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SOIL DEGRADATION RESULTING FROM MIGRATION OF ION LEACHATE IN GOSA DUMPSITE, ABUJA, NIGERIA

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ABSTRACT: The effect of degradation caused by ion leachate migration in the soil of Gosa dumpsite was investigated with reference to water and soil from dumpsite located at Idu Industrial area- Abuja. This was done to determine the health and environmental pollution status caused by heavy metals concentration present in the dumpsite and its effect to inhabitants within the settlement. Soil samples collected during dry and wet season were pretreated and digested using hotplate. The heavy metal concentrations were determined using Atomic Absorption Spectrophotometer. The samples were analyzed for concentration of lead (Pb), cupper (Cu), manganese (Mn), nickel (Ni) and chromium (Cr). Control soil samples were taken 300m away from the dumpsite. The dumpsite was divided into four cardinal points including the centre from which samples were collected for analysis. Water samples were collected from three wells to test for physiochemical properties of PH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (DO), Hardness, Conductivity and Alkalinity. The result showed significant difference in concentration of these metals in the dumpsite and control. The dumpsite was found to contain significant amount of toxic heavy metals. The analytical results indicates that in both dry and wet season, most of the metals concentration were above the World Health Organization (WHO) and Standard Organization of Nigeria (SON) standards, which is a major concern as these metals pose threats to human life, agricultural productivity and unsafe for the inhabitants.

KEYWORDS: Heavy metals, Degradation, Dumpsite, Ion leachate, Pollution.

1 INTRODUCTION

Dumping of industrial and municipal solid waste in our environment has contributed greatly to increase the levels of heavy metals like Cu, Pb, Mn, Cr and Ni in soil and vegetation found in the vicinity of waste dumpsites. According to Federal Environmental Protection Agency FEPA [8], solid wastes are useless, unwanted or discarded materials that arise from man's activities and cannot be discarded through sewer pipe. Places with accumulated solid waste are called refuse dumps or dumpsites**.** Heavy metals pollution posed serious problem for human health and for life in general. Heavy metals are a general collective term which applies to metals and metalloid with a relatively high atomic density greater than 4 g/cm^3 or 5 times or more than water, which is toxic and poisonous at low concentration [7]. The constant dumping of harmful substance into the environment has been shown to have adverse effect on human health, agricultural productivity and natural ecosystems [2]. The dramatic increase in public awareness and concern about the state of the global and local environments which has occurred in recent decades has been accompanied and partly prompted by ever growing evidence on the extent to which pollution has caused severe environmental degradation.

Soil degradation is when soil deteriorates because of human activity and loses its quality and productivity. It happens when soil loses its nutrients, or its organic matter. It also happens when the soil structure breaks down, or if the soil becomes toxic from pollution. The primary cause of soil degradation is erosion, but compaction, salinization, and depletion by nutrient demanding crops may also cause degradation. Rapp(2008),[7]. Most waste deposited in landfills is not inert. Degradation of

