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Sanitation and Water Quality in Port Harcourt Waterfront Settlements

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Authors' contributions

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

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ABSTRACT

Sanitation and water quality are a good measure to judge the living standard and health status of a community. This study focused on the assessment of surface and ground water resources from selected waterfront areas within Port Harcourt metropolis notable for their poor sanitary conditions as receptacles for domestic wastes. Surface water (river) and ground water samples were collected from Abuloma waterfront, Marine Base and Afikpo (Diobu) and their microbiological and physiochemical parameters determined using standard laboratory methods. The microbiological parameters analyzed include total heterotrophic bacteria count (THBC), fecal coliform count, total coliform count, *Salmonella* count, *Shigella* count and *Vibrio* count. The physiochemical parameters monitored include pH, temperature, conductivity, salinity total dissolved solids (TDS), dissolved oxygen (DO), turbidity and biological oxygen demand (BOD). The THBC ranged from 15×10^1cfu/ml to 1.3×10^2 cfu/ml; total coliform count ranged from 0 to 17cfu/ml; all the samples had no fecal coliform; the *Salmonella* count ranged from 0 to 15 cfu/ml; the *Shigella* count ranged from 0 to 30cfu/ml and *Vibrio* count ranged from 0 to 15 cfu/ml. The pH values ranged from 5.9-7.6;

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temperature from 27.5°C to 29.6°C; salinity from 0.012 mg/l to 0.379 mg/l; conductivity from 17.8 μs/cm to 19370 μs/cm; TDS from 12.3 mg/l to 13610 mg/l; DO from 2.41 mg/l -3.4mg/l, turbidity from 0.24 NTU to 1.11 NTU and BOD from 16 mg/l to 120 mg/l. The results obtained showed that the water resources are not safe and pose risk to human health. These findings highlight the need to improve the sanitary condition of waterfront areas and promote water treatment to ensure the health and safety of the public.

Keywords: Sanitation; water quality; health; safety; waterfront.

1. INTRODUCTION

Water is needful and useful to man, as the body's physiological processes are initiated and regulated by it. Water quality refers to the status of water in terms of its safety as regards the presence of physical, chemical and biological agents [1]. Poor sanitation can affect water quality which in turn can adversely impact on human health. The effects can be classified environmentally, socially and economically in terms of pollution of the environment, illness and deaths of citizens, cost incurred during treatments of illnesses, lost time, reduction of working capacity and availability of persons, and illnesses among the vulnerable population in the community [2,3].

Waterfront settlements are common along rivers and water ways in many third world countries, with a distinct feature of squalor and unsanitary disposal of waste. The waste generated on a daily basis in these settlements is raising serious environmental concern because of the spread of pollutants that reduces the quality of air, ground water and surface water [4]. Fecal contamination of water sources is still a problem around the world today, mostly in slum areas of mid-low income countries [5]. The improvement of standards of living through safe drinking water, good sanitation and hygiene may be difficult to actualize in these settlements where the same water meant for domestic use still serve as toilet and waste dump.

Poor sanitation can cause water pollution due to poor waste management practices and this can lead to heightened adverse environmental consequences such as increased chemical concentrations that could cause increased toxicity, eutrophication and salinization which can pose a great threat to the ecosystem [6]. There is also the need to reduce the risk of water related diseases by prioritizing the provision and accessibility of adequately safe drinking water and sanitation in emerging urban centres especially for the poor who dwell in those areas [7].

Polluted water and sanitation are associated with the spread of illness such as diarrhea, typhoid fever, dysentery and cholera [8,9]. For public health concern that epidemic outbreaks caused by certain pathogenic microorganisms can spread very fast within a short time frame, the need for periodic surveillance of water supply is necessary to check the status of the water source [10].

Marine Base, Afikpo (Diobu) and Abuloma waterfronts are densely populated areas, in the capital city of Port Harcourt, Rivers State. The major sources of water are groundwater (borehole) and surface water from the rivers. Because of the dumping of refuse and sewage into the rivers, the water quality both microbiological and physicochemical is bound to be affected. The aim of this study is to examine the sanitary quality of the surface and ground water of selected waterfronts within Port Harcourt, Rivers State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Port Harcourt is the capital city of Rivers State, which is part of the Niger Delta province, which stretches across the Southern end of Nigeria, bordering the Atlantic Ocean. The study selected three waterfronts areas within the city which are Marine Base waterfronts, Diobu waterfronts (Afikpo) and Abuloma waterfronts.

2.2 Samples Collection

A total of 6 samples were collected from three waterfronts settlements using sterile sampling bottles and transported immediately to the laboratory for analyses. The samples collected consists of (3) three surface water and three (3) borehole water (groundwater) from these three locations. The sample collection was done during the wet season (September-October, 2019). The method for samples collection is as described by Nwankwoala and Udom [11].

2.3 Physicochemical Analysis

Physiochemical parameter of the water samples analyzed were pH, temperature, conductivity, salinity. Total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD) and turbidity, taste and odour. All analyses were carried out following standard methods for the examination of water and wastewater described in APHA [12]. Results obtained from the research were compared with the World Health Organization (WHO) limits for potable drinking water in order to ascertain the integrity and safety of water sources.

