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Water quality assessment of Nwangele river in Imo State, Nigeria

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ABSTRACT

Water quality assessment of Nwangele river was undertaken using standard methods. Water samples were drawn from upstream, midstream and downstream of the river and assessed for quality. Results obtained for physicochemical characteristics showed pH (4.83±.0.01-5.00±0.31), total solid (200.00±2.40-613.19±1.10 mg/L), and total suspended solid (49.98±0.11-399.04±2.09 mg/L). Heavy metals found in the river water were iron (0.132±0.01- 0.144±0.02 mg/L), zinc (0.034±0.02- 0.044±0.02 mg/L), mercury (0.004±0.001- 0.011±0.00 mg/L), lead (0.008±0.00- 0.016±0.00 mg/L) and cadmium (0.03±0.01- 0.011±0.00 mg/L). Microbiological studies on the river revealed the presence of *Klebsieilla sp., Vibro sp., Pseudomonas sp., Proteus sp., Escherichia sp., Staphylococcus sp., Shigella sp., Bacillus sp., Serratia sp., Citrobacter sp., and Enterobacter sp* as bacterial isolates with high total heterotrophic bacteria count (THBC), total coliform count (TCC), *Salmonella-shigella* count (SSC), and total viable count (TVC). Nwangele River water is acidic, with high total suspended solid, phosphate and microbial loads. It is therefore advisable to purify water from the river before consumption. This study has assessed the water quality of Nwangele river in Imo State, Nigeria

KEYWORDS: Heavy metals, physicochemical characteristics, microbiological studies, Nwangele river, water quality

INTRODUCTION

Polluted water is one with impaired water quality [1]. The use of such water by different life forms is hampered. This is due to the presence of anthropogenic contaminants [1]. Anthropogenic contaminants are products of anthropogenic activity of man. It has been reported that water pollution is among the leading cause of death and diseases worldwide [2]. The World Health Organization (WHO) noted that 80% of all sicknesses and diseases in the world are associated with water, either directly through contamination with microbes or associated with vectors or caused by metal contaminants that can be detrimental to life [3].

The Nigerian coastal environment with diverse ecosystems, rich natural resources, and large human population is saddled with high anthropogenic activity, which results in generation of anthropogenic contaminants [4,5]. These contaminants pollute water resources, and have been reported to pose a threat to both managements of ecosystems and public health [4, 6,7]. In recent times, the pollution of water resources in Nigeria by anthropogenic activity of man, especially surface water bodies have attracted public attention. Hence, attempts have been made to evaluate the pollution status of some surface water sources within Nigeria by assessment of their water quality [8-18] However, there are also others with unknown pollution status.

Nwangele river is among the rivers in Nigeria with unknown pollution status, and has attracted public attention due to anthropogenic contaminants that empty into the river as a result of anthropogenic activities going on around the river and its banks. Nwangele River is found in Nwangele Local Government Area of Imo State, Nigeria. It is believed to have originated from Isiekenesi town, and passed through villages in Nwangele L.G.A. It is located within Imo River Basin [19]. The river discharges into Oramiriukwa, a tributary of Imo River [19], are mainly depended water bodies by local people. Wastes generated from Joint Hospital (School of Nursing, Amaigbo), Nwanya and Nkwo mmiri markets empty into the river during heavy rainfall. Agro-chemicals also find their way into the river from the surrounding agricultural lands. Human activities such as bathing, washing of cloths, debris from automobile cars, detergents, spent oils, and etcetera, generate chemicals, which flow into the river and pollute it.

As one of the water bodies in Nigeria with un-highlighted pollution status, and considering its importance as a source of water to local people (Nwangele and its environs), there is need to ascertain the pollution status of the river by assessing its water quality. The present study assessed the water quality of Nwangele River with a view to ascertain its pollution status.

MATERIALS AND METHODS

Study Site

Nwangele river is found in Nwangele Local Government Area of Imo State, Nigeria. It is located within Imo river basin. It takes its root from way up Isiekenesi town, and meanders through most Amaigbo areas such as Umuanu and Amaju; and then finally enroute to Owerri Nta where it empties itself into Imo river. The river discharges into Oramiriukwa, a tributary of Imo river.

