GEOCHEMICAL AND GEOTECHNICAL CHARACTERISTICS OF SOIL WITHIN OKE-DIYA DUMPSITE IN SAGAMU SOUTHWESTERN NIGERIA

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ABSTRACT

This research was to determine geotechnical and geochemical characteristics of soil around Oke diya dumpsite in Sagamu Southwestern Nigeria. Five soil samples were collected within dumpsite at depth of 0-20cm to determine their engineering properties in accordance with the British Standards. Another eight (8) soil samples were collected vertically at the depth of 1m interval for geochemical analysis using Inductively Coupled Plasma-Mass Spectrophotometer method (ICP MS).

The specific gravity value ranges between 2.78 – 3.00 which fall within moderate degree of laterization and dehydration. The soil generally can be classified as silty sand of intermediate to high plasticity or compressibility based on the percentage grain size distribution and Casagrande Plasticity Chart. Permeability tests showed low permeability within the range of 1.8 x 10^{-6} cm/s – 2.12 x 10^{-6} cm/s. Therefore the soil has capacity to provide long term protection of groundwater by natural attenuation as a result of the thickness of the unsaturated zone, high silt content and low permeability.

Thirty one elements were determined in the soil samples. The relative abundance of the major and significant trace elements followed the order Al > Fe > K > Mg > Ca > Ti > Na > S > P and V > Mn > Cr > Ba > Sr > Cu > Zn > Pb > Zr > Ni > Sc > Y > Co > Mo respectively. There was a general trend of decrease in metals concentration as the depth of sampling increases.

Result of geo-accumulation index showed that the soil samples were practically uncontaminated with Mn, Ni, Zn, Ba, Cr, Sc, Co, Sr, Cu, Zr and Y, practically to moderately contaminated with Pb and V and was moderately contaminated with Mo. Other contamination assessment showed that the soil fall within low contamination factor with all the trace elements except with Pb which falls within moderately contamination.

Keywords; Trace elements, Landfill, Contamination and Soil.

Introduction

The disposal of wastes generated by human activities within a municipality is generally an urban problem. The waste disposal sites and landfills 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 (Kimmel and Braids, 1974; Baedecker and Back, 1979; Arneth *et al*., 1989; Jankowski, 1997; Odukoya, 2007; Odukoya and Abimbola, 2010.

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 (Zhang et al., 1999; Thuy et al., 2000; Ansari et al., 2000; Kim et al., 1998 and Wilcke et al., 1998 in Morton-Bermea et al., 2002.

These investigations are a necessary part of the environmental impact assessment which is obligatory for a secured landfill site.

The study Area is in Sagamu, South Western Nigeria. The sample area falls within Oke-Diya dumpsite which is situated within the Eastern part of Dahomey Embayment and lies within the Ewekoro depression with Sagamu as part of type section (Fig.1) (Jones and Hockey, 1964). Oke-diya dumpsite is very extensive with a topographical height of about 48.3m with reference to ground level and situated to the North East of old Ikorodu road very close to West Africa Portland Cement. It covers an area of approximately 184m^2. It has been in operation since 1996.

The borehole drilled revealed two principal formations, namely the shale, and the underlying limestone present throughout the area (Fig 2).

Methodology

A total of five surface soil samples were collected at depth ranging from 0-20cm using a stainless steel hand auger within the dumpsite to determine their engineering properties in accordance with the British Standards (Anon, 1990) which include specific gravity, grain size distributions, permeability, plasticity and Atterberg limits. Another eight subsurface samples (0.5g) were collected vertically at interval of 1m (1-8m) for geochemical analysis within the dumpsite (Fig 1). Subsurface samples were stored in sample bags and later air dried in the laboratory at room temperature for two weeks. The already air-dried samples were disaggregated in a porcelain mortal and later sieved through a 2.0mm polyethylene sieve to obtain a <75μm clay fraction for geochemical analysis. The analysis took place in Actlabs, Ontario Canada using Aqua regia digestion and Inductively Coupled Plasma Mass Spectrophotometer (ICPMS) method for trace and major elements analysis.

Results and Discussio

Engineering Properties of soil

Five soil samples were taken systematically within and around the dumpsite to determine their Engineering properties. The various engineering results obtained from the test and the statistical interpretation of the results were shown in Tables 1 and 2.

The specific gravity value ranges between 2.78 – 3.00 (Table 1) which fall within moderate degree of laterization and dehydration. This shows that the soil has the ability to filter out the pollutants or prevent them from getting to the groundwater (De-Graft-Johnson, 1969).

From the percentage grain size distribution and Casagrande Plasticity Chart as shown in Tables 1 and 2, the soils generally can be classified as Silty sand of intermediate to high plasticity or compressibility (MI-MH). High percentage of silt content in the soil of the study area can contribute to the removal of pollution considerably by acting as an effective medium through cation exchange like clay (Table 1). Permeability tests showed low permeability within the range of 1.8 x 10^{-6} cm/s – 2.12 x 10^{-6} cm/s (Table 2).Therefore the soil has capacity to provide long term protection of groundwater by natural attenuation as a result of the thickness of the unsaturated zone, high clay content and low permeability.

