Assessment of Bacteria and Heavy Metal Contamination of River Maboro, Ankpa, Kogi State, Nigeria

ABSTRACT

This research was carried out in Maboro River, in Anpka LGA Kogi State. Samples were collected from three point, upstream, midstream and downstream - and each have a replication of three samples drawn from each point for more accurate result. Analysis of the concentration of some selected heavy metals: Iron (Fe), Lead (Pb) and Copper (Cu), pH, Nitrate and bacteria contamination were carried out. Data collected will be analyzed using Minitab Software and significant means was separated using Duncan Multiple Range Test (DMRT) at 5 % level of probability. Also, data was analyzed for various descriptive statistics (mean, standard deviation, standard error, coefficient of variation). The results revealed that there was no difference in the Fe concentration in all sampling points in the studied river (Upstream = 5.89 mg/l, Midstream = 6.60 mg/l, and Downstream = 5.93 mg/l). While highest Pb (1.79 mg/l) and Cu (4.27 mg/l) were recorded from Upstream. Midstream had Pb and Cu levels of 2.49 and 3.67 mg/l respectively while Downstream had 1.99 and 3.64 mg/l of Pb and Cu respectively. Bacteria contamination mostly occurred in upstream and downstream. This may be due to highest anthropogenic activities occurring at the upstream and the subsequent flow of the contaminants downwards. Highest coliform count was recorded at the downstream between $3.6x10^6$ to $4.3x10^5$ cfu/ml. while highest mean total bacteria was recorded from midstream $2.3x10^6$ cfu/ml (MacConkey Agar) and $4.1x10^6$ cfu/ml (nutrient agar).

Keywords: Surface water, Contamination, Bacteria, Heavy Metals

1. INTRODUCTION

Microbiological contamination refers to the non-intended or accidental introduction of infectious material like bacteria, yeast, mould, fungi, virus, prions, protozoa or their toxins and by-products (Kumari et al., 2019). Surface water pollution is generally caused by pathogens, nutrients, plastics, chemicals such as heavy metals, pesticides, antibiotics, industrial waste discharges, and individuals dumping into waterways. Some known contaminants of concern in drinking water include: Bacteria - Helicobacter pylori, the Salmonella family, and Escherichia coli (E.coli). The presence of coliform bacteria, specifically E. coli (a type of coliform bacteria), in drinking water suggests the water may contain pathogens that can cause diarrhea, vomiting, cramps, nausea, headaches, fever, fatigue, and even death sometimes. The biggest pollutant that surface water faces is usually from fertilizers and other harmful chemicals that are used on farms, in homes, and on infrastructure such as roads. Surface water pollution can also come from sewage leaks and waste products from farms that leach into the environment. Similarly, animals grazing in the surrounding areas also excrete into the environment and the microbial pollutants in part reach surface water bodies through surface runoff (Walker et al., 2019).

Heavy metal contamination in the aquatic environment has attracted global attention due to its abundance, persistence, and toxicity to the environment (Aziz et al., 2023). Accumulation of heavy metals can be transmitted to the trophic level of the food chain resulting in the breakdown of the natural balance of the ecosystems (Soliman et al., 2022). Apart from destabilizing the ecosystem, their potential long-term impact on ecosystem decontamination cannot be disregarded due to its toxic effects, exorbitance and persistence in the environment, and successive development in the environment. Heavy metal residues from the contaminated habitat may lead to bioaccumulation as well as bio-magnification in microorganisms, aquatic vegetation, and fauna, which consequently may enter into the human food chain and create many problems related to human health. The aim of this study was to assess heavy metal and bacteria contamination of River Maboro, Ankpa, Kogi State as well as assessment of the spatial variation of bacterial contamination surface water in study location.

2. MATERIALS AND METHODS

2.1 Study location

The river Maboro transects over five districts located in south earthen of Kogi including Okura Ubele, Ofu, Ankpa, and Otukpo watershed. This river is the major source of the main economic activities in district and most of these activities take place within the river itself and others take place within the catchments such activities include water abstraction, sewage treatment, cattle rearing, agriculture and agro-forestry and many other practices. The Maboro River has its source right within Ankpa town at a place called Ogaji, climate in the local government. Like other urban rivers and streams its faces similar threats of population and understanding its water quality dynamics as an urban river is an important aspect

2.2 Sampling

Three replicates water samples was collected from three sampling sites (upstream, midstream, downstream) in each surface water with the aid of plastic bottles.

