Research Article / Review Article FUPRE JOURNAL 9(1):38-47(2025)

FUPRE Journal

of

Scientific and Industrial Research

ISSN: 2579-1184(Print) ISSN: 2578-1129 (Online)

http://fupre.edu.ng/journal

Geochemical Assessment of Soil in Dumpsites Around Tombia-Amassoma Road, Western Niger Delta

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ARTICLE INFO

Received: 01/12/2024
Accepted: 31/03/2025

Keywords

Contamination factor, Dumpsite, Geo-accumulation index, Groundwater, Multivariate statistical analysis, Pollution

ABSTRACT

This research work focuses on determining the urban geochemistry of soil in dumpsites around Tombia-Amassoma road, western Niger Delta. Nine (9) soil samples were randomly collected within the dumpsite vicinity and two (2) control samples were collected from a distance of about 9.0 km from the dumpsite. The samples were prepared according to standard procedures and analyzed for some heavy metals (Ag, Zn, Cu, Ni and Fe) using the Atomic Absorption Spectrophotometer at Analytical Concept Environmental Consultants Laboratory Ltd, Port Harcourt, Nigeria. The geochemical data was subjected to multivariate statistical analysis and comparisons were made with World Health Organization standard. The results obtained showed that the mean concentrations of Ag (0.54mg/kg), Zn (33.89mg/kg), Cu (31.85mg/kg) and Ni (22.80mg/kg) were within an acceptable limit when compared with WHO standard, while Fe (6329.40mg/kg) exceeded the limits. Geo-accumulation index and contamination factor revealed that the soils around the dumpsite were moderately to heavily contaminated with Fe thereby indicating that the sediment samples are polluted. The study concluded that the soils around the Tombia-Amassoma dumpsite was contaminated with Fe and as such should be discouraged in its usage for agricultural related purposes as these highly toxic trace elements can be absorbed by plants. Therefore, a well-engineered landfill that incorporates the local geology and the topography of the area should be designed so as to prevent infiltration of heavy metals into the soil and shallow groundwater system.

1. INTRODUCTION

The term ‘Urban Geochemistry’ is a unique discipline that is distinguished from general geochemistry by the complex infrastructure and intense human activities associated with concentrated population centers. As stated by Thornton (1991) “This subject is concerned with the complex interactions and relationships between chemical elements and their compounds in the urban environment, the influence of past and present human and industrial activities on these, and the impacts or effects of geochemical parameters in urban areas on plant, animal and human health.” Urban areas present special challenges to geochemists attempting to understand geochemical states and fluxes. Some heavy metals include lead, chromium, arsenic, zinc,

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cadmium, copper, mercury and nickel. The word 'Dumpsite' means a widespread land disposal area and generally known for its common features are being exposed directly to the atmosphere or covered improperly with soil layer and without proper bottom liner support. These features could significantly contribute to pollution and contamination of the total environment.

Urban geochemistry as a scientific discipline provides valuable information on the chemical composition of environments that support large populations and are critical to human health and well-being.

The disposal of wastes generated by human activities within a municipality is generally an urban problem. Dumpsites that are neither properly designed nor constructed consequently, over the years become point source for pollution of the aquiferous units close to them. Apart from being a source of air, soil, sediment and water pollution, chemical and biological reaction inside a dumpsite may cause the generation of toxic liquid that will leach from the dumpsite without liners, thus polluting the surface and the groundwater (Ansari, A. 2002)

There is therefore need to deposit waste in an engineered sanitary landfill with minimum environmental and health risks and at optimum cost. For a landfill to be secured there is need for the study of engineering, geological and chemical characterization and evaluation of the soil within the site. Cases of anthropologic impact associated with urban development such as waste management have been reported in other parts of the world (Zhug, H. et al 2007; Ansari, A. 2002; Wilcke, W. et al 1998). These investigations are a necessary