Soil Geochemistry

Major and Trace elements were analysed for in the soil samples taken at regular depth interval of 2m within the dumpsite to monitor the rate of percolation of the contaminants from dumpsite to the water table. Thirty one elements were analysed for in the soil samples which include Mn, Ni, Ag, Cd, As, Pb, Zn, Ba, Be, Bi, Sb, Sn, W, Co, Cr, Sc, Sr, V,Y, Zr, Cu, Mo, Al, Ca, Fe, Mg, K, Na, Ti and P and S. Trace element like Ag, Cd, As, Be, Bi, Sb, Sn and W were below detection level for all the soil samples and Mo was only detected in the soil sample within 0-1m depth interval. The remaining elements were detected in all the soil samples and the results were presented in Table 3.

The relative abundance of major and trace elements based on the overall mean for the samples were Al > Fe > K > Mg > Ca > Ti > Na > S > P and V > Mn > Cr > Ba > Sr > Cu > Zn > Pb > Zr > Ni > Sc > Y > Co > Mo respectively (Figs 3a-b and 4).

The maximum values for all the major elements were higher than the crustal average values except Na (Table 3, Figs 3a-b).

All the trace elements fall below the crustal average values (Turekian and Wedepohl, 1961) except Pb, V, and Mo for locations 2 and 8, 1and 2 and 2 respectively (Table 4). The concentrations for most of the parameters were inversely proportional to depth which also confirmed the process of natural attenuation (Figs 5a-c). There is greater possibility that larger percentage of these contaminants would have been attenuated before reaching the water table.

It was observed that most metals showed high concentration at location 8 and this may be as a result of absorption ability of shale which is typical of this location at this depth.

Contamination Assessment

The over all assessment of soil quality in the study area based on the geo-accumulation index (Muller, 1981) showed that Mn, Ni, Zn, Ba, Cr, Co, Sr, Sc, Y, Zr and Cu, fall within the practically uncontaminated while Pb, V and Mo fall within the practically uncontaminated to moderately contaminated (Table 5). Soil assessment using the contamination factor and degree of contamination (Hakanson, 1980) showed that the result fall within low contamination for Mn, Ni, Zn, Ba, Co, Cr, Sc, V, Y, Cu, Mo, Ti and within moderately contamination for Pb. The degree of contamination for the study area was 3.69 which also confirmed low degree of contamination (Table 5).

Correlation Analysis

A good correlation exists between Zn and Mn, Ni and Mn, Ni and Pb, Cr and Ni, (Table 6) suggests that metals are from the same sources which are mostly geogenic and partly anthropogenic. The correlation between the trace elements showed a strong relationship except for Cu which showed negative correlation with the other elements. Al, Fe, K and Ca also showed a good correlation with the trace elements except for Cu.

Conclusion

The soil within the dumpsite at Oke-diya in Sagamu, Southwestern Nigeria was monitored to determine its capacity as a good site for landfill and the level of its contamination.

The geology of the study area was characterised by coarse, unsorted sands, sandyclay, shale of considerable thickness and limestone. The specific gravity of the soil showed that the soils were fairly laterized hence suitable for safe disposal site and the plasticity index of the soil can be classified as silty sand of intermediate to high plasticity or compressibility (MI – MH). The permeability test on the soil samples performed showed low permeability within the range of 1.8×10^{-6} to 2.12×10^{-6} cm/s and its porosity was 0.43. Grain size distribution showed that the soil can be classified as silty sand.

The result from the concentration of Major and Trace elements in the soil samples when compared with the crustal average value which was used as the background value showed that all the elements were below the crustal average value except Pb, V, Mo and all the major elements and were inversely proportional to depth.

The Contamination assessments showed that the soil samples were low contaminated with all the metals except Pb, V and Mo which fall within high contamination.

References

Anon (1990): Methods of tests of soil for civil engineering purposes. British Standards Institution, London.

Ansari A.A, Singh I.B, Tobschall H.J (2002): Status of anthropogenically induced metal pollution in the Kanpur-Unnao industrial region of the Ganga Plain India. Environ Geol 38; 25-33.

Arneth J.D, Milde G., Kerndorff, H and Schleyer, R. (1989): Waste deposit influences on groundwater quality as a tool for waste type and site selection for final storage quality. In: Baccini P (ed) *The landfill*, vol 20, (Lecture Notes in Earth Sciences). Springer.

Baedecker, M.J. and Back,W., (1979): Hydrogeological processes and chemical reactions at a landfill. Ground water. 17(5):429–437.

De-GRAFT-Johnson J.W.S (1969): Engineering properties, property of the special session and Engineering properties of lateritic soils Vol. 2 pp 33-34.

Hakanson L. (1980): An ecological risk index of aquatic pollution control. A sedimentological approach. Water resources. 14: 975 – 1001.

Jankowski, J and Acworth R.I. 1997: Development of a contaminant plume from a municipal landfill: Redox reactions and plume variability. In: Chilton J, Hiscock K, Morris B, Nash H, Tellam J, Hennings S (eds) Proceedings of the XXVII Congress of the International Association of Hydrogeologists: Groundwater in the Urban Environment, Nottingham, UK, 21–27 September 1997. Balkema, Rotterdam, pp 439–444.

Jones H.A and Hockey R.D (1964): The geology of South Western Nigeria, Bulletin, Geological Survey, Nigerian No 31 (101pp).