2.4 Microbiological Analysis

The pour plate method was adopted for determination of bacteria present in the water samples, using nutrient agar, MacConkey agar, thiosulphate citrate bite salt sucrose agar and Salmonella-Shigella agar. The determination of Total Heterotrophic Bacterial Count (THBC), total coliform count, fecal coliform count, *Salmonella* count, *Shigella* count and *Vibrio* count followed procedures described in APHA [12]. All plates were incubated in triplicate. Isolates were identified based on their cultural, morphological, biochemical characteristics in reference to Bergey's Manual of Determinative Bacteriology.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Characteristics of Ground Water and Surface Water Samples

The results for physicochemical characteristics of ground water and surface water samples from Marine Base, Afikpo (Diobu), Abuloma are presented in Table 1. The pH values ranged from 5.9-7.6. The pH in water reflects the degree of acidity or alkalinity of the water. In pure water, hydrogen ions (H^+) and hydroxyl ions (OH^-) are in equilibrium making it natural with a pH value of 7. 1n natural conditions pH ranges from 6.5 – 8.5. Any deviation from this range portends abnormality and can be used as an indicator for pollution. Temperature values ranged from 27.5°C to 29.6°C. Temperature is the most significant physical variable that determines the tendency of changes in water quality. All reactions, chemical or biological including the toxicity of several metals in water are temperature dependent.

The values for TDS ranged from 12.3 mg/l to 13610 mg/l. Stanley et al. [1] reported TDS values ranging from 3.0-3.6 mg/l in their study of the water quality of the New Calabar River in Port Harcourt. This implies that the surface water and ground water at the locations of the present study are more polluted with inorganic and organic substances than the New Calabar River. Total dissolved solids is an expression of the combined content of all inorganic and organic substances in liquid. Which are present in a molecular, ionized or micro-granular (colloidal sol) suspended form. Generally the operational definition is that the solids must be enough to survive filtration through a sieve of two micrometers [13].

The salinity values ranged from 0.012 mg/l to 0.379 mg/l. The conductivity of water samples generally varied from 17.8 μs/cm to 19370 μs/cm. Stanley et al. [1] reported a lesser range of salinity (0.013 mg/l to 0.020 mg/l) and conductivity (11.93-12.13 μ s/cm.) for surface water from the New Calabar River in Port Harcourt. Conductivity is the ability of a substance to conduct electricity. The conductivity of water is more or less a linear function of the concentration of dissolved ions. Conductivity itself is not a human or aquatic health concern, but because it is easily measured, it can serve as an indicator of other water quality problems [13]. Electrical conductivity is a useful indicator of mineralizaton and salinity or total salt in water sample. Permissible limit for conductivity is 2500 at 25°C. The limit was in range for all the samples except for Marine Base ground water was high.

Dissolved oxygen (DO) concentration in the water samples ranged from 2.41 mg/l -3.4 mg/l. Stanley et al. [1] reported a higher DO concentration (4.5-7.0 mg/l) for surface water from the New Calabar River in Port Harcourt, an indication that the water samples in the present study are heavily polluted with organic matter. Dissolved oxygen (DO) concentration in unpolluted water normally ranges between 8 and 10 mg/l and concentration below these adversely affect aquatic life [14,15]. DO standard for drinking purpose is 6mg/l whereas for sustaining fish and aquatic life 4-5mg/l [14]. The DO values from this study fell short of the recommended standard for water quality. Decrease in DO concentration could be attributed to breakdown of organic matter by aerobic microbes, giving way for anaerobic bacteria to breed and deteriorate the quality of water [16,17].

Table 1. Pysicochemical characteristics of water sampled from Marine Base, Afikpo (Diobu) and Abuloma waterfronts

Parameters	Marine base		Afikpo (Diobu)		Abuloma		WHO permissible limits
	Ground water	Surface water	Ground water	Surface water	Ground water	Surface water	
pH	6.6	6.8	6.8	7.1	5.9	7.6	6.5-8.5
Temperature (°C)	27.6	29.6	27.5	29.0	27.9	28.6	20-30
Conductivity (*µ*s/cm)	343	12070	17.8	18408	80.6	19370	2500 at 20°C
DO (mg/l)	3.2	2.5	3.4	2.41	3.11	3.2	0-20
Salinity (ppt)	0.016	0.070	0.083	0.111	0.379	0.012	0.15
TDS (ppm)	239	8580	12.3	12850	56.7	13610	1000
Turbidity (NTU)	0.24	0.38	0.32	0.74	0.31	1.11	5
Taste	U	O	O	U	U	O	U
Odour	U	O	O (rotten smell)	U	U	O	U
BOD (mg/l)	120	100	170	62	16	70	0-6

U-unobjectionable; O-objectionable

Turbidity values for the water samples ranged from 0.24 NTU to 1.11 NTU. Stanley et al. [1] reported a higher turbidity (2.9-4.3 NTU), probably because of the dredging activities taking place in the New Calabar River. Turbidity affects fish and aquatic life by interference with sunlight penetration. Pure water has no colour. The presence of dissolved foreign substances in solution alters the colour to blue, green, yellow or brown. Highly coloured water has an oxygen demand, either biological or chemical and is likely to become devoid of dissolved oxygen when held in storage.