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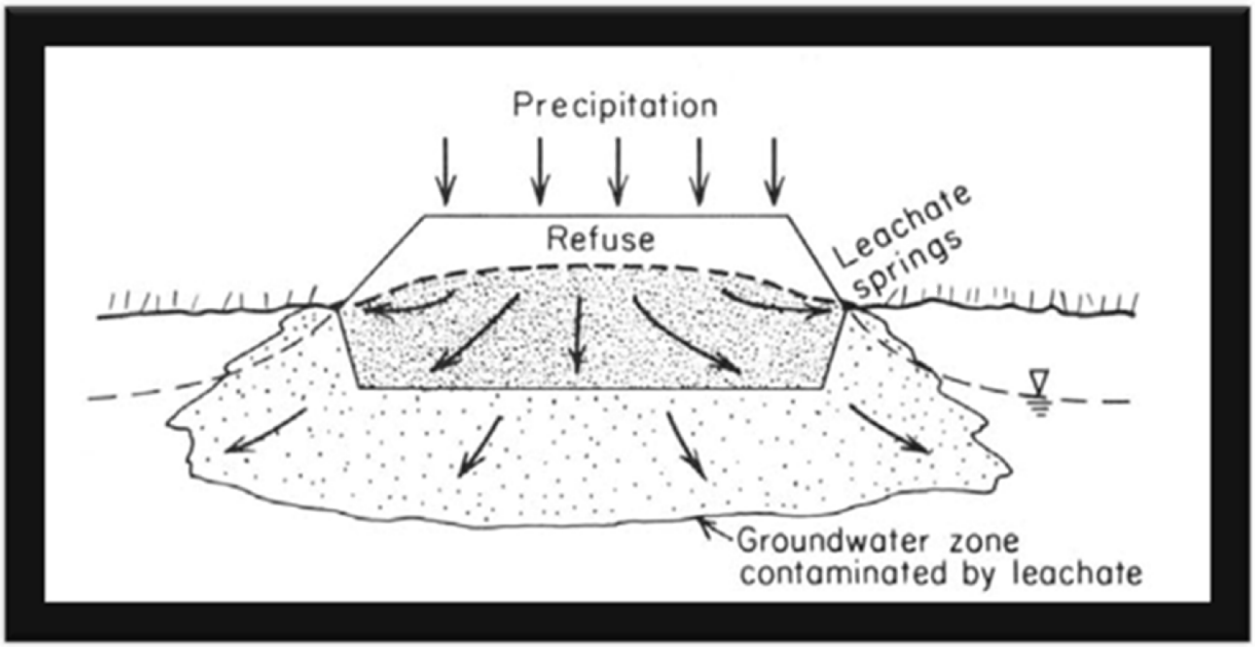
many components of waste including food, paper and textiles consumes oxygen thereby charging the redox potentials of the liquid present and potentially influencing mobility of other constituents. Plastic, glass and metals compounds tend to be less reactive and degrade more slowly. Under some conditions metals may, however become rapidly mobilized. Rain water percolating refuse dumps provides a medium in which waste, particularly organic, can undergo degradation into simpler substance through a range of biochemical reactions involving dissolution, hydrolysis, oxidation and reduction process controlled to a large extent within landfills and dumps by micro organisms primarily bacteria mechanisms [15]. According to [6], [10] in an unsealed landfills an aquifer percolating through landfills and refuse dumps often accumulate or 'mound' within or below the landfill (**fig1**).



(Fig 1) Conceptual diagram of leachate migration from a typical landfill [9].

This is due to production of leachate by degradation process operating within the waste, in addition to the rain water percolating down through the waste. Downward flow from the landfill threatens underlying ground water resources outward flow can result in leachate springs yielding water of a poor quality, often dangerous quality at the periphery of the waste deposit [5].

This research was carried out to investigate the effects of degradation caused by ion leachate migration in Gosa dumpsite as it affects human health and agricultural productivity. Some heavy metals were analyzed from the soil and to determine their toxicity level.

2 MATERIALS AND METHODS

2.1 STUDY SITE

The Gosa dumpsite is located at Idu Local Government Area, F.C.T., Abuja, with coordinates 09^{o} 02.047N 007^{0} 20.216E (Hour Degree Minute) with an altitude of 100 ±3m. This coordinates was taken with a handheld GPS (Global Positioning System) (ETREX) using the WGS84 coordinate system. The area has rough topography with few elevated areas. The study area enjoys a tropical type of climate generally characterised by two extreme temperatures [1]. The mean annual rainfall of the area is 1040mm. The wet/ rainy season last for 5-6 months between April/May to October with the heaviest in August [3]. During the dry season, temperatures ranges from a minimum of 15-24^{o}c in December/ January to a maximum of 32-39^{o}c in April/May. The soil consists of well drained sandy loam and clay loam soil on the Gosa site.

2.2 SAMPLE COLLECTION

Soil samples were collected from the reference site at 10 different points during dry season and 18 different points during wet season at the top surface level and at a depth of 30 cm at each location, starting from the Centre of the dumpsite

to the bottom of the slope. Control samples were collected from a distance at 300 m away from the last sampling point on the dumpsite, bearing in mind that the distance from the road will make them to be less exposed to the pollutants. The land was divided into four cardinal directions away from the centre (North, South, East and West) from which the samples were collected 20m away from the next point, thoroughly preserved in a clean plastic container to obtain a representative sample as illustrated on **Fig 2**

It was then dried under ambient temperature. This was monitored until the samples were totally dried and stored in a labeled polyethene bags prior to analysis in the laboratory.