Kim, K.W, Myung J.K, Ahn J.S, Chon, H.T (1998): Heavy metal contamination in dusts and stream sediments in the Teajon area, Korea. J. Geochem Explor 64; 409-419.

Kimmel, G.E and Braids, O.C. 1974: Leachate plumes in a highly permeable aquifer. *Groundwater*. 12(6):388–392.

Muller G. (1981): Die Schwermetallibelasting der sedimenten des Neckars undseiner Nebenflusse. Chemiker-Zeitung 6: 157-164.

Odukoya, A.M. 2007. Geochemical characterization of soils, sediments and waters around abandoned and active dumpsites in Lagos, Nigeria. PhD Thesis. University of Ibadan, Ibadan. 150p.

Odukoya, A. M. and Abimbola, A. F., (2010); Contamination assessment of surface and groundwater within and around two dumpsites. Int. J. Environ. Sci. Tech., 7 (2), 367-376.

Thuy H.T.T, Tobschall H.J, An P.V(2000); Distribution of heavy metals in urban soils –a case study of Danang-Hoian Area (Vietnam) Environ Geol. 39: 603-610.

Turekian K.K and Wedepohl L.H (1961): "Distribution of elements in some Major Units of Earth Crust" Bull Geology society American 72: 125p.

Wilcke W, Muller S, Kanchanakool N, Zech W(1998): Urban soil contamination in Bangkok; heavy metal and aluminium partitioning in topsoils. Geoderma 86, 211-228.

Zhug H, Ma, D, Xie, Chen X (1999): An approach in studying heavy metal pollution caused by modern city development in Nanjing, China. Environ Geol. 38, 223-224.

