Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 3, No. 8, p. 73-82, 2013
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Effects of sanitary landfills on surface water quality in Calabar Municipality, Cross River State

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Article published on August 24, 2013

Key words: Sanitary landfill, surface water, physico-chemical parameters, Calabar Municipalit.

Abstract

The study assessed the effects of sanitary landfills on surface water quality in Calabar Municipality, Cross River State. Water samples were collected using ragolis plastic containers of 1.5 liters from surface water bodies within landfill sites and analysed using standard methods. DO, BOD and COD values obtained across the course of the river were far below WHO and FEPA minimum permissible limits for the discharge of effluents into surface water. TDS values were within WHO and FEPA minimum permissible limits of 500 mg/L, but turbidity values of the water bodies (2 to 949 NTU) were higher than WHO recommended limit of 5 NTU. The concentration of nitrate (NO_3) and sulphate (SO_4) ranged from 3.20 to 4.956mg/L, and between 3.72 to 194.3mg/L respectively; the values were far below WHO and FEPA maximum permissible levels of 10mg/L and 250mg/L respectively. ANOVA result revealed that the sampled surface water bodies did not vary significantly in the chemical composition of parameters ($F = 0.639$, ≤ 0.05). The study suggested that government and cooperation individuals should institute close monitoring of the various human activities in the area to maintain the cleanliness of the area as well ensure the continuous suitability of surface water bodies

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Introduction

Globally, the reliance on sanitary landfills is a common phenomenon in the disposal of waste materials. But in Nigeria, the lack of capital and appropriate technology for environmentally friendly waste management practices has left most cities and urban areas to rely on landfills for solid waste disposal, and in most cases the landfills are not properly engineered and operated to accepted world standards (Kola-Olusanya, 2005). For the past three decades or so, landfilling has been favoured as a method of waste disposal for a number of reasons, often because it is probably the cheapest available method and also as a result of the availability of holes in the ground. Water as a gift of nature is generally believed to have no enemy. Despite the abundance of fresh water on the earth, many regions are in deep crisis of water shortage due to there being polluted by human activities, or the ever increasing demand by industrialization and high population growth. Thus, groundwater is the alternative source of fresh water in areas where surface water is polluted or particularly in arid and semi-arid region of the world. However, the ground water that is presently rely on is generally been grossly polluted by various sources such as the dumping of wastes in landfills.

Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby site. Such contamination of groundwater resource poses a substantial risk to local resource user and to the natural environment. The impact of landfill leachate on the surface and groundwater has given rise to a number of studies in recent years (Suman *et al.,* 2005). Contamination of groundwater by leachate renders the groundwater and the associated aquifer unreliable for domestic water supply and other beneficial uses. This is far more serious than river pollution because aquifers require extensive time periods for rehabilitation. Once waste is deposited at the landfill (dumpsite) pollution can arise from the migration of both gas and leachate. There are three broad types of contaminants present in leachates that can pollute groundwater and subsequently affects public health. These are hazardous chemicals, conventional and non-conventional contaminates. The cost of cleaning up groundwater contaminated by Municipal Solid Waste landfill leachates require large sum of money and technology, which are presently not available in our society.

Inadequate solid waste management (SWM) is thus a major environmental problem in Calabar metropolis. The contributing factors range from technical problems to financial and institutional constraints. There is an absence of any properly designed solid waste disposal facilities in the state therefore posing contamination risk to both ground and surface waters. Groundwater is known as major source of water supply in the project area and in Calabar in general, and its contamination is a major environmental and health concern. Despite the inherent impact on the environment. Many cities and areas in Nigeria still rely on sanitary landfills for the disposal of household wastes. The implication is the continuous contamination of available water sources with inherent effects on human health. However, literature is sparse on the impact of these sanitary landfills on surface water. In view of this fact, this study therefore focuses on the impact of landfills on surface water quality in Calabar Municipality of Cross River State, Nigeria.