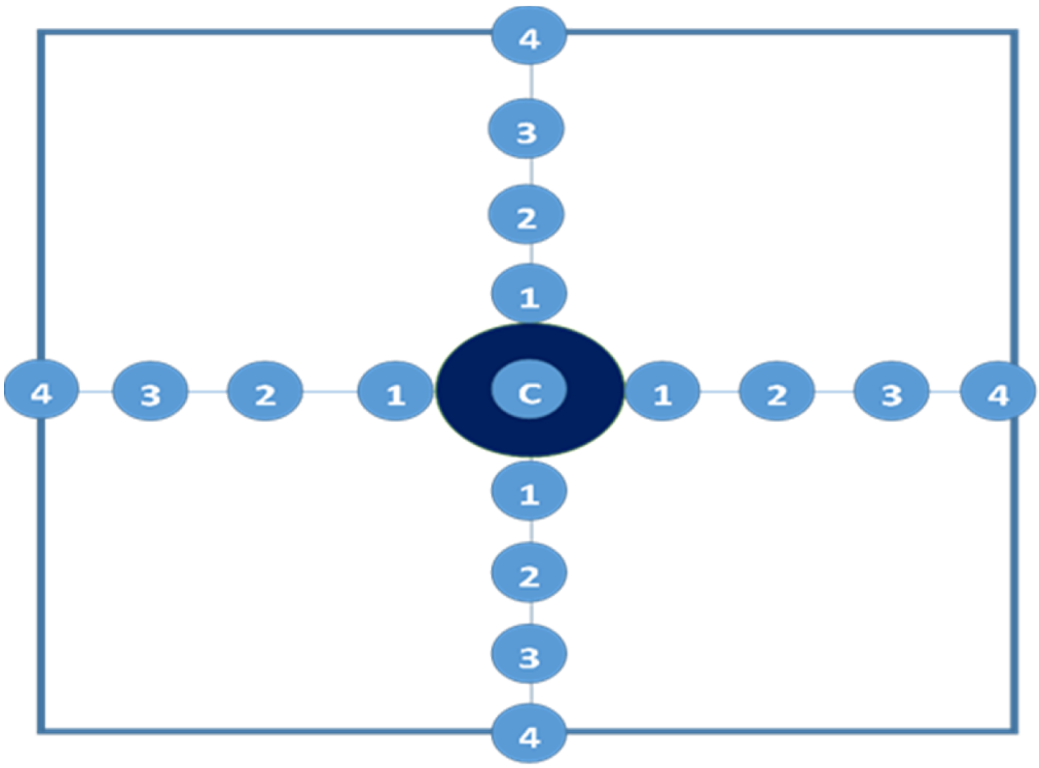


Fig 2- Four cardinal direction of soil sample collection at Gosa dumpsite, Abuja. Where N= North, S= South, W= West and E= East directions.

2.3 MATERIAL PREPARATION AND ANALYSIS

This was achieved in three different stages;

- Sampling and Pre-Treatment stage
- Sampling digestion Method
- Analysis of the sample by using Bulk Scientific Atomic Absorption Spectrophotometer (AAS) in order to determine the concentration heavy metals in the soil.

Water samples from the site were taken from 3 wells situated at different locations. The composition was analyzed for both seasons. Parameters such as Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), PH, Electrical Conductivity, Total Alkalinity and Total Hardness were determined.

Similarly, soil samples were obtained from the site as labeled in fig (2), prior to the soil analysis using Bulk Scientific Atomic Absorption Spectrophotometer (AAS). The samples were digested using acid digestion method.

2.4 SAMPLE PREPARATION FOR DIGESTION SOLUTION

1g of sieved soil sample was weighed into a washed and dried 50 mL beaker using a sensitive weighing balance. 20 mL of acid mixture (3:1) Nitric acid/ per chloric acid mixture was measured and poured into the beaker containing the sample according to [14] and (Selected Method for soil and plant Analysis, Institute of Tropical Agriculture, Ibadan Nigeria), and thereafter transferred to a hotplate at 150°C and allowed to digest gently until a clear solution is obtained or the digest

reduces to about 5 mL. Add distilled water and allow it to boil again before removing it from the hotplate. Digest was then allowed to cool, then filtered and made up to 100 mL mark with distilled water using a 100 mL volumetric flask. The same procedure was repeated for the remaining samples. The filtrate was then transferred to a labeled plastic sample bottle and analyzed for heavy metals concentration using Atomic Adsorptive Spectrophotometer. The experiment was done in the school of Agriculture and Agricultural Technology, department of Water Resources, Agriculture and fisheries Technology laboratory (WAFT), Federal University of Technology, Minna.

The above procedure was repeated at both seasons (dry & wet) and extended to control locations within the vicinity of the site where there are no dumps.

3 RESULTS AND DISCUSSION

The results of analysis of the effect of degradation caused by heavy metals (Ion leachate migration) in Gosa dumpsite and the three wells analyzed are as shown in Table 1, 2 and 3. The metals considered in the study includes those which are micro-nutrient such as copper and manganese, also the non-essential/ toxic heavy metals which are toxic to plants present in the soil at concentration above tolerance is lead but with no trace of chromium and nickel in the soil and water.

