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QUALITY OF THE LAKE WATER AT UGANDA MARTYRS' CATHOLIC SHRINE, NAMUGONGO AND ITS SUITABILITY FOR HUMAN CONSUMPTION

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ABSTRACT

The physical, chemical and bacteriological quality of the lake water at Uganda Martyrs' Catholic Shrine Namugongo was determined in an attempt to ascertain its suitability for human consumption. Pilgrims who visit the shrine come for prayers at various times of the year and drink this water directly from the water body. They attach healing remedies to it. From the parameters investigated it was determined that this water is unsuitable for human consumption judged against the set standards of Uganda National Bureau of standards and World Health Organization. Therefore, pilgrims and communities living nearby should be discouraged from drinking this water in its raw form. It is recommended that a factory be set up to purify this water and/or it is boiled before being drank by the locals and pilgrims.

Key words: Martyrs' shrine, contamination, water, pilgrims, lake.

1.0 Introduction

Uganda Martyrs' Catholic shrine Namugongo (UMCSN) is a place where Christians worship God in honor of the martyrs. Among the martyrs were 22 Catholic converts to Christianity who were killed by the Kabaka (King) of Buganda called Mwanga II. These killings were carried out because of their loyalty to God compared to that for their king. However it should be noted that not all of these men were killed in Namugongo. Charles Lwanga was the martyr who was killed near the site of study where the basilica/shrine is located and some others were killed from a nearby site in Nakiyanja which was the official place of sacrifice then. The executions occurred between November 1885 and January 1887. The Catholic church beatified the martyrs of its faith in 1920 by Pope Benedict XV and were canonized by Pope Paul VI on18th October 1964.

On a daily basis tens and hundreds of Christians flock this site to honor and pray to God through the intercession of these twenty two catholic Uganda Martyrs. The numbers are overwhelming on the 3rd of June every year when pilgrims from many parts of the world visit the site.

Although it is thought that martyrs' lake was excavated in honour of St. Charles Lwanga, at Namugongo, this man-made lake is known to have been created to beautify the place of worship in 1954. The lake was to serve aesthetic purposes but also to be a source of fish for the priests. It should be noted there is no documented literature related to this lake since its creation has no direct linkage to the martyrs. Some of this information was provided verbally by Mr. Ben Tenywa who works in the office of the pilgrims at the shrine.

By the time of the canonization of the Uganda martyrs (1964) this lake was now well established and the altar where mass was celebrated by Pope Paul VI was erected in this water body.

It is against this background of the position of altar that people have attached miraculous powers to the water. In the local news prints (New Vision, Bukedde of 3rd June 2013, 2014, and from a study by AFENET, 2013 several testimonies of people healed from various ailments after drinking or/and using this water in their households have been documented. For that matter people who come for prayers, and those living close to the site drink this water directly from the lake and some take it home for use. Although National water and Sewerage Cooperation (NWSC) installed a tap with safer water within the shrine, water from this stagnant lake believed to be "holy water" is preferred.

There is very limited information on the chemical composition of the water. This study was therefore carried out to determine the quality of this water and its suitability for human consumption since it is used by a large number of pilgrims. 3rd of June also included in the general Roman calendar is celebrated as Martyrs day in Uganda. It is reported that acceptable quality drinking water (potable) is supposed to be free from disease causing organisms, harmful chemical substances, should taste good, and be aesthetically appealing and free from objectionable color and odor (WHO 2011). AFENET, 2013 considered the dilemma of disease prevention and outbreak control versus cultural and religious beliefs at the Uganda Marty's celebrations.

It is an undoubted fact that water is very essential for human life. Man as he tries to satisfy this need for water for his wellbeing, due to its unavailability or scarcity, has found himself compromising with the quality. Humans at-times drink any available water especially if thirsty and unconscious of effects on health associated with water. Other drives for drinking the water minus thinking about its quality will be when one expects something special from this water – for instance a healing remedy. In this regard, the water in Namugongo catholic martyrs shrine has been associated with healing powers.