Materials and methods

Studyarea

Calabar Metropolis is located between latitude 8^{o} 15^{I} E and 8^{o} 20^{I} E, and longitude 4^{o} 45^{I} N and 5^{o} 30^{I} N. The city lies on a peninsula formed by the Calabar River, Great Kwa River, the Cross River State estuary and the Atlantic Ocean. It has a sub-equatorial type of climate; the temperature is moderately high and not fluctuating greatly. The maritime position of Calabar exercises considerable ameliorating influence on its climate. The mean temperature is about $25^{o}C$ with a range of about $8^{o}C$. The annual rainfall exceeds 300 millimeters, most of which comes in the wet season from May to October. The relative humidity is high throughout the year, giving a mean annual figure of about 84%. The vegetation of the area is mainly that of mangrove swamp, the raffia swamp and cultivated vegetable gardens, numerous isolated stands of cultivated semi-wild oil palm and coconut palm trees. There are two major drainage systems in Calabar. These are the Calabar River system and the Great Quo river system. Geologically, the area is composed of two main formations. Thecoastal plain sands, the equivalent of Benin formation, are of tertiary period. This formation consists of light brown to grayish white sands. Sometimes with decomposed feldspar fragments and pockets of clay.

Data collection procedure

Prior to data collection visits were made to the study sites during which, sites for data collection were delineated; surface water samples within and adjoining landfill sites were marked for collection. Water samples were collected using ragolis plastic containers of 1.5 liters. Water samples were collected at the borehole heads. Prior to sample collection, all plastic containers were rinsed thrice with the borehole water. After sampling, the containers will be tightly covered to minimize oxygen contamination, and escape of dissolved gases; the samples were appropriately labeled and stored in a cooler of 4 °C, and immediately taken to the laboratory at the University of Calabar for analysis of physical and chemical parameters using standard methods (APHA, 1998).

Results

Comparative analysis of quality status of selected surface waters

The quality status of water obtained from the four water samples (Table 1) varied spatially due to variation in the location of the water as well their distances from landfill sites within and around their catchment. The Table shows that pH level was high in stations 1, 4 and 2 and low in station 3 with pH values of 8.28, 8.21, 8.16 and 5.73 respectively. For temperature, high value was recorded on station 4 followed closely by station 2 and then station 1, while low temperature value of 26.3 °C was recorded on the third station. Other stations had temperature values ranging from 27.2 - 27.8 °C. The content of dissolved oxygen (DO) happened to high on station 3 followed by stations 1 and 2, low DO value was obtained in station 4 with values of 2.2 mg/L, 0.9mg/L, 0.4mg/L and 0.2 mg/L. respectively (Table 1). In a similar manner, nitrate (NO_3) contents were high on station 3, followed closely by stations 4 and 1 with values of 4.96mg/L, 3.78mg/L and 3.22mg/L respectively. Low nitrate concentration was recorded on station 2 with value of 3.20mg/L. The levels of biological oxygen demand (BOD) differed between the water samples with the station 2 recording high value of 0.06 mg/L, followed by station 4 and then stations 1 and 3 with values of 0.02 mg/L (Table 1).

Table 1. Quality status of selected sachet waters.

Parameters	Station 1	Station 2	Station 3	Station 4
pH	8.28	8.16	5.73	8.21
Tempt (°C)	27.2	27.4	26.3	27.8
EC (us/cm)	11620	10646	93.2	11268
TDS (mg/L)	58.00	53.21	46.6	56.34
DO (mg/L)	0.9	0.4	2.2	0.2
BOD (mg/L)	0.02	0.06	0.02	0.03
COD (mg/L)	0.00	0.003	2.0	0.000
Hardness (mg/L)	280.0	269.4	12.2	271.2
NO_3 (mg/L)	3.216	3.200	4.958	3.781
PO_4 (mg/L)	0.009	0.004	0.000	0.004
SO_4 (mg/L)	188.8	186.2	3.722	194.3
NH_4 (mg/L)	0.018	0.014	0.002	0.014
Na (mg/L)	710.0	690.1	14.80	686.2
CL (mg/L)	1900	1840	26.00	1821
Turbidity (mg/L)	878	846	2	949
Mg (mg/L)	370.0	486.8	4.340	394.1

Station 1: On source point from the landfill (Ikot Effanga); Station 2: Surface water from stream close to the Ikot Effanga landfill; Station 3: Borehole near the Ikot Effanga landfill as alternative water source; Station 4: Surface water from downstream from water board intake Ikot Effanga.

