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Distribution and Impact of Organic-Leachates Linked to Water and Sediment in Otuasega, Niger Delta Region, Nigeria

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Abstract

This study investigated distribution and Impact of organic-leachates linked to water and sediment consumption of contaminated surface and groundwater in Otuasega. There is a need to investigate water-borne related diseases such as stomach disorder associated with the intake of water in the study area. A total of 10 water and sediment samples compromising surface water, groundwater, surface sediment and borehole sediments were collected were analysed in triplicate. Particle size analyses of the air-dried sediments was conducted using a particle size analyser. The American Public Health Association Method (APHA) was used to perform the chemical analysis of the water samples. Here, a liquid-liquid extraction procedure conducted on the samples using 30 mL dichloromethane (DCM) as the extraction agent. The textural characteristics possessed a mean grain size from fine sand (2.23) to coarse silt (4.77), poorly sorted of (1.90) to very poorly sorted (2.28), skewness of negatively skewed (-0.72) to positively skewed (0.71), normal curve kurtosis of (0.62) to very leptokurtic of (2.2.28). Total petroleum hydrocarbon was 0.30 mg/L to 0.52 mg/L, in surface water, and 0.36 mg/L to 0.54 mg/L in groundwater, Total hydrocarbon content was 0.62 mg/L to 0.94 mg/L in surface water and 3.40 mg/L to 4.80 mg/L in groundwater, Fe was 0.12 to 0.63 in surface water and 0.89 to 2.52 in groundwater, Polycyclic Aromatic Hydrocarbon was 0.01mg/L to 0.03mg/L in surface water and 0.02mg/L to 0.59 mg/L in groundwater, While pH was 6.90 to 8.41 in surface sediment and 4.65 to 5.87 in borehole sediment, Total petroleum hydrocarbon was 0.36 mg/Kg to 0.55 mg/Kg, in surface sediment, and 0.21 mg/Kg to 0.34 mg/Kg in bore hole sediment, Total Hydrocarbon Content was 0.87 mg/Kg to 1.44 mg/Kg in surface sediment and 2.90 mg/Kg to 8.86 mg/Kg in bore hole sediment, Fe was 0.55 to 1.54 in surface sediment and 0.20 to 0.43 in bore hole sediment, PAH was 0.88 mg/Kg to 3.99 mg/Kg in surface sediment and 0.01 mg/Kg to 0.0.03 mg/Kg in bore hole sediment respectively. results of these contaminants bound to sediments and water were above the acceptable limits of World Health Organization for drinking water. The characteristics of the borehole sediment significantly controlled the ingress of contaminants into the groundwater. The investigation serves as a baseline study for monitoring by National Oil Spill Detection and Response Agency.

Keywords: Iron, Total Petroleum Hydrocarbon, Total Hydrocarbon Content, Organic contaminants Otuasega, Contaminants, Niger Delta.

Introduction

The concern of residents of Otuasega in recent times is the damage to the environment and human health caused by the occurrence of organo-contaminants into water courses. Water is essential to the sustenance of life in Otuasega and availability to safe drinking water is crucial for human health and well-being of the community.

The main public concern in recent years has been the damage to human health caused by contaminated water through environmental pollution [1]. To ensure the safety of the public's drinking water supply, it's crucial to reduce contamination [2]. Access to safe drinking water is crucial for human health and wellbeing [3]. The health and well-being of humans and ecosystems depend heavily on the quality of water resources available through proper land use planning and the enactment of robust legislation [4]. Failure to protect water sources and inadequate water treatment are the primary reasons for portable water contamination [5].

The concerns with the state of water in Otuasega stem from sweating, bleeding stomach disorders, to blood disorders, congenital disabilities and even cancer, recorded in the community. Therefore, the impacts of water contamination on humans and the ecosystem coupled with the cost of drinking water treatment has provided a thought-provoking investigation on the study, the distribution and impact of organo-leachates linked to water and sediment in Otuasega, Bayelsa State, Niger Delta region of Nigeria.

Thousand tons of solid wastes are daily generated in the country [6] and 90% of these wastes are disposed illegally and haphazardly (without regards for environmental concerns) at various dumping sites on the surface of urban centers like Otuasega community which is capable of causing environmental degradation in its immediate environment [7]. Charles et al. [8] stated that Nigeria generates about 25 million tons of municipal solid wastes (MSW) in a year and forecasted that MSW would increase due to the uncontrolled population growth and fast urbanization.

Pollutants such as crude hydrocarbons, heavy metals, and pesticides are damaging to the environment, wreaking havoc on ecosystems. There is a risk of cancer and mutagenesis, as well as other harmful consequences, especially in humans [9].