The quality of water for drinking is judged according to six broad categories as given by Chhatwal (1999):-

1) Physical properties: color, odor, temperature, turbidity and suspended matter.
2) Microbiological organisms: coliform organisms; fecal coliforms.

3) Inorganic chemicals: alkalinity, dissolved oxygen, pH, total dissolved solids, hardness and about 20 specific inorganic ions.
4) Organic chemicals: carbon-chloroform extracts (CCE), oils and grease, phenols, cyanide and several individual pesticides.
5) Radioactivity: Radium-226, Strontium-90, gross bête emitters.
6) Biochemical oxygen demand and chemical oxygen demand.

Sawyer et al. (2000), report that the amount of undissolved colloidal and suspended matter increase with the degree of pollution. While Chhatwal et al. (1999), further state that if suspended matter is organic it will decompose using dissolved oxygen and produce noxious gases and odors. This will make water less appealing for drinking. High Total Suspended Solids in a water body can often mean higher concentrations of bacteria, nutrients, pesticides, and metals in the water.

Sources of turbidity include: Soil erosion, Waste discharge, Urban runoff, Eroding stream banks, Large numbers of bottom feeders, which stir up bottom sediments, Excessive algal growth. Higher turbidity increases water temperatures, reduces the amount of light penetrating the water, reducing photosynthesis and the production of Dissolved Oxygen.

If not removed, turbidity can promote re-growth of pathogens in the distribution system, leading to waterborne disease outbreaks, which have caused significant cases of gastroenteritis in many places. Although turbidity is not a direct indicator of health risk, studies show a strong relationship between removal of turbidity and removal of protozoa. Fortunately, traditional water treatment processes have the ability to effectively remove turbidity when operated properly (EPA, 2012).

The American Public Health Association (APHA) specifies that drinking water turbidity shall not exceed 0.5 NTUs. However, some scientists think this standard is too generous. They prefer the value reduced to 0.1 NTUs.

The rate of oxygen consumption in a water body is affected by a number of variables: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water. Chhatwal et al. (1999), report that the major problem associated with water pollution has been BOD. The higher the BOD, the higher the organic content of water and the more dissolved oxygen will be used to decompose these organics.

Water shows significant conductivity when dissolved salts are present. The amount of conductivity is directly proportional to the amount of salts dissolved in the water. http://www.stevenswater.com/water_quality_sensors/conductivity_info.html. High conductivity suggests a high trophic status of the water body and is due to high electrolyte content, Rao (1993). From the WHO document (2011), the pH of natural water is controlled by the carbon dioxide/bicarbonate equilibrium and usually ranges from 4.0 to 9.0. The majority of waters are slightly basic (pH > 7) due to the presence of bicarbonates and carbonates.Acidity affects chemical and biological processes taking place in water. These include:

- Dissociation of organic and inorganic molecules, thereby changing toxicity.
- Changing the water solubility of compounds, also influencing toxicity.
- A lower pH may induce enhanced corrosion.
- Different biological species show optimum performance at different degrees of acidity, leading to shifts in species consumption.

No health-based guideline value is proposed for pH. Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters (WHO 2011). Uganda National Bureau of Standards, US 201:2008, recommends the pH for portable drinking water to be between 6.5 - 8.5 pH Units.

Phosphates effects are mainly consequences of emissions of large quantities of phosphate into the environment due to mining and cultivation. Phosphates won't hurt people or animals unless they are present in very high concentrations. Even then, they will probably do little more than interfere with digestion. It is doubtful that humans or animals will encounter enough phosphate in natural waters to cause any health problems. According to http://www.h2ou.com/h2wtrqual.htm, some values for total phosphate-phosphorus and effects are given in table 1below.

Total phosphate/phosphorus	**Effects**
0.01-0.03 mg/L	Amount of phosphate-phosphorus in most uncontaminated lakes
0.025 mg/L	Accelerates the eutrophication process in lakes
0.1 mg/L	Recommended maximum for rivers and streams

Sources of phosphates, in addition to those found in fertilizers, are those found in consumer products as detergent, baking powders, toothpastes, cured meats, evaporated milk, soft drinks, processed cheeses, pharmaceuticals, and water softeners (http://www.freedrinkingwater.com). O'Neil (1995), points out that major cause of increased phosphates in water is due to sewage disposal and the soluble polyphosphates used in detergents to bind the Ca^{2+} and Mg^{2+} ions so as to remove hardness of water.

Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L. Nitrate can reach both surface water as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater disposal and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks. Chhatwal et al. (1999), report that when the ingested nitrates are reduced by microorganisms in the digestive tract to nitrites, the nitrites also oxidize the iron atom present in hemoglobin from Fe^{2+} to Fe^{3+}. The result is a methaemoglobin molecule which is incapable of oxygen transport.

World Health Organization 2011 reports that in humans, in clinical epidemiological studies of methaemoglobinaemia and subclinical increases in methaemoglobin levels associated with drinking-water nitrate, 97% of cases occurred at concentrations in excess of 44.3 mg/l, with clinical symptoms associated with the higher concentrations. The affected individuals were almost exclusively under 3 months of age.

The guideline value for nitrate of 50 mg/l as nitrate (or 11 mg/l if reported as nitrate-nitrogen) is based on epidemiological evidence for methaemoglobinaemia in infants, which is caused by an increase in bacteria that can readily convert nitrate to nitrite (NO_2). This outcome is complicated by the presence of microbial contamination and subsequent gastrointestinal infection, which can increase the risk for these infants significantly (WHO 2011). EPA recommends that infants should not drink water that exceeds 10 mg/l NO_3-N. EPA puts the maximum contaminant level (MCL) in drinking water as nitrate (NO_3) at 10 mg/l.

The most basic test for bacterial contamination of a water supply is the test for total coliform bacteria. Total coliform counts give a general indication of the sanitary condition of a water supply. Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste.Feacal coliforms are considered a more accurate indication of animal or human waste than the total coliforms. *Escherichia coli* (*E. coli*) is considered to be the species of coliform bacteria that is the best indicator of fecal pollution and the possible presence of pathogens.

Presence of coliform bacteria in drinking water, increases risks of one contracting a water-borne illness. Although total coliforms can come from sources other than fecal matter, a positive total coliform sample should be considered an indication of pollution in a water source. Positive fecal coliform results, especially positive *E. Coli* results, are considered an indication of fecal pollution in water (Tebbutt, 1998)

1.1 Statement of the problem

The chemical composition of this water is unknown. This puts at risk the human life, especially those who drink it. This includes the pilgrims who drink this water on the 3rd of June and at some other time when the people assemble privately or communally for prayers as well as those who use this water for home/domestic purposes.

Hence the need to determine the chemical composition of this water, as well as the biological and physical status of this water and compare with the recommended standards of Uganda as provided by the National Bureau of Standards and by the World Health Organization (WHO).

1.2 Objectives

i. To ascertain the source of this water and the possible causes of contamination if any
ii. To determine the pH, electro conductivity, turbidity, total suspended solids biological oxygen demand (B.O.D), phosphates and nitrates in this lake water.
iii. To find out whether this water contains any fecal and total coliforms and the levels of these coliforms.

1.3 Significance of the Study

This study is expected to furnish the administrators, the pilgrims as well as the locals with knowledge about this water and its suitability for consumption.

his study may also help the administrators to devise means of how best to protect this water such that it is not contaminated hence making it safe for human consumption and/or consider more safe water sources.

1.4 Scope of the Study

The study was limited to the physicochemical as well as bacteriological study of this lake water and though healing remedies have been attributed to this water, no attempt was made to prove that.

2.0 Methods

2.1 Study area

Three sites were randomly selected (figure 1). The samples were collected in plastic bottles of volume 500ml and the analysis was carried out from National Water and Sewerage Corporation laboratory in Bugoloobi, Kampala.

