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

Short Research Article

ABSTRACT

This research was carried out to assess heavy metal and bacteria contamination of River Imaboro, Ankpa, Kogi State, Nigeria. Three replicate samples were collected from three sites (upstream, midstream and downstream) in June, 2023. Analysis of the concentration of some heavy metals [Iron (Fe), Lead (Pb) and Copper (Cu)], pH, nitrate and bacteria contamination were carried out. Data collected were analyzed using Minitab software and significant means were separated using Duncan Multiple Range Test (DMRT) at 5 % level of probability. 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 from natural sources such as rock weathering may cause less human and environmental health risks compared to those from anthropogenic activities such as mining, metal-related factories, fertilizer, and pesticide usage in agriculture because they are more mobile and bioavailable (Hoang et al., 2020).

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.

Ocheja et al. (2019) examined the seasonal variations in the quality of Imaboro river water, Ankpa town, Kogi State, Nigeria in March/June 2018. The results indicated a lowering in the water quality of the river with parameters such as temperature, EC, turbidity, BOD, COD, PO4 2-, NH3-N, SO4, Fe, Pb, total coliforms, and E. coli having values above World Health Organization (WHO) and NSDWQ recommended standards for human consumption. Furthermore, the results showed that seasonal variations exist in the physico-chemical and biological characteristics of the water quality of the river. Yunusa et al. (2023) reported that the mean values of the physico-chemical parameters (temperature, turbidity, pH, dissolved oxygen, water hardness, alkalinity, ammonia, nitrate, and nitrite) of River Imaboro were within the acceptable limits of WHO but significant difference were observed between the months of study and sampling sites. The aim of this study was to assess heavy metal and bacteria contamination of River Imaboro, Ankpa, Kogi State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study location

The river Imaboro 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 Imaboro River has its source right within Ankpa town at a place called Ogaji. Ankpa town is located between Latitudes 70^{0}16^{0}N and 7^{0}24^{0}N and Longitudes 7^{0}22^{0}E and 7^{0}51^{0}E. 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 in June, 2023.

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. 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 were analyzed using Minitab Software and significant means were separated using Duncan Multiple Range Test (DMRT) at 5 % level of probability. Also, data was subjected to descriptive statistics (mean, standard deviation, standard error, coefficient of variation).

3. RESULTS

3.1 Concentration of heavy metals in Imaboro, 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 Imaboro River in Anpka LGA Kogi State, taken from upstream, midstream and downstream.

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

Table 2, shows the mean pH and Nitrate concentration of water samples from Imaboro 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 mg/l respectively.

Table 2. pH and Nitrate Concentration of Imaboro 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 Imaboro 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 OlaImaboro 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 Imaboro 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 Olalmaboro River, Ankpa, Kogi State

Presumptive Bacteria Isolated	Upstr eam	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 Metals in Imaboro River, Anpka LGA, Kogi State, Nigeria

The concentrations of Cu, Fe, and Pb in the upstream, midstream and downstream of Imaboro 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 sources of water (Singh & Steinnes, 2020; Hoang et al., 2020). Globally, a decreasing trend for Zn and Pb have been recorded from rivers and lakes while an increasing trend for Fe, Mn, Ni, Cu, Cr, and Cd have been observed with mean dissolved concentration higher in Asia than in Europe (Li et al., 2020).

4.2 pH and Nitrate concentration of Imaboro River, Anpka LGA, Kogi State, Nigeria

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 the environment. Similarly, the nitrate concentrations of Imaboro River, Anpka LGA in Kogi State were within the WHO permissible limits (2011). There are a few 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, possibly due to reduced fertilizer use in the area or reduced runoff from agricultural fields. Another reason may be that 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 Imaboro River, Anpka LGA, Kogi State, Nigeria

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 while highest mean total bacteria was recorded from midstream.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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