Water Sample Collection

The water samples were collected from Nwangele river at three sampling points. The sampling points were Upstream, Midstream and Downstream. The points were at least 120 meters from each other. The sampling was done [37] and bacteriological analyses [20] were performed.

Physicochemical Paramete Analyse

pH and conductivity were measured *in situ* using pH meter and conductivity meter respectively. Total solids (TS), total suspended solids (TSS), and total dissolved solid (TDS) were determined [21]. Total hardness (TH) was done by EDTA titrimetric method. Chloride (Cl^-) was estimated using Argentometric method. Dissolved oxygen (DO) was estimated with modified Wrinkle`s method. Biochemical oxygen demand (BOD) was estimated [22]. Sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), and nitrate (NO_3^-) were estimated using the procedures given by APHA [23]. Heavy metals such as iron, copper, manganese, zinc, chromium, cadmium, arsenic, mercury, cobalt and lead were estimated using atomic absorption spectrophotometer (AAS).

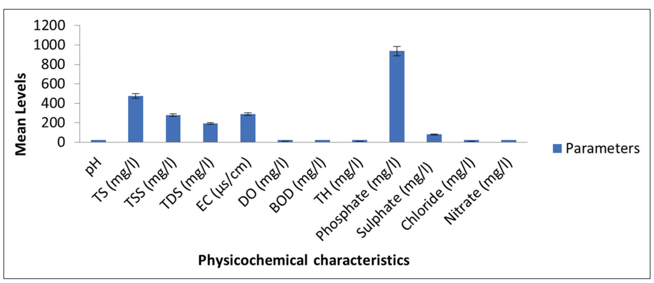

Figure 1: Mean levels of the physicochemical characteristics.

Microbiological Studies

The methods as described by Uzoigwe and Agwa [24] were strictly followed for the isolation of total culturable heterotrophic bacteria, enumeration of total coliforms, isolation of *Salmonella-Shigella* species, and total viable counts (TVC)

Identification of Isolates

Cultural, morphological and biochemical characteristics of the respective isolates were compared with the criteria in Bergey's manual of Determinative Bacteriology [25].

Measurement of pH provides information on the intensity of acidic or basic nature of water [26]. Table 1 represents physicochemical characteristics of Nwangele River. From the Table, pH values of the considered points ranged from 4.83±.0.01 to 5.00±0.31 and were lower than NSDWQ maximum permissible limit and WHO standard. The water body had a mean acidic pH of 4.94 (Figure 1). Akaninwor and Egiwm [15] attributed low pH of a water body to presence of humic acids generated by some death aquatic life forms affected by anthropogenic activity. Effects of acidic water in the stomach [13], on fish production [6] and leaching of heavy metal ions (Ali *et al*., 2013) have been reported. Total solid value of Nwangele river ranged from 200.00±2.40 to 613.19±1.10 mg/L, with a mean value of 474.08 mg/L. The mean total solid is lower than NSDWQ maximum permissible limit. Some of the observed solid may have dissolved in the river to produce total dissolved solid range of 150.02±0.22 to 219.65±0.95 mg/L as observed in the present study, whereas some may have remained un-dissolved as total suspended solid, which ranged from 49.98±0.11 to 399.04±2.09 mg/L The mean for total suspended solid (280.85 mg/L) is higher