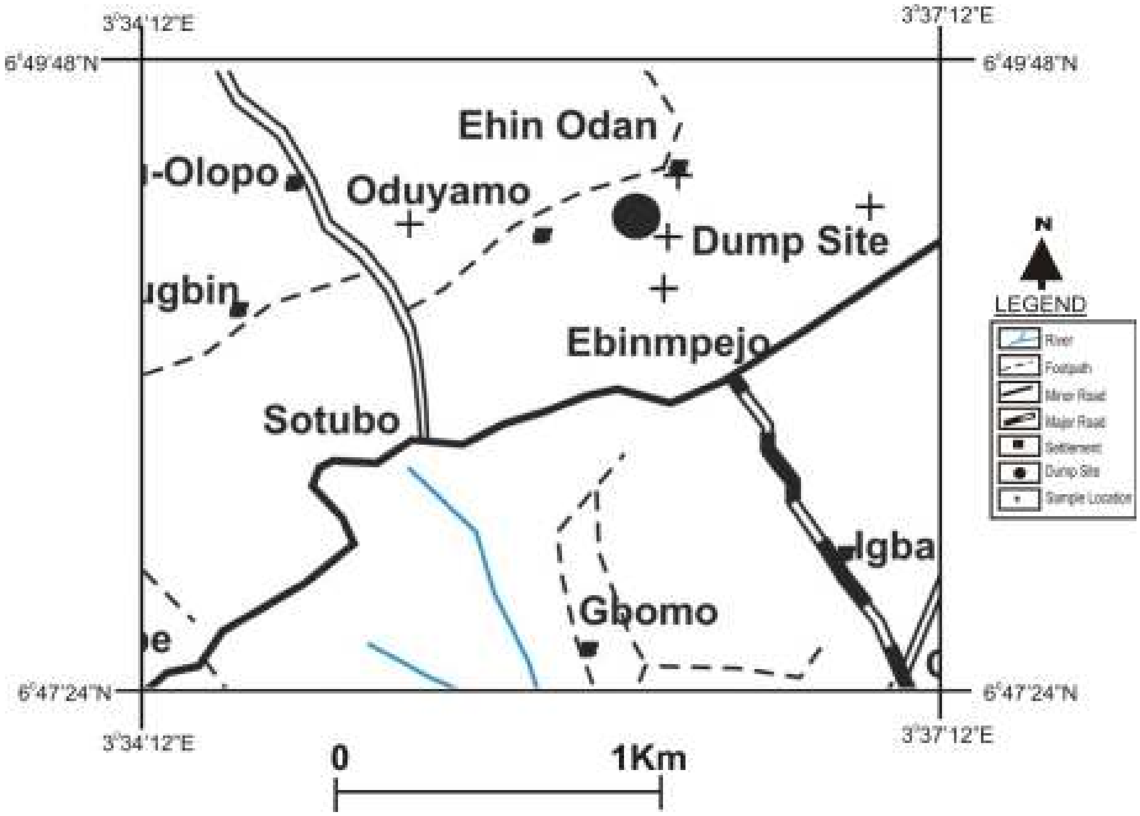


Fig 1: Location map showing the sampling points in Oke-diya

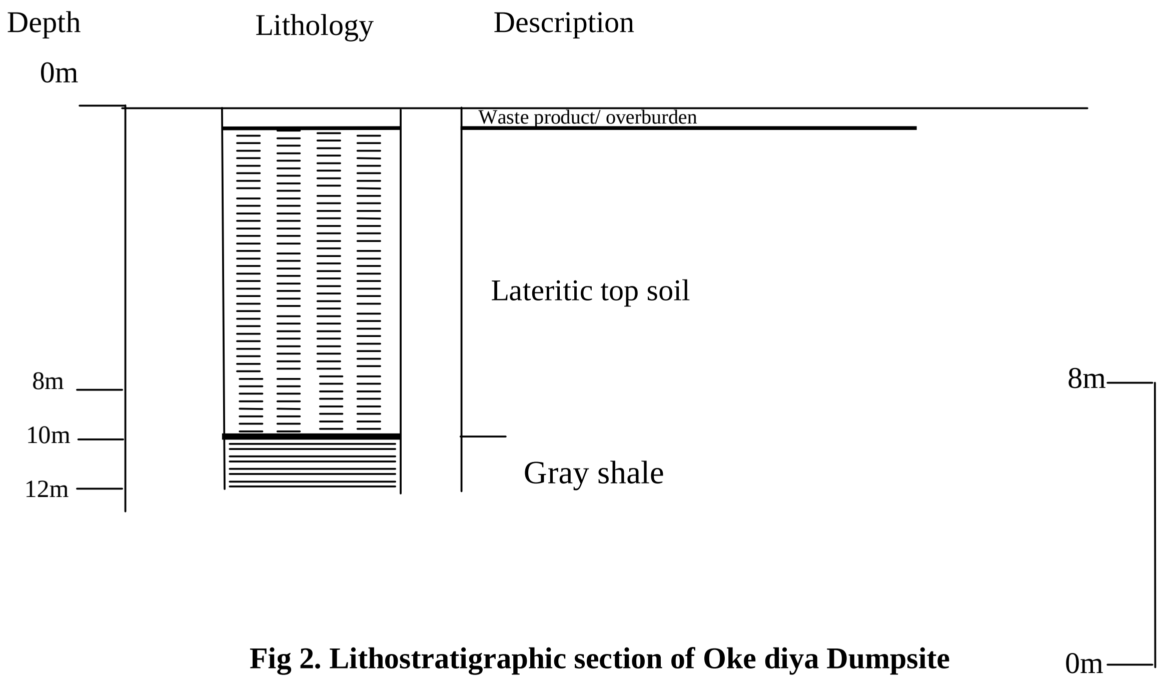


Fig 2. Lithostratigraphic section of Oke diya Dumpsite

Table1: Percentage grain size distribution and grading characteristics of soil in the study area

Location	Clay	Silt	Sand	Gravel
1	7%	60%	31%	2%
2	7%	56%	33%	4%
3	8%	60%	29%	3%
4	10%	57%	30%	2%
5	3%	60%	36%	1%

Table 2: Summary of engineering and index properties of soil

Location	**Specific gravity**	**Atterberg limits (%)**			**Permeability k coefficient x 10^{-6}**	**Rating**
		LL	PL	PI		
1	2.78	33.56	19.28	14.28	1.8	Low
2	2.78	36.72	20.78	15.94	1.95	Low
3	3.00	30.12	15.45	14.67	2.10	Low
4	2.82	30.51	20.83	9.68	2.0	Low
5	2.80	39.22	21.24	17.98	2.12	Low

Table3: Summary of major elements in soil samples within Oke-diya

Parameter (%)	Range	Mean	Standard deviation	Crustal Average
Ca	0.02-0.06	0.04	0.015	0.041
Mg	0.03-0.08	0.06	0.0136	0.021
K	0.04-0.08	0.07	0.0162	0.023
Na	Bdl-0.02	0.02	0	0.024
P	0.009-0.037	0.015	0.00908	0.0011
Ti	0.03-0.05	0.04	0.005	0.005
S	0.007-0.027	0.017	0.00603	0.0003