Based on the results obtained, the concentration of Cu ions found in the dumpsite during the wet season (0.29- 3.90) ppm is higher than the dry season (0.30-2.27) ppm. This is as a result of leachate generation caused by rainfall that percolates the dumpsite. The unauthorized dumping of all kinds of waste will cause serious health damage due to the released of heavy metals that comes from the dumpsite. The concentration of Cu ions in NP1W during wet season was (0.73) ppm, when compared to the WHO limit (2.0) ppm, was within acceptable standard. Sample location point NP2W of Cu ion has concentration of (1.84) ppm, but when compared to WHO limit fell within the acceptable standard. Point NP3W had a concentration of (1.07) ppm also fell within WHO limit. NP4W point with concentration (1.120 ppm is also within WHO limit.

The SP1W location point (0.99) ppm agrees with WHO limit for Cu ion, SP2W location point (2.39) ppm was seen to have exceeded WHO limit, SP3W location point (0.84) ppm was seen within the standard and SP4W location point (0.85) ppm also fell within the standard. EPIW location point was (1.38) ppm, falls within WHO limit, EP2W location point was analyzed as (3.90) ppm which of course is higher than acceptable limit of Cu. EP3W location point (1.23) ppm fell within WHO limit and EP4W location point (1.20) ppm was also within WHO limit. WP1W location point (039) ppm when compared to WHO limit, fell within WHO limit, WP2W location point (0.52) ppm fell within WHO permissible limit, WP3W location point (1.11) ppm was within WHO limit and WP4W location point (0.98) ppm also fell within WHO permissible limit.

According to [4] and [34],WHO admissible limit for Cu ions is (2.0) ppm. It can be seen from Table 1, out of 17 sample location points, only SP2W (2.39) ppm and EP2W (3.90) ppm exceeded WHO limit of Cu (2.0) ppm. Similarly, when all points where compared to control sample, all was higher than control (0.29) ppm, indicating concentration decrease with distance. However, in Table 2 for dry season, out of 9 sample location points, only EPID (2-27) ppm and centre D (2.65) ppm was above tolerance of WHO. When compared to control D (0.73) ppm, only 4 points; centre D (2.65) ppm, WP2D (1.25) ppm, EP1D (2.27) ppm and EP2D (1.10) ppm. The rest of Cu concentration was lesser.

In Table 1, the concentration of Pb in location point NP1W is (0.90) ppm, when compared to WHO limit of Pb (0.01) ppm was found to be above tolerance. Location point NP2W (1.40) ppm exceeds WHO limit, NP3W location point (0.60) ppm was above tolerance and NP4W location point (1.10) ppm exceeds WHO permissible limit. SP1W (2.30) ppm exceeds WHO limit, sample location point of SP2W (4.40) ppm was above tolerance of WHO, SP3W location point (1.10) ppm was above WHO limit and SP4W location point (1.40) ppm also exceeds WHO limit. EP1W location point of Pb ion concentration (1.30) ppm was above tolerance and exceed WHO limit, location point EP2W (6.90) ppm was the highest heavy metal recorded in Pb concentration which of course exceeds WHO limit, EP3W location point (1.50) ppm exceeds the limit of WHO and EP4W location point (1.50) ppm was above WHO limit. WP1W location point with value (0.30) ppm was above WHO limit of Pb (0.01) ppm; WP2W location point (0.60) ppm was above WHO limit, WP3W location point (1.40) ppm exceeds WHO limits, WP4W location point (1.40) ppm was above WHO limit. It should be noted that, centre W (0.50) ppm was above WHO limit.

The concentration of Pb ion in the wet season is higher than the dry season as shown in Table 1 and 2. This is because leachate migration is faster due to rain precipitation on the refuse contaminating underground water and increases the heavy metals found within that period. This observation was seen to be similar to the study carried out by [30]. These results also supported [28] claimed that Pb – containing particles in motor vehicle exhaust tend to be larger in rural areas and near motorways in urban area. The value of Pb ion is higher in NPW during the wet season than the NPD values in the dry season indicating high presence of Pb concentration as shown in table 1 and 2 respectively. According to [35], the permissible limit for Pb ion in soil and water (0.01) ppm when compared to (0.60 -1.40) during wet season (NPW) and (0.30 – 1.30) ppm during dry season (NPD) was above WHO tolerance. From Table 1 and 2, control samples analyzed for Pb is higher in wet season

