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Impact of Human Activities on the Quality of Water in Nyaruzinga Wetland of Bushenyi District - Uganda

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Abstract

The study presents an investigation into the effect of various human activities on the degradation and lowering of water quality in Nyaruzinga wetland which is located in Bushenyi district, South Western Uganda. Water samples were drawn from six different places (one town supply, one water reservoir) and four contaminated sources near the wetland. The results were compared to both national and WHO guidelines. The different parameters assessed included apparent colour (AC), total suspended solids (TSS), turbidity (Tur), total dissolved solids (TDS), electrical conductivity (EC), total hardness (TH), pH and microbial activity using E. coli as a standard test. Experimental methods were composed of complexometric titration, turbidimetry, pH direct meter reading, spectrophotometry and standard plate count, using membrane filter technique. Results obtained revealed that most of the parameters investigated were outside the range recommended by both national standard and World Health Organization (WHO) guidelines. Such results were mainly attributed to fish farming and sewage discharge from the surrounding institutions.

Key words: Nyaruzinga wetland, water quality, pollution, human activities

Introduction

Wetlands in Uganda are estimated to cover approximately 13% of Uganda's total area and they include seasonally flooded grasslands, swamp forests; permanently flooded papyrus and grass swamps as well as upland bogs[1,2]. Wetlands elsewhere in the world are regarded as one of the several natural resources. There are numerous important features of wetlands to note as a resource, such as their ability to treat polluted water by absorbing excess nutrients and able to settle sediments, microphytes removal of phosphorus, control of floods, flow regulation, drought alleviation, water quality protection, water purification, to mention but a few[3-7]. Wetlands can also be used to generate income through ecotourism industry which accounts for the highest national incomes of many countries including a number of developing countries[8-10]. The issue of wetland degradation in Uganda has mainly been attributed to the rapid population growth, increased rate of development like construction of houses that require sufficient and steady amount of water supply and the discharge of effluent from surrounding industries, institutions, and other human activities such as farming. With unacceptable levels of pollutants from these human activities, such important features of wetlands become severely ruined. Management practices of wetlands should consequently consider aspects of the effect of human activities on the water quality and the total value of the wetland. In reality, water quality aspects are determined by waste water with high concentration of nutrients, harmful bacteria such as coliforms and vibriocholera associated with human and animal excreta, worm eggs and shell fish[11, 12]. These contaminants are primarily influenced by anthropological impacts. It is always suggested and indeed a requirement that faecal coli forms (FC) must be absent in any 100 ml sample of water[13,14]. Although the World Health Organization has provided guidelines for drinking water quality, water pollution in various water sources has been increasing over recent decades in most countries[15-18]. Some of the other factors that may be impacting on the flora and fauna of wetlands include among others salinity, turbidity, nutrients, dissolved oxygen, pesticides, acidity and chemicals[1].

Nyaruzinga wetland is situated in Bushenyi district, one of the local administrative units located in South Western Uganda. Bushenyi district has a total area of 4,287skm of which 3,668 skm is dry land and 369 skm is open water. The district has a total of 250 skm of wetlands, constituting 5.8% of the district area. Only 52.8% of the wetlands are permanently wet while 47.2% are seasonally wet. 13% of the wetlands have been converted to subsistence farmland, and 14% into improved pasture. Papyrus and other sedges constitute 40%[19]. The district has three drainage systems; L. Edward/L. George and L. Victoria systems. The Nyaruzinga wetland lies in L. Edward/L. George drainage system and occupies a narrow valley (16.64 hectares or 0.17sq.km) surrounded by steep hills of Kacuncu, Kyeitembe and Kitakuka villages[19]. The Nyaruzinga wetland is situated between latitudes 00°42'South and longitude 30°17' east of the equator. The wetland lies within the wet-semi equatorial region and as such, it experiences a double maximal rainfall pattern with average monthly relative humidity ranging between 68% and 84% during the two rainy seasons. Mean monthly temperature values as high as 30^{o}C are often recorded between the month of June and August though it declines to 20^o C in November and April. Between the months of June and September, the Nyaruzinga wetland is affected by tropical continental air mass making the area warm and dry.