For chemical oxygen demand (COD), high values were recorded on station 3 followed by station 2 with values of 2.0mg/L and 0.003mg/L respectively. In other stations (1 and 4), COD was not detected. Total dissolved solids (TDS) content was high on station 1 followed by station 4 with values of 58.00 mg/L and 56.34mg/L respectively, while low TDS value of 46.6mg/L was obtained on station 3 (Table 4.1). Turbidity values of the water sampled bodies were high on station 4 followed closely by stations 1 and 2 with values of 949 NTU, 878 NTU and 846 NTU respectively. Low turbidity value was reported on station 3 with value of 2 NTU. Level of total hardness was high on station 1 followed by stations 4 and 2 with values of 280mg/L, 271.2mg/L and 269.4mg/L respectively, while low value of 12.2mg/L was obtained on station 3. In addition, the proportion of sulphate (SO_4) in the sampled water bodies was high on station 4 followed by stations 1 and 2 with values of 194.3mg/L, 188.8mg/L and 186.2mg/L respectively.

For the proportion of ammonium (NH_4) in the water samples, high value of 0.018mg/L was recorded on station 1, followed by stations 2 and 4 with values of 0.014 respectively, while station 3 had a low value of 0.002mg/L. The content of chloride was high on station 1 with value of 1900mg/L, followed closely by station 2 with value of 1840mg/L and then the fourth station with value of 1821mg/L, while low chloride content was recorded again on station 3 with a value of 26.00mg/L. High magnesium content of 486.8 mg/L was recorded on station 2, followed by stations 4 and 1 with values of 393.1mg/L and 370mg/L respectively, while low value of 4.34mg/L was obtained on 3. Furthermore, high content of electrical conductivity (EC) was obtained on station 4 with value of 11620µs/cm, followed by stations 4 and 2 with values of 11268µs/cm and 10646µs/cm respectively, while station 3 recorded the lowest value of 93.2µs/cm. Finally, high content of sodium (Na) was obtained on station 1 with value of 710mg/L, followed by stations 2 and 4 with values of 690.1mg/L and 686.2mg/L respectively, while station 3 recorded the lowest value of 14.80mg/L (Table 1). Comparatively, station water sample is adjudged the most suitable for domestic use and aquatic sustenance as the proportion of its parameters is low and far within WHO permissible limits; this is followed by station 2 and then station 4. Station 1 is the most polluted of the water bodies as most of its measured parameters are higher than other stations; the contents of Mg, Cl and turbidity among others exceeded WHO and FEPA maximum permissible limits

Table 2 Physico-chemical parameters of selected water samples.

Parameters	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Permissible limit WHO	FEPA
pH	8.28	8.16	5.73	8.21	6.5-8.5	6.5-85
Tempt (oC)	27.2	27.4	26.3	27.8	35	35
EC (us/cm)	11620	10646	93.2	11268	200	
TDS (mg/L)	58.00	53.21	46.6	56.34	500	500
DO (mg/L)	0.9	0.4	2.2	0.2	8-10	10
BOD (mg/L)	0.02	0.06	0.02	0.03	10	3
COD (mg/L)	0.00	0.003	2.0	0.000	40	-
Hardness (mg/L)	280.0	269.4	12.2	271.2	-	-
NO_3 (mg/L)	3.216	3.200	4.958	3.781	10	10
PO_4 (mg/L)	0.009	0.004	0.000	0.004	2	2
SO_4 (mg/L)	188.8	186.2	3.722	194.3	250	250
NH_4 (mg/L)	0.018	0.014	0.002	0.014	30	
Na (mg/L)	710.0	690.1	14.80	686.2	200	200
CL (mg/L)	1900	1840	26.00	1821	600	600
Turbidity (mg/L)	878	846	2	949	5.0	5.0
Mg (mg/L)	370.0	486.8	4.340	394.1	50	50