Rural-urban migration has led to growth of the urban population and the resultant effect is huge production of different types of municipal solid wastes (MSW) ranging from degradable to non-degradable, deposited in landfills popularly described as dumpsite, which have adverse effects on the environment and human health. Open dumps are generally unsanitary and constitute malodorous places in which disease-carrying vermin such as rats and flies proliferate [Bellebaum, J. 2005]. The dumpsites are not basement prepared for selective adsorption of toxic substances hence; it is susceptible to the discharge of pollutants to nearby water and to the air through leachates and dumpsites gases respectively [Abdus Sallam, N. et al 2011]. Industrialization, population growth and unplanned urbanization have partially or completely turned our environment to dumpsites [Alimba, C. et al 2006].

This work aims at determining the urban geochemistry of soil in dumpsite around Tombia-Amassoma Road, Western Niger Delta. The objectives of this study therefore include:

1. To determine the fractional concentration of heavy metals in soil.
2. Evaluate possible impact of heavy metals on soil in the study area.
3. To determine the mobility factor indices of heavy metals in waste dumps and control soils;
4. To evaluate the relationship between mobility factor of heavy metals and contamination of environmental flora and fauna in study vicinity.

2. THEORETICAL ANALYSES

Perason's correlation matrix was used to show relationships between analyzed parameters and this gives an insight into the similarity or difference in the sources of these parameters in the medium of interest. Various soil geochemical indices were also used and they included enrichment factor, index of geo-accumulation, contamination factor as well as pollution load index. The aim of using them was to determine the level of contamination and possible pollution contributed by the various analyzed parameters in the soil.

Location and Accessibility

The study area is located on the coordinate of Latitude N4º58'57.654" and Longitude E6º19'24.498". The dumpsite is located along Tombia-Amassoma Road Yenagoa, Western Niger Delta as shown in the figure below.

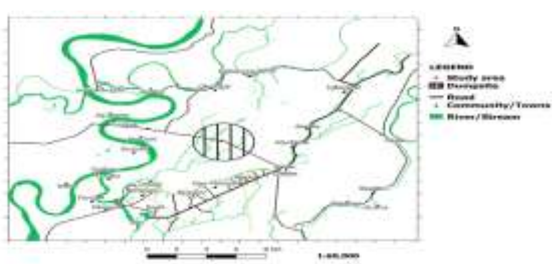

Figure 1: Map of the study area

Plate 1: The Dumpsite along Tombia-Amassoma Road.

3. METHODOLOGY

This research work involved field studies and geotechnical investigation of soil from dumpsite in Tombia-Amassoma road, Yenagoa Local Government of Bayelsa State. In this Chapter, the sampling procedures, the location of sampling points, equipment's, material and methods employed in the analysis of several geochemical parameters is presented.

Material used included portable global positioning system (GPS) device (model GARMIN GPS 76 CSX), polyethylene plastic cans. Relevant maps (topographic and geological) were gotten from Federal University of Petroleum Resources, Effurun and Niger Delta University. The atomic absorption spectrophotometric (AAS GBS 908PBM model) was used for heavy metals analysis of soil samples. All analysis was done at Analytical Concept Environmental Consultants Laboratory Ltd, Port Harcourt, Rivers State – Nigeria. Softwares including ArcGIS, suffer 12, excel, SPSS were used also, multivariate statistical analysis was used for the data analysis of this research work.

Materials used for this research work varies from materials used in the field for gathering of samples to materials used in the laboratory for testing and analysis of the samples.

4. RESULTS AND DISCUSSIONS

The concentrations in mg/kg of all analyzed parameters were tabulated and compared to WHO (2009) standard as shown in Table 1.

Table 1: Summarized statistics of sediment sample physical and chemical characteristics compared against WHO (2009) standards.