Nyaruzinga wetland which was our study area is the only source of water that supplies the neighbouring towns (Bushenyi and Ishaka). Nyaruzinga wetland has three major tributaries of Kyeitembe, Bweranyangi and Kikuba streams. Tributary streams increase wetland fertility by depositing nutrient rich loads of sediments. The wetland is mainly dominated by *Cyperus papyrus* that is used for fencing, making crafts, thatching and mulching by the local communities. Wild Animals that inhabit the place include among others; mud fish, monkeys, birds and snakes. There has been a considerable variation in the water quality due to encroachment on the Nyaruzinga wetland by the local communities. The most considered water pollutants contributed by these human activities include aquatic organisms which require carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur and other elements for survival. Secondly, due to increased human population surrounding these wetlands, it is suspected that there is an increment in the human excreta and other pollutants that cause water quality degradation.

In pursuant of the above concerns, the study was instituted to investigate the influence of human activities on the quality levels of the water in Nyaruzinga wetland by quantifying the numbers of *E. coli* in water samples in conjunction with the various quantities of physio-chemical aspects in streams, wells and piped water.

Material and Methods

Water samples for laboratory analysis were collected in 500 ml plastic bottles previously disinfected, rinsed with distilled water and dried. The *E. coli* counts and physico-chemical parameters were determined after every two weeks, for six months. The chemical ionic species were analyzed in the second week of every month, for six months. Six sampling sites were chosen by simple random sampling, targeting degraded areas around Nyaruzinga wetland. The samples were kept in a refrigerator at 4 ^{o}C. The sample source and sampling locations are shown in table-1.

Microbial analysis tests: Six petri dishes were labeled A, B, C, D, E, and F according to the water sample sites mentioned earlier. In each petri dish, a water sample (10 ml) was measured using a 100 ml measuring cylinder and filtered through a 47 mm, 0.45 µm pore size membrane filter. The filter funnel was rinsed with hot water and left to cool in sterilized aluminium plate. Using sterile forceps, the membrane filter(s) were transferred to the petri dishes containing a pad saturated with membrane laural sulphate broth medium (2 ml), incubated for 18 hours, and after checked for colon forming units (CFU). Yellow colonies were observed with unaided eye in the normal room day light and counted.

Measurement of physico-chemical parameters: The conductivity (EC) in µS/cm was recorded using a conductivity meter model 470, England. TDS was measured (value in ppm) by selecting the TDS key while the electrode remained in the water sample used to measure conductivity. Total suspended solids (TSS) were determined using a 47 µm fibre filter papers of known weight, and water samples filtered through the filter paper measured and the weight of solids was recorded as the weight difference. A pH meter (model 370), England was calibrated using buffer solutions of pH 4 and 7, and the pH values were recorded for each sample after every 30 minutes. Turbidity was measured using a Hatch 2100 N turbid meter and readings recorded in nephelometric turbidity units (NTU). Total hardness (TH) was investigated using complexometric methods, whereby borax buffer solution plus Eriochrome Black T (3 drops) indicator solution were titrated with EDTA for the given samples. Apparent colour (AC) recorded in concentration (ppm) of chemical ionic species was evaluated using atomic absorption spectrophotometry (AAS) using HARCH DR/2000, version 3.1, and the wavelengths were adjusted to 455 nm. Total alkalinity was determined by mixing measured samples (50 ml) with an indicator and then titrated with 0.02 N hydrochloric acid. The average volume of the acid was recorded in table- 2 below.

Results and Discussion

There were considerable variations in the physico-chemical and microbiological parameters for samples from the different sites. The physico-chemical parameters and their values are represented in table 2. The microbiological parameters at sites and their variation with time are indicated in figures-9 and 8 respectively. Figures-3, 4, 5, 6, 7 and 8 represent physico-chemical parameters such as TSS (ppm), AC (Pt/Co), turbidity (NTU), pH, total alkalinity (ppm), conductivity and TDS respectively.