Physico-chemical parameters of selected surface water samples

The physico-chemical parameters obtained across selected surface water around landfill areas are shown in Table 2. The Table shows that the pH level is alkaline with pH values ranging from 5.73 to 8.28. The pH value is high on station 1 and on station 3. This implies that the pH level of the stream may not affect the metal solubility and hardness of the water. A river with high alkalinity levels according to Ipeaiyeda & Onianwa (2011) will be able to supply adequate amounts of carbonate, bicarbonate and hydroxide ions in solution to bind up free protons and metals. Increase in alkalinity level means the surface water contains elevated levels of dissolved solids. The pH values obtained across the river body are above WHO and FEPA maximum tolerable level of 8.5 respectively. The level of temperature ranges from 26.3 to 27.8 ^{o}C with the station having the highest value of 27.8^{o} C (Table 2). These concentrations however are normal for aquatic lives, and have minimal effects on acidity (Ewa *et al.,* 2011).

Table 3. Zero-order correlation matrix of the concentration of parameters.

	pH	Tempt	EC	TDS	DO	BOD	COD	Hard	NO_3	PO_4	SO_4	NH_4	Na	CL	Turb	Mg
pH	1															
Tempt	.912	1														
EC	.999*	.912	1													
TDS	.933	.820	.945	1												
DO	-.934	-.986^{+}	-.929	-.796	1											
BOD	.407	.423	.374	.052	-.553	1										
COD	-.999*	-.920	.997*	-.917	.945	-.439	1									
Hard	.999*	.910	.999*	.930	-.934	415	-.999*	1								
NO_3	-.945	-.748	-.938	-.843	.817	-.504	.945	-.948	1							
PO_4	.791	.517	.803	.900	-.525	-.060	-.769	.791	-.827	1						
SO_4	.999*	.930	.998*	.925	-.950	.422	-.999*	.999*	-.933	.764	1					
NH_4	.971	.804	.975^{+}	.966^{+}	-.824	.254	-.962^{+}	.971^{+}	-.952^{+}	.914	.960^{+}	1				
Na	.999*	.909	.998*	.926	-.935	.424	-.999*	.999*	-.950^{+}	.788	.998*	.970^{+}	1			
CL	.999*	.906	.998*	.927	-.932	.423	-.999*	.999*	-.952^{+}	.791	.998*	.971^{+}	.999*	1		
Turb	.995*	.946	.996*	.932	-.956^{+}	.390	-.995*	.995*	-.910	.752	.998*	.952^{+}	.994*	.993*	1	
Mg	.962	.894	.952^{+}	.800	-.952^{+}	.640	-.917^{+}	.964^{+}	-.945	.647	.966^{+}	.892	.967^{+}	.967^{+}	.953^{+}	1
FC	.559	.192	.547	.477	-.312	.394	-.553	.566	-.794	.727	.525	.661	.571	.576	.477	.586
TC	.792	.517	.778	.653	-.628	.576	-.793	.798	-.947	.753	.771	.824	.802	.806	.732	.837

*Correlation is significant at the 0.01 level (2-tailed)
$^{+}$Correlation is significant at the 0.05 level (2-tailed)

Table 4. ANOVA result.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9860758.264	3	3286919.421	.639*	.592
Within Groups	3.497E8	68	5143086.606		
Total	3.596E8	71			

*Difference between means is insignificant at 5% significant level (2tailed) .

