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Microbiological Safety of Small Pelagic Fishery: Case of L. Albert, Uganda

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Abstract

Microbiological data was generated as a pre-requisite for development of a quality management system for small pelagic fisheries on L. Albert. Representative landing sites known for small pelagic fishery on L. Albert namely Butiaba, Walukuba and Bugoigo were assessed for water quality and overall hygiene using microbiological indicators. Contact surfaces were swabbed and they included; fishing boat, small pelagic fish (skin), fisher hands, fishing net. The Heterotrophic Plate Counts (HPC) indicated that the offshore water quality was significantly higher than inshore water ($\rho<0.05$) notwithstanding the relatively high counts; $1.36x10^4$ to $2.0x10^5$ CFU/mL. E. coli count was highest in the inshore water of Walukuba at $>1.1x10^5$ and lowest in offshore water (Bugoigo) at $1.0x10^2$ MPN/100mL. Vibrio spp. showed seasonality as it was absent in water samples analysed in June while it was detected in October for all landing sites. Presumptive biochemical characterization indicates that the dominant species are V. cholerae and V. parahaemolyticus. Total Plate Counts (TPC) were high especially from the fishing boats ($2.76x10^5$ CFU/10cm^2) and nets ($6.35x10^6$ CFU/10cm^2). Fishers' hands (Bugoigo), when washed had relatively lower counts ($3.18x10^2$ CFU/10cm^2) compared to unwashed ($6.2x10^4$ CFU/10cm^2) however, washing was not the usual practice. The highest count on small pelagic fish was $1.96x10^5$ while the lowest was $1.4x10^3$ CFU/10cm^2. Generally, the microbiological quality of the lake water was poor and varied with season and distance from the shore. Hygiene and sanitation of fishers, small pelagic fish and fish handling surfaces of the selected landing sites was unsatisfactory.

Keywords: Sanitation, hygiene, water, fish, quality.

Introduction

Uganda is gifted by nature and endowed with significant fisheries resources. The potential for both capture fisheries and aquaculture production is great considering that about 20% of Uganda's surface area is covered by water. The five major water bodies include; lakes Victoria, Kyoga, Albert, Edward and George. There are over 300 fish species; consisting of Haplochromines (90%) and large pelagic fishes. Specific species that are exploited for domestic or export markets include; *Lates niloticus* (Nile perch), *Oreochromis niloticus* (Nile tilapia), the cat fishes *Bagrus* and *Clarias*, while the small pelagic fishes "sardine-like" include; *Rastrineobola argentea* (Mukene), *Neobola bredoi* (Muziri) and *Brycinus nurse* (Ragoogi). Virtually, all the fish species are caught by artisanal methods and landed at 1,200 reception centres or landing sites scattered along the shores of various water bodies. The fisheries sub sector contributes 2.5 % to national GDP in form of incomes, employment and food security to about 3 million Ugandans. Lake Albert is located in the western arm of the African Great Rift Valley and supports the most diverse commercial fisheries in Uganda with at least 55 species that vary markedly in size[1].

Small pelagic fisheries have been growing in importance as a source of animal protein for both human and animal feed production, incomes and employment. Currently, this sub-sector contributes 45.6% of the total fish production in Uganda[2]. L. Albert is the second most productive lake in Uganda with annual catches estimated at 151,600MT. Small pelagic fish species; Muziri and Ragoogi constitute 80% of the annual catch on L. Albert valued at USD 32.34Million[3]. As such, small pelagic fisheries are crucial for rural and national development. The lake is a direct source of livelihood for an estimated 8800 fishers residing at some of the major landing sites that include Bugoigo, Ntoroko, Butiaba, and Wanseko[4]. Small pelagic fishes are traded domestically as well as regionally[2]. The growing export market for small pelagic fish has reinforced the need for compliance to international quality and safety standards which is a pre-requisite requirement in a highly competitive market.

However, the trade in these small pelagic fishes is faced with drawbacks that may be categorized into social and technical attributes. Over the years, there has been an influx of immigrants from Kigezi and West Nile regions of Uganda and also from the neighbouring countries of Democratic Republic of Congo (DR-Congo) and South Sudan. This influx has led to overcrowding at most landing sites along the L. Albert shoreline. Consequently, sanitation and hygiene has proven to be a major challenge at these fish landing sites. For example, it was reported that one pit latrine served approximately 1500 people at Wanseko landing site[5]. Considering that the fishing community on L. Albert is also engaged in a number of other activities such as primary fish processing and livestock rearing, the sanitary status is found wanting. This is because all these human activities contribute to pollution of the lake and its environment as a result of poor waste disposal, sewage effluents and agricultural discharges. The overall effect of this anthropogenic mismanagement of waste is the deterioration of water quality and susceptibility to water-borne diseases[6]. The quality of water from L. Albert has been monitored regularly since 1994, albeit with sporadic reporting[7].

