Original Research Article

EVALUATION OF SURFACE WATER CONTAMINATION BY LEACHATE FROM UNCONTROLLED LANDFILLS: A CASE STUDY OF YENAGOA CENTRAL WASTE DUMP, NIGERIA.

ABSTRACT

Recently, surface water pollution has generated grave concerns because of anthropogenic activities including inadequate management of waste. Therefore, this study is concerned with the evaluation of surface water contamination by leachate from uncontrolled landfill in Yenagoa Bayelsa State, Nigeria. Three surface water samples were taken from a river adjacent to an uncontrolled landfill and analyzed. The Downstream (SW 1) and Upstream points were taken 50 meters from the southernmost and northernmost ends of the landfill, while the Central point (SW 2) was also taken 50 meters from the central edge of the landfill. The parameters analyzed were, pH, EC, TDS, COD, BOD, TH,NH_4^+, SO_4^{2-}, NO_3^-, Phosphate, Cd, Cr, Cu^{2+}, Pb, Zn, Ca^{2+}, Mg^{2+}, Na^+, Fe^{2+}, K^+, as well as Total coliform count using standard methods. The concentration of these parameters were compared with NSDWQ and WHO to ascertain their levels within the surface water. The surface water analysis across the Downstream (SW 1) showed that parameters like pH, EC, TDS, TA, TH, Na, K, Fe, BOD, COD, Phosphate and Total Coliform Count, recorded 7.18, 2,450 µS/cm, 1,225 mg/l, 534.9 mg/l, 270 mg/l, 122.92 mg/l, 69.42 mg/l, 9.48 mg/l, 25 mg/l, 16 mg/l, 7.5 mg/l and 2.80 X 10^6 cfu/ml respectively. All these values were above NSDWQ and WHO recommended values for potable water. When compared to samples from SW 2 and SW 3, SW 1 samples had higher concentration of parameters. However, some metals and heavy metals like Pb, Cu, Zn, Cd and Cr were below equipment detectable limits for all sampled locations. It was confirmed therefore that Downstream (SW 1), was the most contaminated among the three sampled surface water points, in this study. Pearson's correlational analysis also confirmed that some parameters indicated unity. It was recommended that surface water sources around landfills should be properly monitored to curb water pollution.

Keywords: Contamination, Downstream, Surface water, Pollution, Leachate, Uncontrolled Landfill

1.0 INTRODUCTION

Uncontrolled waste dumps in municipalities of developing nations/cities have in recent times given rise to various forms of nuisance such as rodents' proliferation, air pollution (odor), soil pollution (peculation/infiltration) as well as water pollution (overland flow). When waste is not properly managed, it interferes with the environmental, which reduces the aesthetic value of the particular area used for waste disposal (waste littering). When waste is not adequately disposed, its byproducts also poses a threat to those who come in contact with the environmental resources within the dumpsite. The inadequate handling of waste has resulted in serious ecological, environmental and health concerns [1]. The open dumping of municipal solid waste in landfills is one of the oldest and most common disposal methods adopted in most of the countries, particularly developing ones [2]. Landfill leachate is generated when rainwater percolates through the waste layers in a landfill, in which process organic and inorganic constituents of the waste get dissolved, transported and deposited at the bottom of the landfill by gravity [3]. Some of the components of landfill leachate may be categorized as a water-based solution of four groups of contaminants dissolved organic matter, inorganic macro-components, heavy metals, and xenobiotic organic compounds [4]. The most important potential environmental concern associated with landfill is the formation of leachate and the subsequent contamination of soil and water resources [5, 6].

Water is life, it is a global significant and valuable renewable resource for human life and economic growth. Water has remained the most abundant and most important resource of man, every life depends on it for various reasons. It has prided itself over the years as the source of life on planet earth without which nothing survives. Water exist in the atmosphere as vapor, on the earth surface as surface water and below the earth surface as ground water. Majority of the surface water available on the earth is saline in nature, only a small quantity is fresh water and therefore requires adequate conservation for human accessibility. Freshwater has become a scare commodity due to anthropogenic activities of over exploitation and pollution. Pollution is caused when a change in the physical, chemical or biological condition in the environment harmfully affect quality of human life, as well as plants and animals [7].