The temperature value obtained for this study corroborates those of Akan *et al.*, (2010), Saidu and Musa (2012) of 26 to 29 ^{o}C. The concentration of dissolved oxygen (DO) is high on station 3 with a value of 2.2 mg/L and low on station 4 with value of 0.2 mg/L. (Table 2). DO measure the degree of pollution by organic matter, the destructive of organic substances as well as the self-purification capacity of the water body. The depletion of DO on station 4 may be attributed to the huge amount of organic load which require high level of oxygen for chemical oxidation and breakdown, thereby resulting in the deterioration in oxygen (Iwara *et al.,* 2012). DO values obtained across the course of the river are far below WHO and FEPA minimum permissible limit of 8 and 10 mg/L for the discharge of wastewater. The standard for sustaining aquatic life is stipulated at 5mg/L, a concentration below this value adversely affects aquatic biological life, while concentration below 2mg/L may lead to death for most fishes (Chapman, 1997).

Table 5. LSD Multiple Comparisons of means.

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Stn. 1	Stn. 2	54.85167	755.94581	.942*	-1453.6147	1563.3180
	Stn. 3	878.74700	755.94581	.249*	-629.7194	2387.2134
	Stn. 4	21.02628	755.94581	.978*	-1487.4401	1529.4927
Stn.2	Stn. 1	-54.85167	755.94581	.942*	-1563.3180	1453.6147
	Stn. 3	823.89533	755.94581	.280*	-684.5710	2332.3617
	Stn. 4	-33.82539	755.94581	.964*	-1542.2918	1474.6410
Stn. 3	Stn. 1	-878.74700	755.94581	.249*	-2387.2134	629.7194
	Stn. 2	-823.89533	755.94581	.280*	-2332.3617	684.5710
	Stn. 4	-857.72072	755.94581	.261*	-2366.1871	650.7457
Stn. 4	Stn. 1	-21.02628	755.94581	.978*	-1529.4927	1487.4401
	Stn. 2	33.82539	755.94581	.964*	-1474.6410	1542.2918
	Stn. 3	857.72072	755.94581	.261*	-650.7457	2366.1871

Difference between means is insignificant at 5% significant level (2tailed) Source: SPSS output (version 20.0).

This implies that DO of the selected surface water may not adequately sustain aquatic lives. The DO value obtained in this study is far below the values reported elsewhere (Akan *et al.,* 2010; Omole & Longe, 2008). Similarly, the levels of biological oxygen demand (BOD) differ between the sampled surface water, with the station 2 recording high value of 0.06 mg/L, while station 1 has the low value of 0.02 mg/L (Table 4.2). These values are far below WHO and FEPA minimum allowable limits of 10 and 3 mg/L respectively. Biological oxygen demand (BOD) represents the amount of oxygen required for the biological decomposition of organic matter under aerobic condition. It indicates how much oxygen is needed for microbes to oxidize a given quantity of organic matter (Chukwu, 2008; Iwara *et al.,* 2012). The relatively high BOD value recorded on station 2 means there are greater quantities of degradable wastes from the landfill sites and household wastes. According to Chapman (1997), BOD is an important water quality parameter and is very essential in water quality assessment. However, the more organic materials present in the wastewater discharged into the stream, the higher the BOD as well as chemical oxygen demand (COD) content.

The COD often called the reducing capacity measures the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The COD values range from 0.00 to 2.0 mg/L. These values are below the 40 mg/L recommended limit of WHO. However, BOD value (obtained on station 2) corresponds to the low DO levels noticed at this point. The BOD and COD contents reveal that the sampled surface water has low level of organic pollution. Furthermore, total dissolved solids (TDS) range from 46.6 to 58.00 mg/L with station 1 recording high value of 58.0 mg/L, while station 3 has low value of 46.6 mg/L (Table 2). The high TDS value at on station 1 may be attributed to the discharge of several materials of solid wastes from the landfill site and household waste as well as lack of sedimentation facility to separate the solid wastes from the liquid wastes before discharge. The values of TDS are within WHO and FEPA minimum permissible limits of 500 mg/L. Thus, the inflow of the effluents resulted in the increase in TDS on station 1.