Parameter	Unit	Minimum	Maximum	Mean	WO (209)
pH		4.7	6.9	5.88	6.5
EC	µs/cm	124	503	248.31	1000
Fe	Mg/kg	5745.3	6697.0	6329.4	0.30
Zn	Mg/kg	8.96	69.02	33.89	50
Cu	Mg/kg	6.04	92.24	31.85	36
Ni	Mg/kg	2.85	94.71	22.79	35
Ag	Mg/kg	0.02	1.3	0.54	4.4

Correlation Matrix

Table 2: Pearson's Correlation Matrix showing relationship between analyzed parameters

	Ph	EC (µs/cm)	Ag (Mg/Kg)	Zn(Mg/Kg)	Cu (Mg/Kg)	Ni (Mg/Kg)	Fe (Mg/Kg)
Ph	1	0.511	0.092	0.177	0.229	-0.030	-0.045
		0.109	**0.788**	**0.602**	0.499	**0.930**	**0.894**
	11	11	11	11	11	11	11
EC (us/cm)	0.511	1	-0.182	0.103	-0.133	-0.294	0.014
	0.109		**0.592**	**0.764**	**0.698**	0.381	**0.967**
	11	11	11	11	11	11	11
Ag (Mg/Kg)	0.092	-0.182	1	**.853****	**.875****	**.832****	-0.195
	0.788	**0.592**		0.001	0.000	0.001	**0.565**
	11	11	11	11	11	11	11
Zn(Mg/Kg)	0.177	0.103	**.853****	1	**.933****	**.770****	-0.390
	0.602	**0.764**	0.001		0.000	0.006	0.236
	11	11	11	11	11	11	11
Cu (Mg/Kg)	0.229	-0.133	**.875****	**.933****	1	**.782****	-0.380
	0.499	**0.698**	0.000	0.000		0.004	0.249
	11	11	11	11	11	11	11
Ni (Mg/Kg)	-0.030	-0.294	**.832****	**.770****	**.782****	1	-0.116
	0.930	0.381	0.001	0.006	0.004		**0.734**
	11	11	11	11	11	11	11
Fe (Mg/Kg)	-0.045	0.014	-0.195	-0.390	-0.380	-0.116	1
	0.894	**0.967**	**0.565**	0.236	0.249	**0.734**	
	11	11	11	11	11	11	11

** Correlations above 0.5 indicate significant positive correlation.

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5. DISCUSSION AND FINDINGS

The results of physicochemical parameters measured were compared to the WHO (2009) standards and are displayed in the figures below.

