

**PHYSICO-CHEMICAL, HEAVY METAL AND MICROBIOLOGICAL
CONCENTRATIONS IN SOIL AND WATER SAMPLES AROUND VERITAS
UNIVERSITY CAMPUS, OBEHIE, SOUTHEASTERN NIGERIA**

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ABSTRACT: *This study aims at evaluating the physico-chemical, heavy and microbiological concentrations in soil and water samples around Veritas University, Obehie, Abia State, Nigeria to prevent the risk on the public health. Standard sampling and analytical methods were employed during the study. Results of the study revealed that the concentrations of heavy metals in borehole water samples were low (mostly < 0.001), and hydrocarbon were also below detection limit in all borehole samples. The concentrations of heavy metals in surface water were also low, ranging from < 0.001 mg/l in some cases, with the highest single value being 0.165mg/l for iron. Total hydrocarbon content was also below detection levels in surface water showing unpolluted conditions. Heterotrophic bacteria densities were high in soil samples, ranging from 1.0×10^4 to 3.5×10^5 cfu/g soil. Densities of heterotrophic fungi were high in some locations, ranging from 1.0×10^3 to 1.5×10^5 cfu/g. Counts of petroleum degrading bacteria and fungi were generally high. Percentage petroleum degrading bacteria and fungi were greater than 1 % in all samples, except at one location. Microbial populations of soils particularly high in petroleum degraders (> 1 %) show that the soils have been exposed to contamination from petroleum products. High counts in some of the samples indicate normal microbial growth and activities. Heterotrophic bacteria and fungi contribute to good quality soil in terms of fertility. The quality of the borehole and surface water quality is fairly good hence, regular monitoring of water quality in the area is very necessary.*

KEYWORDS: Surface Water, Soil Microbiology, Heavy Metals, Borehole, Pollution, Obehie

INTRODUCTION

Water is used for a variety of purposes such as drinking, washing, bathing, recreation as well as numerous other varied industrial applications, the wholesomeness of these water bodies has become an issue of great concern. Water pollution is a burning issue all over the world, in recent years; an increasing awareness has developed on the impact of human activities on the environment because the environment has witnessed a continuous and rapid deterioration which cause pollution in all its abiotic and biotic components.

Soil is the preeminent source of most biologically active trace elements such as Lead, Cadmium, Chromium, Nickel, Silver, and Zinc that reach man through plants and animals (Mitchell and Burridge, 1979). The trace element content of soil depends on the nature of its parent rocks and also the amount of sewage sludges, industrial wastes and fertilizer impurities entering the soil (Williams and David, 1976; Singh *et al.*, 2005).

The occurrence of heavy metals in soils and groundwater is directly related to soil characteristics that determine the rate of water movement and the pollutant dynamics on the soil exchange complex (Nagendrappa *et al.*, 2010; Yerima *et al.*, 2014). Therefore, heavy metal concentrations in soils and groundwater resources vary from one place to another and depend on climatic conditions. Extensive studies have been conducted to obtain data on the heavy metals in soils from varieties of environments throughout the world, including industrialized cities (Edet & Ntekim, 1996; Singh *et al.*, 2005; Asaah *et al.*, 2006; Odigi *et al.*, 2011; Zhongping *et al.*, 2011; Amadi & Nwankwoala, 2013; and Onyeobi & Imeokparia, 2014). The impact of human activities in the urban, municipal and populated area makes surface water bodies like streams, river, lagoons, etc, and ground water bodies to be susceptible to contamination from pollutants. Pollution of soil and water by heavy metal occurs due to industrial wastes, application of fertilizer, corrosion of sheeting, wires, pipes, and burning of coal and wood (Hashem, 1992).

According World Health Organisation report on guideline for drinking water 2008, Safe drinking-water, as defined by the Guidelines, does not represent any significant risk to health over a lifetime of consumption; including different sensitivities that may occur between life stages. For this reason, particular concern has become apparent regarding the adequacy of the quality of water resource; both surface and groundwater resources. If the distribution of heavy metals in soils and groundwater has been studied by several previous researchers around the world, very limited efforts have been devoted to the interrelationships between soil classes, occurrence of heavy metal in soil profiles and groundwater and the geochemical parameters affecting heavy metals retention in each class of soil. This study therefore, is aimed at determining the concentration and distribution of the physico-chemical, heavy metals in the soils and surface water as well as boreholes around the study area. This study also aims at evaluating the anthropogenic and/or geogenic contribution to the enhancement of heavy metals.