Turbidity reflects the amount of suspended and dissolved solids in the water. It is the opposite of transparency, which measures the depth of illumination or the depth to which light can penetrate. The fluctuations in turbidity and transparency values are a function of the degree of turbulence of the water. The turbidity values of the water bodies were high (2 to 949 NTU) which is higher than WHO recommended limit of 5 NTU mostly on stations 1, 2 and 4. The high turbidity is partly due to high level of humic acid and sediments from run-off feeding the water bodies. The turbidity value of the river suggests that the river is more transparent on station 3 than on station 4 which is most turbid/non-transparent (Table 2). The discharge of the effluent with total hardness of 12.2 - 280 mg/L into the river accounted for the increase in hardness levels on station 1. The level of total hardness increased on station 1 and 4. This implies that these water bodies presumably have been accumulating much dissolved calcium and magnesium ions that could possibly cause hardness. An increase in hardness level adversely affects detergent performance which constitutes the major problem to people who rely on the surface water for laundry purpose (Iwara *et al.,* 2012). The maximum permissible limit of 500 mg/L is required by WHO for water above which it is described as hard water. Hence, water from the selected surface water is within WHO permissible limit. Water of hardness level 50-100 mg/L is classified as moderately soft, while 100-150 mg/L is slightly hard, while above this value is hard.

The concentration of nitrate (NO_3) and sulphate (SO_4) ranges from 3.20 to 4.956mg/L, and between 3.72 to 194.3mg/L respectively. The values of NO_3 and SO_4 are high on stations 3 and 4 respectively as a result of the discharge of effluents directly into the water bodies from landfill sites. The levels of nitrate and sulphate are far below WHO and FEPA maximum permissible levels 10mg/L and 250mg/L respectively for the discharge of effluents. The levels of nitrate if not controlled according to Akan *et al.*, (2010) may give rise to methaemoglobinemia and encourage eutrophication. On the other hand, phosphate (PO_4) values range from 0.000 to 0.009mg/L with high value recorded on station 1. This low value means that effluents from cleansing chemicals are not discharged into the surface water. The phosphate levels obtained across the sampled surface water are far below WHO and FEPA limit of 2mg/l for the discharged of wastewater into surface water. Nevertheless, ammonium (NH_4) value ranges from 0.002 to 0.018mg/l which indicates that the water samples are free of ammonium contamination. The NH_4 value recorded in this study is far below values of 142 and 180 mg/l reported by Akan *et al.,* (2010). The level of ammonium obtained across the sample water is below WHO maximum permissible levels 30mg/l for the discharge of wastewater.

However, the discharge of effluent into the surface water on station 1 is responsible for its high value (Ipeaiyeda & Onianwa, 2011). The content of chloride ranges from 26.00 - 1900 mg/L with high and low values recorded on stations 1 and 3 respectively (Table 2). The range mostly on stations 1, 2 and 4 reveals that chloride levels are much lower than WHO and FEPA permissible chloride limit of 600 mg/L for effluent discharge into surface water (Table 2). The discharge of effluent into the surface water constitutes a pollution source of chloride in addition to the chloride level sourced from the dissolved mineral in the river (Ipeaiyeda & Onianwa, 2011). Also, magnesium content ranges from 4.34 – 486.8 mg/L with high and low values recorded on stations 2 and 3 respectively. The range mostly on stations 1, 2 and 4 are higher than WHO and FEPA permissible limits of 50 mg/L respectively for effluent discharge into surface water (Table 2).

