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Physico-Chemical and Bacteriological Quality of Mbagathi River, Kajiado County, Kenya

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Abstract:- Water pollution, being a common hazard not only to human health but also the environment at large, has subsequently raised an issue as to what measures we can take to end this. This study wasdone specifically on Mbagathi River and the results compared to the WHO drinking water quality standards. Physico-chemical parameters measured were; turbidity, total dissolved solids, chemical oxygen demand (COD), biological oxygen demand (BOD), nitrates and phosphates. For bacteriological contamination, total coliforms and faecal coliforms were analysed. Across the different sampling points, One-way analysis of variance (ANOVA) was used to test for the significant difference ($p \leq 0.05$) of all the parameters. Pearson correlation was used to determine the relationship between the parameters. TDS(423-487mg/l), BOD(3.88-10.45mg/l) and nitrates (23.50-62.70mg/l) were within the WHO standards for drinking water. However, turbidity (2.72- 105.33 mg/l), COD (15.90-35.33mg/l), phosphates (2.10-3.35mg/l), total coliforms (7-2400 MPN/100ml) were above the standards. Frequent monitoring of the water is important, so as to safeguard the public health.

Keywords*;- Contamination, Water.*

I. INTRODUCTION

Water is an important resource and therefore sustains human life and other living creatures (Engel, *et al.,* 2011). Aquatic ecosystems are therefore prone to pollutants considering their sensitivity and easy accessibility making them vulnerable due to the human activities (Fernandez-luquen*et al.,* 2013). Water pollution has therefore led to scarcity of clean water for consumption considering the large amount of water that is lost through contamination making it unfit for not only humans but also other creatures,

Fernandez-luquen*et al.,* 2013, highlights that water pollution is the introduction of chemical substances into water in concentrations that risk the life of humans and other creatures. Pathogenic contamination, being a major factor of pollution, is mainly brought about by poor hygiene and sanitation in handling water.In addition to that, toxic chemicals in water also pose a high risk to human health. Consequently, all these factors have a negative impact on human health resulting to death when not carefully handled (Schwarzenbach*et al.,* 2010).

Considering the increasing human population along Mbagathi River, the demand for clean water has increased as well for various purposes such as drinking, irrigation and domestic use. (Engel *et al.,* 2011). Despite the increase in population, there is no existing water treatment plan within the area to ensure that the water is free from pollutants even though there are human activities taking place. This, therefore results to municipal, agricultural and residential waste being disposed in the rivers within the area.

The aim of this study was to look into the level of bacteriological loads and determine the levels of selected physico-chemical parameters along Mbagathi River catchment. The findings of this study would guide the measures to be taken towards reducing the extent of pollution in the river making the water fit for consumption.