Environmental pollution has inherently been associated with health issues including the spread of diseases, i.e., typhoid and cholera, some of which are largely seen as waterborne diseases [10]. There are also noncommunicable diseases (NCDs) that are brought about due to environmental pollution, such as cancer and asthma, or several defects evident at birth among infants [11]. The significant adverse effects of environmental pollution on health-related outcomes have largely been evidenced in low-income countries, where an estimated 90% of the deaths are, in fact, caused by that type of pollution. The two most established forms of pollution in low-income countries are those of air and water. This is contrary to the economies that are rapidly developing, where the toxicity of chemicals and pesticides constitutes the main forms of environmental pollution [12].

Many developed nations have been able to address the problem of leachate production in waste dumpsites through sanitary landfill systems, various wastes to wealth agenda and modern waste recycling and reuse technology [13]. But the problem is worse especially in developing countries where there is no modern waste disposal system in practice. The waste disposal method of landfill practiced in countries like Nigeria is usually far from recommended standards [14]. Landfills or dumpsites have been identified as one of the major threats of groundwater resources due to the production of leachates and its migration through the soil into the aquifer [15]. Other threats to groundwater resources include industrial effluents discharges, residential effluents discharges, agricultural chemicals and fertilizers applied on farms, oil spills and leakages, as well as salt water intrusion and urban surface runoff [16].
The remediation of contamination sites is necessary to restore the functionality of the contaminated environment for both environmental preservation and urban growth.

In recent times, the effect of leachates on groundwater resources has attracted lots of attention due to its overwhelming environmental importance, and the ever-increasing population will continue to rely on groundwater as the main source of water supply [17]. Contamination of groundwater resources from leachates could pose a considerable risk to human health and the natural environment. About two million people die each year, as a result of contaminated water and poor sanitation, of which 90% are children [18]. Groundwater, surface water and soil play a crucial role in the migration of contaminants in the food chain. Migration of the contaminant to an aquifer is a function of the mineralogical and textural characteristics of the sediment [19]. The highly clayey soil impedes the migration of contaminants and may act as a barrier system. The highly porous and permeable sediment enhances the migration of contaminants into groundwater. Iron is a recurring contaminant in groundwater in the Delta region of Nigeria. The occurrence of iron in this region is in two forms, namely in the ferrous and oxidation states [19]. this form, they readily associate and dissociate to form complexes in the redox processes; by this complexing the groundwater quality.

Methodology

The method used to achieve the research purpose are Filed method, Laboratory method and Geographic Information system.

Location and Geology

Otuasega is located within latitude 4.9353° N and longitude 6.4184° E.

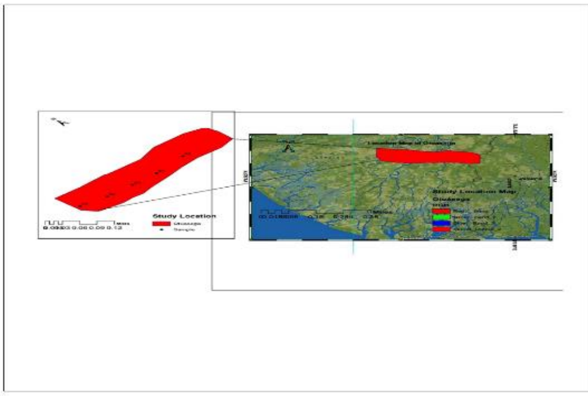

Figure 1: Location Map of The Study Area.

The geology comprises recent sediments of the Benin formation pulled in from the sediments of the Rivers Benue and Niger.

Data Collection

Five (5) surface water samples five (5) surface sediment samples, five (5) ground water samples and five (5) bore hole sediments samples were collected from surface sediment and borehole sediment and surface water and groundwater. Samples wells at a depth of 15.5m for borehole and 1m each for surface sediment and 100m each for surface water and were analyzed in triplicate for organo-contaminant characteristics.

Method of Data Analysis.

Data collected from the result of the analysis for both sediment and water samples were analyzed by comparing the results to W.H.O standard [19] using statistical tools such as mean, correlations and the use of bar charts for pictorial representation.

Results and Discussion

Textural analysis of borehole and surface sediments in Otuasega was carried out to characterize the spatial variation in grain size characteristics qualitatively and statistically. The different tables below show the result of the grain size distribution of 5 locations of surface sediments and borehole sediments each in my study area. (Table1and 2).

Table 1. Summary of textural characteristics of surface sediments (The Author).

Sample	Mean	Kurtosis	Sorting	Skewness	Characteristics of sediments
1	3.50	0.61	2.12	0.06	Very fine sand
2	2.37	0.68	1.99	0.71	Fine silt
3	3.17	0.49	2.28	0.11	Very fine sand
4	2.80	0.65	2.12	0.33	Fine sand
5	4.83	1.97	1.9	-0.72	Coarse silt

Table 2. Summary of textural characteristics of Borehole sediments (The Author).