(1.20) ppm than that of the dry season (0.70) ppm. It is caused by water migration due to heavy rainfall which increases the level of leachate generation. On the average, the concentration of Pb in wet and dry season is lower compared to Pb concentration in the dumpsite as shown in Table 1 and 2

Conclusively, from Table 1 all 17 location points exceeded WHO limit of Pb (0.01) ppm. However, when compared to control W, 9 location points: WP4W, WP3W, EP3W, EP2W, EPIW, SP4W, SP2W, SPIW and NP2W were higher while the remaining 7 location points: NP1W, NP3W, NP4W, SP3W, WP1W, WP2W and centre D were lesser with EP4W having same concentration with control W (1.20) ppm. Similarly, in Table 2 the concentration of all sample points of Pb was seen to be higher than WHO limit of Pb (0.01) ppm. However, 4 location points of Pb: SP2D, EPID, WP2D and centre D were found higher than control D while sample points NP1D, NP2D, SP1D and WP1D were lesser, EP2D was having same concentration as that of the control D.

The result in Table 1, 2 and 3 shows Mn concentration as the highest recorded. It was found higher than WHO (2007) limit in both seasons and the three wells within the dumpsite. Mn ions was recorded highest in NP3W of wet season as (8.40) ppm which the same value with control W. The concentration of Mn ion was considered very high not only in all sample location points at the dumpsite but in the control on both seasons: Control W (8.40) ppm and Control D (14.10) ppm. This could be as a result of waste deposited in the dumpsite containing more concentration of Mn and pollutant emitted from the exhaust of motor vehicle and other sources.

However, when Mn concentration at various location points in wet season were compared to control W (8.40) ppm, all values were lesser except for NP3W which equals the value of Control W. Similarly, in dry season as shown in Table 2. When all sampling points were compared to control D (14.10) ppm, all were below control D.

The high presence of Mn heavy metals concentration can lead to Neurological disorder in humans and are toxic to plants [4].

The presence of Cr indicates very low availability in the soil and water samples shown in Table 1, 2 and 3. But on the average, the presence of Cr ion is lower in wet and dry season. It has values ranging from (0.000- 0.1010) ppm in NPW of wet season and (0.000- 0.006) ppm in NPD of dry season, indicating high presence in wet season compared to dry season.

According to [17] and [35], the permissible limit for Cr concentration is (0.05) ppm. The soil and water samples collected from gosa dumpsite was analysed with no trace of Ni ion as shown on Table 1, 2 and 3, hence was within the permissible limit of World Health Organisation [35] and [17]. This indicates no presence of Ni heavy metal from the various kind of waste deposited there.

Control samples for soil and water analyzed during wet and dry season had no trace of Ni but with (0.003) ppm concentration of Cr which indicates little or no presence of Cr as shown on Table 1, 2 and 3. Therefore, Ni was not seen to be present in all analyzed samples; there is no detection of metal in trace quantity. Based on this result obtained, there was a gradual increase in the concentration of heavy metals of the centre to other points within the dumpsite.

The pH values obtained from the result of the well analysis WP2 and WP3 falls within the WHO water quality standard of 6.5-8.5. The values obtained were 6.64 and 6.42 respectively, while WP1 falls below the standard with 5.37 which makes it acidic. World Health Organization [17] admissible limit for pH value in quality water is 6.5-8.5([3], [33].

The electrical conductivity of the three well water samples in Gosa dumpsite was high indicating high presence of conducting ions. The values obtained in the conducting measurement are all within the acceptable standard with readings below as shown on Table 3.

The values of alkalinity in the three wells are high except of the value in WP1 as shown on table 3. Total alkalinity in $CaCO_3$ for all wells fall within the limit with values ranging between 30-130mg/l. Although, when there is no World Health Organization's standard admissible limit for alkalinity in the well water, may contribute to hardness of underground waste water resources. This was shown in levels of hardness in all well points, falls within the limit of WHO.

According to [4], water quality is low when its dissolve oxygen is lower than 9.2ppm and the suspended solid is higher than 9.2ppm. Hence the well water, if untreated before discharge into the environment for drinking is a potential source of water pollution within the vicinity. While the values obtained from the wells was within the acceptable standard ranging between (4.6-6.4)mg/l as shown on Table 4.3. DO in waste water is desirable because it prevents the formation of noxious odours.