It is therefore important to assess the water quality and hygiene around the landing sites as a pre-requisite for subsequent interventions. A number of indicators are used to determine the microbiological quality of lake waters. The main human pathogens responsible for water contamination are *Salmonella* spp, *Camphylobacter* spp, *Staphylococcus aureus, Pseudomonas aeruginosa, Clostridium botulinum, Vibrio cholerae* and *Escherichia coli*[8]. However, some of the commonly used pollution indicators are; *Escherichia coli*, Faecal *Streptococci*, Sulphite-reducing Clostridia and Bacteriophages[9]. This study sought to use microbiological indicators to assess the safety risk posed to the small pelagic fisheries at selected major landing sites of L. Albert namely; Butiaba, Walukuba and Bugoigo.

Material and Methods

Study Area: The research was carried out at three major landing sites on Lake Albert where large quantities of small pelagic fish catches were landed on a daily basis, These included; Butiaba, Walukuba and Bugoigo. The microbiological quality of water and degree of hygiene of the fishers, fishing boats, fishing nets were determined during the study period from September 2012 to June 2014.

Sample Collection: Water sampling was done using a modified method[10]. Briefly, four duplicate samples were obtained from each of the selected landing sites. Approximately 400 mL of water was obtained at two spots, 50 M apart both inshore and offshore at each of the selected landing sites. Swabs were obtained in duplicate from freshly landed fish (Ragoogi and Muziri), the fishing boats, fishers' hands and fishing nets. All samples were subjected to temporary storage in a portable freezer (WAECO, CoolFreeze CF-50) at -2°C before transfer to the laboratory refrigerator (Toshiba GR-E161) at 4^0C.

Microbiological Analysis: Water samples were subjected to Total Coliforms (TC), *E. coli*, Vibrio spp and HPC analysis. Swabs were analysed for Total Plate Counts (TPC), Total Coliforms (TC), and *E. coli*. HPC analysis was done using a method quoted in ISO 6222 where water samples were cultured on Yeast Extract Agar by the pour plate technique and incubated at 36°C for 48 h[11]. Vibrio spp. analysis was done in steps involving enrichment, that is, incubation in Alkaline Peptone Water (35°C for 8 h) preceding incubation of streaked TCBS agar plates at 35°C for 24 h[12]. All other analyses were done using standard methods derived from ICMSF[13].

Statistical Analysis: The Log_{10} values of Heterotrophic Plate Counts were subjected to one-way ANOVA ($\rho<0.05$) using the Statistical Analysis System Software (Version 8.1, 2000).

Results and Discussion

Water Quality: The results as shown in figure-1 indicate that water quality was generally poor as shown by the high Heterotrophic Plate Counts.

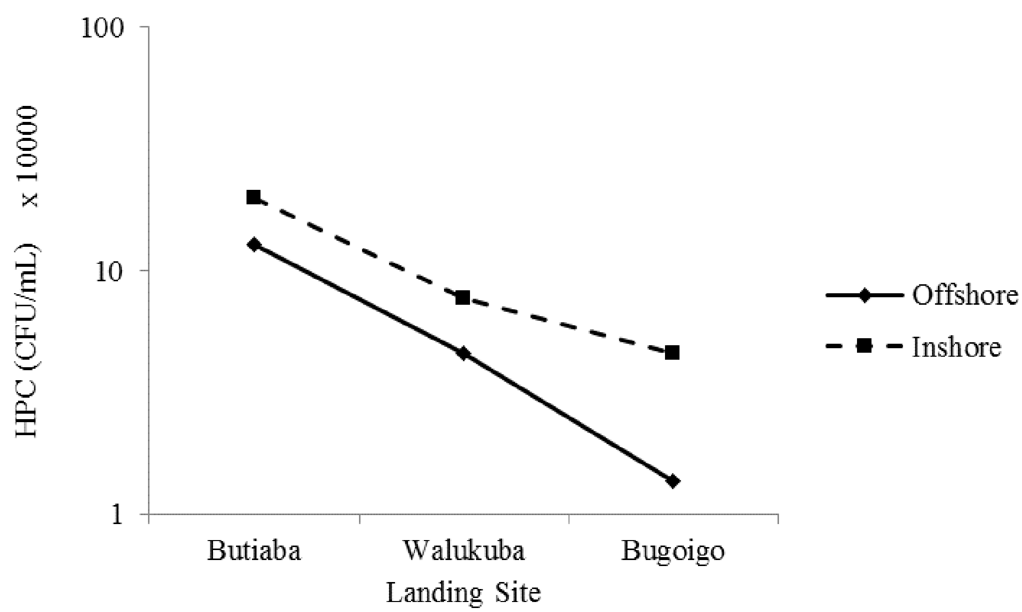

Figure-1
Heterotrophic Plate Count of water from three landing sites on L. Albert