Table-1
Sampling locations in Nyaruzinga wetland

Sample No.	Source	Sampling location
A	Near sewage discharge grounds	Valley College
B	Near Fish ponds	Nyabubare village – Bumbeire sub-county
C	Near Dip tank	Bushenyi Farm Institute
D	Near raw water reservoir	Bushenyi town
E	Near car washing bay	Bushenyi town
F	Treated tap water	Town water supply

Table-2
Average results of the physico-chemical variations of the different sites in Nyaruzinga wetland

Parameters	A	B	C	D	E	F	International Standards for raw water	International Standards for potable water
TSS(ppm)	52.5	37.52	32.63	24.62	29.37	9.81	100	0
TDS(ppm)	545.63	92.17	40.98	57.81	54.77	148.52	3500	500
Tur (NTU)	236.17	295.33	165.17	191.17	211.33	123.67	300	5
AC (Pt/Co)	986.50	626.50	236.83	385.33	415.33	109.00	1000	300
EC (µS/cm)	614.04	53.98	53.32	35.75	42.35	176.17	1500	15
pH	7.27	6.54	5.67	5.68	5.74	6.03	6 – 8	6.5 – 8.5
TH (ppm)	43.61	16.21	0.08	33.84	27.90	20.41	1500	500
TA (ppm)	90.86	87.52	64.78	71.45	73.88	83.73	-	-

Figure-1
Sampling and sampling sites: Map Uganda showing location of Nyaruzinga wetland

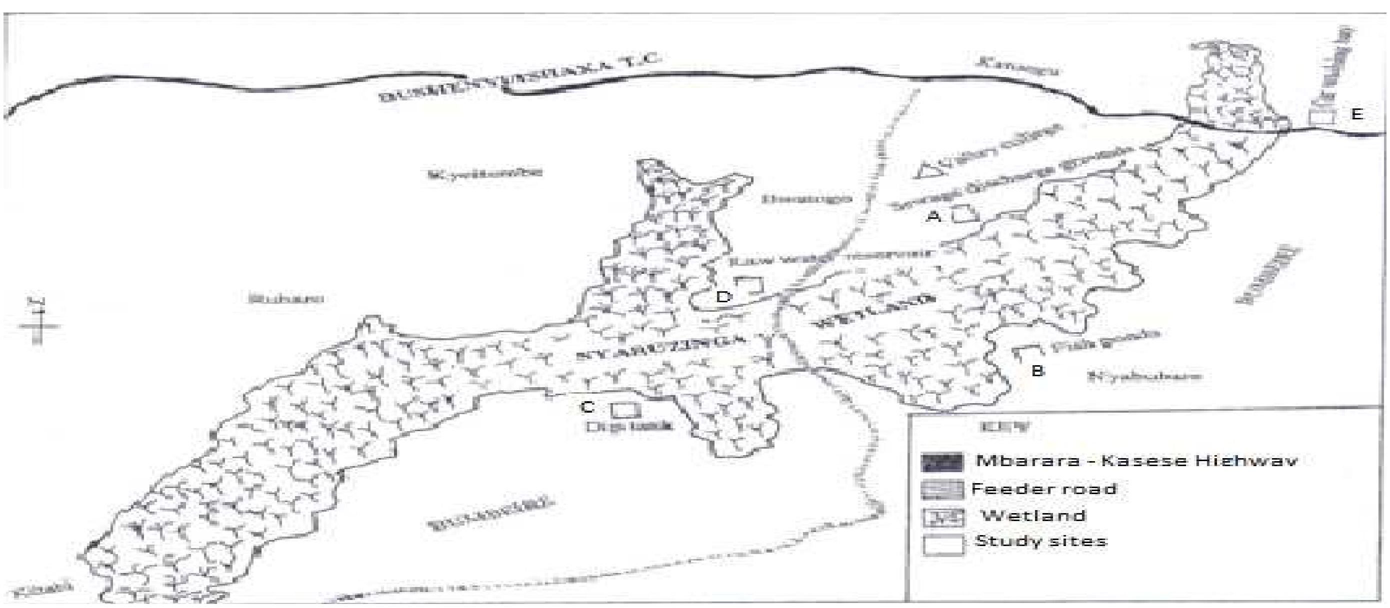

Figure-2
Map showing study sites around Nyaruzinga wetland

Total suspended solids: The TSS indicates solid materials both organic and inorganic matter that lower water quality. Suspended solids can result from erosion from urban runoff and agricultural land, industrial wastes, bank erosion, bottom feeders (such as carp), algae growth or wastewater discharges. Table-2 and figure-3 show that the average TSS values at different locations were higher than the values recommended by both national and international standard guidelines. High TSS values were probably due to poor filtration methods for tap water.