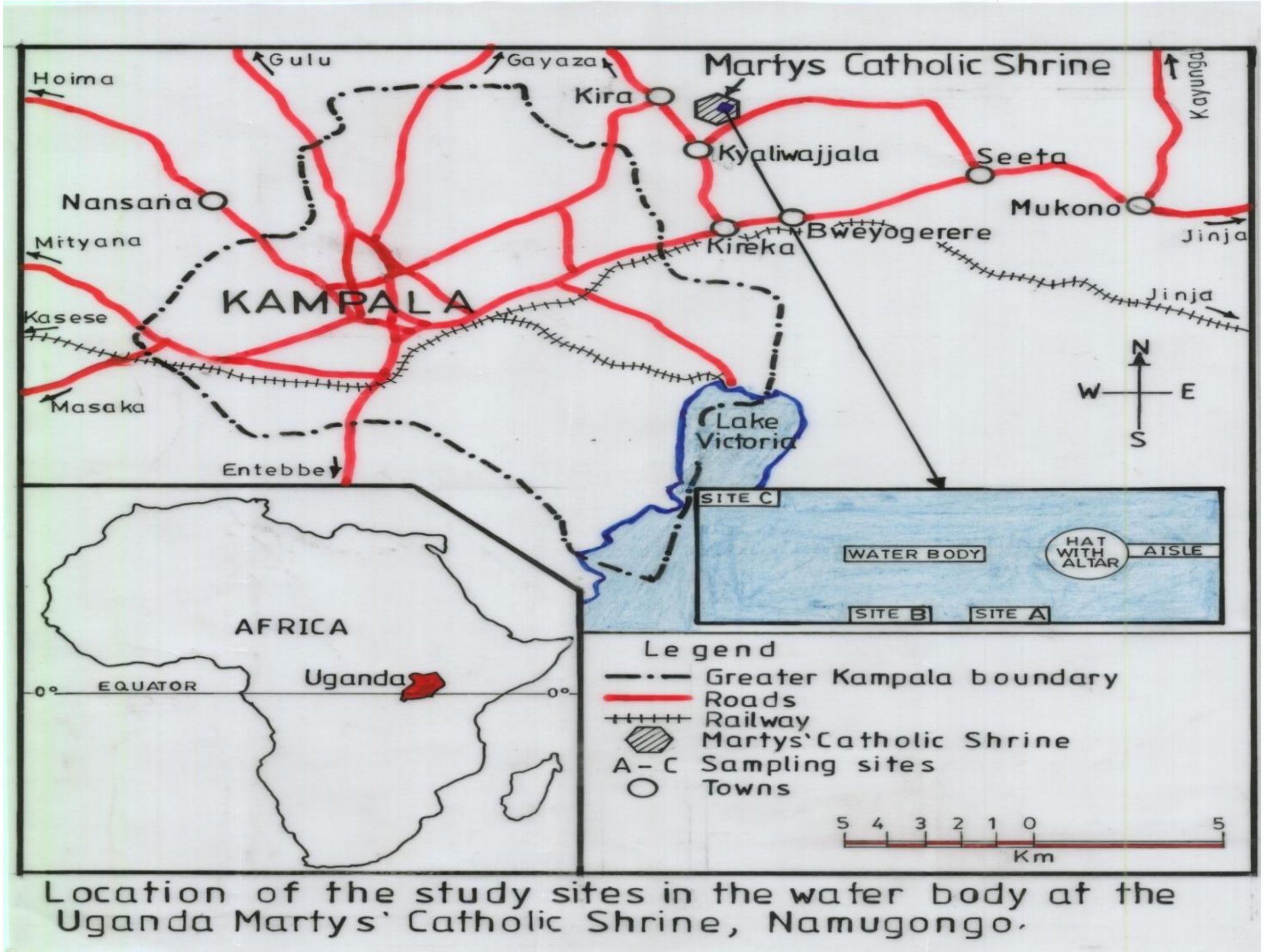

Figure 1

Figure 2: The Study Site

2.2 pH:

This was done by use of the electrometric method. A pH meter was used.

2.3 Biochemical Oxygen Demand (BOD):

BOD was determined by use of the Azide modification of Wrinkler method. (oxygen electrode method)
Calculation

$$\text{BOD, mg/l} = \frac{D_1 - D_2}{P}$$

Where,

D_1 = DO of dilute samples immediately after preparation, mg/l
D_2 = DO of diluted water after incubation at 20°c, mg/l
P = decimal volumetric fraction of sample used.