HPCs for offshore water; $1.28x10^5$, $4.59x10^4$ and $1.36x10^4$ were lower than inshore water; $2.0x10^5$, $7.68x10^4$ and $4.59x10^4$ CFU/mL for Butiaba, Walukuba and Bugoigo respectively and, the difference was significant (ρ<0.05). Total Coliforms and *E. coli* counts were high (table-1). This was a pointer to faecal contamination of water from the three landing sites sampled.

Table-1
Total Coliform and E. coli Analysis of Water Samples

Sample Description	Landing Site	Parameter	
		TC (MPN/100ml)	E. coli (MPN/100ml)
Offshore water	Butiaba	$>1.1x10^5$	$4.0x10^3$
	Walukuba	$>1.1x10^5$	$2.0x10^4$
	Bugoigo	$7.0x10^3$	$1.0x10^2$
Inshore water	Butiaba	$>1.1x10^5$	$2.0x10^4$
	Walukuba	$>1.1x10^5$	$>1.1x10^5$
	Bugoigo	$1.5x10^4$	$2.3x10^3$

Vibrio spp. is an important pathogen for assessment of water quality. Qualitative Vibrio analysis results are shown in table-2 and figure-2.

Table-2
Vibrio spp. Analysis of Water Samples

Sample Description	Landing Site	Vibrio spp.(/25ml)	
		June	October
Offshore water	Butiaba	-	+
	Walukuba	-	+
	Bugoigo	-	-
Inshore water	Butiaba	-	+
	Walukuba	-	+
	Bugoigo	-	+

Water samples were all negative for Vibrio spp. in June representing the dry season and all but one (Bugoigo, offshore water) positive in October representing the rainy season.

Landing Site Hygiene: Assessment of swabs of various contact surfaces is represented in table-3. Generally, Total Plate and Total Coliform Counts were high.

Discussion: Water Quality: The inshore water showed greater contamination than off shore water. This trend could be associated with the level of contamination attributed to human and animal activity. Poor sanitation and waste disposal onshore compared to offshore result into the observed relatively high concentration of microbial contaminants. Furthermore, overall water quality for the three landing sites, in descending order was Bugoigo, Walukuba and Butiaba (figure-1). Higher water contamination could be attributed to the growing human population and increasing lakeside activities in the respective landing sites of Butiaba, Walukuba and Bugoigo. This region has a high population growth rate of up to 5.2% per annum[14]. The high growth rate is exacerbated by government resettlement schemes that allow people from densely populated and natural disaster prone areas such as Bududa as well as influx of immigrants from Democratic Republic of Congo to less populated or low risk areas.

Quality guidelines for fresh and marine waters state that the median limit for secondary contact (any use of the water) is 10^3 faecal coliform organisms per 100 mL[15]. A previous report by Wagga Wagga City Council showed that faecal coliform level of Lake Albert water was generally below 100 faecal coliforms per 100 mL. However, the sampling points were not indicated. In that study it was also noted that there was seasonality in faecal coliform level of the lake. During the rainy season contamination of lake water is brought about by surface run-off while in the dry season it is by livestock[7]. The faecal coliform (*E. coli*) levels obtained in this study were high and in some instances just fell short of raw sewage, pegged at 10^6-10^7 per 100mL[16].