When foreign elements enter the water column, or when the minerals found in water exceed the acceptable amount, the water is said to be contaminated; water pollution describes the presence of materials in water that interfere unreasonably with one or more beneficial uses of water [8]. When this happens, some health concerns are raised, health hazards arising from waste management and disposal associated activities and their ability to pollute surface water consequently need to be analyzed specifically for the conditions in a given setting. Surface water pollution is caused mainly due to several processes of inadequate waste management from various sources including industrial waste, agricultural waste, institutional waste and municipal waste etc. The impact of leachate on surface water and other water resources has attracted a lot of attention because of its devastating environmental and health significance. Leachate migration from landfills poses a high risk to water resource if not satisfactorily managed [9]. Most lakes and rivers in the world are seriously polluted nowadays due to the human interference with the ecological balance. The growing population which has increased waste generation potentials has brought about severe environmental, economic, and social difficulties in both developed and developing countries [10]. This has therefore caused an existential concern to residents within regions assigned for waste disposal

2.0 Description of the study area

The landfill is located off Edepie-Amassoma road, Etelebu in Yenagoa Local Government Area of Bayelsa State, and operated by Bayelsa state Environmental Sanitation Authority. As at the time of this study, the site which began operations from around 2008 had an average life span of about 11 years. The landfill also had a height of about 2m and covers a total area of about thirty-six kilometers square (36 km^2). A pictorial view of the landfill is presented in Figure 1 below.

The hydrogeological condition of the landfill site was consistent with the regional hydrogeological setting of Lagos area as depicted by [11]. The waste dump services wastes generated from the Yenagoa municipality. This waste dump is unlined and situated in the Niger Delta wetlands which houses a good chunk of the wastes generated across the growing city.

Figure 1: An Image Showing a Pictorial View of the Waste Dump

3.0 MATERIALS AND METHODS

3.1 Sample collection

The study area was described using Geographic Information System (GIS). Every sampling point was picked with the help of a standard Global Positioning System (GPS). To determine the degree of surface water pollution, three surface water samples were taken around the dumpsite and labeled SW 1 - SW 3. Two samples were taken at the landfill's Northernmost and Southernmost ends, while the third was taken at the center of the nearby creek, which provided inhabitants with protein (fish). The samples were taken with the help of clean 1.5L plastic bottles.

Table 1: Details of Sampling Sites

S/N	SAMPLING LOCATIONS	COORDINATES		DESCRIPTION
		LATITUDE (N)	LONGITUDE (E)	
1.	Surface Water (SW1)	4° 59' 58.78788"	6° 20' 11.51412"	Downstream Pont
2.	Surface Water (SW2)	4° 59' 40.14"	6° 19' 57.91"	Central Surface Water
3.	Surface Water (SW3)	4° 59' 27.68064"	$6^0$19'43.92804"	Upstream Point

After collection, the samples were immediately placed in ice coolers for transportation to the laboratory and stored in refrigerator. The samples were collected on the month of March. The water quality parameters dealt with were physical, chemical and biological characteristics [12]. Water quality parameters were analyzed in accordance with standard laboratory methods [13], they were; pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Hardness (TH), Ammonium (NH_4^+), Sulphate (SO_4^{2-}), Nitrate (NO_3^-), Phosphate and Heavy Metals such as Cadmium (Cd), Chromium (Cr), Copper (Cu^{2+}), Lead (Pb), Zinc (Zn), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Iron (Fe^{2+}) and Potassium (K^+) ions, as well as Total coliform count.

4.0 RESULT AND DISCUSSIONS

In this study, a total of three surface water samples were taken for laboratory analysis. The three samples were analyzed for, Physico-chemical characteristics, heavy metals, and microbiological load. The variations of parameters from sampling points SW 1, SW 2, SW 3 as compared with Nigerian Standard of Drinking Water Quality (NSDWQ) and World Health Organization (WHO) [14, 15] are shown in Table 2 below.

