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Water Quality Assessment of the New Calabar River

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Authors' contributions

This work was carried out in collaboration between all authors. Author HOS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OMI and AN managed the analyses of the study. Author OMI managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Water is one essential natural resource whose quality must be periodically assessed and managed. This study was conducted within the Choba portion of the New Calabar River. Surface water samples were collected from three points along the river course and analyzed for their physicochemical and microbiological properties. The physicochemical parameters monitored were temperature, pH, salinity, dissolved oxygen, total dissolved solids, biochemical oxygen demand, chemical oxygen demand, chloride, nitrate, phosphate, sulphate, oil and grease, cadmium, chromium, copper and lead. Results for all monitored physicochemical parameters were within recommended limits except for cadmium (Cd) and lead (Pb). Total aerobic heterotrophic bacterial (THB) counts of the water samples ranged from $5.1x10^4$ – $8.3x10^7$, total coliform (TC) count ranged from $1.5x10^3$ – $4.3x10^5$ cfu/100 ml and total thermotolerant coliform (TTC) count ranged from 4.9 $x10^2$ - 3.7 $x10^5$ cfu/100 ml. The results indicated that the water from the New Calabar River has poor microbiological quality, according to quality guidelines for drinking water.

Keywords: Water quality; physicochemical; microbiological.

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1. INTRODUCTION

Water quality refers to the relative abundance of physical, chemical and biological agents whose presence in water render it unacceptable aesthetically or for consumption. Urbanization and human population explosion brings a gradual deterioration of water quality [1]. Many natural water bodies in developing countries are nauseatingly polluted with industrial effluents, sewage and runoffs [2-5]. A disturbing fact is that water sources available for agricultural, industrial, recreational and commercial purposes in these countries are left untreated before use [6-7].

River water quality in Nigeria is deteriorating; particularly those situated near areas experiencing quick economic development and have become economic centres [8]. The New Calabar River is an important river artery at the western fringe of the oil city of Port Harcourt, Nigeria. The water quality is in constant threat to deterioration due to human activities. The surface water quality of the New Calabar River has been reported to be affected by domestic and industrial wastes. The specific contaminants of the river water varies from time to time and may include a combination of naturally occurring chemical elements, oxygen demanding substances both natural and anthropogenic, pathogens and factors that can alter the physical chemistry of water such as temperature, pH, electrical conductivity and discolouration [9].

Water quality is an issue of environmental and public health concern because the survival of organisms depends on it [10]. Prevention of river pollution requires effective monitoring of physicochemical and microbiological parameters [3]. Surface water quality is not a static condition. Hence, periodic assessment for its suitability for domestic, agricultural, industrial, recreational purposes, as well as for ability to sustain aquatic life is a continuous necessity. The aim of this study was to ascertain the current surface water quality parameters of the New Calabar River.

2. MATERIALS AND METHODS

2.1 Study Area and Samples Collection

The New Calabar River is a low lying deltaic river located in Rivers States, in the oil-rich Niger Delta Region of Nigeria. The New Calabar River lies between 4º30' and 4º49'N and 6º59' and 7º00' and empties into the Atlantic Ocean. Water samples were collected at peak of the wet season from three points at the Choba portion of the rivers. Point 1 is proximate to an effluent discharge point of a food processing company (Dufil Prima Foods), 2 is proximate to the work yard of an oil servicing company (Ascot Offshore Nigeria Limited) and 3 is proximate to University of Port Harcourt staff quarters. All samples were collected and transported to the Microbiology laboratory of the University of Port Harcourt for immediate analysis.

2.2 Microbiological Analysis

Water samples were serially diluted and pour-plated in nutrient agar (NA) supplemented with 1.0% NaCl and incubated at 35℃ for 24 hrs to determine total aerobic heterotrophic bacterial (THB) count. Total coliforms and total thermotolerant coliforms were detected and quantified with the use of Eosin methylene blue (EMB) agar. *Salmonella-Shigella* Agar (SSA) was used to confirm and identify *Salmonella* and *Shigella*. All plates were in triplicate. Isolates were identified based on their cultural, morphological, biochemical characteristics and by reference to Bergey's Manual of Determinative Bacteriology.