***2.4 Nitrate*:** Determined by Cadmium Reduction Spectrophotometric method

Calculation

The readings obtained on the Spectrophotometer are expressed as mg/l NO_3. Since the sample was diluted the final reading was obtained as:

= D x Reading obtained mg/l NO_3.

Where D = The dilution Factor

2.5 Total Phosphate:

Determined by Persulphate method using a Spectrophotometer DR 3900 reading at 880nm

Calculations

Sample TP conc. mg/L $= \dfrac{mg / TP \times 1000}{SampleVol.(ml)}$

2.6 Total Suspended Solids:

This was determined by use of the photometric method. A Spectrophotometer DR 3900 at 630 nm was used.

2.7 Turbidity:

This was determined by use of the Nephelometric method.

2.8 Electrical Conductivity:

This was determined by use of a conductivity meter.

2.9 Coliforms:

This was determined by membrane filtration method using laurel sulphate broth

2.10 Data Analysis:

t-test was carried out using the SPSS Program to determine whether the mean values obtained for each of the samples are either above or below the test values as given by UNBS and WHO.

3.0 Results

A total of 24 samples were collected in a period of four (4) weeks.

Table 2: Average readings for the three sites for each sample collected

		Samples							
Parameters	site	1	2	3	4	5	6	7	8
pH	A B C	8.35 8.91 8.71	7.25 8.76 8.84	7.75 7.61 7.78	7.33 7.89 8.73	7.41 7.83 8.44	7.07 7.05 6.97	7.71 7.1 7.29	7.05 6.71 7.71
Conductivity (µS/cm)	A B C	150 140 144	151 143 145	146 147 136	127 136 148	131 142 147	166 161 153	155 152 152	147 142 129
Turbidity (NTU)]	A B C	52.6 47.0 50.0	47.5 40.8 39.7	50.6 55.6 50.9	45.3 46.3 46.5	44.5 47.9 47.4	37.5 38.9 43.1	37.0 38.2 40.4	99.7 88.6 111.0
Total suspended solids (mg/L)	A B C	446 441 432	433 417 391	457 479 443	394 392 401	386 412 407	49 47 58	42 42 48	67 63 74
Total phosphorus (µg/L)	A B C	345 297 264	361 358 345	584 278 286	279 265 224	263 236 245	320 310 315	298 304 316	312 308 324
Nitrate nitrogen(mg/L)	A B C	0.01 0.0 0.0	0.0 0.7 0.9	0.2 0.3 0.0	1.0 1.5 0.2	0.3 0.2 2.8	0.2 0.1 0.1	0.09 0.2 0.16	0.3 0.2 0.4
Biochemical Oxygen Demand(mg/L)	A B C	14.5 13.9 13.2	12.1 12.2 11.0	10.2 16.9 11.7	11.3 10.7 10.4	12.4 13.5 12.9	11.4 12.0 11.6	10.4 11.0 11.6	14.5 14.0 14.8
Total coliform	A B C	60 35 20	420 390 430	140 20 20	210 190 240	190.0 200.0 220.0	90 67 48	60 60 70	80 100 94
Fecal coliform (CFU/100ml)	A B C	8 5 3	67 44 52	11 5 3	14 10 15	30 33 29	20 16 12	24 26 30	41 32 48

Table 3: The mean value of each of the parameters for the water samples taken

Parameter	1	2	3	4	5	6	7	8	Overall mean
pH	8.66	8.28	7.71	7.98	7.89	7.03	7.37	7.16	7.76
Conductivity (µS/cm)	144.67	146.33	143.00	137.00	140.00	160.0	153.0	139.33	145.42
Turbidity (NTU)]	49.87	42.67	52.37	46.03	46.60	39.83	38.53	99.77	51.96
T.S.S(mg/L)	439.67	413.67	459.67	395.67	401.67	51.33	44.00	68.00	284.21
T.phosphorus (µg/L)	302.00	354.67	382.67	256.00	248.00	315.00	306.0	314.67	309.88
Nitrate-Nitrogen(mg/L)	0.003	0.53	0.17	0.900	1.10	0.13	0.15	0.30	0.41
B.O.D(mg/L)	13.87	11.77	12.93	10.80	12.93	11.67	11.0	14.43	12.43
T. coliform (CFU/100 ml)	38.33	413.33	60.00	213.33	203.33	68.33	63.33	91.33	143.92
F. coliform (CFU/100 ml)	5.33	54.33	6.33	13.00	30.67	16.00	26.67	40.33	24.08