2.3 Laboratory Analysis

Water samples collected were analyzed for: pH, lead (Pb), copper (Cu), and iron (Fe), nitrate, mean total bacteria and coliform count, and bacteria occurrence.

2.3.1 Digestions of Water Samples for Heavy Metal Determination

Thoroughly mixed sample was taken in an evaporating silica dish and acidified to methyl orange with conc. H_2SO_4, and 5mL conc. HNO_3 was also added. 2 mL of 30 % H_2O_2 was added to reduce chromate (if any). Next, mixed sample was evaporated by 10mL water and mixed with 5 mL conc. HNO_3 in purpose to transfer to 125 conical flask. The content was not allowed to dry during digestion. 1-2 ml of concentrated HNO_3 was further added to dissolve the remaining residue, and a few glass beads were also added to prevent bumping, and 50mL distilled water was added. Solution was boiled to dissolve the solids and then filtered through the sintered glass crucible. Thee filtrate was transferred to a 100 mL volumetric flask and made up to the mark with distilled water. The resulting solution was of 3N in H_2SO_4. Aliquots of the solution were used for the determination of metals. For determination of lead, 50 mL of ammonium acetate solution was added in the flask itself. Determination of heavy metals (iron - Fe, copper - Cu, and lead - Pb) in the water samples was done by preparing samples volumetrically and using a digital spectrophotometer as described in the manufacturer's instruction manual.

2.3.2 Determination of pH and Nitrate

pH was determined with the use of a portable pH meter (Aquariums/pH7). The meter was calibrated prior to use with buffer solutions of pH 7, 4 and 10 of known calibration standard. The probe of the meter was dipped into the sample and values obtained as displayed on the screen of the equipment. The determination of nitrate was done by the phenoldisulphonic acid method.

2.3.3 Microbiological Analysis

The labelled water samples collected from each location were analyzed as soon as they were submitted on Ice pack to the laboratory. The samples were diluted ten-fold (serial dilution) until dilution 10^{-5} was obtained. The 1 ml of 10^{-4} and 10^{-5} dilution was inoculated into molten nutrient Agar, Macconkey Agar and coliform count Agar in petri dishes that were appropriately labeled respectively. The inoculated media were allowed to set and plates were hereafter incubated at $35^{o}C$ for 24 hours and plates were inverted before incubation.

Colony forming Units (CFU/mls) on nutrient agar, Macconkey agar and coliform count agar were counted at the end of 24 hours incubation. Gram staining and microscopic observation were recorded. Sub-culture on selection and differential media, Macconkey Agar, Eosin methylene blue Agar and Hektoen enteric agar for further identification.

***Biochemical characterization*:** Catalase test, citrate utilization test, and triple sugar iron Agar were used to conduct biochemical test on the isolates from the water samples to presumptively identify the bacteria.

2.4 Statistical Analysis

Data collected will be analyzed using Minitab Software and significant means will be separated using Duncan Multiple Range Test (DMRT) at 5 % level of probability. Also, data was analyzed for various descriptive statistics (mean, standard deviation, standard error, coefficient of variation).

3. RESULTS

3.1 Concentration of heavy metals in Maboro, Ankpa Lga Kogi State

Table 1 shows the mean, minimum, maximum, SD, SEM, and CV concentration of selected heavy metals, Iron(Fe), Lead(pb), and Copper (cu) in Maboro River in Anpka LGA Kogi State, taken from upstream, midstream and downstream.