Table 2: Summary of Temporal Variation of Physico-Chemical Properties of Leachate Samples

Sample ID (Borehole Sampling points)	NSDWQ (2015)	WHO GUIDELINES (2011)	SW 1	SW 2	SW 3
pH	6.5-8.5	6.5-8.5	7.18	6.91	6.96
Temp.		25	22.3	21.3	21.6
EC	1000	1000	2,450	1,298	852
TDS	NS	500	**1,225**	649	426
SO2-4	100	500	20	24	24
NO3	50	50	0.4	0.1	0.1
PO3-4	NS	0.1	7.5	0.67	0.67
NH4		NA	0.09	0.022	0.022
TA	NS	200	534.9	290.2	193.5
BOD		5	16	16	14
COD		10	25	17	12
TH	250	200	270	250	260
Pb	0.01	0.01	<0.001	<0.001	<0.001

Cu	**1**	**2**	<0.001	<0.001	<0.001
Zn	**3**	**3**	<0.001	<0.001	<0.001
Fe	**0.3**	**0.3**	9.48	3.67	1.03
Ca	**NS**	**75**	14.06	8.15	11.8
Mg	**20**	**20**	19.67	9.77	6.59
K		**20**	69.42	31.72	8.32
Na	**200**	**200**	122.92	59.93	23.47
Cd	**0.003**	**0.003**	<0.001	<0.001	<0.001
Cr	**0.05**	**0.05**	<0.001	<0.001	<0.001
Total Plate Count	**10**	**0**	2.80×106	2.44×106	2.78×106

NB: All parameters are in mg/l except Temp., EC and Total plate count. ^{0}C, µS/cm and cfu/ml.

Figures 2 and 3 shows the percentages of the Physico-chemical and microbial characteristics of the surface water analyzed during the sampling period.

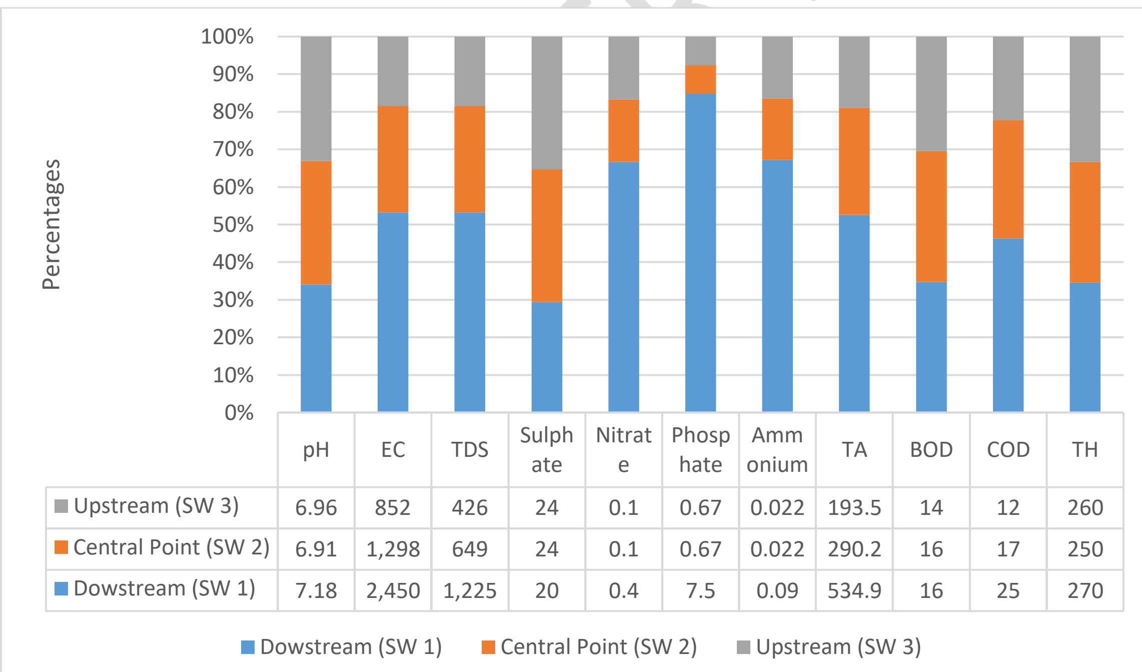
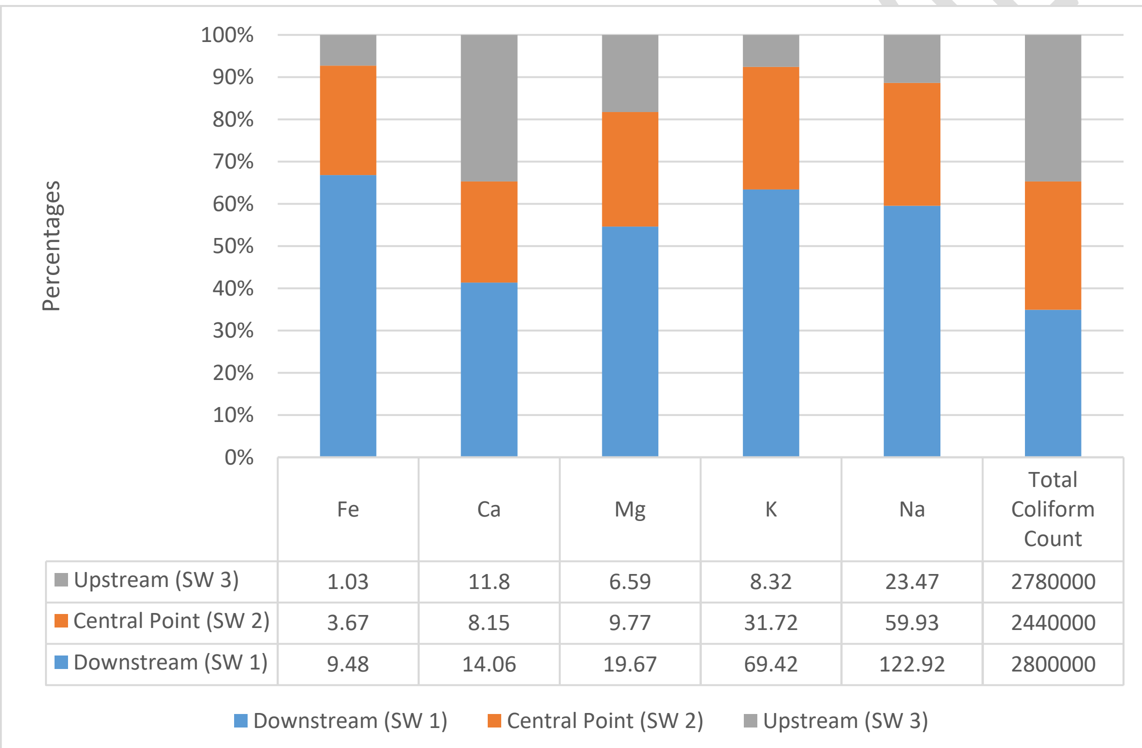