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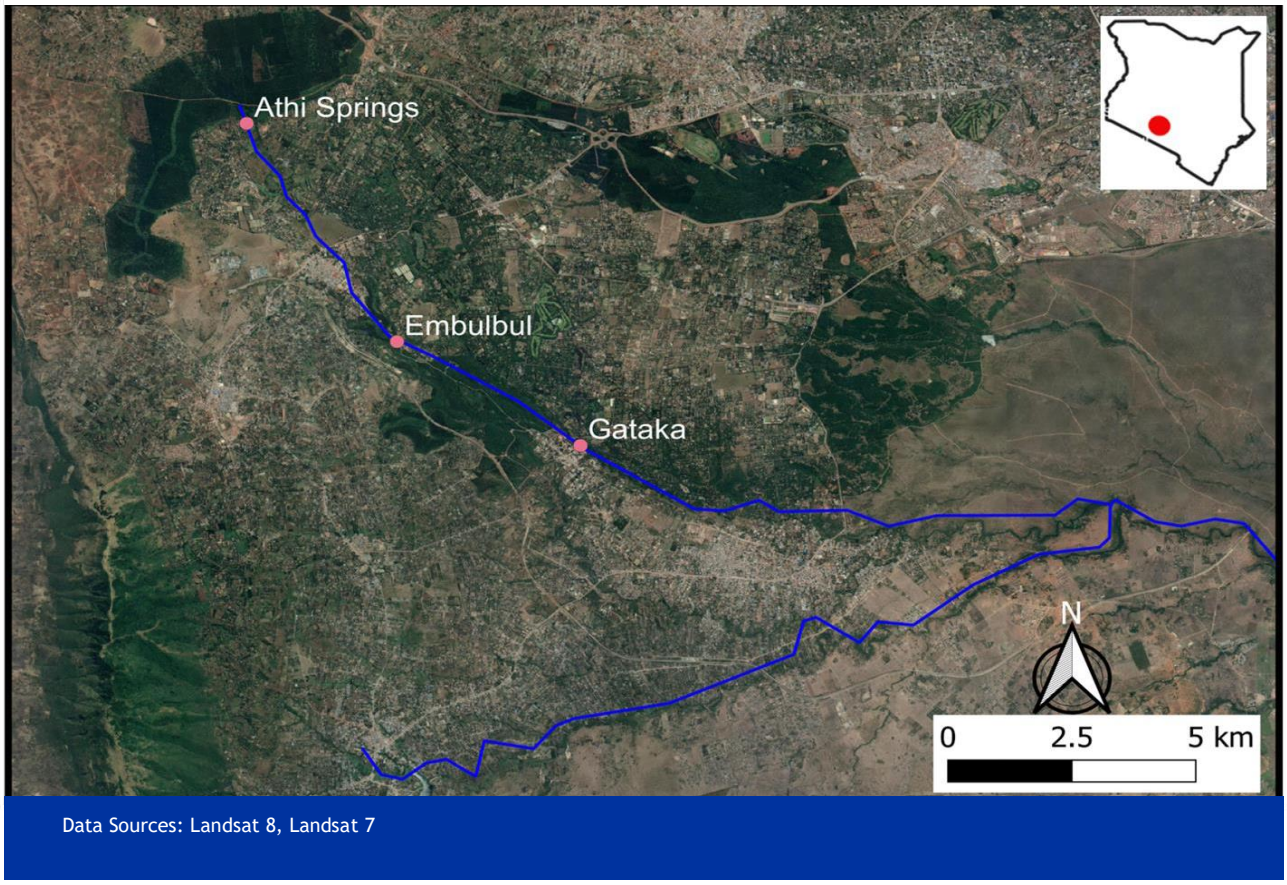
II. MATERIALS AND METHODS

A. Study area

MAPOFMBAGATHIRIVERINDICATINGSAMPLINGPOINTS



MAP 1

The river under study is Mbagathi River specifically Athi springs to Gataka. The study took place in Kajiado County, Kajiado-North sub-county. The river is surrounded by a hilly terrain at the catchment area (Athi Springs) and a flat terrain as it moves downstream.

A. Sampling sites and sample collection

Samples were collected at certain points of the river based on the intensity of human activities. At the Athi springs, there were minimal human activities and therefore made it easier to determine the least amount of pollutants available. At Embulbul, there was municipal waste being channelled into the river. Gataka, which is the downstream point of the river, was an access point where a number of samples were collected considering the increased number of population surrounding the area which reflects on the human activities as well.

Sampling was done from November 2021 to March 2022. This was done once every month. Standard meters were used to measure the physicochemical water parameters on-site. Plastic sampling bottles were used to preserve the samples after collection. They were rinsed with the river water before collection and after each collection, they were labelled; point of collection, time and date of collection.

B. Sample analysis

At the laboratory, physicochemical parameters; biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates and phosphates were analysed according to their standard testing procedures (Length, 2016).For the bacteriological test, it was done using a coliform (MPN) count which was achieved through the membrane filtration method.

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C. Data analysis

Analysis of the data collected was done using one-way Analysis of Variance (ANOVA) to test the significant differences at $p \leq 0.05$ between the parameters of different sampling points. Post-Hoc Tukey test was used to separate the means where significant differences were found to exist (Bjorklund, 2015). Similarly, Pearson correlation was used to find the relationship among the water quality parameters at the different sampling sites (Abdelmalik, 2018).