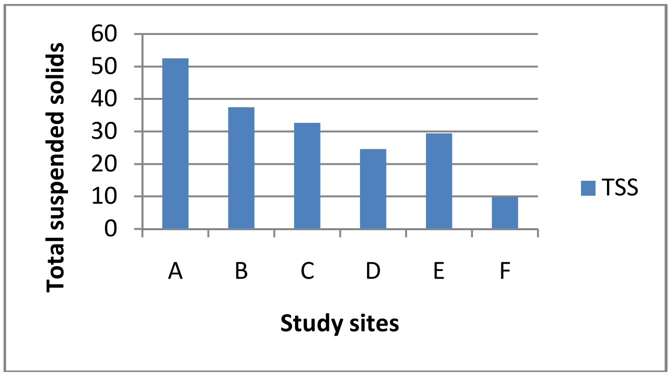

Figure-3
Variation of TSS (ppm) at different sites

Apparent colour (AC): Apparent colour describes the colour of the whole water sample, and consists of colour from both dissolved and suspended components. Except for raw water sample from station C, the average values of AC for raw water samples from other stations were higher than the recommended international standards of 300 Pt/Co, the highest average value (986.50 Pt/Co) being experienced at station A. The average value (109.00 Pt/Co) for potable water was lower than that recommended by international standards of 15 Pt/Co. From table-2 and figure-4, levels of pollution in Nyaruzinga wetland were due suspended and dissolved matter, presence of organic and inorganic colloids in water, food materials added into fish ponds, humus materials, algae, weeds, protozoa and dirty water from car washing bays.

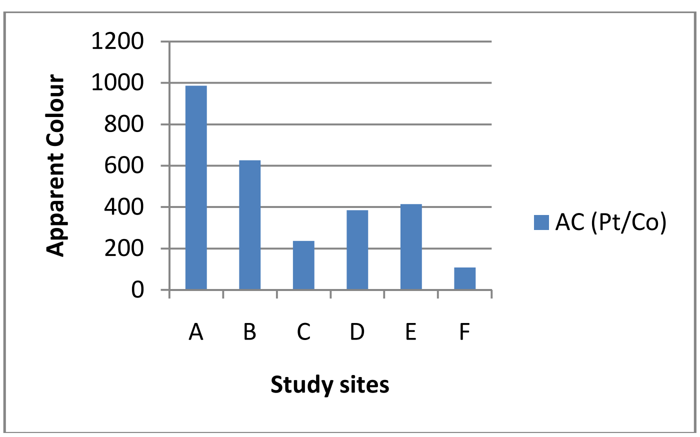

Figure-4
variation of apparent colour at different study sites

Turbidity: Turbidity is a decrease in the transparency of a solution due to the presence of suspended and some dissolved substances, which cause incident light to be scattered, reflected, and attenuated rather than transmitted in straight lines. The higher the intensity of the scattered or attenuated light, the higher will be the value of turbidity. The concentration of free-living nematodes in the raw water source generally increases the turbidity of the water. The higher the turbidity, the larger the concentration of free-living nematodes there will be. The average value (123 NTU) for potable water was about 25 times higher than what is recommended by international standards (5 NTU)[13,14]. Table-2 and figure-5 indicate that although raw water samples showed values within the recommended range, the highest average value (293.55 NTU) was recorded near the fish ponds in the wetland.

