THE PHYSICOCHEMICAL EFFECT OF LEACHATES ON GROUND WATER WITHIN OKPUNO-EGBU UMUDIM DUMPSITE NNEWI, ANAMBRA STATE NIGERIA

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Abstract: *Water samples were collected from six different borehole sites at radial distances of 50metres, 90metres, 100metres, 130 metres 150 metres and 220 metres respectively within the vicinity of Okpuno-Egbu, Umudim, Nnewi dumpsite in Anambra State, Nigeria and analyzed for physicochemical properties, microbiological and heavy metals levels. The parameters determined were the turbidity, conductivity, pH, total dissolved solids (TDS), Total Hardness, Iron, Nitrate, Phosphate, Sulphates, Magnesium, Chloride, Calcium and heavy metals such as Copper, Zinc and Lead, Cadmium using conventional equipment and standard laboratory procedures. These parameters were compared with control samples and the established international and national standards - World Health Organization (WHO),U.S Environmental Protection Agency(USEPA) and National Agency for Food and Drug Administration and Control(NAFDAC). The water samples from borehole sites within radial distances of 50 to 130 meters from the dumpsite geographical location was found to contain high concentrations of cadmium above approved standards. This study among other things revealed firstly, that the dumpsite leachates are a major source of the Cadmium pollution in this geographic location and secondly, the contaminant level of the water from the various sites are a function of the proximal distance to the dumpsite and the topography of the borehole site.*

Keywords: *Ground water, leachates, cadmium, dumpsite, pollution, physicochemical, borehole*

1. Introduction

Water is the primary channel of human and animal exposure to chemicals leaching from scores of municipal waste, industrial waste, hazardous waste sites (HWS), leaching of minerals from natural deposits, accidental spills and leaks, and agricultural practices which are the chief source of ground water pollution. The U.S. Environmental Protection Agency (EPA) declared these HWS as one of the principal threats to the environment and living organisms [1]. The difference of ground water quality in any area is a function of physicochemical quality parameters which are influenced by geological formations and anthropogenic activities of the area [2].

Groundwater pollution is mainly due to the process of industrialization and urbanization that has progressively developed over time without any regard for environmental consequences [3].

Researchers have worked on the environmental impact assessment of various possible pollution sources on the quality of groundwater. This has been receiving global attention in the present [2], [3], and [4]. The major sources of pollution in groundwater are leachates from refuse dumpsites, industrial liquid waste, domestic waste, salt water intrusion, application of agricultural chemicals, oil spillage and pipeline vandalization and geological formations. These sources produce pollutants ranging from heavy metals, Chlorinated hydrocarbon, phenols, cyanides, pesticides, major inorganic species and bacteria.

In major dump sites in most municipalities, wastes are burnt in the open and ashes abandoned at the site. The act of burning destroys the organic life, oxidize metals, hence enriching the ashes left behind in metals. The leachates from these dump sites filter through the soil and pollute the aquifer in the surrounding areas. The use of compost from dump site for land reclaims especially among the local residents is a dangerous trend due to the considerable amount of waste dumped

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haphazardly within the residential areas. Landfills have been identified as one of the major threats to groundwater resources [2].

In refuse dumpsites, solid wastes gradually release its initial interstitial water and some of its decomposition by-products into aquifer, through the waste deposit. Such leachates contain innumerable organic and inorganic compounds. These wastes generate pollutants, majorly Cl^- and N^- species. These leachates from these dump sites according to researchers constitute major source of heavy metal pollutant to both soil and aquatic environment.

Nnewi, the second largest city in Anambra Statein Nigeria and one of the most populous cities in Nigeria is experiencing problems of municipal waste management; this is largely due to unplanned development, rural-urban migration and natural increase in commercial and industrial activities within the city. So far, this growth has not been complimented by improvement in the quality of the urban environment. Instead, these demographic expansion, increased industrialization and commercial activities have caused an astronomical increase in the volume and diversity of solid wastes generated in the city [5].

2. Materials and Methods

2.1 Site Description

The study area shown in figures 1 and 2 is the Okpuno-Egbu, Umudim Nnewi refuse waste dump site (Landfill) situated opposite the National Engineering Design Development Institute, (NEDDI), along the Okigwe-Oba-Onitsha Road, Coscharis Bus Stop, Nnewi in Nnewi North Local Government Area of Anambra State, Nigeria. The current solid waste generation from this city is about 3000 tonnes/day. The dumping site is located at the following latitude 6°00´40.88´´N and longitude 6°54´26.87´´ E.