III. RESULTS AND DISCUSSIONS

Site/ Parameter	Athi Springs	Embulbul	Gataka	WHO limit	P- value
Turbidity (NTUs)	2.72 ± 1.09	23.53 ± 9.49	105.33± 4.68	0.3	0.00
TDS (mg/L)	423.00± 8.16	469.75± 10.1	487.0 ± 8.29	600	0.97
BOD (mg/L)	3.88± 1.14	3.95 ± 1.22	10.45 ± 3.47	5mg/l	0.22
COD (mg/L)	15.90 ± 4.04	18.70 ± 3.85	35.33 ± 3.61	10mg/l	0.72
Nitrates (mg/L)	23.50± 2.04	38.55± 4.38	62.70± 5.06	50mg/l	0.32
Phosphates (mg/L)	2.10± 1.07	3.35± 1.63	3.34± 3.55	0.1mg/l	0.00

Table 1: Mean ± Standard deviations of the physico-chemical parameters

A. Total Dissolved Solids

Total Dissolved Solids (TDS) values ranged from 487.0 ± 8.29 (mg/L) in Gataka to 423.00 ± 8.16(mg/L) in Athi Springs. The high levels of dissolved solids in Gataka (Table 1), could be linked to the high amount of municipal waste channelled into the river, together with siltation from farming activities in the area (Table 4). Other studies which have shown an increased TDS level downstream include: River Ikpoba in Benin which increased from 47.69±2.4 to 154.7±3.4 mg/L (Length, 2016).

B. Turbidity

The turbidity values ranged between 105.33 ± 4.68 NTUs at Gataka to 2.72 ± 1.09 NTUs at Athi springs. The high turbidity at Gataka (Table 1) could be attributed to the high number of suspended solids in the waste water from the municipal and the human activities along the river especially from the pesticides and fertilizers which are used by the farmers. The low turbidity at Athi spring is attributed to the low human activities and since it is a protected area, there is no soil erosion (Table 1). The turbidity of mbagathi water is higher and within the range of Athi and Kauthuluni Rivers, Kenya which ranged between 0.60 to 1235.60 NTUs (Nzung, 2019).

C. Biological Oxygen Demand

The mean values of biological oxygen demand (BOD) range between 10.45 ± 3.47mg/L in Gataka to 3.88± 1.14mg/L in Athi springs (Table 1). The high BOD at Gataka is attributed to the large amount of organic matter from the farms and the municipal sewage which is digested by the bacteria. Low BOD in Athi spring is attributed to little amount of organic matter as this is a protected area and therefore less organic matter. Comparative studies which have indicated low BOD levels include: Orem streams in Nigeria which indicated BOD levels of 3.60 mg/l (Ugbaja & Ephraim, 2019).

D. Chemical Oxygen Demand

The mean concentration of COD ranged between 35.33 ± 3.61mg/L in Gataka to 15.90 ± 4.04mg/L in Athi springs (Table 1).The amount of COD increased downstream, indicating an increase in the amount of chemicals channeled to the river. Gataka in specific, has very high amounts of both COD and BOD, making it unfit for human use. A study which had results within and above those of Mbagathi River include; River Ikpoba in Benin which had a range of between 15.8 mg/l to 883 mg/l (Length, 2016).

E. Nitrates

The study revealed that the concentration (mg/L) of nitrates varied along the river. The mean concentration ranged from 23.50 mg/L at Athi springs to 62.70 mg/L at Gataka (Table 1).The concentration of nitrates in a river is influenced by agricultural activities in the area especially where there is application of fertilizers (Mahmud & Said, 2013).The low ion of nitrates at Athi spring point could be attributed to low agricultural activities around this point. Downstream, there is an increase in human population and activities such as farming which use fertilizers to increase productivity. The study is similar to one done in Anko River, Ethiopia whose nitrate concentrations ranged between 1.6mg/l and 3mg/l (Gebre, 2017).