Figure 2: Percentage composition of surface water parameters within the sampling points

All the sampled parameters showed variations across the sampling points. It was observed from the chart above that the values for pH of the surface water samples ranged from 6.96 - 7.18, but were within the WHO recommended range. The EC which ranged from 852 - 2450 and Total

Dissolved Solid (TDS) with range from 426 - 125 showed similar trends. They both had values that were greater than the regulatory standards at the Downstream (SW 1) and the Central point (SW 2). Concentration of Sulphate (SO_4^{2-}), Nitrate (NO_3), Phosphate (PO_4^{3-}) and Ammonium (NH_4) also showed similar patterns. They all had the same concentrations at Upstream (SW 1) and SW 2, however, the values at SW 3 were higher. When compared with NSDWQ and WHO standards, they fell within permissible limits. Total Alkalinity, BOD, COD and Total Hardness values ranged between 193.5 – 534.9, 14 - 16, 12 – 25 and 250 – 270 respectively. When compared with the regulatory standards, it was observed that they were all above WHO standards except for the TA value at the Downstream (SW 3). The higher BOD_5 and COD values indicate the presence of organic matter in water.



	Fe	Ca	Mg	K	Na	Total Coliform Count
Upstream (SW 3)	1.03	11.8	6.59	8.32	23.47	2780000
Central Point (SW 2)	3.67	8.15	9.77	31.72	59.93	2440000
Downstream (SW 1)	9.48	14.06	19.67	69.42	122.92	2800000

Figure 3: Percentage composition of some metals and microbial load of surface water within the sampling points

All the heavy metals in the surface water analyzed (Pb, Cu, Zn, Cd, and Cr) in this stud were below instrument detectable limits (BDL). However, the microbial load within the surface water sampled at all points indicated a huge population much more than the acceptable NSDWQ and WHO standards for potability. The high concentration of parameters in the three surface water samples indicated surface water contamination.

Pearson's correlation was also used to determine parameters that had a relationship to indicate their common source.

The correlation matrices for 18 measured variables during sampling analysis are illustrated in Tables 3 below.

