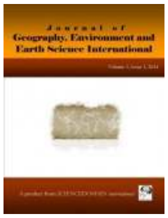

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Assessment of Physico-chemical Properties of Kasarani Section of River Thome, Nairobi

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Authors' contributions

This work was carried out in collaboration between all authors. Author AK carried out the experiments of the study and wrote the first draft of the manuscript. Author KK designed the study and monitored the experimental process and author NMG designed the study and reviewed the results of the study. All authors read and approved the final manuscript.

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ABSTRACT

This paper discusses the results of a study done in River Thome which is located in Nairobi county in Kenya. The purpose of the study was to establish whether the river water meets the set quality standards for surface water and irrigation water. It was established that the river water has been negatively impacted by wastewater from various human activities along the river stretch studied. The study analyzed levels of selected physico- chemical properties of Kasarani stretch of River Thome. Water samples were collected for laboratory analysis from five different stations. Mean level ranges of the physico-chemical properties were as follows: Water temperature, 18.1-27.3℃ pH, 6.6-8.1; dissolved oxygen (DO), 0-10.8 mg/L; total alkalinity, 25-298.0 $CaCO_3$ mg/L; biological oxygen demand (BOD), 0.1-118.9 mg O_2/L, and electrical conductivity, 160.0-496.0 µS/cm. Based on the levels of measurements such as the BOD concentration and DO levels, the river water is unfit for drinking, watering animals and irrigation of crops eaten raw. The results indicate that the water of a greater stretch of Thome River is polluted with domestic wastewater, agricultural and/ or surface run off.

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1. INTRODUCTION

Surface water bodies (lakes, rivers and reservoirs) are the main sources of water for agriculture, human consumption and industry [1]. Unfortunately, the available water resources are progressively getting polluted [2]. Water pollution results from human activities, which make the water unfit for human use, unsuitable for industrial use and adversely affect aquatic flora and fauna [3]. Two thirds of the world's population faces both water shortage and problems associated with water pollution [4]. Direct dumping of household and industrial wastewaters into water bodies without treatment, is a major cause of water pollution especially in developing countries [5]. In urban areas of most developing countries, overflowing sewers, leaks from illegal sewer connections or broken sewer pipes are common sources of human fecal contamination of surface waters [3].

Water pollution is presently a serious threat to both environmental and public health. Human health problems can results from consumption of contaminated food or water [6], ingestion of recreational water and through skin exposure to contaminants present in water bodies [7]. High nutrient concentrations in water bodies lead to growth of undesired plants (eutrophication) especially algal blooms, which may produce toxins lethal to human beings and aquatic life [8]. Eutrophic conditions decrease the resource value of rivers, lakes, and estuaries such that recreation, fishing, hunting, and aesthetic enjoyment are hindered [9].

Unplanned housing projects and other informal settlements are being established in Nairobi city at rates not matched by the rate of provision of waste disposal infrastructure. Consequently, large quantities of raw sewage and household wastewater drain directly into the city's rivers from housing estates and slums located along the riverbanks. Many of Nairobi's rivers are heavily polluted to the extent that their waters are unsuitable for use even in crop irrigation [10].

It is very important to ensure that water bodies are not subjected to any form of pollution. Regular analysis and monitoring of water quality in aquatic systems is essential to help us establish the condition of the water bodies in order to take corrective or preventive measures against any polluting events or sources [11]. In this endeavour, this study was designed to establish the physico-chemical properties of River Thome in Nairobi.

2. MATERIALS AND METHODS

2.1 Study Area

The present research was done at Kasarani in Nairobi County, Kenya (Latitude: 01° 13' N and Longitude 36° 53' E) as shown in Fig. 1. This is located about 10 kilometers from Nairobi city along Nairobi -Thika highway. The surrounding area is characterized by upcoming residential estates, small scale farms and hotels. Kasarani is a fast growing residential area where housing is a mixture of one storey houses and low rise apartments blocks, some of which are still under construction. The river studied is a sub tributary of Nairobi River and it arises from Kiambu County.

2.2 Data Analysis and Collection

Field analyses of water temperature, dissolved oxygen, pH and electrical conductivity were measured using respective parameter electrodes contained in a digital multiline P4 WTW meter. Composite samples for laboratory analyses were collected in 250 ml sample bottles and transported to the laboratory for analysis. The samples were analyzed within four hours from the time of collection or refrigerated at 4℃ to avoid deterioration.

Total alkalinity was determined by titrating 100 ml water samples with 0.02 N standard HCl using mixed Bromocresol green-methyl red indicator to determine the titration end point. The volume of acid titrated was used to calculate total alkalinity following the formula outlined in APHA [2]. Biochemical oxygen demand was estimated using the method outlined in APHA [12].

Samples for orthophosphate analyses were filtered through pre-washed Whatman glass fiber filters and analyzed following the procedure outlined in APHA [2]. The absorbance level of the treated samples was determined with a spectrophotometer and the phosphate concentrations calculated based on the absorbance values of standards with known PO_4-P concentration that were subjected to the same treatment as the samples. Samples for

Fig. 1. Map of the study area, Nairobi county, Kenya

NO_3-N determination were also filtered as for those of phosphates. Five milliliters of water samples were taken into 12 ml nessler tubes in duplicates and 2 ml of sodium salicylate solution added [13]. The samples were pretreated following the procedure outlined in APHA [12]. The absorbance level of the treated samples was determined with a spectrophotometer and the nitrate concentrations calculated based on the absorbance values of standards with known NO_3-N concentration.

