A preliminary investigation to water and soil quality in four forest reserves near Kampala, Uganda

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ABSTRACT

There are four forest reserves that are located on the outskirts of Kampala, Uganda that area conservation groups have deemed extremely important to protect through restoration practices and the enhancement of environmental research and education. These reserves, which have suffered greatly from human encroachment, are part of the once expansive lowland forests adjacent to Lake Victoria, the second largest freshwater lake in the world. Although the biodiversity of living species is being studied in this region, the geologic component is lacking. This poster highlights baseline geologic data (e.g. soil and hydrology assessments, water chemistry) collected from Kitubulu, Zika, Mabira, and Mpanga Forests. The preliminary data collected may indicate early stages of environmental degradation. Elevated Fe and low pH in some surface waters may indicate influence of mine tailings, whereas depleted dissolved oxygen may indicate increased turbidity from siltation.

The preliminary data set has defined measurable and practical geologic parameters that should be monitored continuously in order to discus the overall health of the Lake Victoria catchment basin. To date, there has been no systematic monitoring of watershed health in this area because of lack of laboratory analysis capacity in Uganda. Employing the help and support of local conservation groups, and college students from Makerere University, are essential to the success of a long term soil and water quality monitoring program.

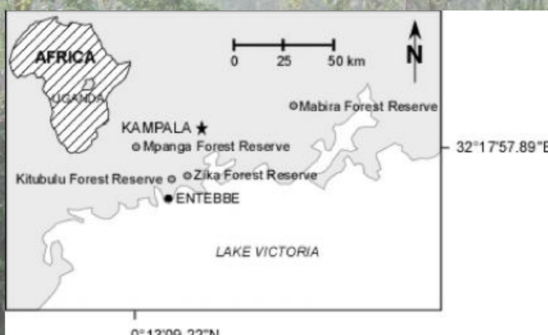


FIGURE 1. Site map of the four forest reserves located near Uganda's captial citym Kampala.

METHODS AND MATERIALS

The field data collection was carried out in the dry month of June. A reconnaissance survey was first conducted to locate the possible water bodies within the forest reserves. Open water bodies (streams and lakes) were considered optimal for water sampling. Sites that were accessible and safe to sample were selected. The locations of sampling sites were marked using GPS though in some instances due to either bad weather or dense canopy cover it was not possible to take readings. As many samples as possible were collected at each forest reserve. Time, ultimately, was the limiting factor in the collection of more data.

Water samples were collected at each sample site using 0.5 liter plastic bottles. All parameters were measured in the field immediately upon collection. The water quality parameters measured at each forest reserve includes temperature, pH, dissolved oxygen, total ammonia, total phosphates, total hardness, total chlorine, total iron. A preliminary geologic site assessment was also conducted.

RESULTS

The authors measured a low dissolved oxygen level (2 ppm) and a basic pH of 8.4 at both sites in Kitubulu forest reserve (Table 1). The water temperature was much warmer than at the other forests we visited; ranging from 23.2 to 27.7 °C. A range in hardness was identified at the two locations (50-240 ppm).

The authors were able to identify and sample five locations at Mabira forest reserve. Water temperature ranged from 19.3-19.8 °C. At location M3 a pH of 4.0 was recorded; the other locations ranged from 6.8-7.8. The dissolved oxygen measured at location M3 was < 10 ppm. This dissolved oxygen was found to be similar at the other locations (ranging from 8.9-10). The iron was found to be 0.3 ppm at all of the Mabira forest sample sites, except M3, where it rose to 7.2 ppm. The water temperature at two sample locations in Zika forest reserve was recorded at 20.7 and 20.8 °C. The pH at both locations was slightly acidic at 6.2. The dissolved oxygen at Z1 was 7.0 ppm and 7.8 ppm at Z2. The total hardness was measured at 25 ppm (Z1) and 50 ppm (Z2). Total iron content in both water samples was measured at 0.3 ppm.

At Mpanga forest reserves the water temperature was reported at 20°C (P1) and 22.7°C (P2) at two locations. At P1 the pH was measured at 6.2, P2 at 7.2. The dissolved oxygen was measured at 6.3 and 7.2 ppm, for Z1 and Z2, respectively. Some total iron is reported at P1 (0.3 ppm), but none at P2. At all sample sites in all four forest reserves the total ammonia reported was 0.25 ppm.

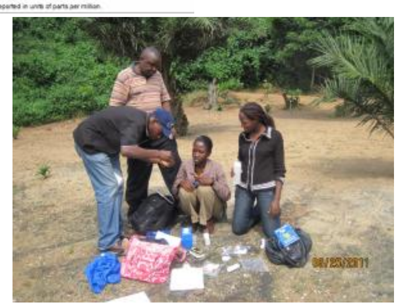
The second part of the field investigation included analysis for both soil color classification and grain size texture (Table 2). All soil samples monitored for grain size was found to be coarse sand except for the sample collected at K1 (fine sand) and Z2 (medium sand). The color of the soil varied between forest reserves and between locations within each forest reserve. At Kitubulu forest reserve the color was found to be reddish-brown at K1, light grey at K2. At Zika forest reserve, very dark yellowish-brown was determined to be the color at Z1 and black for Z2. Four soil samples were analyzed at Mabira forest resrve. Three of these (M1, M2, M4) are established to be black in color; M3 was classified as olive brown. The soil at Mpanga forest reserve varied between the two locations; P1 was very dark grey, P2 was reddish-brown.