During a research by [4], it was discovered that there is a significant relationship COD and BODs of domestic and waste waters. Since the greater the decomposable organic matter, the greater the BODs value [4], the results of this research imply low levels of micro organism as a result of low values of BODs which are 1.6, 3.0 and 3.4 for WP1,WP2 and WP3 respectively.

The BOD values of 1.6 – 3.4mg/l can be said to be low as BOD determination is an empirical determination of the amount of oxygen required to oxidize organic matter in the sample, which can be used to measure pollutant rate of water body.

The COD are equally very low indicating that the well water contains less amount of organic matter. Research according to George et al (2003), the ratio of BOD/COD for untreated water is normally from 0.3 to 0.8 but for the well under investigation ranged from 0.11 to 0.25 which are very low and hence falls below the admissible limit. It indicates a low organic strength of domestic and industrial waste water.

Therefore, these results should be a source of a major concern to the inhabitants of Gosa dumpsite, farming and drinking water from the surrounding not only in Gosa in Idu industrial area but to others who are in similar affected areas.

Table3.1 Analysis of soil samples collected from Gosa dumpsite for heavy metals concentration in wet season

Samples Location	Heavy Metals Concentration In(ppm)			
	Cu	Pb	Mn	Cr
NPIW	0.73	0.90	7.50	0.010
NP2W	1.84	1.40	7.10	0.003
NP3W	1.07	0.60	8.40	0.003
NP4W	1.12	1.10	4.80	0.006
SPIW	0.99	2.30	4.30	0.000
SP2W	2.39	4.40	4.30	0.003
SP3W	0.84	1.10	4.30	0.006
SP4W	0.85	1.40	4.60	0.006
EP1W	1.38	1.30	5.50	0.003
EP2W	3.90	6.90	7.30	0.003
EP3W	1.23	1.50	5.20	0.000
EP4W	1.20	1.20	6.20	0.006
WP1W	0.39	0.30	2.50	0.000
WP2W	0.52	0.60	5.00	0.003
WP3W	1.11	1.40	3.10	0.006
WP4W	0.98	1.40	4.80	0.006
CENTRE W	0.55	0.50	8.10	0.003
CONTROL W	0.29	1.20	8.40	0.000
WHO LIMIT	1.0	0.01	0.5	0.05

Table 3.2 Analysis of soil samples collected from Gosa dumpsite for heavy metals concentration in dry season

Samples Location	Heavy Metals Concentration In(ppm)			
	Cu	Pb	Mn	Cr
NPID	0.30	0.30	3.60	0.000
NP2D	0.46	0.50	6.50	0.006
SP1D	0.39	0.20	3.40	0.003
SP2D	1.10	1.30	4.20	0.000
EP1D	2.27	1.60	6.30	0.006
EP2D	0.43	0.70	4.10	0.000
WP1D	0.41	0.30	3.20	0.003
WP2D	1.25	1.10	4.50	0.003
CENTRE D	2.65	1.20	4.20	0.006
CONTROL D	0.73	0.70	14.10	0.003
WHO LIMIT	1.0	0.01	0.5	0.05

NPD – North Point in Dry Season
SPD – South Point in Dry Season
EPD – East Point in Dry Season
WSD – West Point in Dry Season

CENTRE –Centre of the dumpsite in Dry Season
CONTROL – Control Sample in Dry Season

Table 3.3 Analysis of water samples from three different wells In Gosa dumpsite

Parameters	WP1	WP2	WP3	WHO (2004) Standard
Cu (ppm)	0.15	0.13	0.12	1.0
Mn (ppm)	1.20	6.80	3.60	0.5
Pb (ppm)	0.00	0.00	0.00	0.01
Cr (ppm)	0.003	0.003	0.003	0.05
Ni (ppm)	0.00	0.00	0.00	0.02
Temperature (^{0}C)	29	29	28	5-50
pH	5.37	6.64	6.42	6.5-8.5
Conductors	316	977	661	1000
Hardness (Mg/l)	50	90	192	500
Alkalinity (Mg/l)	30.6	130	103	500
DO (Mg/l)	4.6	5.0	6.4	
BOD (Mg/l)	1.6	3.0	3.4	
COD (Mg/l)	14.8	12	15.2	

The effect of heavy metal concentration in Gosa dumpsite with respect to the control sample and WHO standard are presented below in fig 3.01 – 3.14.