Sample	Mean	kurtosis	Sorting	Skewness	Characteristics of sediments
1	2.23	0.62	2.37	0.39	Fine sand
2	2.37	0.77	2.44	0.35	Fine sand
3	2.70	0.69	2.35	0.19	Fine sand
4	4.77	1.52	1.90	-0.8	Coarse silt
5	3.86	1.94	1.58	0.66	Very fine sand

Correlations of Organic Contaminants in Surface Sediment.
The Pearson correlation of BOD and pH was found to be very high negative correlation and statistically significant (r = -.922, p<.005). As a result, a decrease in BOD would result in a decrease in pH. The Pearson product correlation of BOD and THC was found to be highly positive and statistically significant (r = -.916, p<.005).Hence, this shows that an increase in BOD would lead to a higher pH, while DO and THC Pearson product correlation was also found to have a very high positive correlation and to be statistically significant (r = -.938, p<.005).The Pearson product correlation of PAH and Fe was found to be a highly positive and statistically significant correlation (r = -.951, p<.005) and the rest indicate a non-significant correlation. (Table 3).

Table 3. Pearson correlation of organic contaminants in surface sediment (The Author).

	pH	TPH	THC	Fe	BOD	COD	DO	PAH
pH	1							
TPH	0.608	1						
THC	-0.747	-0.237	1					
Fe	0.586	-0.017	-0.178	1				
BOD	-.922*	-0.418	.916*	-0.464	1			
COD	-0.826	-0.837	0.276	-0.53	0.582	1		
DO	-0.518	-0.177	.938*	0.129	0.773	0.049	1	
PAH	0.44	-0.267	-0.154	.951*	-0.349	-0.3	0.149	1

Correlation is significant at the 0.05 level.

Correlations of Organic Contaminants in Borehole Sediment
The Pearson product correlation of BOD and THC found in (Table 4) was very high negative correlation and statistically significant (r = -.944, p<.005). Hence, this shows that a decrease in BOD would lead to a decrease in THC. COD and BOD Pearson product correlation was found to have a very high positive correlation and to be statistically significant (r =.994, p<.005). Hence, this shows that an increase in COD would lead to a higher BOD, while others indicate a non-significant correlation. COD and THC Pearson product correlations, as well as DO and THC Pearson product correlations, found to have a very high negative correlation and to be statistically significant (r = -.963, p<.005) and (r = -.956, p<.005), respectively.
The Pearson product correlation of DO and BOD, D0 and COD, found to be a very high positive correlation and statistically significant (r =.997, p<.005) and (r = -.998, p<.005), respectively.

Table 4. Correlation of organic contaminant in borehole sediment (The Author).

	pH	TPH	THC	Fe	BOD	COD	DO	PAH
pH	1							
TPH	0.078	1						
THC	-0.682	-0.049	1					
Fe	0.332	0.243	0.042	1				
BOD	0.793	0.268	-.944*	0.235	1			
COD	0.745	0.207	-.963**	0.206	.994**	1		
DO	0.741	0.267	-.956*	0.202	.997**	.998**	1	
PAH	0.763	-0.471	-0.367	0.468	0.423	0.412	0.372	1

The pH of the samples in surface water was between 5.86 to 6.76 while groundwater is between 6.54 to 7.65, thus pH for surface sediment samples was between 6.90 to 8.41 while borehole sediment was between 4.65 to 5.87. This indicated that the pH of surface water samples was more acidic in nature than those recorded in groundwater samples, thus the pH of borehole sediment was more acidic than surface sediments samples, though all of them fell below the W.H.O permissible limits of 6.8 to 8.5 and did not meet the standards. These findings corroborated with works of other researchers.

(Fig. 1 & 2). The low pH could be as a result of the breakdown of the organic matter derived from vegetation cover and humus buried in sediments at the dumpsites, and subsequent infiltration of run-off (acid rain) through the porous soil and permeates into the groundwater. High acidic content may lead to health risk such as dermatosis and leachate infiltration to groundwater samples may have resulted in odour and bad taste.

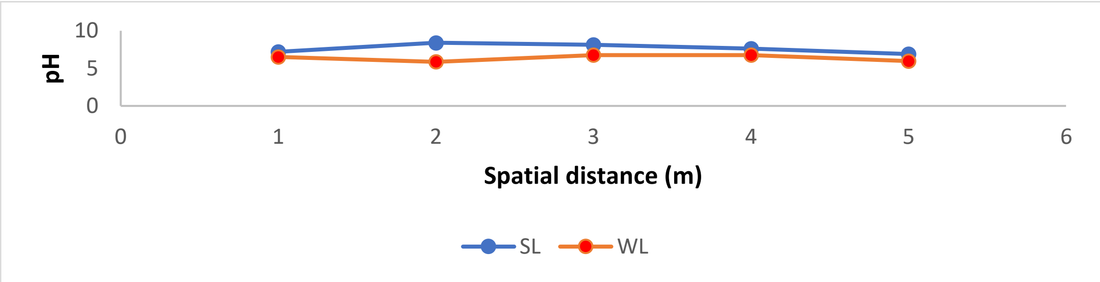

Figure 2: pH in surface sediment SL) and surface water (WL)

