledge of the heavy metal potential risk to human well-being from personal experience or any other sources. Of those who were able to suggest specific health issues, not even one of them scored a higher percentage response than others. Such inconsistencies demonstrated that rather than actual knowledge, it is self-estimated knowledge from which they decided the effect of metal pollution on human well-being. Actually, because of problem-damping and problem-amplifying with time and space, different local communities have varying discourses of the same pollution (Comby et al., 2014). The low knowledge of the effects of heavy metal contamination on people's and fish health among the community members was attributed to limited risk communication to the wetland dwellers. The wetlands communities' responses about the specific risk were limited to the distorted information that reached them from the different sources. Moore (2016), states that what complicates environmental pollution risk communication is the quality of the information passed on to the public media due to exaggeration for a dramatic effect. Therefore, national-level strategies should be developed for environmental risk communication and should be based on appropriate risk communication principles that ensure the sources and effects of heavy metal risk contaminants on biodiversity and human health are effectively communicated (Ramírez et al., 2019).

Pollution risk perception depends on risk communication which is also based involvement of community members and policymakers (Lahr and Kooistra, 2010). Local community leaders and other players many times fail to convey the risks and any other important information with an adequate approach (Grasmuck and Scholz, 2005). This impairs the understanding of risks and larger acquiescence of management options mutually agreed upon. With a good foundation, the involvement of the local communities in the development of capacity for the management steers the ultimate sustainable exploitation of natural resources (Utsala, 2013). The sustainable well-being of L. Victoria wetland dwellers with respect to heavy pollution depends on the establishment of a good pollution risk communication policy before specific pollution preventions are developed. While communicating the risks,

appropriate communication skills are important and the disseminator should be perceived as a trustworthy and responsible person (Lahr and Kooistra, 2010).

In addition, to other means, media plays a fundamental role in the information exchange between the public, science and policy, inspiring prompt adoption of pollution guidelines at the local, regional or national level.

Different countries have utilized a variety of means at policy and public levels to prevent and treat metal harmfulness arising from environmental influences, accidents and occupational exposure (Bhargava et al., 2017). For instance, banning the use of certain pesticides and agrochemicals, and developing more effective wastewater treatment means that reduce the metal pollution content in the wetlands (Ustaoğlu et al., 2020). There is a need to have wetland fish consumption advisory based on a comprehensive information base ranging from what fish eat and fish species' exposure to heavy metal pollution. For instance, to control fish mercury pollution and reduce human mercury exposure due to contaminated fish consumption, a complete set of information about mercury pollution in different fish species and health risks associated with fish consumption was made available to enable the public to make responsible decisions needed (Boischio and Henshel, 2000). The use of appropriate communication measures ensure that all community members are reached using expert knowledge in a layman's understanding to guard against misunderstanding (Lahr and Kooistra, 2010).

Based on the clear relationship between education and risk perception, there is also a need to enhance the curriculum at different levels of education in the country concepts. Community education programmes to increase awareness of sources of heavy metal pollution and their related risks can also alleviate low-risk communication. A comprehensive heavy metal mitigation plan should be developed that takes into consideration the local communities' perceptions of the environmental pollution risk problem and devises actions that promote sustainable use of wetlands. There should be a Wetlands Resources Advisory to operate risk communication programmes among the exposed population due to the consumption of contaminated fish from the wetlands.

Conclusion

The major determinants of community perception of heavy metal pollution risk were age group, education background and livelihood activities which were attributed to the impact of these parameters and their influence on people's concern with environmental problems. Education was a significant predictor of community perception and this emphasized the need to enhance the curriculum with environmental pollution and risk perception concepts at the different education levels, including community environmental communication programmes to increase awareness of heavy metal pollution problems and their related risks. The limited knowledge of any specific implications of heavy metal on human and fish health was an indicator of low pollution risk communication among wetland dwellers. Therefore, as monitoring of pollutants for control continues, there is a need to develop strategies for national environmental policy on pollution risk communication using appropriate and effective communication means about heavy metal pollution in the wetlands.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

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