Biological oxygen demand (BOD) values ranged from 16 mg/l to 120 mg/l. Stanley et al. [1] reported a much lower BOD level (3.5-3.9 mg/l) in their study. Biological oxygen demand test is useful in determining the relative waste loading, and higher degree therefore indicates the presence of large amount of organic pollutant and relatively higher, level of microbial activities with consequent depletion of oxygen content. The higher values could be due to surface runoff from the surroundings as well as the organic loading from sewage and domestic waste into the river.

The surface water from Marine Base and Abuloma, and the ground water from Afikpo (Diobu) where objectionable in terms of taste and odour. Odours originate from biological sources such as algae, decayed organic matter and various reactions mediated by bacteria and fungi.

3.2 Microbiological Quality of Surface and Ground Water Samples

Results of microbiological quality of surface and ground water from Marine Base, Afikpo (Diobu), Abuloma are presented in Table 2. Ground water sample from Abuloma had the highest total heterotrophic bacterial count with a value of $1.3x10^2$cfu/ml while ground water from Marine Base had the least value of $1.5x10^1$cfu/ml. No coliform was detected in ground water sample from Abuloma while ground water from Afikpo (Diobu) had the highest total coliform count of 17cfu/ml. All the samples had no fecal coliform. Their presence in water is an indication of possible pollution of such water sources. The water samples were analyzed for fecal coliform which is noted to be one major bacteria of public health concern all over the world. Fortunately all the samples gave a zero cfu/ml value for fecal coliform bacteria. Stanley et al. [1] reported THBC ranging from $5.1x10^4$ – $8.3x10^7$ and total coliform count ranging from $1.5x10^3$ – $4.3x10^5$ cfu/100 ml for the New Calabar River, which are higher than results in the present study.

Salmonella was not detected in ground and surface water samples from Abuloma as well as ground water from Marine Base, while surface water from Afikpo (Diobu) had the highest *Salmonella* count of 15cfu/ml. *Salmonella* sp are well known bacteria of public health importance, usually found in water, food and the soil including fecal matter [18]. For instance, *Salmonella typhi* is the causative agent (pathogen) that causes typhoid fever. These three water sources can pose sanitary risk and can be classified as unsafe for use.

Shigella was not detected in ground water from Marine Base while ground water from Afikpo (Diobu) had the highest *Shigella* count of 30 cfu/ml. Presence of *Shigella* is an indication that the water sources in which it was detected is

Table 2. Microbiological quality of Surface and Ground Water Samples

	Sample	THBC cfu/ml	Total Coliform cfu/ml	Fecal coliform cfu/ml	*Salmonella* cfu/ml	*Shigella* cfu/ml	*Vibrio* cfu/ml	Remark
Marine Base	Ground Water	15	1	0	0	0	0	---
	Surface Water	43	10	0	15	11	11	SR
Afikpo (Diobu)	Ground Water	30	9	0	6	3	15	SR
	Surface Water	35	17	0	7	30	0	SR
Abuloma	Ground Water	134	0	0	0	1	0	---
	Surface Water	65	2	0	0	6	14	SR

SR=sanitary risk

unsafe because *Shigella* is a pathogenic microorganism of public health importance [18].

Vibrio was not detected in ground water from Marine Base and Abuloma as well as surface water from Afikpo (Diobu), while ground water from Afikpo (Diobu) had the highest *vibro* count of 15cfu/ml. This means that water samples from these locations pose sanitary risk and can be classified as unsafe. *Vibrio* sp is also another pathogenic microorganisms of concern to man, because it is the causative agent for the well-known cholera which had caused the deaths of thousands of children and the aged in the past and is still of serious concern to man today [18].

Proper sanitation exercise at regular intervals must be observed to promote and maintain the water quality of water resources. In the same vein, intermittent monitoring of the microbiological and physiochemical parameters of water would help to promote water safety. This study observed that the existing sanitary facilities in the waterfronts settlements are toilets provided by the local government councils or private toilets built by individuals. The toilets provided by the communities in the study areas were on the elevated platform above the high tide level. No sanitary means of disposing human waste existed rather the usual practice was disposal of night soil and other waste materials into the river. The toilets were simply shift overhung toilets with human waste directly disposed into the river. Despite the provision of communal toilets for the households in several congested residences, there are still a number of families who do not have any toilet facilities. This indiscriminate dumping or disposal of wastes into the river causes serious environmental hazards and health risks.

4. CONCLUSION

This study has shown that ground water and surface water in waterfronts in Port Harcourt have objectionable quality in terms of their physicochemical and microbiological parameters, and harbour some pathogens of interest such as *Salmonella* sp*, shigella sp* and *vibrio* sp. The water sources in these waterfront areas require some level of treatments to ensure water safety.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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