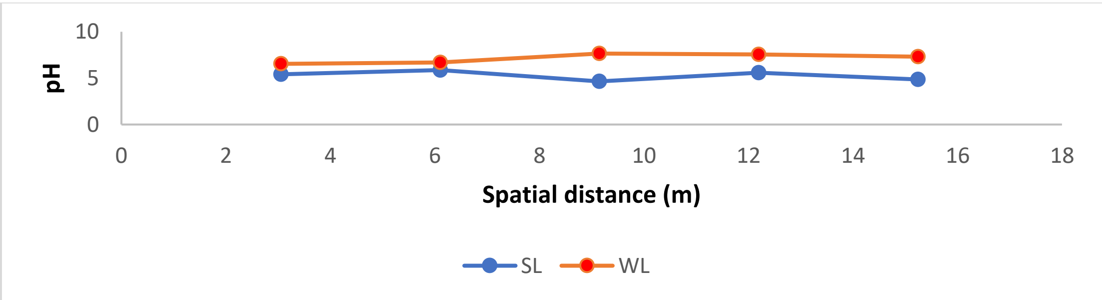

Figure 3: pH in borehole sediments (SL) and groundwater (WL).

Total petroleum hydrocarbon in surface water was between 0.30 mg/L to 0.52 mg/L, while ground water was between 0.36 mg/L to 0.54, thus total petroleum hydrocarbon in surface sediment was between 0.36 mg/Kg to 0.55 mg/Kg, while total petroleum hydrocarbon in borehole sediment was between 0.21 mg/Kg to 0.34 mg/Kg. this indicate that TPH in ground water samples are higher than surface water, while TPH in surface sediments are higher than TPH in bore hole sediments, though all of them fell above the W.H.O permissible limits of 0.001 mg/L to 0.437mg/L and did not meet the standards, these findings corroborated with works of other researchers.

The high TPH could be as a result of contaminated soil, oil spill, pesticides, automobile oils and urban rain water emissions. Effects of TPH in human are known to cause decreased immune function, breathing problem, severe kidney, and liver damage [3]. (Fig. 3 & 4).

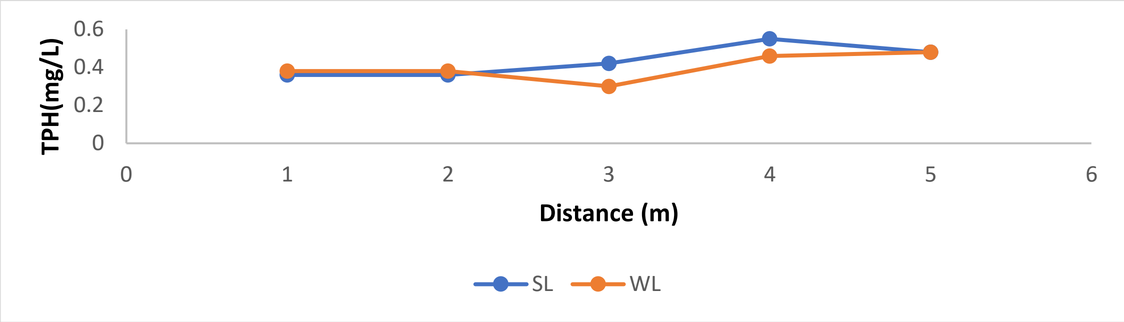

Figure 4: TPH in surface sediment (SL) and surface water Samples (WL).

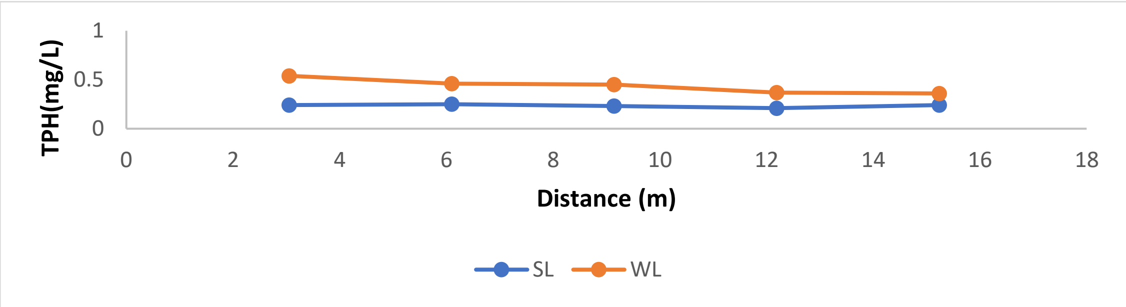

Figure 5: TPH in Borehole sediment (SL) and groundwater (WL).