Table 1: Physicochemical parameters of Nwangele river

Parameters	Upstream	Midstream	Downstream	NSDWQ Standards (MPL)	WHO Standard
pH	$4.83\pm0.0.01^{a}$	5.00 ± 0.31^{b}	4.98 ± 0.20^{b}	6.5-8.5	6.50-8.50
Total solid (mg/L)	200.00 ± 2.40^{a}	609.04 ± 1.02^{b}	613.19 ± 1.10^{c}	500 mg/l	NHB
Total suspended solid (mg/L)	49.98 ± 0.11^{a}	399.04 ± 2.09^{c}	393.54 ± 4.27^{b}	NAD	50.00
Total dissolved solid (mg/L)	150.02 ± 0.22^{b}	210.00 ± 1.84^{a}	219.65 ± 0.95^{c}	NAD	250.00
Electrical conductivity (μS/cm)	224.27 ± 4.15^{a}	313.43 ± 3.01^{b}	327.84 ± 1.04^{c}	1000	NHB
Dissolved oxygen (mg/L)	11.34 ± 0.17^{a}	9.87 ± 0.13^{a}	9.45 ± 0.19^{a}	NAD	10.0
Biological oxygen demand (mg/L)	2.29 ± 0.01^{a}	3.12 ± 0.84^{b}	3.09 ± 1.02^{b}	NAD	10.0
Total hardness (mg/L)	12.50 ± 0.18^{b}	9.87 ± 0.13^{a}	9.45 ± 0.19^{a}	150	500
HCO_3^-(mg/L)	24.40 ± 1.04^{a}	54.90 ± 2.01^{c}	51.38 ± 1.05^{b}	-	-
PO_4^{3-} (mg/L)	937.58 ± 9.01^{b}	933.60 ± 7.90^{a}	940.50 ± 4.00^{c}	-	-
SO_4^{2-} (mg/L)	49.87 ± 3.16^{a}	101.75 ± 1.17^{c}	90.78 ± 2.08^{b}	100	NHB
Cl^- (mg/L)	10.65 ± 0.78^{a}	12.43 ± 1.81^{ab}	13.14 ± 0.56^{b}	250	250
Nitrate (NO_3^-mg/L)	0.67 ± 0.01^{a}	0.98 ± 0.10^{b}	0.90 ± 0.05^{b}	50	50

Results are means and standard deviation of triplicate determinations: Values with different letters of the alphabets along the same row are statistical significant ($p<0.05$) letters of the alphabets along the same row are statistical significant ($p<0.05$) NSDWQ (MPL): Nigerian Standard for Drinking Water Quality; MPL: Maximum Permissible Limits; WHO: Wold Health Organization; NHB= No Health Baseline

Table 2: Heavy metals levels of Nwangele river (mg/L)

Parameters	Upstream	Downstream 1	Downstream 2	NSDWQ (MPL)	WHO Standard
Iron	0.132±0.01[a]	0.139±0.04[b]	0.144±0.02[c]	0.3	0.3
Copper	0.011±0.00[a]	0.139±0.00[b]	0.144±0.09[c]	1.0	2.0
Manganese	0.028±0.01[a]	0.037±0.00[b]	0.044±0.01[c]	0.2	0.20
Zinc	0.034±0.02[a]	0.044±0.02[b]	0.039±0.01[ab]	3	NHB
Chromium	0.021±0.00[b]	0.011±0.00[a]	0.026±0.01[c]	0.05	0.05
Cadmium	0.03±0.01[a]	0.011±0.00[c]	0.009±0.002[b]	0.03	0.003
Arsenic	0.011±0.00[a]	0.013±0.00[ab]	0.018±0.00[b]	0.01	0.01
Cobalt	0.015±0.001[a]	0.024±0.01[b]	0.018±0.01[ac]	-	-
Lead	0.013±0.00[a]	0.008±0.00[c]	0.016±0.00[b]	0.01	0.01
Mercury	0.004±0.001[a]	0.009±0.001[ab]	0.011±0.00[b]	0.01	0.006

Results are means and standard deviation of triplicate determinations: Values with different letters of the alphabet along the same row are statistical significant ($p<0.05$) NSDWQ (MPL): Nigerian Standard for Drinking Water Quality; MPL: Maximum Permissible Limits; WHO: World Health Organization; NHB= No Health Baseline