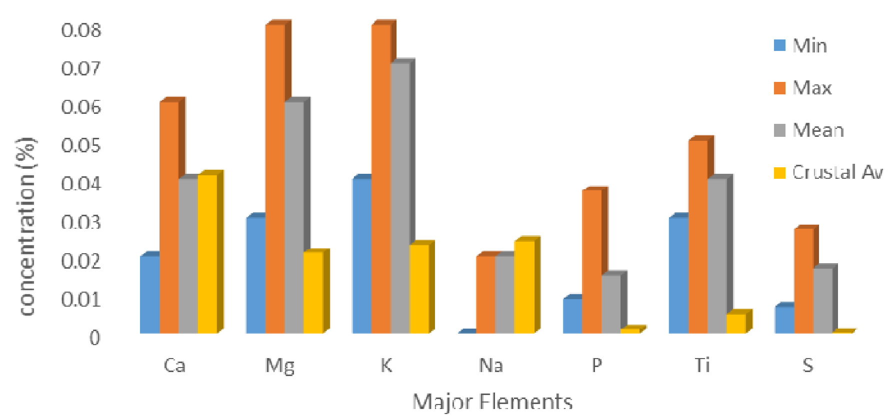


Fig 3a. Plot of summary of major elements with ASC

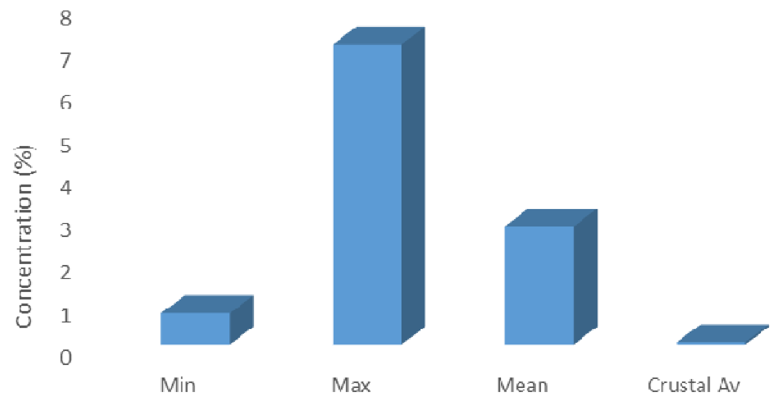


Fig 3b. Plot of summary of Fe with ASC

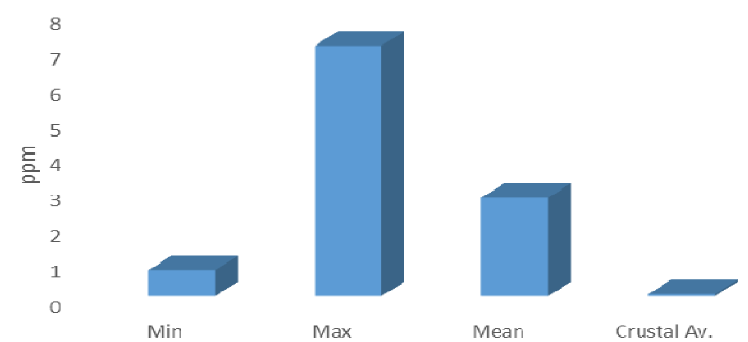


Fig 3b. Plot of summary of Fe with crustal average

Table4: Summary of Trace elements in soil samples within Oke-diya dumpsite.

Parameter (ppm)	Range	Mean	Standard deviation	Crustal Average
Mn	47 – 83	65.25	12.94	1, 000
Ni	3 – 9	5.63	2.233	75
Pb	5 – 18	11.38	4.357	12.5
Zn	12 - 24	18.88	4.543	70
Ba	25 – 76	36.25	16.088	500
Co	Bdl – 2	1.38	0.696	22
Cr	17 – 65	38.88	17.273	100
Sc	3 – 7	5.63	1.6536	20
Sr	7 – 150	31.88	17.323	375
V	33 – 155	82.00	45.335	110
Y	1 – 3	2.00	0.5	35
Zr	8 – 23	13.38	4.554	165
Cu	12 – 28	21.25	5.225	50
Mo	Bdl – 2	0.25	0.6187	1.5
Al	1.15-4.40	2.81	1.060	0.081