2.3 Physicochemical Analyses

Turbidity, temperature, pH, Dissolved Oxygen (DO), Total Dissolved Solid (TDS), salinity and conductivity were analysed in situ with a HORIBA, U-51 series Multi-parameter water quality checker. Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), chloride, sulphate, phosphate, nitrate, oil and grease were determined as described by the American Public Health Association [11]. Atomic absorption Spectrophotometry was used for heavy metals analysis.

2.4 Statistical Analysis

Analysis of Variance (ANOVA) was used to establish significant differences within parameters from different sampling points of the river at ($P<0.05$).

3. RESULTS AND DISCUSSION

The results obtained from physicochemical analysis of the New Calabar River water samples are shown in Table 1. Measured parameters were compared against the World Health Organization [12] standards for portable water.

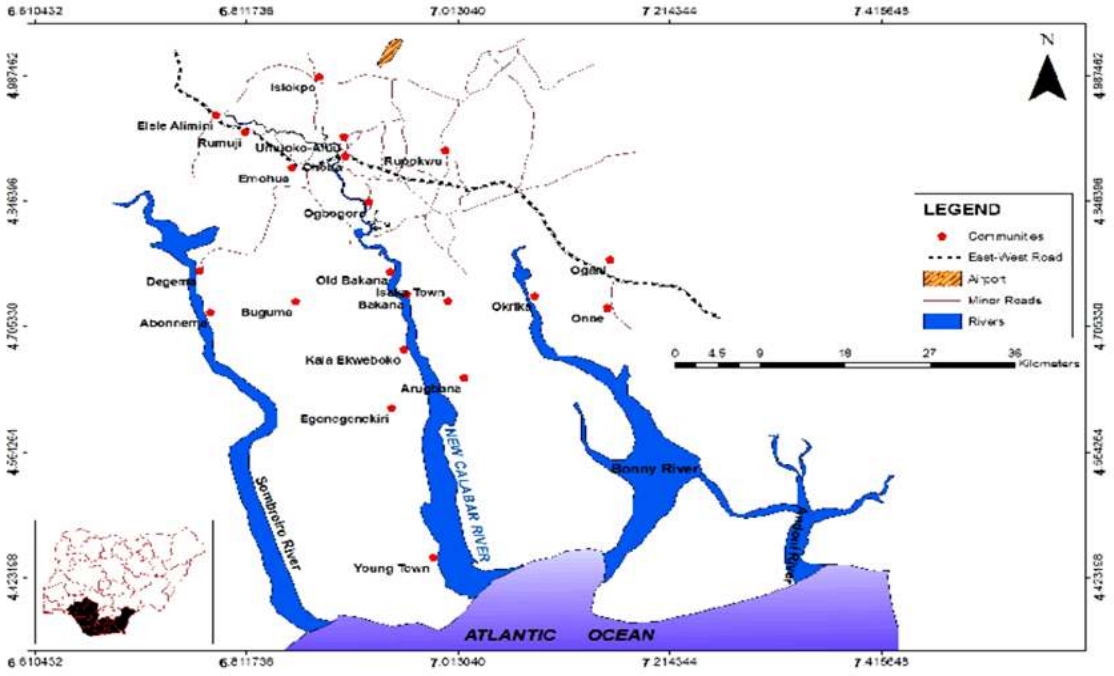

Fig. 1. Map of lower Niger Delta showing the New Calabar River

The temperature ranged between 27.3 and 28.4. Temperature has impact on the acceptability of other physicochemical and biological parameters. As such, high water temperature is not acceptable. The pH range of 6.7 – 7.1 observed in this study was within acceptable limit. Likewise results for all other physicochemical parameters except for cadmium (Cd) and lead (Pb). Presence of high levels of lead, cadmium and other metals beyond the WHO standard are commonly reported in rivers in Nigeria industrial cities due to wanton dumping of waste in the water ways [9,13,14]. Presence of heavy metals in the river could be attributed to refuse dumping, sand dredging and industrial effluents. There were no significant differences in physicochemical parameters for water samples from the different points.