F. Phosphates

The concentration of phosphates ranged from 2.10±1.07 mg/L in Athi springs to 3.35±1.65mg/L in Gataka (Table 1).Phosphates can leach through soils and affect the ground water supply, but surface run-off of soils is the highest concern of phosphate contamination in streams and rivers (Mahmud &Said, 2013).Land uses can be attributed to the increased phosphate concentration between Athi springs and Embulbul. Comparatively, this study is similar to River Mohokare water quality analysis in Lesotho, with a phosphate range of 0.34mg/l to 1.14mg/l (Chatanga *et al.*, 2019).

G. Bacteriological Analysis

Site/ Parameter	Athi Springs	Embulbul	Gataka	WHO limit	P- value
Total Coliforms (MPN/100ml)	2415.0± 10.0	2400.0± 0.0	184.0± 52.19	Nil	0.04
Faecal Coliforms (MPN/100ml)	360.0± 33.91	2400.0± 0.0	7.25± 5.06	Nil	0.01

Table 2: Mean concentrations ± Standard deviations of Bacteriological Contamination

IV. TOTAL AND FECAL COLIFORMS

The mean total coliforms concentrations ranged between 2415.0± 10.0 MPN/100ml in Athi springs to 184.0± 52.19 MPN/100ml in Gataka.The increased number of coliform bacteria indicates pollution, which comes from waste waters from households in the surrounding settlements. The total coliform results in this study were similar to the study in River Ikpoba in Benin whose concentrations were above 1500 MPN/100ml (Length, 2016).The mean fecal coliform concentrations ranged between 2400.0± 10.0 MPN/100ml at Athi springs to 7.25± 5.06 MPN/100ml at Gataka. High fecal coliform counts in Embulbul could be attribute to the drainage of sewage into the river while at the Athi springs, it could be attributed to the animal waste dropped as animals drink water.These results are supported by previous studies conducted in River Awash Ethiopia, whose count was above 760MPN/100ml (Kebede *et al.*, 2020).

A. Correlation Analysis

	BOD	COD	$N0_3$	PO_3	T.C	F.C	TDS	Turbidity
BOD	1	0.93*	0.87**	0.60*	-0.84	-0.51	0.62*	0.87**
COD	0.93*	1	0.95**	0.44	-0.92	-0.47	0.76*	0.96**
NO_3	0.86*	0.95*	1	0.39	-0.90	-0.26	0.88*	0.97**
PO_3	0.60*	0.44	0.39	1	-0.12	-0.11	0.37	0.26
T.C	-0.84*	-0.92*	-0.92**	-0.12	1	0.61*	-0.69*	-0.97**
F.C	-0.51	-0.47	-0.26	0.11	0.61*	1	0.12	-0.45
TDS	0.62*	0.76*	0.88**	0.37	-0.69*	0.12	1	0.82**
Turbidity	0.87*	0.96*	0.97*	0.26	-0.97**	-0.45	0.82*	1

Table 3: Correlation analysis of water parameters

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Total coliforms had a negative correlation with all other parameters except fecal coliform, while fecal coliforms had a negative correlation with other parameters except TDS. From the above correlations, majority of the parameters had a significant correlation of either $p< 0.01$ or $p< 0.05$. The correlation between the physico-chemical and bacteriological parameters is similar to a study done in the streams of Gondor town, Ethiopia (Tessema *et al.*, 2019).

V. CONCLUSION

- Mbagathi River has microbiological contamination in terms of fecal and total coliforms as it exceeded the World Health Organisation (WHO) drinking water standards.
- Physicochemical parameters; COD, turbidity and phosphates were higher than theWHO standards. However, total dissolved solids (TDS) and nitrates were within the standards.

RECOMMENDATIONS

- Provision of adequate and clean drinking water to the residents living around Mbagathi River.
- Frequent monitoring of the water quality, to enhance improved public health conditions.

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