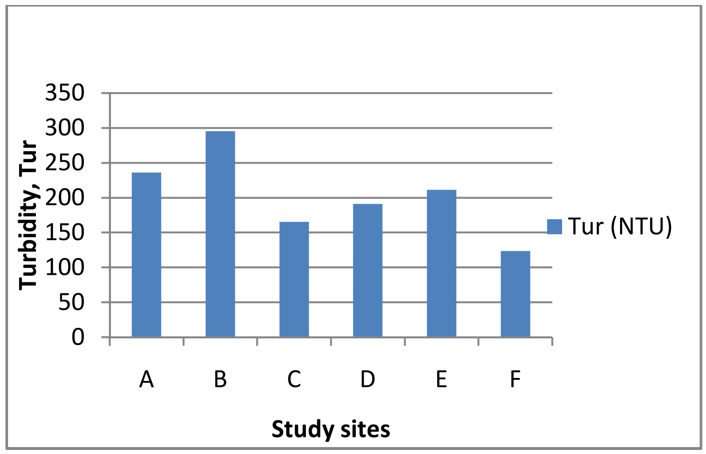

Figure-5
Variation of turbidity (NTU) at different study sites

pH: pH of water indicates the extent for alkalinity and acidity. From table-2 and figure-6, low average values observed (stations C, D and E), are mainly attributed to presence of bicarbonates, free carbon dioxide and weak organic acids in raw water. With exceptions to stations A and B, the rest of the samples for both potable and raw water were slightly acidic and outside the recommended range by international standard guidelines (pH 6.5 – 9.0). pH values beyond permissible range can affect mucus membranes of cells and cause corrosiveness in water supply system[18].

Total alkalinity: Total alkalinity is a measure of the basic constituent of water. It is dependent on the concentration of the substance which would raise the pH of water. These are mainly hydroxide, carbonate and bicarbonate ions. High levels of alkalinity indicate the presence of strongly alkaline industrial water. It is shown from results table – 2 and figure-7 that station A, which was located near sewage discharge grounds for Valley College, one of the biggest secondary schools in Western Uganda, showed high levels of alkalinity (90.86 ppm). If carbonate is present in greater quantities, the pH will be greater than 8.3. From the results indicated above, all the sampling stations did not show high carbonate concentrations since their pH values are all below 8.3. Below pH 8.3, the alkalinity is due to presence of bicarbonate and carbon dioxide.

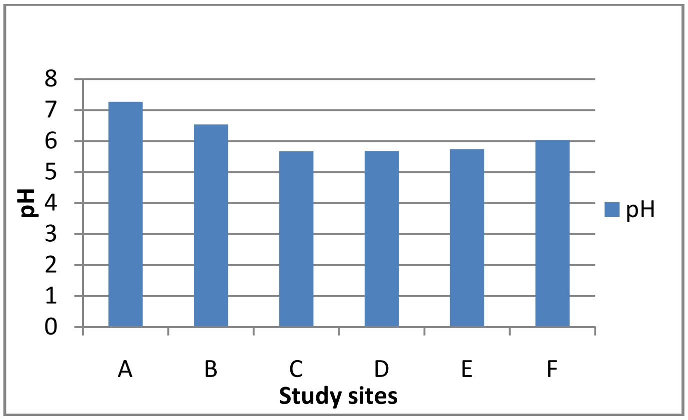

Figure-6
Variation of pH at different sites

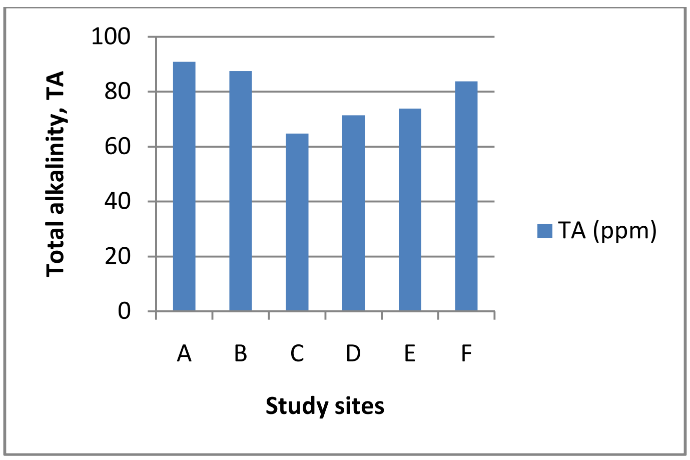

Figure-7
Variation of total alkalinity at different sites

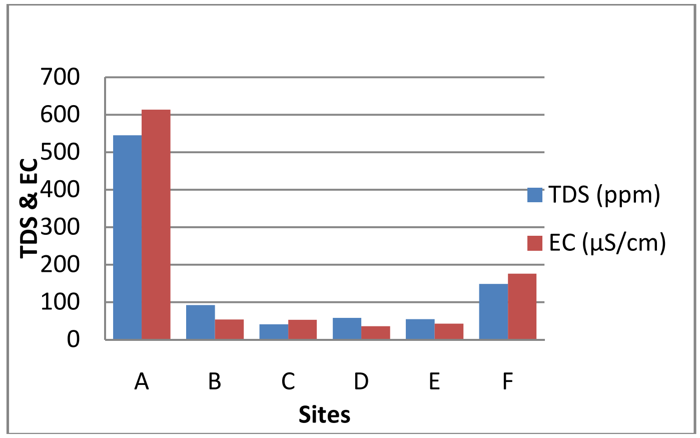

Figure-8
Variation of conductivity and total dissolved solids (TDS) at given sites