3. RESULTS

Mean water temperature varied narrowly amongst the five sampling sites with a mean range of 22.0 to 23.51℃. Highest pH value (8.1) was recorded at Kasarani sampling while the lowest (6.6) was recorded at Sportsview. Median pH values at all sampling sites were generally neutral (Table 1). Less polluted sites such as Safari Park (based on DO concentration) had lower pH during the wet season and higher pH during dry season. Electrical conductivity values ranged between 286.53 and 327.40 µS/cm. A wide range of total alkalinity was recorded with a pronounced pattern of lower levels during the wet season and high levels during the dry season. One way analysis of variance (ANOVA) test revealed significant differences in mean biological oxygen demand values among sampling sites (P= 0.05, n= 20). Based on Tukey's mean separation procedure, mean BOD at Safari Park sampling site was significantly lower than at Kasarani and Sportsview (Table 1).

Phosphorus concentrations showed a distinct seasonal pattern of change during the study period. A one-way ANOVA test revealed a significant difference in mean PO_4-P concentrations at different sampling sites (P= 0.05, n= 20). Total nitrogen concentrations were highest at Sports view and lowest at Safari Park sampling site. There was no significance difference among the sampling stations throughout the study period (P=0.05, n=100) as revealed by a one way ANOVA test and no distinct pattern in seasonal changes was observed.

4. DISCUSSION

Water temperature varied narrowly among the five sampling sites during the present study. This was primarily because the water temperature changes were largely influenced by the prevailing weather conditions. Electrical conductivity range recorded in this study is much higher than that

Table 1. Mean values of physico-chemical properties and median value for pH recorded at different sampling stations

Site	pH	DO (mg/L)	Akalinity (mg $CaCO_3$/L)	Conductivity (µS/cm)	Temperature (°C)	BOD (BOD_5 mg O_2/L)
Safari Park	7.22	6.44	69.32	203.30	23.35	11.56
Kasarani	7.11	2.81	126.97	313.40	22.72	33.69
Icipe	7.23	3.19	112.08	286.53	21.96	24.40
Sportsview	6.98	1.64	124.85	327.40	23.51	28.15
Warren	7.05	3.15	122.11	312.20	22.68	23.52

Table 2. Mean values of selected nutrients at different sampling stations

Site	PO_4-P (µg/L)	TP (µg/L)	NO_3-N (µg/L)	TN (µg/L)
Safari Park	177.8	220.8	654.7	169.2
Kasarani	424.0	595.0	529.3	1932.2
Icipe	182.6	278.3	627.4	1441.8
Sportsview	364.2	599.6	634.0	2312.3
Warren	234.9	446.7	717.2	2002.7

obtained at Rivers Mubuku and Nyamugasani, Uganda (78.0 – 91.0 µS/cm and 89.0 – 110.0 µS/cm respectively), [14]. A new source of wastewater effluent upstream of Icipe sampling site was identified and it may have contributed to a drastic increase in conductivity levels towards the end of the study period. River Thome pH water range was within the range for freshwaters, which usually have a pH of between 6.5 to 8.2. A median pH of 7.4 is from this study is lower than a median value of 8.35 obtained by Jonnalagadda et al*.* [15] for the Odzi River water which is highly alkaline. The comparatively high levels of dissolved oxygen levels at the Safari Park sampling site can be attributed to the much lower level of human activities upstream which translates into a low microbial activity. A case of reduced dissolved oxygen with an increase organic load was reported for Nairobi River [16].

Biological oxygen demand (BOD) values obtained at most sites confirm that the river is generally polluted as unpolluted waters usually have BOD values of less than 5 mg O_2 /L [17]. This is, however, below the mean BOD of raw sewage (300.0 mg/L) [18]. Based on the BOD values obtained, the river water can be classified as unsuitable for human consumption unless treated. The high nutrient levels indicate that the river receives domestic effluents or agricultural runoff rich in phosphorus and nitrogen [19]. At some of the sampling stations, especially Sportsview, it was common to find livestock being grazed along the riverbanks and the animals were drinking water directly from the river. Livestock wastes enrich river water with organic wastes rich in nutrients, which raises the load of phosphorus and nitrogen. This was also reflected by the nutrient levels obtained from the study. Also, introduction of organic matter into a water body causes depletion of dissolved oxygen [20] as shown by the results of this study.

5. CONCLUSION

This study indicates that anthropogenic activities contribute to the pollution currently observed in some cities in Kenya where wastes are disposed indiscriminately especially from small and medium scale businesses, farms and households. River Thome is polluted by domestic, agricultural and surface run off wastewater. The source of the domestic sewage could be the commercial units and residential houses along the river. The small unit farms at some few areas along the river have also contributed to contamination of the river water. Corrective and preventive measures to stop the pollution and constant water quality monitoring programmes should be put in place as a step towards water pollution abatement.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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