Furthermore, the content of electrical conductivity (EC) ranges from 93.2 to 11620µs/cm with station 1 having the highest value of 11620µs/cm, and station 3 recording the lowest value of 93.2µs/cm (Table 2). The value on station 3 is within WHO maximum permissible limit of 200µs/cm, while the values on other stations are far above WHO Maximum permissible limits for the discharge of wastewater. This means that the water samples on station 1, 2, and 4 are polluted with effluents from landfill sites within their catchments; this further suggests that the sampled waters may be harmful to aquatic live. High concentration of conductivity and salinity in water has been reported to cause severe danger to both aquatic and human lives (Ewa *et al.,* 2011). The conductivity value obtained in this study is high compared to the values reported by similar studies (Omole & Longe, 2008; Saidu & Musa, 2012). Conductivity in water analysis is used to indicate the contents of dissolved solids in water because the concentration of ionic species determines the conduction of current in an electrolyte and it is unsafe to aquatic live the moment it is above the permissible limit (Saidu & Musa, 2012). The conductivity value obtained in this study is attributed to the high discharge of effluents (organic wastes) into the available surface water.

Pearson's correlation

In addition, the Pearson's correlation matrix in Table 3 indicates that the pH range of the selected water samples, chloride, Na, turbidity, NH_4, SO_4 and total hardness had substantial effects on the quality status of the surface water. The pH ranged led to the decrease and insignificant association between the parameters. Indeed, the Table generally shows significant and insignificant (positive and negative) associations between the measured parameters. However, significant positive association were observed between EC and pH, EC and COD, pH and hardness, EC and hardness, pH and SO_4, EC and SO_4, SO_4 and hardness, NH_4 and pH, NH_4 and EC, NH_4 and TDS, NH_4 and SO_4, Na and pH, Na and EC, Na and hardness, Na and SO_4. Other positive and significant association were found between CL and ph, CL and EC, CL and hardness, CL and SO_4, CL and PO_4, CL and Na, turbidity and pH, turbidity and EC, turbidity and hardness, turbidity and SO_4, turbidity and NH_4, turbidity and Na, turbidity and CL as well as between Mg and ph, Mg and EC, Mg and hardness, Mg and SO_4, Mg and Na, Mg and turbidity.

On the other hand, negative and significant relations were observed between DO and temperature, COD and pH, hardness and COD, SO_4 and COD, NH_4 and COD, NH_4 and NO_3, Na and BOD, Na and NO_3, CL and COD, CL and NO_3, turbidity and DO, turbidity and COD, Mg and DO (Table 4.3). No significant association was observed between FC and TC and the measured parameters. Thus, the positive and significant correlations between the above mentioned parameters show that they originated from identical source. It is also an indication of common sources of pollution (Adelekan & Alawode, 2011), whereas, the negative and significant associations are indication of varied sources of pollution. This therefore implies that the quality status of surface water is influenced by identical and non-identical sources of pollution within and around their catchment.

Analysis of variation in water quality around landfills

The researcher sought to find out whether the water quality of surface water bodies around landfills vary significantly. The hypothesis was tested using One-Way ANOVA. Result obtained is depicted in Table 4. The result shows that water quality of surface water bodies around landfills does not vary significantly. This therefore means that the sampled surface water around landfill sites do not vary significantly in the chemical composition of parameters. This decision is contingent on the p-Value of .592 being greater than the level of significance at 5%.

In addition, the result of multiple comparisons of means between the sampled water bodies is presented in Table 5. The result reveals that there were no significant differences between the stations. For instance, station 1 did not show any significant difference with station 2, this pattern was also observed with stations 3 and 4 and so on. This implies that the concentration of pollutants in the sampled water bodies may be of relative proportions.

Conclusion

The result obtained showed that the quality status of selected water bodies in the area was not impaired or polluted. This is because some of the measured physico-chemical parameters particularly pH, temperature, DO, BOD, COD, NO_3, PO_4, SO_4, NH_4 were within WHO and FEPA maximum permissible levels, whereas, EC, TDS, turbidity, CL and Mg mostly on stations 1, 2 and 4 were above the permissible limits. The inter-correlation between the parameters shows they may or may not be affected by same activities within the study. The study recommends government and cooperation individuals to institute close monitoring of the various human activities in the area to maintain the cleanliness of the area as well ensure the continuous suitability of water bodies.

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