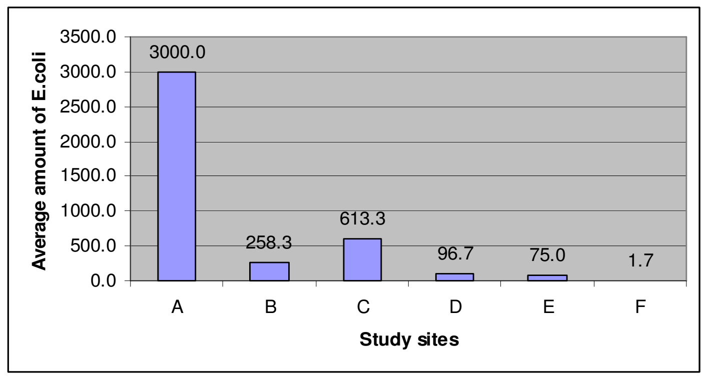

Figure-9
Variation of *E. coli* as CFU/100 ml of water samples at given study sites

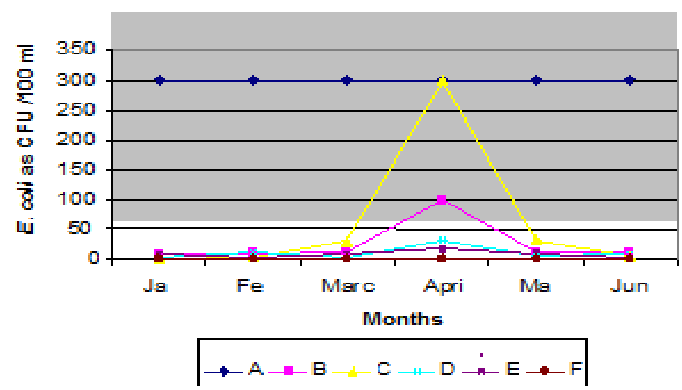

Figure-10
Variation of *E. coli* as CFU/100 ml of water samples with time (months) from all the sites

onductivity and Total Dissolved Solids: To convert EC (µS/cm) of water sample into approximate concentration of TDS (ppm) in the sample, a conversion factor is used. The factor depends on the composition of dissolved solids and can vary between 0.54-0.96. This value, 0.67 is used as an approximation. TDS (ppm) = EC (µS/cm) x 0.67. Table-1 and figure-6 indicate that conductivity is directly proportional to total dissolved solids.

Microbial evaluation of given samples: Station A had the highest numbers (3000 CFU/100 ml) of *E. coli* in water samples. The average number at this station was observed to be about 5 times the average numbers at station C with the next highest number (613.3 CFU/ 100 ml). From figures-7 and 8, it is shown that potable water recorded some *E. coli* numbers (1.7 CFU/100 ml) though at a lower value.

It should be noted that the test kit that was used did not give observations beyond 3000 CFU per 100 ml of water samples. Consequently, observations greater or equal to 3000 CFU per

100 ml of water samples were recorded as 3000 CFU in figure-9. Results showed that higher values were observed during the months of March to May. During this month, there was a lot of rain washing away faecal materials into the wetland. This finding suggests that seasonality has an impact on the amount of *E. coli* in the water samples.

Conclusion

The study reveals most physiochemical parameters investigated were outside the recommended range by World Health Organization. Figure-9 shows that high concentration of *E. coli* was particularly observed during wet season than the dry season. Main pollution to Nyaruzinga wetland is attributed to sewage discharges from surrounding institutions and domestic waste water from residential homes. On average, there is poor water treatment of potable water by the responsible organization to reduce the risk of infection by *E. coli.*

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