2.1.1 Water Analyses

The six borehole sites chosen for this study had an average depth of 160 metres and located within the radial distances of 50m, 90m, 100m, 130m, and 220m from the centre of the dumpsite and are marked samples A-F respectively according to their radial distances. For each of the borehole analyzed, 10 litres of the groundwater samples were collected in sterilized polyethylene terephthalate (PET) bottles, stored at 25°C and analyzed. The samples were analyzed for physical, chemical and bacteriological factors. The qualitative analyses were carried out at the water laboratories of the Owena River Basin Authority, Benin City, Nigeria. The physical parameters examined were the odour, taste, colour, turbidity and temperature. Chemical parameters analyzed were pH, Total Suspended Solids, Total Dissolved Solids (TDS), Total Hardness, Iron, Nitrate, Nitrite, Chloride, Phosphate, Sulphate, Magnesium Calcium and heavy metals such as Copper, Zinc, Cadmium and Lead. The pH was determined using a Mettler Toledo (GmbH 8603 Schwerzenbach) pH meter by direct measurement, analog mercury thermometer was used in making temperature measurements and Turbidimeter was used for turbidity determination. The samples were also analyzed for total dissolved solids (TDS), total hardness, iron, nitrate (NO_3), nitrite (NO_2), Calcium, Chloride were carried out using titration methods in the laboratory using the approved standards for the examination of water. The concentrations of heavy metals such as Copper, Zinc, Cadmium and Lead in water samples were determined with an atomic absorption spectrophotometer. Also, bacteriological assay was used in the determination of *Streptococcus Faecalis*, Fungi/Yeast, Coliform bacteria and *Escherichia Coli.* All the results were compared with the World Health Organization (WHO) and the National Agency for Drugs Administration and Control (NAFDAC) in Nigeria.

Figure 1: Okpuno Egbu Refuse Dump Site

Figure 2: Okpuno Egbu Refuse Dump Site

3. Results and Discussion

The results of the characterization test and the microbiological examination conducted for the water samples are shown in tables 1- 12 below:

Table 1 The Physico-chemical characterization of Water Sample A

PARAMETERS	**SAMPLE(A)**	**NAFDAC**	***WHO**	****USEPA**
Colour	Colourless	Colourless		
Odour	Odourless	Odourless		
Taste	Tasteless	Tasteless		
pH	7.5	8.5-8.5		
Conductivity (µS/cm)	107.5	1000		
Turbidity (NTU)	107.5	5		
Total Suspended solid	0	3		
Total dissolved solid	78.0	500		
Phenol Alkalinity	Nil	100		
Total Alkalinity	12.20	100		
Total Hardness as $CaCO_3$	21.10	100		
Chloride	63.19	100		
Nitrate	0.15	10		
Phosphate	0.06	0.2		
Sulphate	0.90	100		
Calcium	4.10	75	0.5	0.5
Magnesium	2.92	20	0.3	-
Iron	ND(= Not detected)	0.3	2.0	1.3
Copper	ND	1.0		
Lead	ND(= Not detected)	0.01		
Cadmium	0.03	0.003	0.003	0.005

Table 2 Microbiological Examination for Sample A

Organism (cfu/ml)	**Result**	**NAFDAC LIMIT**
Presumptive Coliform	0	0
E.Coli	0	0
Streptococcus faecalis	0	0
Aerobic mesophilic count	1	100
Fungi/ Yeast	0	100

Table 3 The Physico-chemical characterization of Water Sample B

PARAMETERS	**SAMPLE (B)**	**NAFDAC**	***WHO**	****USEPA**
Colour	Colourless	Colourless		
Odour	Odourless	Odourless		
Taste	Tasteless	Tasteless		
pH	7.40	6.5-8.5		
Conductivity (µS/cm)	99.5	1000		
Turbidity (NTU)	0	5		
Total Suspended solid	75.50	3		
Total dissolved solid	0	500		
Phenol Alkalinity	Nil	100		
Total Alkalinity	24.40	100		
Total Hardness as $CaCO_3$	18.00	100		

PARAMETERS	SAMPLE (B)	NAFDAC	*WHO	**USEPA
Chloride	63.19	100		
Nitrate	0.10	10		
Phosphate	0.08	0.2		
Sulphate	1.45	100	0.5	0.5
Calcium	3.61	75	0.3	-
Magnesium	2.19	20	2.0	1.3
Iron	ND(= Not detected)	0.3		
Copper	0.07	1.0		
Lead	ND (= Not detected)	0.01		
Cadmium	0.05	0.003	0.003	0.005