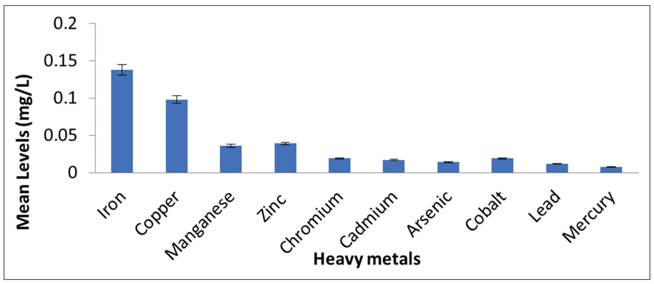

Figure 2: Mean heavy metals in Nwangele river

than WHO standard. The effect of consuming water with high solid has been reported by Akubugwo *et al*. [10]. The electrical conductivity of the studied river ranged from 224.27±4.15 to 327.84±1.04 μS/cm and has a mean value (288.51 μS/cm) that is lower than NSDWQ maximum permissible limit. Ray *et al*. [27] noted the relationship between electrical conductivity (EC) and total dissolved solid (TDS) in water. The importance of dissolved oxygen (DO) and biological oxygen demand (BOD) as applied to a water body cannot be over emphasized [23, 28]. According to Garg *et al*. [29], DO concentration of more than 5.00 mg/L support aquatic life. The dissolved oxygen levels of the present study ranged from 9.45±0.19 to 11.34±0.17 mg/L with a mean value of 10.22 mg/L. The biochemical oxygen demand (BOD) levels of the studied water body ranged from 2.29±0.01 to 3.12±0.84 mg/L with a mean BOD value of 2.83 mg/L. The observed BOD levels were lower than their respective dissolve oxygen levels (DO). This could be indication that oxygen demand generally did not exceed the oxygen production and aeration rate for each of the considered points. It therefore has no effect on the dissolved oxygen deficiency [30]. According to Moore and Moore [31] category of water based on BOD levels, Nwangele river water could be seen as being fairly clean since its BOD levels and the mean value fall with 2-3 mg/L. The total hardness for the points ranged from 9.45±0.19 to 12.50±0.18 mg/L with a mean total hardness value of 10.61 mg/L for the river. The observed total hardness values and the mean are lower than both NSDWQ maximum permissible limit and WHO standard. Gray [32] noted that water with degree of hardness of 0-50mg/L is classified as soft water. Soft water is known to form leather easily with soap. Different authors have noted the relationship between sulphate, phosphate, and nitrate levels of a water body to influence of human activities such as farming on lands surrounding it [10]. Phosphate ranged from 933.60±7.90 to 940.50±4.00 mg/L with a mean value of 937.23 mg/L. The high phosphate levels could be behind the existence of some blue-green algae on the water surface of Nwangele river. On comparing the levels of phosphate to that of sulphate 49.87±3.16 to 101.75±1.17 mg/L, and nitrate 0.67±0.01 to 0.98±0.10 mg/L. One may conclude that more phosphate based fertilizer may have been used on farm lands surrounding Nwangele river, followed by sulphate and then nitrate based types. High nitrate concentration in drinking water is associated with the development of methaemoglobinaemia in infants [33]. Chloride ranged from 10.65±0.78 to 13.14±0.56 mg/L with a mean value of 12.07 mg/L. The levels of sulphate, chloride and nitrate, and their mean values were lower than WHO standards and NSDWQ maximum permissible limits.

Levels of heavy metals (Table 2) in Nwangele river and their means values (Figure 2) revealed the presence of iron (0.132±0.01 -0.144±0.02 mg/L) with a mean value of 0.138 mg/L, copper (0.011±0.00 - 0.144±0.09 mg/L) with a mean value of 0.098 mg/L, manganese (0.028±0.01-0.044±0.01 mg/L) with a mean of 0.036 mg/L, zinc (0.034±0.02-0.044±0.02 mg/L) with a mean of 0.039 mg/L, chromium (0.011±0.00-0.026±0.01 mg/L) with a mean of 0.019 mg/L, cadmium (0.009±0.002-0.03±0.01 mg/L) with a mean value of 0.017 mg/L, arsenic (0.011±0.00-0.018±0.00 mg/L) with a mean value 0.014 mg/L, cobalt (0.015±0.001-0.024±0.01 mg/L) with a mean value of 0.019 mg/L, lead (0.008±0.00-0.016±0.00 mg/L) with a mean value of 0.012 mg/L, and mercury (0.004±0.001-0.011±0.00 mg/L) with a mean value of 0.008 mg/L. Cadmium and arsenic levels were higher than their respective WHO standards. Levels of lead in upstream, downstream and the mean values were higher than WHO standard. Mercury levels in midstream and downstream, and the mean value were high than WHO standard. Some known health effect of heavy metals found in water has been reported by Akubugwo *et al*.[10].