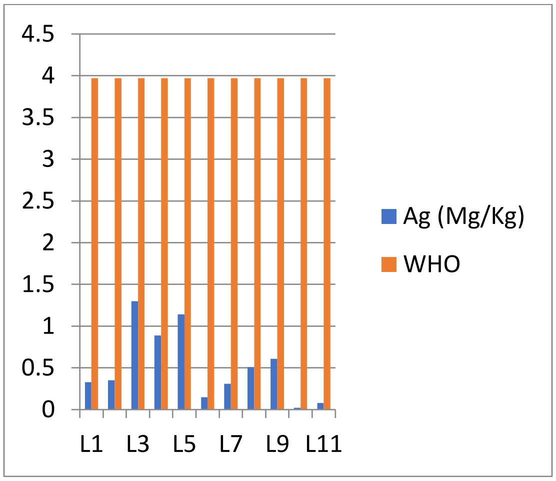

Figure 2: Showing comparison between Ag to WHO 2009 standard

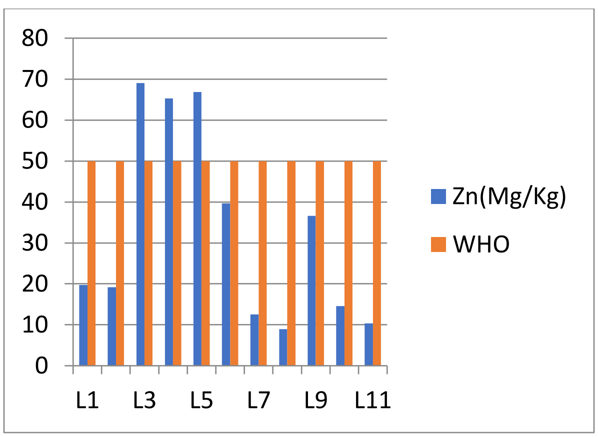

Figure 3: Showing comparison between Zn to WHO 2009 standard

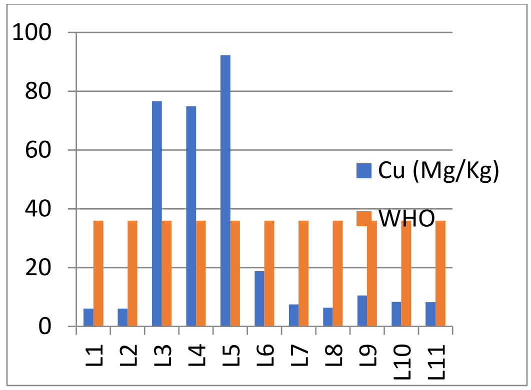

Figure 4: Showing comparison between Cu to WHO 2009 standard

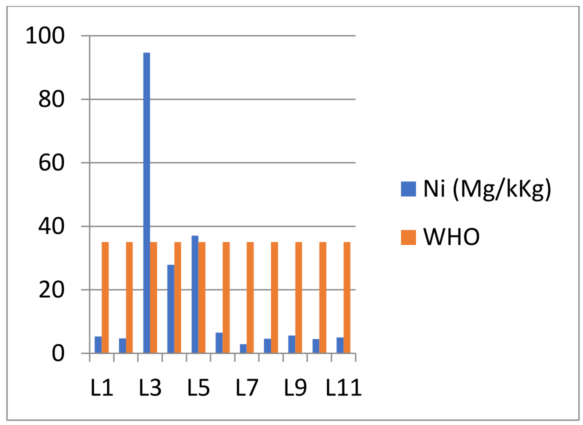

Figure 5: Showing comparison between Ni to WHO 2009 standard

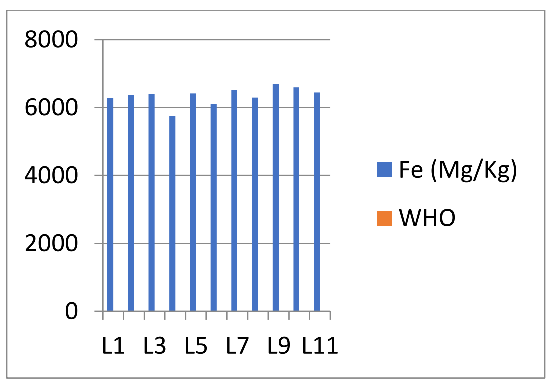

Figure 6: Showing comparison between Fe to WHO 2009 standard

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Correlation Matrix

Pearson's correlation matrix (Table 3) shows the relationship between the parameters. Only correlation coefficients above 0.5 were chosen since these indicate very high positive correlation. Correlations such as those indicated in the table suggest that the presence of one of them in the study area depends on the other and that they both are likely to have the same source as being responsible for their presence in the study area. For example, an increase in pH (increase towards basicity) would result in an increase in bicarbonate concentration and a decrease in pH will result in a decrease in bicarbonate concentration.

Enrichment Factor (EF)

The calculated results of EF of heavy metals in the sediment investigated for each sample from location 1 to location 11 using iron (Fe) as a reference point for this study shows that the area has a minor enrichment.