Table 4 Microbiological Examination for Sample B

Organism (cfu/ml)	Result	NAFDAC LIMIT
Presumptive Coliform	5	0
E.Coli	0	0
Streptococcus faecalis	0	0
Aerobic mesophilic count	12	100
Fungi/ Yeast	0	100

Table 5 The Physico-chemical characterization of Water Sample C

PARAMETERS	Sample C	NAFDAC	*WHO	**USEPA
Colour(CTU)	1	Colourless		
Conductivity (µS/cm)	22.20	1000		
Turbidity(NTU)	1	5		
pH	6.20	6.5-8.5		
Suspended solid	1	3		
Total Dissolved soil	16.10	500		
Total alkalinity	24.40	100		
Total Hardness as $CaCO_3$	7.00	100		
Chloride	34.08	100		
Nitrate	0.10	10		
Phosphate	0.80	0.2		
Sulphate	2.45	100		
Calcium	1.20	75		
Magnesium	0.97	20		
Iron	0.12	0.3		
Copper	0.09	1.0		
Lead	ND	0.01	-	-
Cadmium	ND	0.003	0.003	0.005

Table 6 Microbiological Examination for Sample C

Organism (cfu/ml)	Result	NAFDAC LIMIT
Presumptive Coliform	0.002	0
E.Coli	0	0
Streptococcus faecalis	0	0
Aerobic mesophilic count	$1.2x\ 10^4$	100
Fungi/ Yeast	0	100

Table 7 The Physico-chemical characterization of Water Sample D

PARAMETERS	**Sample D**	**NAFDAC**	***WHO**	****USEPA**
Colour(CTU)	1	Colourless		
Conductivity (µS/cm)	82.60	1000		
Turbidity(NTU)	2	5		
pH	6.20	6.5-8.5		
Suspended solid	0	3		
Total Dissolved soil	59.9	500		
Total alkalinity	36.60	100		
Total Hardness as $CaCO_3$	26.00	100		
Chloride	41.90	100		
Nitrate	0.15	10		
Phosphate	1.20	0.2		
Sulphate	3.20	100		
Calcium	7.62	75		
Magnesium	1.70	20		
Iron	0.09	0.3		
Copper	0.07	1.0		
Lead	ND	0.01		-
Cadmium	ND	0.003	0.003	0.005

Table 8 Microbiological Examination for Sample D

Organism (cfu/ml)	**Result**	**NAFDAC LIMIT**
Presumptive Coliform	0.00	0
E.Coli	0	0
Streptococcus faecalis	0	0
Aerobic mesophilic count	$2.4x\ 10^4$	100
Fungi/ Yeast	0	100

Table 9 The Physico-chemical characterization of Water Sample E

PARAMETERS	**Sample E**	**NAFDAC**	***WHO**	****USEPA**
Colour(CTU)	0	Colourless		
Conductivity (µS/cm)	16.20	1000		
Turbidity(NTU)	0	5		
pH	6.30	6.5-8.5		
Suspended solid	0	3		
Total Dissolved soil	11.75	500		
Total alkalinity	12.20	100		
Total Hardness as $CaCO_3$	6.00	100		
Chloride	38.34	100		
Nitrate	0.10	10		
Phosphate	1.10	0.2		
Sulphate	2.50	100		
Calcium	1.20	75		
Magnesium	0.73	20		
Iron	0.13	0.3		
Copper	0.07	1.0		
Lead	ND	0.01	-	-
Cadmium	ND	0.003	0.003	0.005

Table 10 Microbiological Examination for Sample E

Organism (cfu/ml)	**Result**	**NAFDAC LIMIT**
Presumptive Coliform	0.00	0
E.Coli	0	0
Streptococcus faecalis	0	0
Aerobic mesophilic count	70	100
Fungi/ Yeast	0	100

Table 11 The Physico-chemical characterization of Water Sample F

PARAMETERS	**Sample F**	**NAFDAC**	***WHO**	****USEPA**
Colour(CTU)	0	Colourless		
Conductivity (µS/cm)	86.50	1000		
Turbidity(NTU)	1	5		
pH	6.30	6.5-8.5		
Suspended solid	0	3		
Total Dissolved soil	62.70	500		
Total alkalinity	48.80	100		
Total Hardness as $CaCO_3$	38.00	100		
Chloride	45.40	100		
Nitrate	0.10	10		
Phosphate	1.30	0.2		
Sulphate Calcium	2.80 8.02	100 75		
Magnesium	4.37	20		
Iron	0.10	0.3		
Copper	0.08	1.0		
Lead	ND	0.01	-	-
Cadmium	ND	0.003	0.003	0.005