Study Area Description

The study location (Fig. 1) is within the coast plan sand of the Niger Delta area. The area lies within a sub-horizontal geomorphologic terrain with a measure of undulations arising from uneven surface area erosion. Ground elevation ranges between 10-12 meters above mean sea level. The local geology is of the coastal plain sand, which is Miocene in age and form parts of the most strata of the outcropping Benin Formation. These consist of extensive thickness of brownish, coarse to medium sand with subordinate clay and silt. The area is associated with luxuriant freshwater vegetation typical of a tropical rainforest. Mean annual rainfall exceeds 2000mm.

The hydrology of the study site is influenced by its high precipitation rate with a mean annual rainfall of over 2,500mm, the over burden lithologic strata that over lie the aquifer, and the sometimes undulating topography. Surface waters are received from non-tidal seasonal fresh water flows. Recharge of the aquifer will be by rainwater that eventually moves through the over burden into the aquifer. Recharge depends on rainfall intensity and distribution and amount of surface runoff. Groundwater occurs under confined conditions at the site on account of the essentially clayey soil overlying the aquifer. The existence of this over burden-confining layer will determine whether or not groundwater contaminants introduced into the soil will reach the aquifer. During construction at the site, the protective soil vegetation is removed. Concentrated surface flow of rainwater rills the soil and changes the slope value, which may eventually result in sheet/gully erosion. The cohesive, stiff consistency of the over lying clayey soil will help to limit the degree of this environmental hazard.

RESULTS AND DISCUSSION

Soil and Water Microbiology

The microbiological profile of soil samples in the area is presented in Table 1. Heterotrophic bacteria densities were high in soil samples and CW A and CW D and slightly high in samples CW B and CW C, ranging from 1.0×10^4 to 3.5×10^5 cfu/g soil. Densities of heterotrophic fungi were high in sample CW A and not very high in other samples, ranging from 1.0×10^3 to 1.5×10^5 cfu/g. Counts of petroleum degrading bacteria and fungi were generally high. Percentage petroleum degrading bacteria and fungi were greater than 1 % in all samples, except at CW 1. Microbial populations of soils particularly high in petroleum degraders ($> 1\%$) show that the soils have been exposed to contamination from petroleum products. High counts in some of the samples indicate normal microbial growth and activities. Heterotrophic bacteria and fungi contribute to good quality soil in terms of fertility. The heterotrophic bacteria counts of surface water samples was 2.0×10^3 to 2.4×10^3 cfu/ml while that of borehole samples ranged from 3.1×10^3 at BH 1 to 2.5×10^4 cfu/ml. Fungi counts ranged from 1.0×10^2 to 1.4×10^2 for borehole and 1.4×10^2 to 1.5×10^3 cfu/ml, for surface water samples. Tables 2 & 3 shows the microbial populations of water and borehole samples in the study area. Heavy metal concentrations are low (Table 4). The values obtained revealed that heavy metal concentrations do not pose a threat in the soil quality, hence poor indicator of heavy metal pollution.

Physico-Chemistry of Water

Water quality variables in borehole samples were compared with international standards for drinking water. pH values fell short of the WHO standards in all boreholes but was within the USEPA maximum criteria. The values of chloride and nitrate were however, within the WHO standards. The concentrations of heavy metals in borehole water samples were low (mostly < 0.001), and hydrocarbon were also below detection limit in all borehole samples.

The concentrations of heavy metals in surface water were low, ranging from < 0.001 mg/l in some cases, with the highest single value being 0.165mg/l for iron at WS 3. Total hydrocarbon content was also below detection levels in surface water showing unpolluted conditions. Table 5 shows the heavy metal and Total Hydrocarbon concentrations in water samples from the study area.

Table 1: Microbial Populations of Soil Samples from the Study Area

S/N	Sampling Station	THB (cfu/g)	THF (cfu/g)	PDB (cfu/g)	PDF (cfu/g)	%PDB (cfu/g)	%PDF (cfu/g)
1	CW A	3.1×10^5	1.5×10^4	1.0×10^3	3.9×10^3	0.3	26
2	CW B	2.9×10^4	4.2×10^3	1.8×10^3	1.6×10^3	62.1	38.1
3	CW C	1.0×10^4	1.0×10^3	3.5×10^3	3.5×10^3	30.0	> 100
4	CW D	2.7×10^5	1.8×10^3	1.8×10^3	1.8×10^3	6.3	100