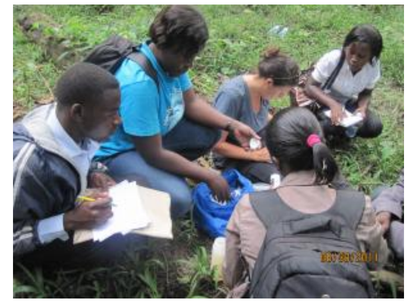
SITE NAME AND SAMPLE NUMBER	Temperature °C	pH	Dissolved Oxygen	Phosphate	Total Hardness	Total Chlorine	Total Iron	Total Ammonia
Kitubulu- K1	27.7	8.4	<2	15	50	0	0	0.25
Kitubulu- K2	23.2	8.4	<2	0	240	0	0	0.25
Mabira- M1	19.3	7.8	8.8	5	240	0	0.15	0.25
Mabira- M2	19.5	7.8	10	5	50	0	0.3	0.25
Mabira- M3	19.6	4.0	<10	5	0	0	7.2	0.3
Mabira- M4	19.7	7.2	9	5	50	0	0.3	0.25
Mabira- M5	19.8	6.8	9	5	50	0	0.3	0.25
Zika- Z1	20.8	6.2	7	5	25	0	0.3	0.25
Zika- Z2	20.7	6.2	7.8	5	50	0	0.3	0.25
Mpanga- P1	20	7.2	7.2	5	50	0	0.3	0.25
Mpanga- P2	22.7	6.2	6.3	5	50	0	0	0.25

Please note that all chemical measurements are reported in units of parts per million.

Table 1. Water chemistry collected from four forest reserves near Kampala, Uganda. Please not that all chemical measurements are reported in units of parts per million. Also, all data and chemical tests were completed in the field using simple test kits.

Photograph 1. A research team from Makerere University was determined prior to data collection. The research team included professors and graduate students from Makerere University. Nearby stake holders, and forestry and water professionals from Kampala assisted in the field. In two weeks time we were able to collect and analyze data from four forest reserves. This exceeded expectations of the research team.





Photograph 2. Dr. Jovanelly teaches Makerere University graduate students how to complete water chemistry and soil analysis. This was the first time that the Makerere University students used such instrumentation.

TABLE 2. Soil descriptions and Munsell chart colors reported for each of the sample sites within the four forest reserves near Kamapala, Uganda. The next anticipated phase is the analytical determination of soil mineraology. This would greatly help with area farming practices and conservation.

SITE NAME AND SAMPLE NUMBER	Munsell chart color	Grain Size Classification
Kitubulu- K1	reddish brown	fine sand
Kitubulu- K2	light grey	coarse sand
Mabira- M1	black	coarse sand
Mabira- M2	black	coarse sand
Mabira- M3	olive brown	coarse sand
Mabira- M4	black	coarse sand
Mabira- M5	black	coarse sand
Zika- Z1	very dark yellowish brown	coarse sand
Zika- Z2	black	medium sand
Mpanga- P1	very dark grey	coarse sand
Mpanga- P2	reddish brown	coarse sand

DISCUSSION AND CONCLUSIONS

The first goal of this preliminary study was to determine the potential for establishing long term water and soil monitoring stations at the four forest reserves near the capital city of Kampala that are endangered by human encroachment and misuse. Through this research project the authors were able to select sampling locations that are both safe and accessible.

The second goal was to collect a baseline data set of water and soil analysis at each of the forest reserves. Although preliminary, the results of the water chemistry may provide some evidence of landscape degradation already occurring. A very acidic pH of 4.0 was reported at site M3 at Mabira forest reserves. This site was also had an unusually high total iron content of 7.2 ppm (USEPA recommends 0.3 ppm in drinking water) and a hardness of 0 ppm (classifies as soft water). Although suspect, the chemical conditions could reflect an environment impeded by mining or leaching. For example, in areas known to have acid mine drainage the buffering ability of water is depleted by neutralizing carbonate and bicarbonate ions to form carbonic acid (H_2CO^3).

Once exposed to acid mine drainage, the affected carbonate buffering system is not able to control changes in pH as well. The buffering system is completely destroyed below a pH of 4.2, where all carbonate and bicarbonate ions are converted to carbonic acid. The carbonic acid readily breaks down into water and carbon dioxide (Farrner and Richardson, 1981).
At Site 3, we measured an acidic pH and reported no hardness. Moreover, 0.5 km upstream at site M1, the total hardness was reported at 240 ppm (classified as very hard water); this is the highest reading reported at Mabira forest reserves. Water hardness has been known to be a useful indicator of upstream mining activity because often it is found to be considerably higher in watersheds with active or abandoned mines.

The very low dissolved oxygen readings (<2ppm) reported at both sites in Kitubulu forest reserve are also of concern. Dissolve oxygen levels below 2 ppm can result in the demise of both vertebrates and invertebrates living in a water system. Our second hypothesis to explain the low dissolved oxygen involves siltation blocking light that prevents photosynthesis to produce oxygen. The authors believe that these temperatures and dissolve oxygen values have little to do with the collection site as Kitubulu is a dense evergreen canopy rainforest and the stream was shaded. Moreover, the sample day was cloudy. Sedimentation from an upstream carwash bay and an illegal adjacent sand pit may be adding siltation (turbidity) to this stream causing it to inadvertently warm. the large value (15 ppm) reported for phosphate at K1 is likely a runoff signature from the detergent being used at the car wash bays or sewage from nearby homestead communities. The recommended level of total phosphorous in stream ecosystems to avoid algal blooms is 0.01 to 0.1 ppm (USEPA, 1988). Raw sewage typically has phosphate levels around 10 ppm (Laws, 2000). The jump in total hardness at site K2 is curious and comes without explanation.

For references see: Jovanelly, T.J., Okot-Okumu, J., and Godwin, E. (2012). A preliminary investigation to water and soil quality in four forest reserves near Kampala, Uganda. *Journal of Environmental Hydrology,* Vol. 20, Paper 10, 1-9.