According to Akubugwo *et al*. [10] and Pipes [34], microbial presence in a water body is an index of biological pollution. Bacterial isolates from Nwangele river as presented in Table 3 showed organisms such as *Klebsieilla sp*., *Vibro sp*., *Pseudomonas sp*., *Proteus sp*., *Escherichia sp*.,

Table 3: Bacterial isolates from Nwangele river

Gram Staining	Spore staining	Motility	Catalase	Oxidase	Indole	Urease	Lactose	Maltase	Suspected organism
-ve	-ve	-ve	+ve	-ve	-ve	+ve	A	A	*Klebsieilla sp.*
+ve	-ve	-ve	+ve	-ve	-ve	-ve	A	A	*Vibro sp.*
-ve	-ve	+ve	+ve	+ve	-ve	+ve	-ve	-ve	*Pseudomonas sp.*
+ve	+ve	+ve	-ve	+ve	+ve	+ve	-ve	A	*Proteus sp.*
-ve cocci	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	*Escherichia sp.*
-ve rod	-ve	+ve	+ve	+ve	+ve	-ve	A	A	*Staphylococcus sp.*
-ve rod	-ve	-ve	+ve	+ve	-ve	-ve	-ve	-ve	*Shigella sp.*
-ve rod	+ve	+ve	-ve	-ve	-ve	+ve	-ve	-ve	*Bacillus sp.*
-ve rod	-ve	+ve	-ve	-ve	-ve	-ve	A	A	*Serratia sp.*
-ve rod	-ve	+ve	+ve	-ve	+ve	+ve	A	A	*Citrobacter sp.*
-ve rod	-ve	-ve	+ve	-ve	-ve	-ve	A	A	*Enterobacter sp.*
-ve rod	-ve	-ve	+ve	-ve	-ve	-ve	A	A	*Klebsiella sp.*

Key: -ve=negative, +ve=positive, A=acid

Table 4: Dominant species of isolated bacteria with respect to the sampling points considered

Organism	Upstream	Midstream	Downstream
Proteus sp.	√√	√√	√
Pseudomonas sp.,	√√	√√	√
Vibro sp.	√√	√	√
Klebsiella sp.	√√	√	√√
Escherichia sp.	√	√√	√
Serratia sp.	√	√√	√
Staphylococcus sp.	√	√	√
Enterobacter sp.	√	√	√√
Shigella sp.	√	√	√
Bacillus sp.	√	√	√
Citrobacter	√	√	√√

Key: √= present in the sampling point; √√= dominant specie in the sampling point

Table 5: Groups of isolated bacteria from Nwangele river with respect to the sampled points

Organism (cfu/mL)	Upstream	Midstream	Downstream
THBC	1.2×10^4	2.3×10^4	2.4×10^4
TCC	6.0×10^2	9.0×10^2	1.0×10^2
SSC	5.0×10^2	8.2×10^2	9.1×10^1
TVC	4.1×10^3	7.1×10^3	8.0×10^3

THBC=Total heterotrophic bacteria count; TCC=Total coliform count; SCC=S*almonella Shigella* count; and TVC=Total viable count

Staphylococcus sp., Shigella sp., Bacillus sp., Serratia sp., Citrobacter sp., and Enterobacter sp. These bacteria become important when their implications are considered in the body of humans. These isolated organisms have been implicated as agents of different diseases [20, 35-36]. With respect to sampling points, dominant species of isolated bacteria were also examined. Dominant species of isolated bacteria with respect to sampling points considered as presented in Table 4 revealed that organisms such as *Proteus sp.* and *Pseudomonas sp.* were dominant in upstream and downstream; *Vibro sp.*, was dominant in upstream; *Klebsiella sp.* was dominant in upstream and downstream; *Escherichia sp.* and *Serratia sp.* were dominant in midstream; *Enterobacter sp.* and *Citrobacter sp.* were dominant in downstream while *Staphylococcus sp., Shigella sp.*, and *Bacillus sp* were not dominant in any of the considered sampling points. Groups of isolated bacteria from Nwangele river as presented in Table 5 were high. From the results, downstream produced the highest groups of total heterotrophic bacteria count (THBC), total coliform count (TCC), *Salmonella-shigella* count (SSC), and total viable count (TVC); followed by those of the midstream and then upstream. Anthropogenic activity of man could be behind the observed increase in bioloads along the sampling points.

CONCLUSION

The present study has shown that Nwangele river water is an acidic one, with high total suspended solid, phosphate and microbial loads. It is therefore advisable to purify the water from the river before consumption. This study has assessed the water quality of Nwangele river in Imo State, Nigeria.

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