Total hydrocarbon content in surface water ranged between 0.62 mg/L to 0.94mg/L while it ranged between 3.40 mg/L to 4.80 mg/L in groundwater, thus total hydrocarbon content in surface sediment ranged from 0.87 mg/Kg to 1.44 mg/Kg while borehole sediments ranged between 2.90 mg/Kg to 8.86 mg/Kg. this indicates that THC in groundwater is higher than THC in surface water, while THC in bore hole sediments is higher than THC in surface sediments. though all of them fell above the W.H. O permissible limits of 0.3 mg/L and did not meet the standards, these findings corroborated with works of other related works. The high THC could result of oil spill, pesticides, automobile oils and urban urban stormwater discharged. High THC in could cause health issues such as asphyxiation, narcosis (depression of the central nervous system) cardiac arrest and aspiration, high THC can also cause lack of oxygen, decrease in crop yield, and effects on aquatic plants [22]. (Fig. 5 & 6).

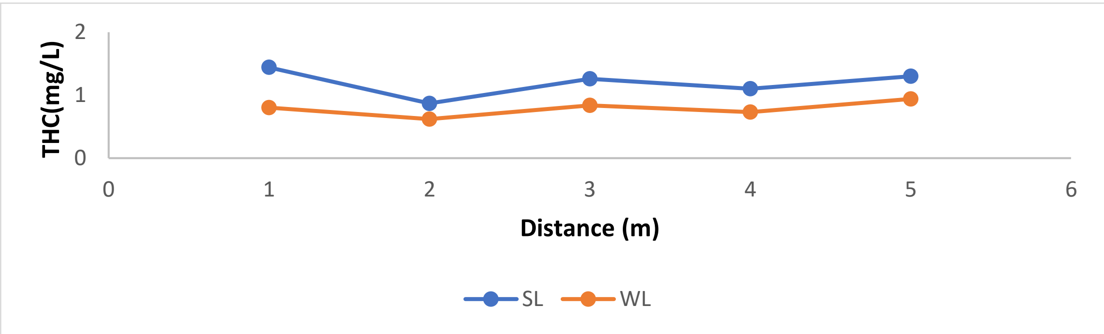

Figure 6: THC in surface sediment (SL) and surface water (WL).

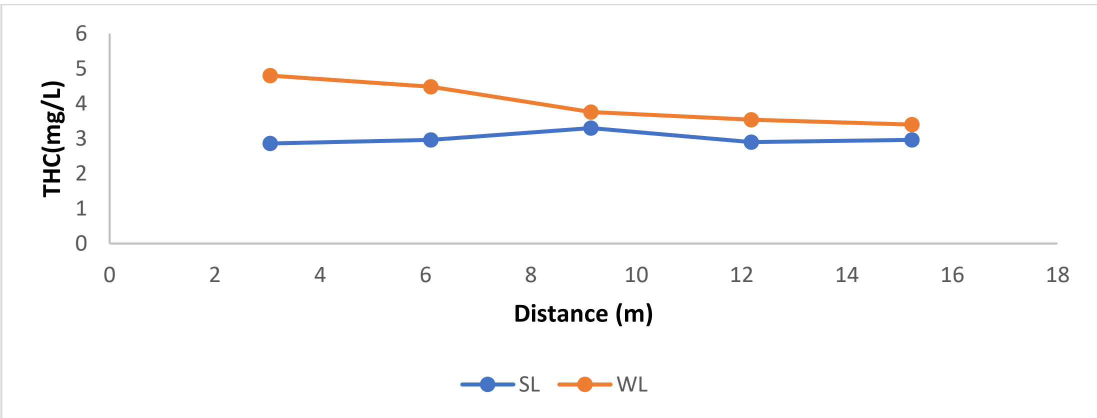

Figure 7: THC in Borehole sediment (SL) and groundwater (WL).

Fe content in surface water ranged between 0.5 mg/L to 0.63 mg/L while it ranged from 0.89 mg/L to 2.52 mg/L in groundwater, thus Fe contents in surface sediment sample is between 0.55 mg/Kg to 1.54 mg/Kg, while it ranged between 0.20 mg/Kg to 0.43 mg/Kg in borehole sediments, this indicate that Fe content in ground water is higher than the Fe content in surface water, while the Fe content in surface sediments is higher than the Fe content in ground water, though all of them fell above the W.H.O permissible limits of 0.3 mg/L in water and 0.8 mg/Kg in sediments, and did not meet the standards, these findings corroborated with works of other related works that has done. The high iron content in both sediment and water could be as a result of anthropogenic sources in the dumpsite, such as domestic effluents (Fig. 8 & 9).

High iron content in drinking water can lead to diabetes, hemochromatosis, stomach problems and nausea. It can also damage the liver, pancreas, and the heart.