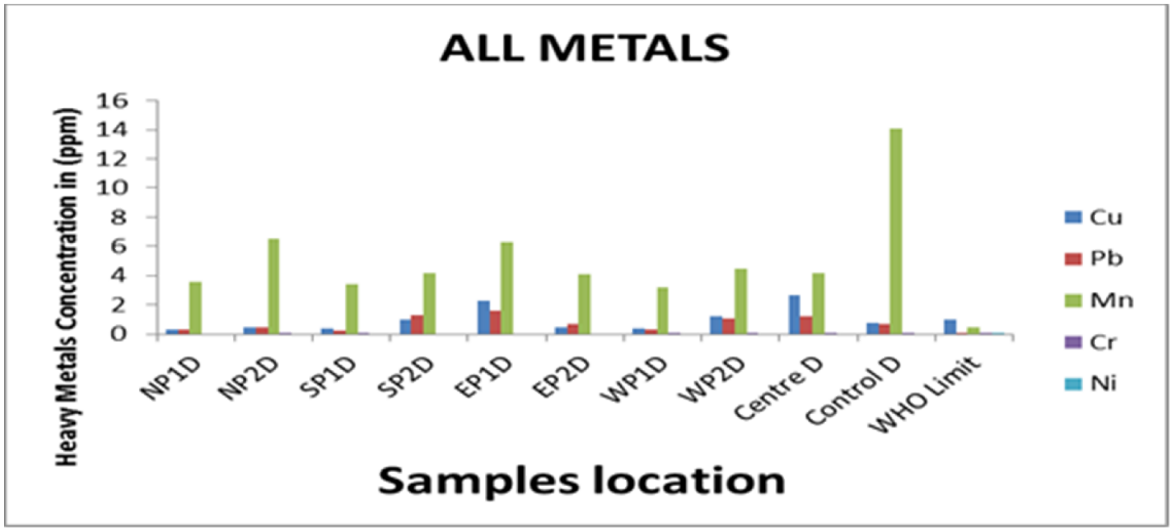


Fig 3.01 A plot of heavy metals concentration against sample locations of all metals during dry season

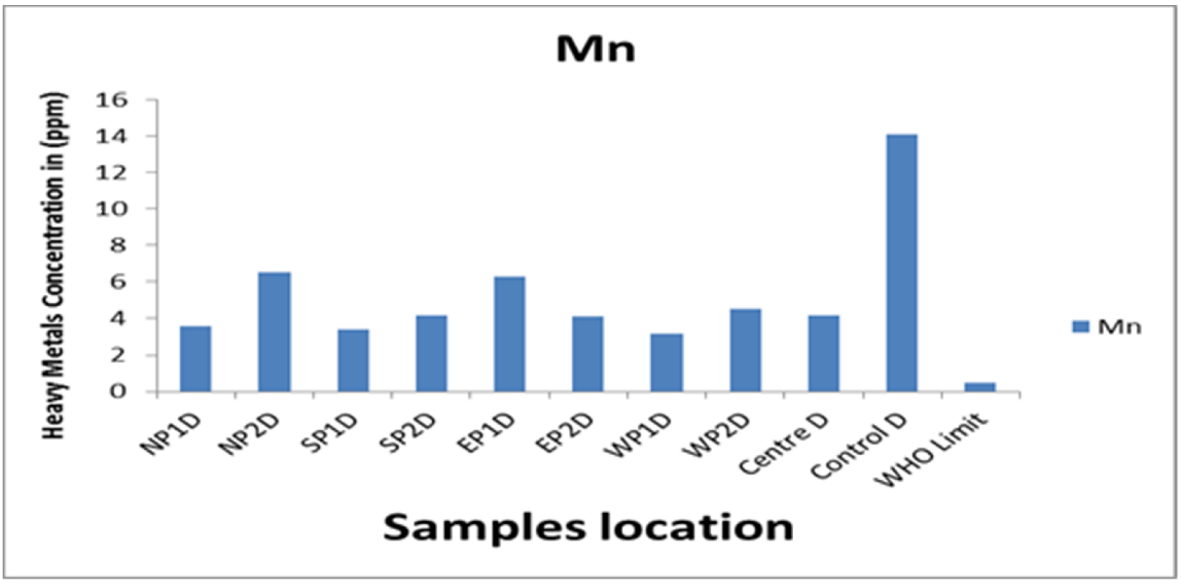


Fig 3.02 A plot of manganese concentration against sample location during dry season