Table 12 Microbiological Examination for Sample F

Organism (cfu/ml)	**Result**	**NAFDAC LIMIT**
Presumptive Coliform	0.00	0
E.Coli	0	0
Streptococcus faecalis	0	0
Aerobic mesophilic count	80	100
Fungi/ Yeast	0	100

For the microbiological examination and characterization tests conducted, all limits are in mg/l except otherwise stated. The organism detected are graded in Cfu/ml= colony forming unit per millimeter. Samples C-F recorded a high aerobic mesophilic count.

It was found that the samples A-D (shown in tables1-7) tested have high value of Cadmium which is harmful to the human body. The maximum contaminant level (MCL) for cadmium is 0.005 mg/L or 5 (parts per billion) ppb. The United States Environmental Protection Agency has set this level of protection based on the best available science to prevent potential health problems. Most countries including Nigeria are adopting this MCL

standard. Some people who drink water containing cadmium in excess of the MCL over many years could experience kidney damage.

4. Conclusions

This study examined the effect of dumpsite leachates on the drinking water within the vicinity of Okpuno-Egbu, Umudim, Nnewi in Anambra State. The physicochemical parameters tested were the Colour, Odour, Taste, pH, Conductivity (µS/cm), Turbidity (NTU), Total Suspended solids, Total dissolved solids, Phenol Alkalinity, Total Alkalinity, Total Hardness as $CaCO_3$, Chloride, Nitrate, Phosphate, Sulphate, Calcium, Magnesium, Iron , Copper, Lead and Cadmium. Most of the quality parameters tested was found to fall within international and national water quality standards except the detection of Cadmium which is a toxic heavy metal. This makes the water not potable.

The non-existence of adequate waste disposal and management system has been a serious problem in most cities in Nigeria. The government has not been able to tackle this menace in cities with high industrial activities like Nnewi, Anambra State; this is largely due to the high cost involved. There is insufficient data on physicochemical status of dumpsites in most cities in Nigeria. The data recorded in this study will help the appropriate authorities involved in Environmental Protection to plan towards remediation of the environment.

Regular water quality monitoring in areas with dumpsite is encouraged. Increasing the frequency of water sampling and analysis on the study areas is needed to effectively monitor the impact of dumpsites, particularly on environment and human health.

There is the need for appropriate government agencies in Nigeria to initiate an active phytoremediation process in combination with physicochemical methods to recover the dumpsite from contaminants and reduce the level of pollution in the surrounding environment.

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5. References

[1]. R.S.H. Yang, and E.R. Rauckman, "Toxicological studies of chemical mixture of environmental concern at the national toxicology program: health effects of ground water contaminants." *Toxicology*, 47, 1987 pp. 15–34.

[2]. A.O. Majolagbe,, A.A. Kasali, and L.O. Ghaniyu, "Quality assessment of groundwater in the vicinity of dumpsite in Ifo and Lagos, Southwestern Nigeria." *Advances in Applied Science Research*, 2(1): 2011, pp. 289-298.

[3] G.L. Sia Su, "Assessing the effect of a dumpsite to groundwater quality in Payatas, Phillipines." *American Journal of Environmental Sciences*, 4(4): 2008, pp. 276-280.

[4] S. Abul, "Environmental and Health impact of solid waste disposal at Mangwaneni dumpsite in Manzini: Swaziland." *Journal of Sustainable Development in Africa*, (2010). 12(7).

[5] G.O. Adewuyi, and M.A. Opasina, "Physicochemical and heavy metals assessment of leachates from Apenrin abandoned dumpsite in Ibadan City, Nigeria." *E-journal of Chemistry*, 7(4): 2010, pp. 1278-1283.

[6] WHO (World Health Organization) Revision of the WHO Guidelines for Water Quality Report of the First Review Group Meeting on Inorganics, (Netherlands) World Health Organization Geneva WHO/PEP 1991, pp.18.

[7] United State Environmental Protection Agency, Toxicity Characteristic leaching Procedure, Method 1311, SW 1992, pp. 846.