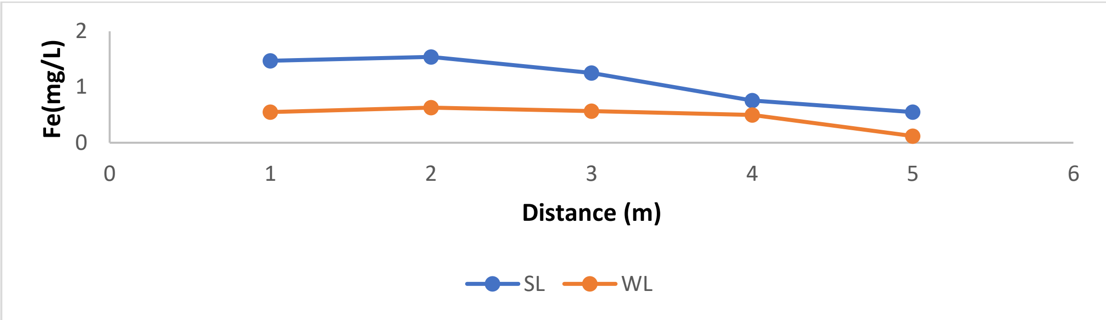

Figure 8: Fe in surface sediment (SL) and surface water (WL).

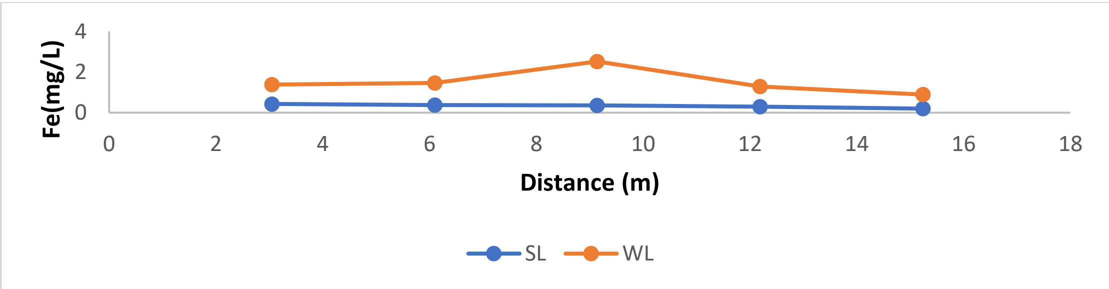

Figure 9: Fe in Borehole sediment (SL) and groundwater (BL).

The values of biochemical oxygen demand (BOD) recorded were between 47.16 mg/L to 60. 4 mg/L in surface water and 49.95 mg/L to 60.75 mg/L in ground water, and 21.86 mg/Kg to 38.50 mg/Kg in surface sediment and 37.44 mg/kg to 44.22 mg/kg in bore hole sediment respectively. The amount of BOD in groundwater is higher than the amount of BOD in surface water, while the amount of BOD in borehole sediment is higher than the amount of BOD in surface sediment which were all above the W.H.O recommended limits of 2.5 mg/L. in water. BOD is the amount of oxygen required by microorganisms for stabilizing biologically decomposable organic matter under aerobic conditions. When the BOD of water is high the dissolved oxygen concentration will reduce because the oxygen available in the water is being used by the bacteria. Thus, the higher the BOD value the greater the amount of organic matter in the water samples [21]. The high BOD in the groundwater samples indicates contaminated water by organic matter from the dumpsite leachate, hence the groundwater around the dumpsite may not be safe for human consumption. Water with a high concentration of BOD is a common feature of organically contaminated in the water bodies.

The recorded BOD agreed with the work of John and Brownson [13]. but in contrast with the work of Besufekad et al., [14]. (Fig. 9 & 10).

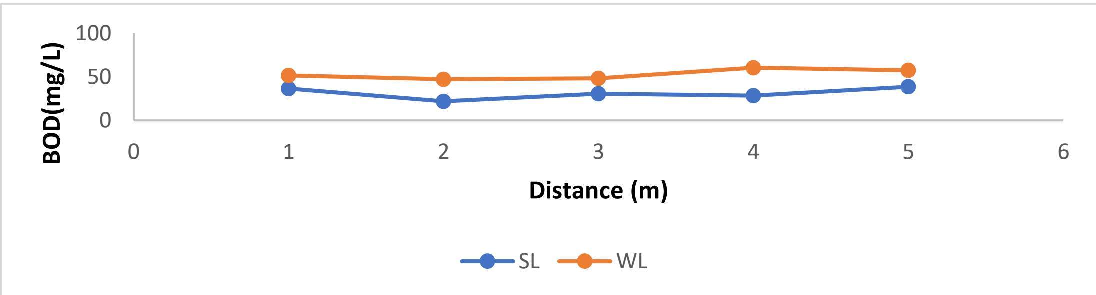

Figure 10: BOD in surface sediment (SL) and surface water (WL).