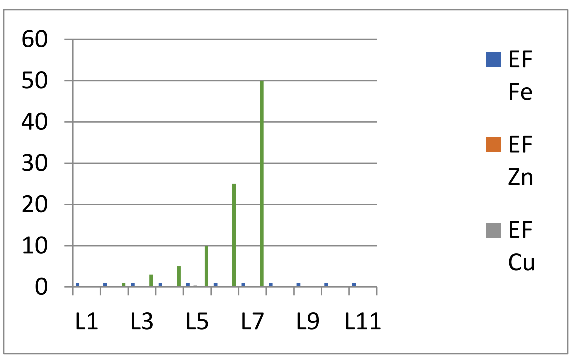

Figure 7: A graphical representation showing the minor enrichment in the heavy metals within the study area.

Geo- accumulation Index (I-GEO)

The calculated results of Igeo of heavy metals in the sediment investigated for each sample taking Iron (Fe) as a reference point from location 1 to location 11 shows moderately to heavily contaminated by (3.02)

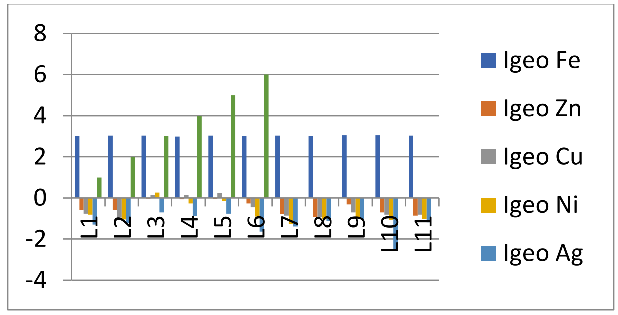

Figure 8: A graphical representation showing that the study area has moderate to heavy Fe contamination.

Pollution Load Index (PLI)

Pollution severity and its variation along the different locations were determined with the use of pollution load index. This index is a quick tool in order to compare the pollution status of different places. The PLI as calculated in table ranges from 0.58 to 5.18 with PLI average of 2.13 which is >1 thereby indicating that the sediment samples are polluted.

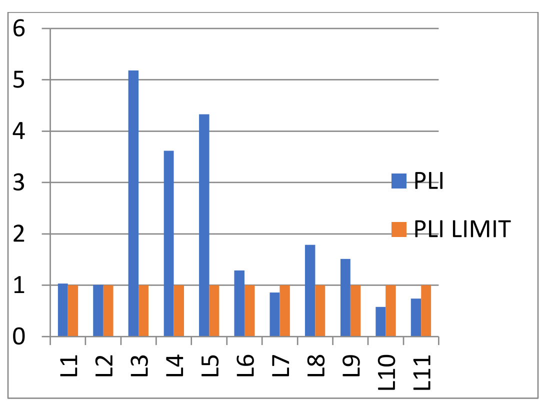

Figure 9: Showing the presence of heavy metal pollution in the study area.

Contamination Factor (CF)

Result from Table 7 shows the Contamination Factor of all the metals; silver ranging from 0.0045 to 0.29 with mean of 0.12, Zinc ranges from 0.21 to 1.79 with mean of 0.84, copper ranges from 0.17 to 2.56 with mean of 0.88, nickel ranges from 0.08 to 2.71 with mean of 0.65 and iron ranging from 1447.2 to 1686.9. The table proposed by Bonnail et al., (2016) states if the values are ≤ 1 it shows low or no CF. The values of the contamination from the metals from location 1 to location 11 shows that there is contamination factor of the metals using Iron (Fe) as a reference point which is > 1.

Fractional Distribution of Heavy Metals and Possible Impact on Soil of the Study Area

Figures 12-16 below show the fractional distribution for the five different heavy metals in accordance to sample locations in the study area;

1. **Silver (Ag)**

The distribution of Ag in the study area was highly contaminated around Location 3 and Location 5 ranging from (1.14 -1.30mg/kg) and the rest of the area was fairly contaminated ranging from (0.02-0.89mg/kg).