Table 3: Pearson's Correlation for Surface Water of March, 2019 Analysis Using Microsoft Excel

	pH	*Temp.*	*EC*	*TDS*	*SO2-4*	*NO3*	*PO3-4*	*NH4*	*Alkalinity*	*BOD*	*COD*	*Hardness*	*Fe*	*Ca*	*Mg*	*K*	*Na*	*Total Plate Count*
pH	1																	
Temp.	0.992603	1																
EC	0.900976	0.841638	1															
TDS	0.900976	0.841638	1	1														
SO2-4	-0.98474	-0.95632	-0.96274	-0.96274	1													
NO3	0.984738	0.956325	0.962737	0.962737	-1	1												
PO3-4	0.984738	0.956325	0.962737	0.962737	-1	1	1											
NH4	0.984738	0.956325	0.962737	0.962737	-1	1	1	1										
Alkalinity	0.899014	0.839199	0.99999	0.99999	-0.96151	0.96151	0.96151	0.96151	1									
BOD	0.341644	0.225018	0.715576	0.715576	-0.5	0.5	0.5	0.5	0.718713	1								
COD	0.844011	0.772656	0.993129	0.993129	-0.92447	0.924473	0.924473	0.924473	0.993646	0.792406	1							
Hardness	0.939829	0.974355	0.698535	0.698535	-0.86603	0.866025	0.866025	0.866025	0.695307	0	0.609994	1						
Fe	0.884565	0.821398	0.999336	0.999336	-0.92447	0.952241	0.952241	0.952241	0.99949	0.740558	0.996734	0.671992	1					
Ca	0.885313	0.935217	0.595898	0.595898	-0.79087	0.790872	0.790872	0.790872	0.592278	-0.13455	0.497825	0.990906	0.566236	1				
Mg	0.91705	0.861854	0.999255	0.999255	-0.97246	0.972457	0.972457	0.972457	0.999071	0.688083	0.987872	0.725632	0.997185	0.626448	1			
K	0.845005	0.773833	0.993344	0.993344	-0.92518	0.92518	0.92518	0.92518	0.993853	0.791272	0.999998	0.611464	0.996882	0.499434	0.988159	1		
Na	0.854757	0.785422	0.995306	0.995306	-0.93204	0.932044	0.932044	0.932044	0.995731	0.779821	0.999793	0.626002	0.998172	0.515381	0.990829	0.999829	1	
Total Plate Count	0.680159	0.764125	0.294752	0.294752	-0.54219	0.542194	0.542194	0.542194	0.290448	-0.45658	0.1809	0.88968	0.259731	0.943025	0.331412	0.182725	0.200888	1

A perfect positive correlation between TDS and EC (r = 1, p ≤ 0.01), NH_4 and NO_3 (r = 1, p ≤ 0.001) and PO_4^{3-} and NO_3 (r = 1, p ≤ 0.001) was observed and this meant that they had exactly the same contributor which could be mud and putrescible wastes brought in by the infiltrating rain water and organics.

The strong positive correlation between EC and pH, TDS and pH, TA and EC, TA and TDS, COD and EC (r = 0.98, p ≤ 0.01) in March, 2019 signified that they had nearly the same contributors (the dissolved ions). A significant negative correlation was also observed between TA, COD, Fe, Mg, K, Na and SO_4 (r = -0.9615, -0.92447, -0.92447, -0.97246, -0.92518, -0.93204) respectively, indicating the opposing distribution of these pair variables.

5.0 CONCLUSION

The surface water analysis across the Downstream (SW 1) showed that parameters like pH, EC, TDS, TA, TH, Na, K, Fe, BOD, COD, Phosphate and Total Coliform Count, recorded 7.18, 2,450 µS/cm, 1,225 mg/l, 534.9 mg/l, 270 mg/l, 122.92 mg/l, 69.42 mg/l, 9.48 mg/l, 25 mg/l, 16 mg/l, 7.5 mg/l and 2.80 X 10^6 cfu/ml respectively. All these values were above NSDWQ and WHO recommended values for drinking water. When compared to samples from SW 2 and SW 3 sampling locations, SW 1 samples had higher concentration of parameters. However, some metals and heavy metals like Pb, Cu, Zn, Cd and Cr were below equipment detectable limits for all sampled locations. It was confirmed therefore that SW 1, was the most contaminated among the three sampled surface water points, in this study. The microbial load within all the samples greatly exceeded the recommended WHO for drinking water.

Therefore it was recommended that citing of landfills should be done after a proper study of the environment since they have been confirmed to contribute contaminants into the environment.

Surface water sources within landfills should also be properly monitored to avoid ingestion of contaminated water.

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