Table 1. Concentration of Heavy metals in Maboro River, Ankpa, Kogi State

Site	Fe (MgL^{-1})	Pb (MgL^{-1})	Cu (MgL^{-1})
Upstream	5.89	1.79	4.27
Mean	5.89	1.79 a	4.27 a
Minimum	5.80	1.60	4.13
Maximum	5.98	1.98	4.41
SD	0.09	1.19	0.14
SEM	0.05	0.11	0.08
CV	1.52	10.6	3.27
Midstream	6.60	2.49	3.67
Mean	6.60a	2.49b	3.67 b
Minimum	6.50	2.48	3.61
Maximum	6.70	2.51	3.74
SD	0.10	0.01	0.06
SEM	0.05	0.009	0.03
CV	1.51	0.61	1.81
Downstream	5.93	1.99	3.64
Mean	5.93	1.99b	3.64 b
Minimum	5.85	1.96	3.58
Maximum	6.10	2.02	3.70
SD	0.12	0.03	0.06
SEM	0.07	0.01	0.03
CV	2.09	1.50	1.64

Note: Means in a column with different letters are statistically significant at 5 % level of probability. SD = Standard Deviation, SEM = Standard Error of Mean, CV = Coefficient of Variation.

3.2 pH and Nitrate concentration of Maboro River, Ankpa Lga Kogi State

Table 2, shows the mean pH and Nitrate concentration of water samples from Maboro river, Ankpa Local Government, Kogi State. It was observed that there was no significant difference in the pH of water samples from the upstream, midstream, and downstream. There was no significant difference in the Nitrate concentration of water samples from the upstream, midstream and downstream with concentration value of 3.05, 3.11 and 3.05 respectively.

Table 2. pH and Nitrate Concentration of Maboro River, Ankpa, Kogi State

Site	pH	Nitrate (MgL^{-1})
Upstream	7.30	3.05
Mean	7.30	3.05
Minimum	6.8	3.04
Maximum	7.80	3.06
SD	0.50	0.01
SEM	0 .28	0.006
CV	6.84	0.32
Midstream	6.73	3.11
Mean	6.73	3.11
Minimum	6.70	3.08
Maximum	6.80	3.15
SD	0.05	0.03
SEM	0.03	0.02
CV	0.85	1.12
Downstream	7.50	3.05
Mean	7.50	3.05
Minimum	7.40	3.04
Maximum	7.60	3.06
SD	0.10	0.01
SEM	0.05	0.006
CV	1.33	0.32

3.3 Mean Total Bacteria and Coliform Count of Maboro River, Ankpa Lga Kogi State

The mean total bacteria for the upstream ranged $2.1x10^6$ to $3.2\ x10^6$ (Nutrient Agar) and $1.2x10^6$ to $1.7x10^6$ (MacConkey Agar) while Coliform count Agar was between $1.7x10^6$ to $3.1x10^5$. For the midstream, mean total bacteria for the upstream ranged $1.2x10^6$ to $4.1\ x10^6$ (Nutrient Agar) and $1.1x10^6$ to $2.3x10^6$ (MacConkey Agar) while Coliform count Agar was between $1.2x10^6$ to $2.4x10^5$. On the otherside, Downstream had mean total bacteria for the upstream ranged $2.3x10^6$ to $3.2\ x10^6$ (Nutrient Agar) and $1.1x10^6$ to $2.1x10^6$ (MacConkey Agar) while Coliform count Agar was between $3.6x10^6$ to $4.3x10^5$.

Table 3. Mean Total Bacteria and Coliform Count of Olamaboro River, Ankpa, Kogi State

Sample	Nutrient Agar(CfU/ml)	MacConkey Agar cfu/ml	Coliform count Agar (cfu/m/l)
UR 1	$3.2\ x10^6$	$1.7x10^6$	$3.1x10^5$
UR 2	$2.1x10^6$	$1.2x10^6$	$1.7x10^6$
UR3	$2.6x10^6$	$1.4x10^6$	$2.4x10^6$
MR 1	$1.2x10^6$	$1.1x10^6$	$2.4x10^5$
MR 2	$4.1x10^6$	$2.3x10^6$	$2.3x10^6$
MR3	$2.6x10^5$	$1.7x10^6$	$1.2x10^5$
DR 1	$2.3x10^5$	$1.1x10^5$	$4.3x10^5$
DR 2	$3.2x10^5$	$2.1x10^5$	$3.6x10^5$
DR3	$2.7x10^5$	$1.6x10^5$	$3.9x10^5$

Note: UR = upstream, MR = Midstream, DR = Downstream.