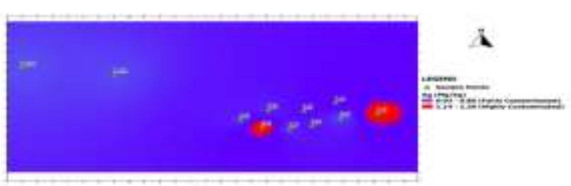

Figure 10: Spatial Distribution Map of Silver (Ag) in the Study Area

2. **Copper (Cu)**

The distribution of Cu in the study area was highly contaminated around Location 3, Location 4 and Location 5 ranging from (70.94-92.24mg/kg) and the rest of the area was fairly contaminated ranging from (6.04-18.84mg/kg).

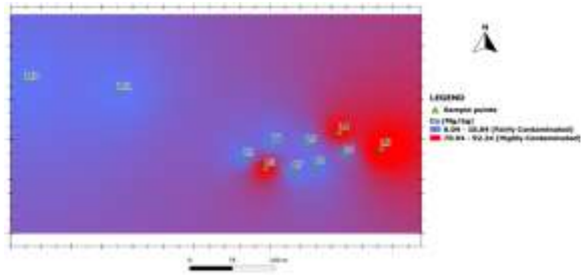

Figure 11: Spatial Distribution Map of Copper (Cu) in the Study Area

3. **Zinc (Zn)**

The distribution of Zn in the study area was highly contaminated around Location 3, Location 4 and Location 5 ranging from (65.32-69.02mg/kg) and the rest of the area was ranging from moderate (36.57-39.64mg/kg) to fairly contaminated (8.96-19.74mg/kg).

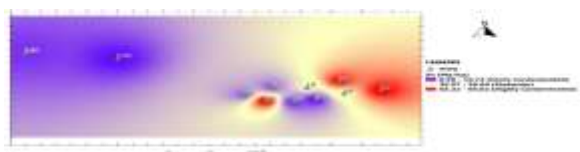

Figure 12: Spatial Distribution Map of Zinc (Zn) in the Study Area

4. **Nickel (Ni)**

The distribution of Ni in the study area was highly contaminated around Location 3 with the value (94.71mg/kg) and the rest of the area was ranging from moderate (27.89-37.06mg/kg) to fairly contaminated ranging from (2.85-6.56mg/kg).

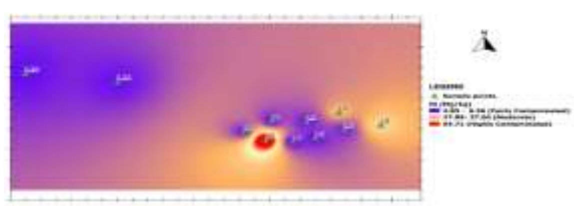

Figure 13: Spatial Distribution Map of Nickel (Ni) in the Study Area

5. Iron (Fe)

The distribution of Fe in the study area was highly contaminated all Locations ranging from (6517-6697mg/kg) except from Location 4 with concentration value of (5745.3).

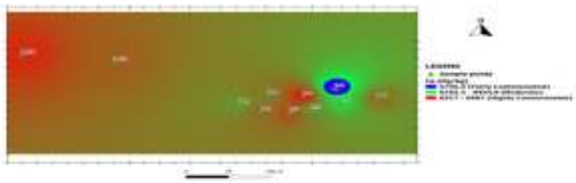

Figure 14: Spatial Distribution Map of Iron (Fe) in the Study Area

6. CONCLUSION

The geochemical analytical data of the soil samples revealed that the Tombia-Amassoma dumpsite and its environs had higher heavy metal concentrations when compared with the control sample that is about 9.0 km away from the site. This may be connected with the dumping of inorganic waste materials in the dumpsite. The result also revealed the following trend in their order of geo-accumulation in the soil: Fe > Zn > Cu > Ni > Ag. Contamination factor (CF) and geo-accumulation (I_{geo}) index further geo confirmed that the soil from the dumpsite was moderately contaminated with Fe, and presently uncontaminated with Zn, Cu, Ag and Ni. The Pollution Load Index described the study area as being polluted at the time of the study and hence remediation measures are required.

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