In table 2 and 3, it is shown that the water is alkaline. Conductivity values indicate that the water had dissolved substances. Site A had a higher electro-conductivity. The values for nitrate – nitrogen were consistently low in all the samples.

Table 4: Comparison of mean values of parameters with UNBS and WHO standards

Parameter	Sample Mean Value	UNBS standard	WHO standard
pH	7.76	6.5-8.5	No guideline proposed.
Conductivity (µS/cm)	145.42	2500	2500
Turbidity [Nephelometric Turbidity Units (NTU)]	51.96	10	5
Total suspended solids (mg/L)	284.21	1500	Depends on location (500)
Total phosphorus (µg/L).	309.88	-	Not regulated
Nitrate nitrogen (mg/L	0.41	11 (short term exposure)	11
Biochemical oxygen demand (mg/L)	12.43	-	0.75-1.5
Total coliforms (CFU/100ml)	143.92	100 (maximum of 1% of sample)	0
Fecal coliform (CFU/100ml)	24.08	1 (maximum of 1% of sample)	0

The table shows that all readings were higher than the recommended levels of UNBS and WHO except pH, conductivity, nitrate nitrogen and total suspended solids.

To complement results in table 4, a t-test was carried out and results given in table 5.

Table 5: t test values obtained

Parameters	t value	Comment
pH	-5.330	Within limits. Accepted.
Conductivity	-1.230	Accepted value.
Turbidity	10.599 (UNBS) 11.862 (WHO)	Not accepted. Above the standards.
Total suspended solids	-32.509 (UNBS) -5.770 (WHO)	Accepted value.
Total phosphorus	-	Accepted.
Nitrate nitrogen	-82.641	Accepted.
Biochemical oxygen demand	N/A (UNBS) (WHO)	Not accepted. Above the standard.
Total coliform	1.728 (UNBS) 5.663 (WHO)	Not accepted for both. Above standards.
Fecal coliform	6.589 (UNBS) 6.875 (WHO)	Not accepted for both. Above standards.

Table 5 shows that the mean values of BOD, total coliforms, turbidity, fecal coliforms levels were above the recommended standards.

4.0 Discussion

4.1 pH:

The pH was slightly alkaline and for many samples it never rose above the accepted limits of a range of 6.5 to 8.5 as given in table 3, table 5. pH is a factor that must be considered in chemical coagulation, disinfection, water softening and corrosion control, (Sawyer, 2000). Since the pH was within the accepted standards it makes this water qualify as easily processed.

4.2 Conductivity:

Table 3 shows that site A had a higher electrical conductivity, followed by site B and site C. This could be because site A is the principal entrance of the runoff whereby salts are carried by the water from the catchment areas. The overall average showed that this water was within the accepted standards for both UNBS and WHO. Therefore the salts dissolved (ionic content) in the water were low, and the trophic status of this lake is still low. This was also deduced by Rao (1993) in waters with similar levels of conductivity.

4.3 Turbidity:

The mean values of turbidity in the water samples (table 5) in comparison to the accepted standards were high above the recommended levels. Run-off, being one of the sources of this water, may be significantly contributing to the turbidity and contamination of this water. According to Sawyer (2000), turbidity as far as drinking water is concerned is important because:

a). Aesthetically any turbidity in drinking water is automatically associated with possible waste water pollution and health hazards.

b). Filterability of the water is made more difficult and costly when turbidity is high.

c). Disinfection becomes high to realize because with high turbidity many pathogenic organisms may be encased in particles and protected from the disinfectant.