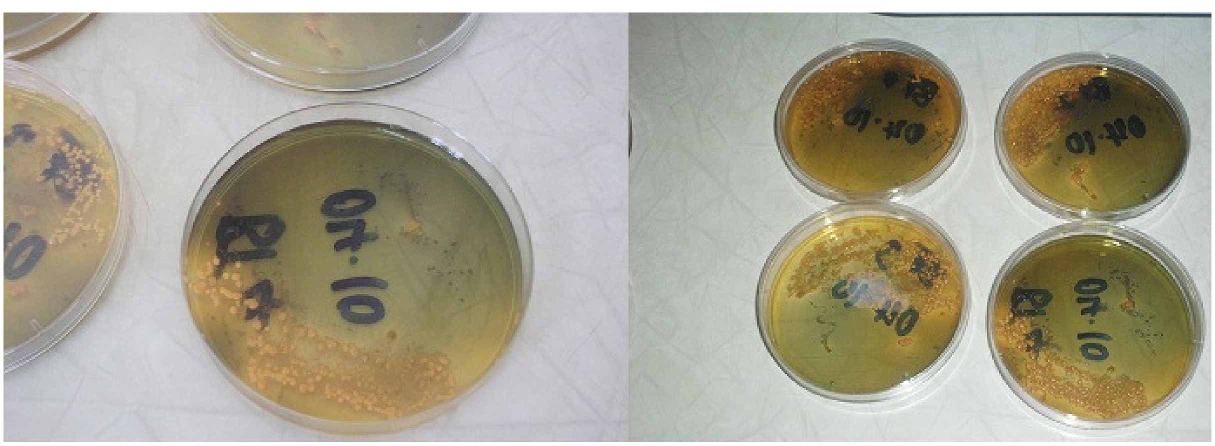

Figure-2
Streaked TCBS Agar plates showing yellow colonies of presumptive V. cholerae in water samples from Butiaba

Table-3
Microbiological Analysis of Swabs

Landing Site	Swab Type	Parameter		
		TPC (CFU/10cm^2)	TC (MPN/10cm^2)	E. coli (MPN/10cm^2)
Butiaba	Fishing Boat	2.76×10^5	500	500
	Fish	7.6×10^4	1100	200
	Fisher Hands (unwashed)	1.5×10^4	210	70
	Fisher Hands (washed)	3.2×10^3	23	7
	Fish Net	1.6×10^6	>1100	>1100
Walukuba	Fishing Boat	2.5×10^5	>1100	>1100
	Fish	1.96×10^5	1100	1100
	Fisher Hands (unwashed)	1.0×10^5	>1100	>1100
	Fisher Hands (washed)	4.7×10^3	40	15
	Fish Net	2.0×10^6	1100	1100
Bugoigo	Fishing Boat	1.44×10^5	1100	1100
	Fish	1.4×10^3	23	11
	Fisher Hands (unwashed)	6.2×10^4	70	40
	Fisher Hands (washed)	3.18×10^2	15	Nil
	Fish Net	6.35×10^6	>1100	500

Analysis of Vibrio spp. showed that there was seasonal distribution of the pathogen (table-2). Water samples evaluated in June tested negative for Vibrio spp. while those in October were positive (figure-2). Furthermore, the distribution of Vibrio spp. varied from one landing site to another. Preliminary biochemical characterization of Vibrio spp. cultured on TCBS Agar plates was indicative of presumptive *V. cholerae* in water samples from Butiaba while *V. parahaemolyticus* was predominant in those from Bugoigo and Walukuba. Outbreaks of cholera have been previously reported on Lake Albert landing sites such as Butiaba[6]. Butiaba is more populous with more lakeside activities compared to Walukuba and Bugoigo and this probably contributed to greater contamination of its waters. Lakeside activities directly contributed to pollution of the lake. The majority of pollutants are in organic form or sediment. Some of the pollutants typically included; bird and animal faeces, sediment and particulate matter, pathogens from unauthorised sewer connections, storm water and general litter. Ultimately, this means that water quality remains poor as reported by Wagga Wagga City Council[7].

Landing Site Hygiene: The swabs obtained from various surfaces showed high counts of hygiene indicator microorganisms for all landing sites thus signalling that they were heavily contaminated. There is still a lack of proper primary processing surfaces as most of the catch is handled on bare ground (soil/mud) or on unclean fish nets. Contact surfaces are the primary sources of cross contamination for both pathogens and spoilage microorganisms[17]. Such conditions hasten fish spoilage and predispose consumers to food borne illnesses. Some fishers in Bugoigo had previously received basic training in hygienic handling practices and as such the microbial counts were relatively lower than those of Walukuba and Butiaba landing sites. Washing of hands resulted in an exponential reduction in the observed Total Plate Counts. This shows that with proper sensitisation and targeted interventions, the level of hygiene and sanitation of the landing sites can be improved. There is need for a concerted effort to improve landing site handling and primary health care facilities backed by implementation of the tenets of personal hygiene and environmental sanitation among the fisher populace. Landing sites are the first stop in the fish processing and distribution chain therefore quality assurance programs should target them to ensure that products reaching the secondary processor and final consumer are of acceptable quality as per national and international standards.

Conclusion

Overall water quality for the three landing sites was poor and heavy contamination with faecal coliforms points to pollution associated with inadequate sanitary facilities and human activities such as livestock rearing. *Vibrio* spp. prevalence in the lake waters is seasonal and thus it is important to institute a continuous or sustained water quality monitoring program to better understand the variation in the lake's microflora over time. General landing site hygiene and sanitation was found wanting. It is therefore critical that the fishers and handlers are regularly trained in good hygienic practices and the necessary infrastructural support such as construction of proper sanitary facilities provided.

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