*** BDL means Below detection limit**

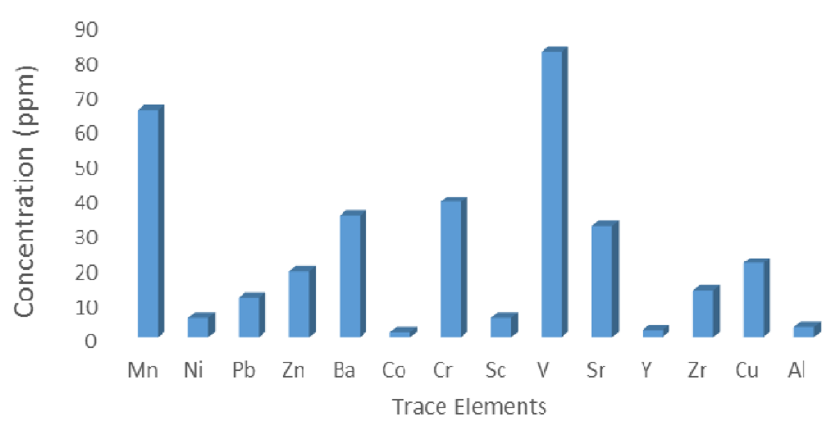


Fig 4. Plot of mean values of Trace Elements

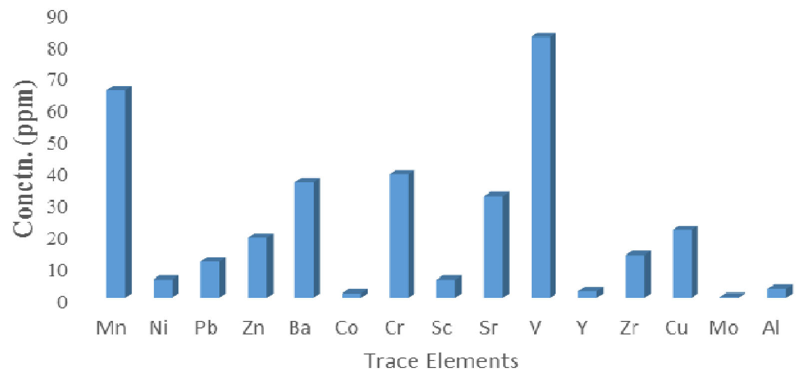
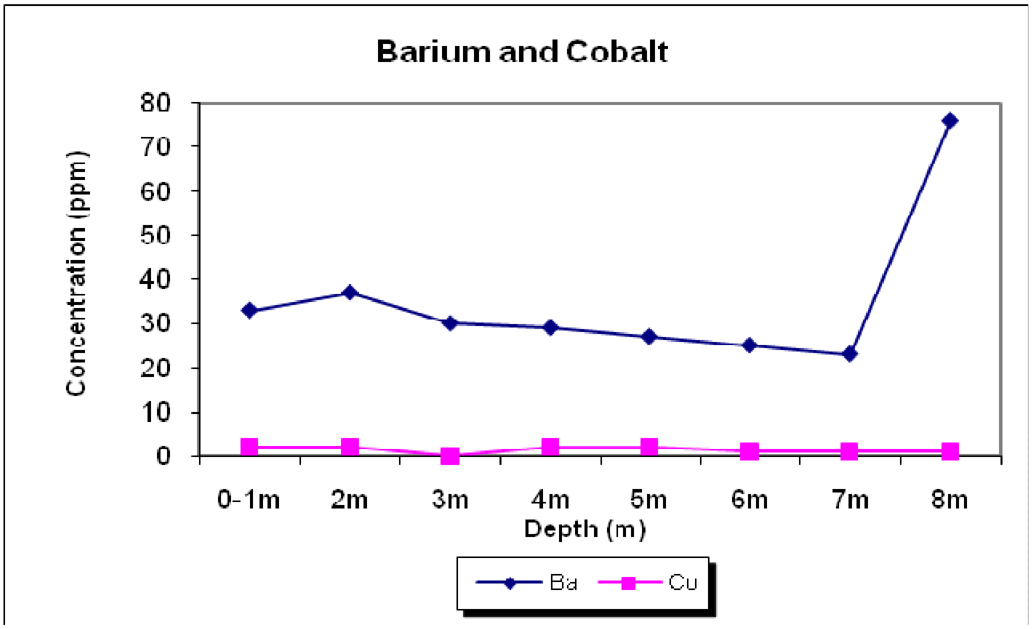


Fig. 4. Plot of mean values of Trace elements



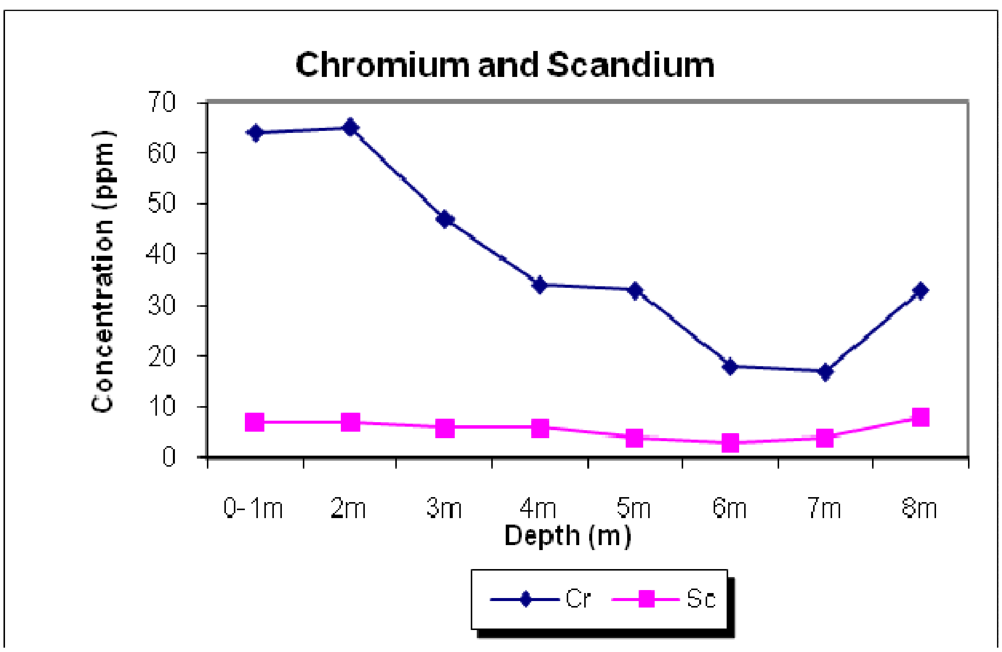
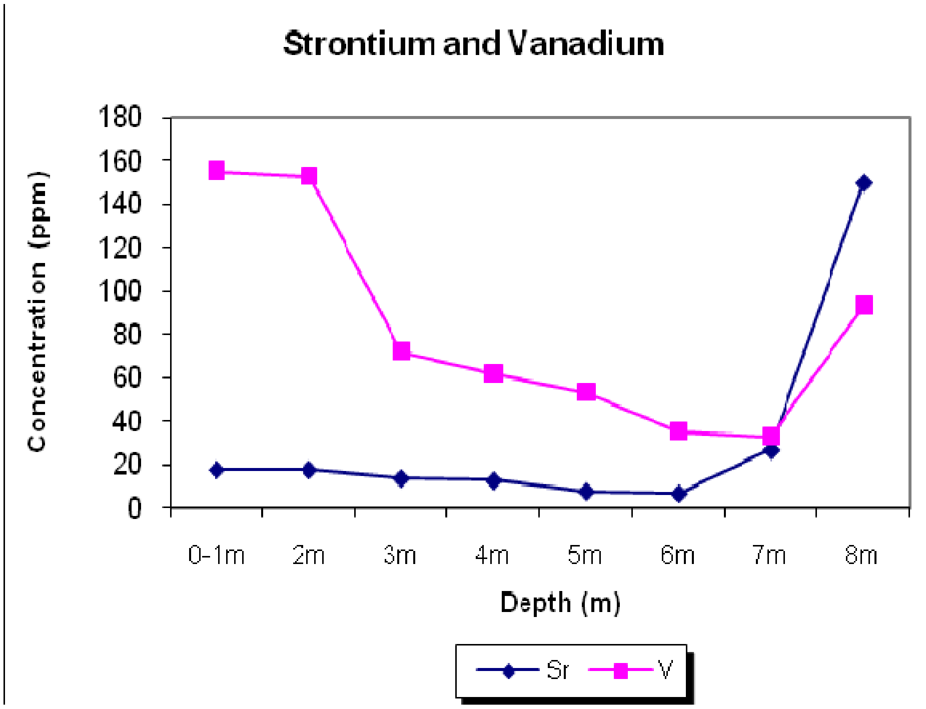