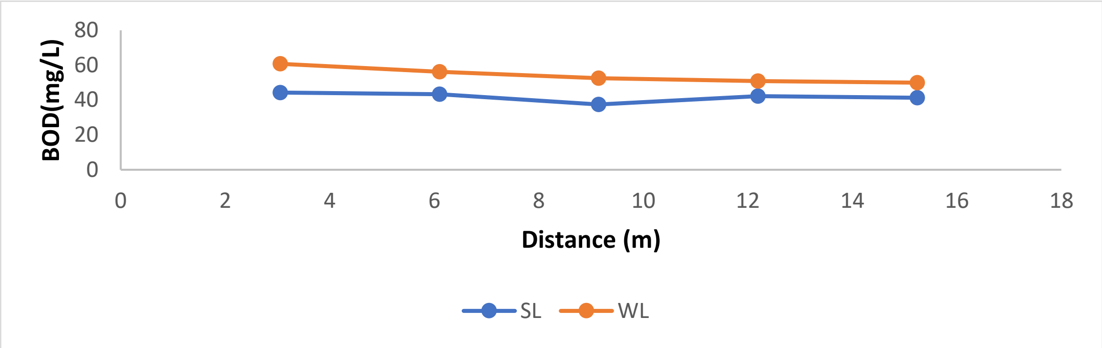

Figure 11: BOD in borehole sediment (SL) and groundwater (WL).

The chemical oxygen demand (COD) values in surface water ranged between and 136.77 mg/L to 166.40 mg/L in groundwater samples, while COD values in surface sediment samples ranged between 110.21 mg/Kg to 130.84 mg/Kg and 101.50 mg/Kg to 119.85 mg/Kg in bore hole sediment samples. which were above the maximum permissible limit of 2.5 mg/l set by W.H.O [20]. The value of COD in surface water samples is higher than the amount of COD values in groundwater samples, while the amount of COD values in surface sediments samples is higher than the amount of COD values in borehole sediments. The high COD values of the water samples indicate the presence of significant chemically oxidizable organic contaminants in the surface water and groundwater, which infers that the surface water and groundwater under study may not be safe for drinking. The highest COD values of 130.84 mg/Kg and 166.40 mg/L is observed in both water and sediment is an indication that the dumpsite leachate is contributing to the organic contaminant concentrations of the surrounding groundwater (Fig. 11 & 12).

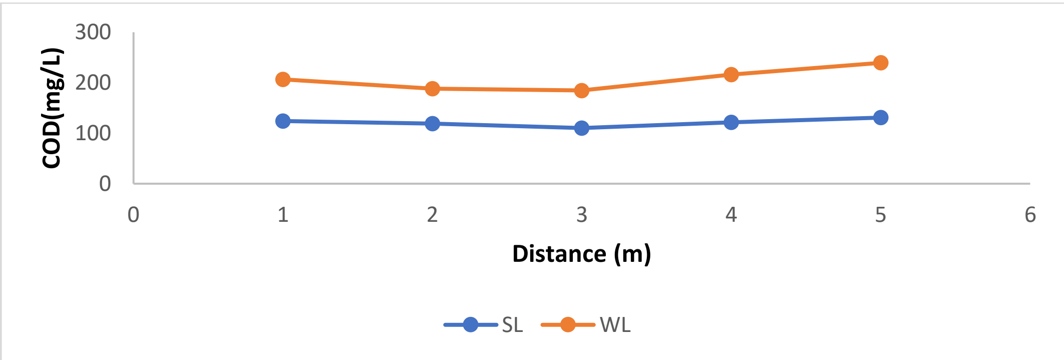

Figure 12: COD values in surface sediment (SL) and surface water(WL).

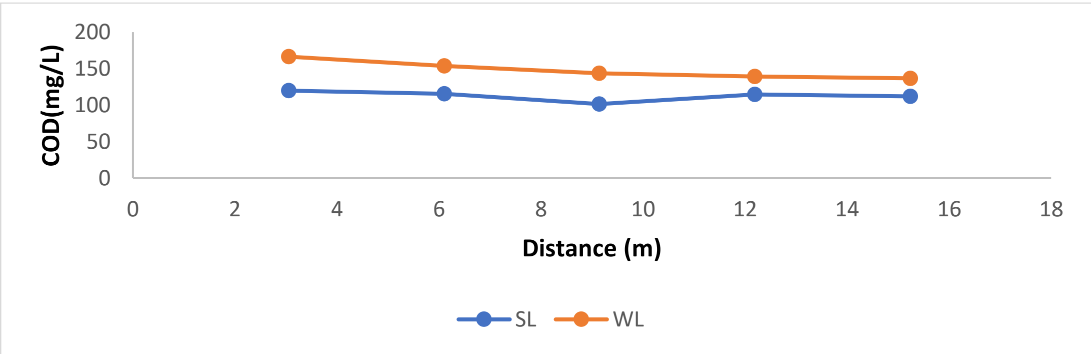

Figure 13: COD values in borehole sediment (SL) and groundwater (WL).