The heterotrophic plate count results for bacteria are presented in Table 2. The total aerobic heterotrophic bacterial (THB) counts of the water samples ranged from $5.1x10^4$ – $8.3x10^7$. Total coliform (TC) counts ranged from $1.5x10^3$ – $4.3x10^5$ cfu/100 ml and Total thermotolerant coliform (TTC) counts ranged from 4.9 $x10^2$ - 3.7 $x10^5$ cfu/100 ml. Heterotrophic bacteria reflects the contamination extent by easily decomposable organic matters, while the faecal coliform points to presence of faecal matter [15]. Total coliforms and thermotolerant colifoms counts exceeded in several folds the recommended limit for portable water. High level of faecal pollution of river water renders it unsuitable for drinking purpose. Point 2 reported more microbial presence than the other sampling points. Point 2 is close to the Choba market and serves as dumping site for easily decomposable organic waste. This probably was the reason for the high microbial load. The results indicated that the water from the river has poor microbiological quality, according to quality guidelines for drinking water.

The specific microbial isolates of the water samples are shown in Table 3. *Bacillus* sp., *Proteus* sp., *Staphylococcus aureus, Serratia* sp., *Klebsiella* sp., *Enterobacter* sp.,and *Salmonella* sp. were isolated from the water samples, with point 2 showing greater species diversity. *E. coli* and *salmonella* represent important water-borne pathogens. Enterohaemorrhagic *E. coli* have emerged as a serious gastrointestinal pathogen in many countries, albeit from consumption of contaminated meat [16,17]. Salmonellae are frequently found in streams that receive sewages and industrial wastes and is associated with salmonellosis [18]. The consumption of the river water poses potential health risk for humans.

Table 1. The physicochemical parameters at the different points in NCR

Parameter	Point 1	Point 2	Point 3	WHO standard
Temperature (℃)	28.2	28.4	27.3	20-30
pH	7.1	6.7	6.7	6.5-8.5
Chloride (mg/l)	8.24	9.31	6.00	250
Phosphate (mg/l)	0.14	0.25	0.10	2
Nitrate (mg/l)	0.33	0.32	0.24	50
Sulphate (mg/l)	25.1	30.4	23.2	250
DO (mg/l)	6.1	7.0	4.5	0-20
TDS (mg/l)	3.0	3.1	3.6	1000
BOD (mg/l)	3.5	3.5	3.9	0-6
COD (mg/l)	5.6	5.4	6.2	NA
Turbidity (NTU)	2.9	3.6	4.3	5
Salinity (ppt)	0.018	0.020	0.013	0.5
Conductivity (uS/cm)	12.13	11.93	12.07	1000
Cr (mg/l)	<0.001	<0.001	<0.001	0.05
Cu (mg/l)	0.110	0.083	0.062	2
Pb (mg/l)	0.280	0.220	0.120	0.01
Zn (mg/l)	<0.001	<0.001	<0.001	3
Cd (mg/l)	0.0102	0.073	0.050	0.003
Oil and Grease	0.044	0.037	0.020	NA

NA = Not available

Table 2. Mean microbial counts of NCR water samples

Microbial count	Point 1	Point 2	Point 3
Total heterotrophic bacterial (THB) (cfu/ml)	$6.2x10^4$	$8.3x10^7$	$5.1x10^4$
Total coliform (TC) (cfu/100 ml)	$2.8x10^3$	$4.3x10^5$	$1.5x10^3$
Total thermotolerant coliform (TTC) (cfu/100 ml)	2.3×10^3	3.7×10^5	4.9×10^2

Table 3. Microbial isolates present in NCR water samples

Isolate	Point 1	Point 2	Point 3
Bacillus sp.	+	-	+
Proteus sp.	+	+	-
Staphylococcus aureus	+	+	+
Escherichia coli	+	+	+
Klebsiella sp.	+	+	-
Serratia sp.	+	+	+
Enterobacter sp.	+	+	+
Salmonella sp.	+	+	-
Shigella sp.	-	-	-

+= Present, -= Absent

4. CONCLUSION

This study has shown that water from the New Calabar River does not meet the water quality standard for good drinking water. Presence of water-borne pathogens of faecal origin renders the water unsuitable for human consumption. The potential risks of infection for consumers are evident and prompt intervention is advised.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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