Fig 5a: Concentration of Trace elements in soil sample at different depth interval



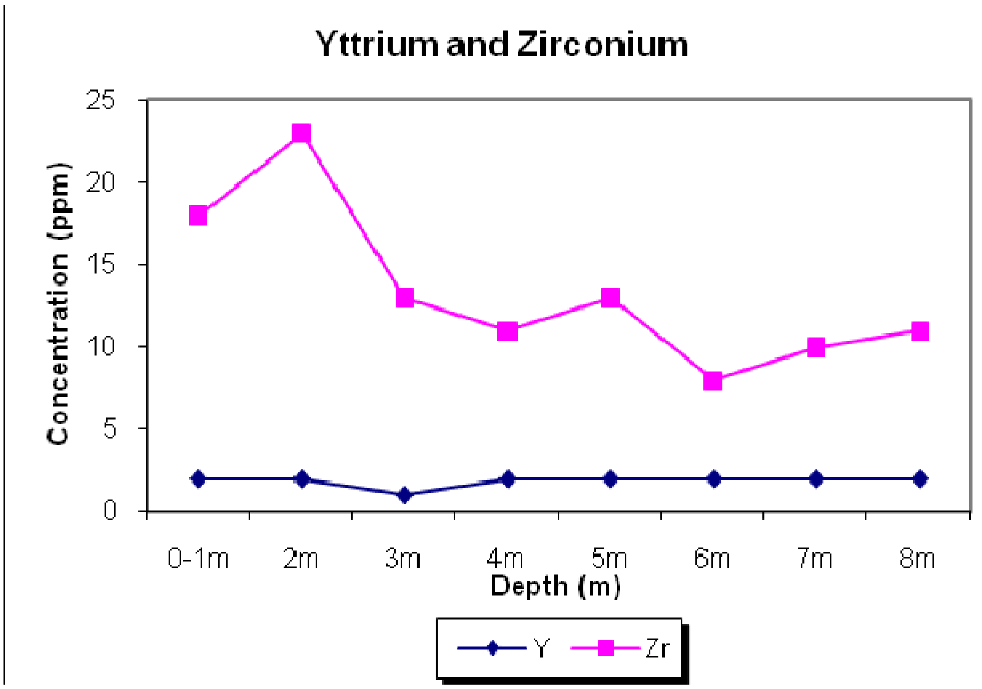
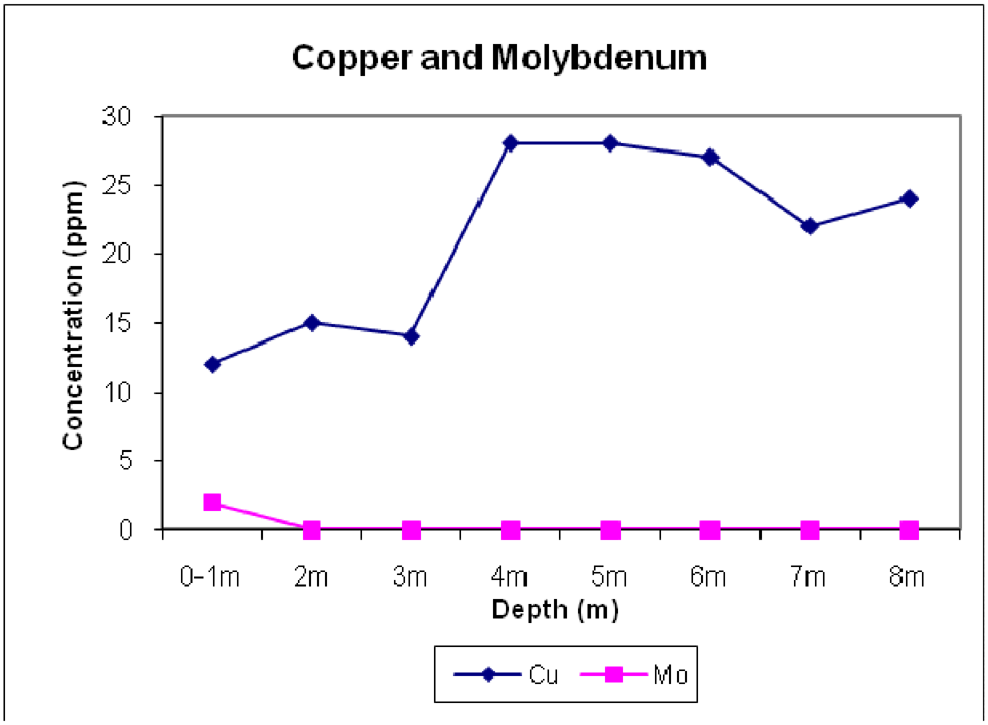