Polycyclic aromatic hydrocarbon (PAH) values ranged between 0.01 mg/L to 0.03 mg/L in surface water and 0.02mg/L to 0.59mg/L in groundwater, while PAH was 0.88 mg/Kg to 3.99 mg/Kg in surface sediment and 0.01 mg/Kg to 0.03 mg/Kg in borehole sediment. The values of PAH samples found in groundwater is higher than the values in surface water, while the values of PAH found in surface sediment samples is higher than the borehole sediments samples. The permissible limit of PAH is 0.2 mg/L set by W.H.O. Surface water samples and borehole water samples are within the permissible limit of 0.2 mg/L while surface sediment is above the permissible limit, there is a variation in ground water sample with low and high PAH in different depth. The geochemical analysis of PAH indicate that the concentration of surface water sample is higher than the surface sediment sample, while the concentration of ground water sample is also higher than the borehole sediment sample, which is an indicator of contamination in the study area. PAH can cause the following issues such as reduced lung function, exacerbation of asthma, and increased rate of obstructive lung diseases and cardiovascular diseases. Common causes of PAH include oil, gas, wood, garbage etc, which are activities that take place in the dumpsite and close to the dumpsite. (Fig. 14 & 15).

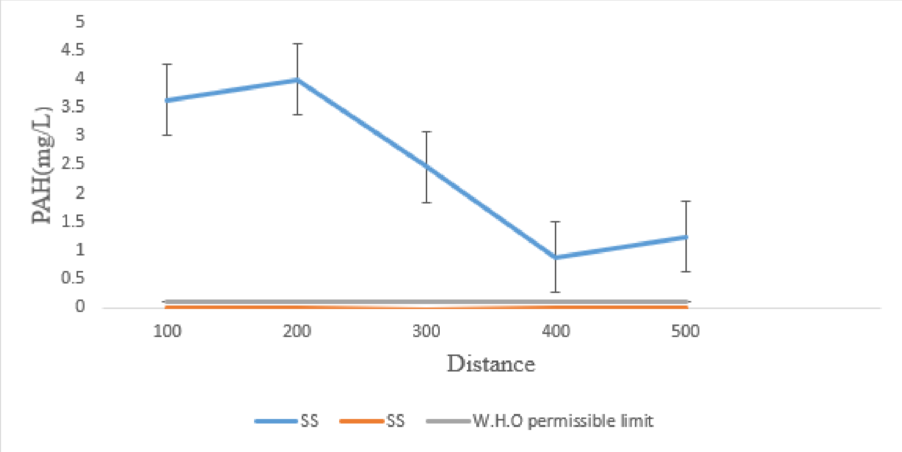

Figure 14: Plot of PAH versus distance in surface sediment (SS) and surface Water (SW). (Author).

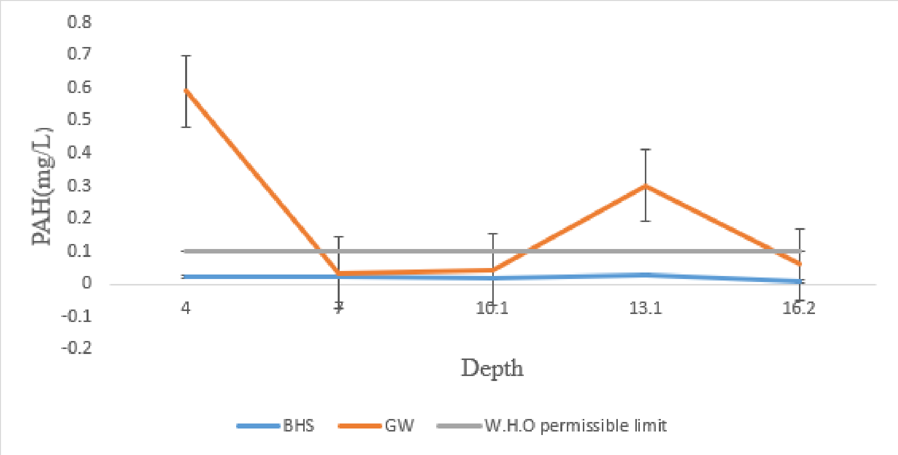

Figure 15: Plot of PAH versus depth in borehole sediment (BHS) and ground Water (GW) (Author)

Conclusion

This study investigated the distribution and impact of some organic contaminants in the study area. There is a piece of evidence that organic contaminants are above WHO permissible limits at the surface and subsurface.

In terms of geo-ethics, politically it reduces the population of people living in the community if proper care and management system will not be put into place and thereby causing high rate of death in the community as a result of these organic contaminates, it will also reduce the economical standard in the community, this includes lower land values, reduced tourism, wasted resources and cleanup cost. In term of social- economic it affects the air, water and health, reduces property values, and diminishes investments and infrastructure in the community.

organic contamination of groundwater, which limits its use and causes economic losses, environmental problems and reduces the agricultural productivity of the soil. All of these substances contribute to the greenhouse effect and depletion of the ozone layer. They also reduce photosynthetic capacity of plants, increase cancer rates in humans and animals, and increase the risk of respiratory disease.

In agriculture, farmers are using more and more organic chemicals in an effort to provide sufficient quantities of produce, but the resulting pollution has enormous potential for environmental damage.

Monitoring of groundwater quality and further research to develop a model for predicting pollution status of groundwater wells to abate the ill effects in Otuasega.

The studies have also provided baseline information to the national oil spill response and detection Agency, Ministry of Science and Technology, Ministry of Environment for shoreline protection and coastal monitoring.

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