Thus it is evident that this water will require treatment by chemical coagulation or flocculation and filtration before it can be recommended for consumption.

4.4 Total Suspended Solids (TSS)

Table 3 shows that TSS was higher for site B followed by site A and least at site C. The possible explanation could be related to the force or speed with which the runoff enters the water body. The substances may be carried by the force of the water away from site A and speed is reduced as it continues to site B. Table 4 shows that none of the samples exceeded the accepted standard. The TSS being low make this water lack the noxious smell which would make this water less appealing for drinking, due to the decomposition of the organic matter which would consequently reduce the DO, Chhatwal et al. (1999). And this low value of TSS points to low concentration of bacteria, nutrients, pesticides and metals. (www.bcn.boulder.co.us)

4.5 Phosphates

From table 3, the phosphates levels were high. That would account for the algal bloom and the greenish color of the water (figure 2). www.h2ou.com report that 25 μg/L of total phosphate accelerates the eutrophication process in lakes. All levels were found to be above 100 μg/L. It is however reported that phosphates won't hurt people, unless present in very high concentrations where they would do no more than interfere with digestion. And this could be the reason why phosphates are not given a guideline.

4.6 Nitrate-nitrogen:

From the general observation the levels of nitrate-nitrogen were low, and at some time there was completely no nitrate-nitrogen (table 3). We also noted that the values were higher at site C followed by B and least at A. On comparison of the mean values with the UNBS and WHO standards (table 5) the readings were within the accepted standards.

For that matter this water is not a threat with all the hazards related to nitrates consumption like methaemoglobinaemia especially in children as this would happen at levels of concentration higher than 44.3mg/L (WHO 2011).

4.7 Biochemical Oxygen Demand (BOD):

The BOD of the water was higher at site B and nearly the same for sites C and A, (table 3). Table 5 shows that the mean values of BOD were above the accepted standards. The implication of a high BOD is that there was a high pollution in this water body especially from organic matter, since the higher the organic matter in water the more dissolved oxygen will be used to decompose these organics, Chhawtal et al. (1999). Sources of BOD to the study sites could be from the leaves of the number of trees around this lake (figure 2), grass clippings from residential areas and the substances carried along with runoff from the nearby school.

4.8 Total coliform:

From Table 3 and table 4, all the values for the fecal coliforms at the three sites indicate that site A had more total coliforms compared to C, and to site B.

The mean value lies above the accepted standards (table 5), and from the t-test we can confidently affirm that this water had pathogenic bacterial contamination as seen from the presence of indicator organisms (coliforms) www.health.ny/coliform_bacteria.

4.9 Feacal coliform (Escherichia coli):

The mean values are above the accepted standards. Using the t values, we confirm that grave dangers are anticipated by drinking this water in its raw form. Presence of faecal coliforms in drinking water increases risks of one contracting water-borne diseases and is an indication of pollution of this water body (WHO, 2011)

Though people say that none has ever taken this water and complained of sickness this should not be the reason for taking this water in its untreated form for there is now evidence from this study that the water is not healthy for human consumption. And even if the water has 'healing remedies' it is not good either to put God to test by deliberately drinking this water with the hope that God will come to one's aid. Humans have the intelligence which should be used to better our lives and those of others.

The presence of coliforms is an indication that there could be disease causing organisms hence a danger to human consumption.

5.0 Conclusion

The lake water at Uganda Marty's Catholic Shrine, Namugongo is unsuitable for human consumption. It is recommended that this water is treated before consumption otherwise its consumption should be discouraged.

6.0 Recommendations

- To re-channel the runoff such that little or none of it enters this lake. The other option will be to construct a filtering point e.g. an artificial swamp such that the runoff is filtered before entering the lake.
- A fence (figure 3) now erected should be used to limit the number of people who have contact with the lake water. This is hoped to reduce on chances of misuse and contamination.

Fig 3: The newly constructed fence around the lake at the shrine.

- Users of this water should boil the water before drinking it and people discouraged from drinking the water directly from the water body despite "the healing powers" attached to this water.
- Treat the water such that it is bottled and people or pilgrims can access this water at an affordable fee.

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