Fig 5b: Concentration of Trace elements in soil sample at different depth interval



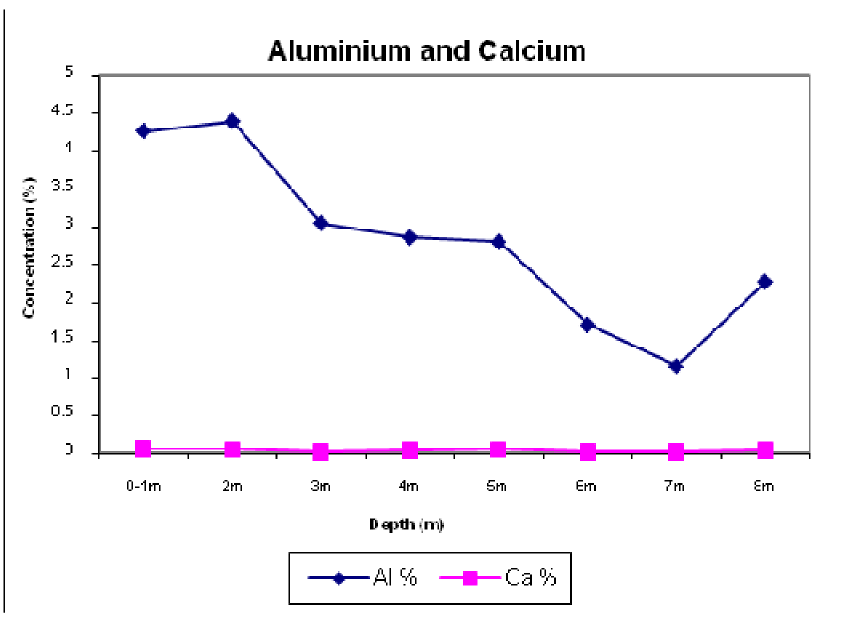


Fig 5c: Concentration of Trace elements in soil sample at different depth interval

Table 5: The Results of Contamination Factor/Degree of Contamination and impact of each metal on soil quality

Trace Elements	Range	Percentage (%)	Classification
Mn	0.047 – 0.083	1.76	Low contamination factor
Ni	0.4 – 1.2	2.03	Low contamination factor
Pb	0.4 – 1.44	24.69	Moderately contamination factor
Zn	0.17 – 0.34	7.29	Low contamination factor
Ba	0.05 – 0.152	1.97	Low contamination factor
Co	Nd – 0.091	1.70	Low contamination factor
Cr	0.12 – 0.65	10.55	Low contamination factor
Sc	0.15 – 0.35	7.65	Low contamination factor
Sr	0.2 – 4.3	2.31	Low contamination factor
V	0.3 – 1.41	20.21	Moderately contamination factor
Y	0.029 – 0.086	1.55	Low contamination factor
Zr	0.048 – 0.139	2.20	Low contamination factor
Cu	0.24 – 0.56	11.53	Low contamination factor
Mo	Nd – 1.33	4.53	Low to moderately contamination factor
Degree of contamination	3.6		Considerable degree of contamination

Table 6. The correlation matrix of major and trace elements in the study area.

	Cu	Mn	Pb	Zn	Ni	Ba	Cr	Sc	V	Sr	Al	Ca	Fe	Mg	K	Na
Cu	1.00															
Mn	-0.66	1.00														
Pb	-0.54	0.65	1.00													
Zn	-0.48	0.93	0.42	1.00												
Ni	-0.74	0.94	0.81	0.75	1.00											
Ba	-0.01	-0.03	0.62	-0.15	0.14	1.00										
Cr	-0.79	0.92	0.81	0.74	0.97	0.12	1.00									
Sc	-0.51	0.61	0.83	0.45	0.74	0.72	0.69	1.00								
V	-0.73	0.79	0.92	0.53	0.95	0.33	0.94	0.77	1.00							
Sr	0.10	-0.27	0.40	-0.38	-0.08	0.96	-0.11	0.57	0.12	1.00						
Al	-0.64	0.93	0.78	0.79	0.95	0.06	0.97	0.62	0.89	-0.20	1.00					
Ca	-0.22	0.54	0.69	0.32	0.69	0.23	0.68	0.52	0.75	0.06	0.76	1.00				
Fe	-0.68	0.76	0.90	0.49	0.92	0.26	0.90	0.68	0.98	0.05	0.87	0.72	1.00			
Mg	0.64	-0.08	0.16	-0.13	-0.03	0.16	-0.11	-0.04	0.03	0.09	0.07	0.52	0.10	1.00		
K	-0.53	0.26	0.64	0.01	0.48	0.68	0.45	0.81	0.61	0.66	0.29	0.28	0.58	-0.22	1.00	
Na	0.41	0.23	-0.21	0.37	0.06	-0.14	-0.11	0.09	-0.17	-0.16	0.02	0.06	-0.19	0.39	0.22	1.00
Ti	-0.36	0.53	0.11	0.48	0.45	-0.61	0.46	-0.15	0.33	-0.73	0.50	0.17	0.48	0.01	-0.13	0.01