Table 2: Microbial Populations of Water Samples in the Study Area

Metal	Boreholes Samples			Surface Water Samples		
	BH 1	BH 2	BH 3	WS 1	WS 2	WS 3
Nickel (mg/l)	2.5×10^4	3.1×10^3	2.0×10^4	2.0×10^3	2.4×10^3	2.4×10^3
Vanadium (mg/l)	1.0×10^2	1.4×10^2	1.0×10^2	1.4×10^2	1.5×10^3	3.0×10^2

Table 3: Physico-Chemical Parameters of Water Samples from the Study Area

Parameter	Boreholes Samples			Surface Water Samples			Standards
	BH 1	BH 2	BH 3	WS 1	WS 2	WS 3	
pH	8.5	8.4	6.0	6.0	5.8	6.1	7-8 ^a 5-9 ^b
Conductivity (µS/cm)	24	13	18	9	9	10	-
TDS (mg/L)	10	7	7	3	5	4	-
Salinity (ppt)	0	0	0	0	0	0	-
Chloride (mg/L)	0.2	0.2	0.2	0.2	0.2	0.1	200 ^a 250 ^b
Turbidity (NTU)	-	-	-	-	-	-	-
Nitrate (mg/L)	4.2	51	49	1	1	2	-
Phosphate (mg/L)	1.4	0.8	2.4	0.2	0.5	0.4	45 ^b
	0.21	0.18	0.19	0.25	0.31	0.22	-

a = World Health Organization Highest Desirable Level (WHO, 2006)

b = United States Environmental Protection Agency Maximum Criteria (USEPA, 1991)

Table 4: Heavy Metal Concentration (mg/kg) of the Related Soil Samples

S/N	Sampling Station	Cm Depth	Pb	Cr	Cd	Ni
1	CW A 01	0 - 15	0.24	0.31	<0.001	0.08
2	02	0 - 15	0.20	0.28	<0.001	0.06
3	CW B 01	0 - 15	0.15	0.24	<0.001	0.10
4	02	0 - 15	0.18	0.18	<0.001	0.05
5	CW C 01	0 - 15	0.10	0.22	<0.001	0.12
6	02	0 - 15	0.22	0.20	<0.001	0.10
7	CW D 01	0 - 15	0.16	0.14	<0.001	0.18
8	02	0 - 15	0.12	0.16	<0.001	0.20
9	Soil Standard*		2 – 100	5 - 1000	0.01 - 7	10 - 1000

Table 5: Heavy Metal and Total Hydrocarbon Concentrations in Water Samples from the Study Area

Metal	Boreholes Samples			Surface Water Samples		
	BH 1	BH 2	BH 3	WS 1	WS 2	WS 3
Nickel (mg/l)	<0.001	0.012	0.002	<0.001	<0.001	<0.001
Vanadium (mg/l)	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Chromium (mg/l)	0.018	0.012	<0.001	0.002	0.001	<0.003
Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (mg/l)	<0.001	<0.001	<0.001	0.033	<0.001	<0.001
Iron (mg/l)	0.182	0.097	0.079	0.004	0.165	0.064
Copper (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (mg/l)	0.034	0.045	0.172	0.002	0.002	0.004
Manganese (mg/l)	0.008	0.005	0.011	0.002	0.011	0.18
Oil & Grease (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL

CONCLUSION

This study provides an update on our current understanding of the environmental health effects of heavy metal pollution, soil and water quality around the study area. This study revealed that the values of the physico-chemical properties were however, within the WHO standards. The concentrations of heavy metals in borehole water samples were low (mostly < 0.001), and hydrocarbon were also below detection limit in all borehole samples. The concentrations of heavy metals in surface water were low, ranging from < 0.001 mg/l in some cases, with the highest single value being 0.165mg/l for iron at WS 3. Total hydrocarbon content was also below detection levels in surface water showing unpolluted conditions.

Counts of petroleum degrading bacteria and fungi were generally high. Percentage petroleum degrading bacteria and fungi were greater than 1 % in all samples, except at CW 1. Microbial populations of soils particularly high in petroleum degraders (> 1 %) show that the soils have been exposed to contamination from petroleum products. High counts in some of the samples indicate normal microbial growth and activities. Heterotrophic bacteria and fungi contribute to good quality soil in terms of fertility. There is need for regular monitoring of soil, surface and groundwater quality in the area for heavy metal contamination and pollution.

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