3.4 Bacteria Occurrence in Maboro River Ankpa, LGA in Kogi State

Bacteria occurrence is presented in Table 4. The results showed that *Enterobacter spp* was present in upstream and midstram; *E.coli, Nocardia spp,* and *Pseudomona spp* were present in upstream and downstream; *Salmonella spp* was only present in downstream while *Lactobacillus spp* was only present in upstream.

Table 4: Bacteria occurrence in Olamaboro River, Ankpa, Kogi State

Presumptive Bacteria Isolated	Upstream	Upstream	Upstream	Midstream	Midstream	Midstream	Downstream	Downstream	Downstream
Enterobacter spp	+	+	+	+	+	+	-	-	-
E.coli	+	+	+	-	-	-	+	+	+
Proteus spp	-	-	-	+	-	-	-	-	-
Websiella spp	-	-	-	-	-	-	-	-	-
Pseudomona spp	+	+	+	-	-	-	-	+	-
Salmonella spp	-	-	-	-	-	-	+	+	+
Micrococcus	-	-	-	-	-	-	-	-	-
Bacillus spp	+	-	-	-	+		-	+	+
Nocardia spp	+	-	-	-	-	-	-	+	-
Lactobacillus spp	+	-	-	-	-	-	-	-	-
Shigella	-	-	-	-	-	-	-	-	-

Note: occurrence (+) and non-occurrence (-) of some bacteria.

4. DISCUSSIONS

4.1 Concentration of Selected Heavy Metal

The concentrations of Cu, Fe, and Pb in the upstream, midstream and downstream of Maboro River in Ankpa LGA Kogi state were above WHO (2004) permissible limits. This may be due to anthropogenic sources such as agricultural activities and solid waste disposal into the river. For example, Cu may be present in surface water due to the release of Cu-containing industrial effluents while Pb may be due to the disposal of lead-containing waste. The continuous use or the use of large amounts of fertilizers and amendments to increase crop production can cause contamination of soils and waters due to some harmful impurities like heavy metals contained in them (Singh & Steinnes, 2020; Hoang et al., 2020).

4.2 pH and Nitrate concentration of Maboro River, Anpka LGA in Kogi State

The WHO standard of pH water concentration is 6.5 to 8.5 and when compared to the results recorded from the studied locations, the pH is within the threshold that cannot cause harm to human and their environment. Similarly, the nitrate concentrations of Maboro River, Anpka LGA in Kogi State were within the WHO permissible limits. There are a few different reasons why the concentration of nitrate in surface water may be low. One possible reason is that the amount of nitrogen entering the water body is low, perhaps due to reduced fertilizer use in the area or reduced runoff from agricultural fields. Another possible reason is that the nitrate is being removed from the water by denitrification, a process in which bacteria convert nitrate into nitrogen gas. This process can occur when nitrate-rich water enters anoxic (oxygen-poor) environments, such as wetlands or groundwater aquifers.

4.3 Bacteria Contamination in Maboro River, Anpka LGA Kogi State

Bacteria contamination mostly occurred in upstream and downstream. This may be due to highest anthropogenic activities occurring at the upstream and the subsequent flow of the contaminants downwards. Surface water pollution can also come from sewage leaks and waste products from farms that leach into the environment. Similarly, animals grazing in the surrounding areas also excrete into the environment and the microbial pollutants in part reach surface water bodies through surface runoff (Haldar et al, 2022). Highest coliform count was recorded at the downstream while highest mean total bacteria was recorded from midstream. The presence of Escherichia coli (E. coli) in surface water is an indication of fecal contamination and can pose a health risk to humans. E. coli is a common intestinal bacterium that is found in the feces of warm-blooded animals, including humans. While most strains of E. coli are harmless, some can cause serious illness, including diarrhea, kidney failure, and even death. Surface water contaminated with E. coli can be a source of illness for people who swim in or otherwise come into contact with the water. This is particularly a concern in recreational waters such as lakes, rivers, and oceans.

5. CONCLUSIONS

The result from the study showed that there was no difference in the Fe concentration in all sampling points in the studied river. While highest Pb and Cu were recorded from upstream. Bacteria contamination mostly occurred in upstream and downstream. This may be due to highest anthropogenic activities occurring at the upstream and the subsequent flow of the contaminants downwards. Highest coliform count was recorded at the downstream between while highest mean total bacteria was recorded from midstream.

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