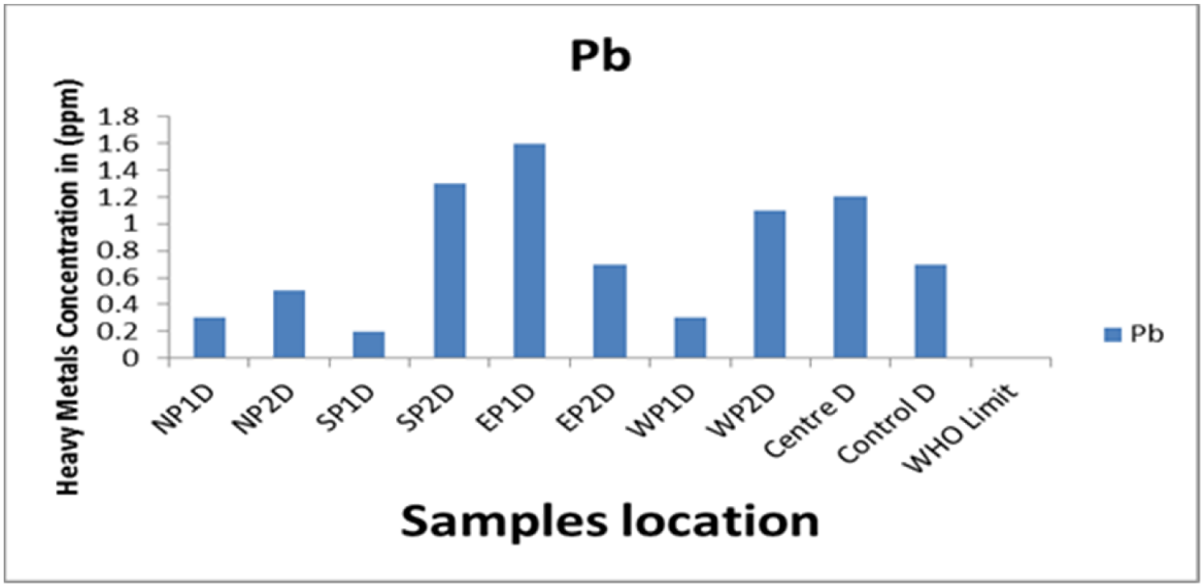


Fig 3.03 A plot of lead concentration against sample location during dry season.

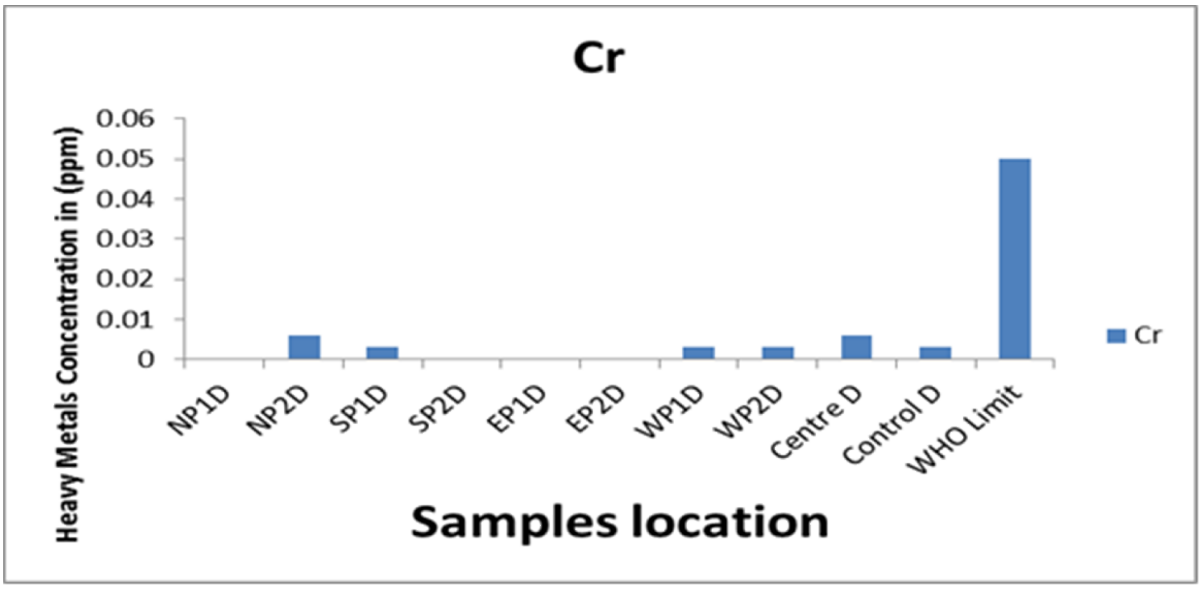


Fig 3.04 A plot of chromium concentration against sample location during dry season

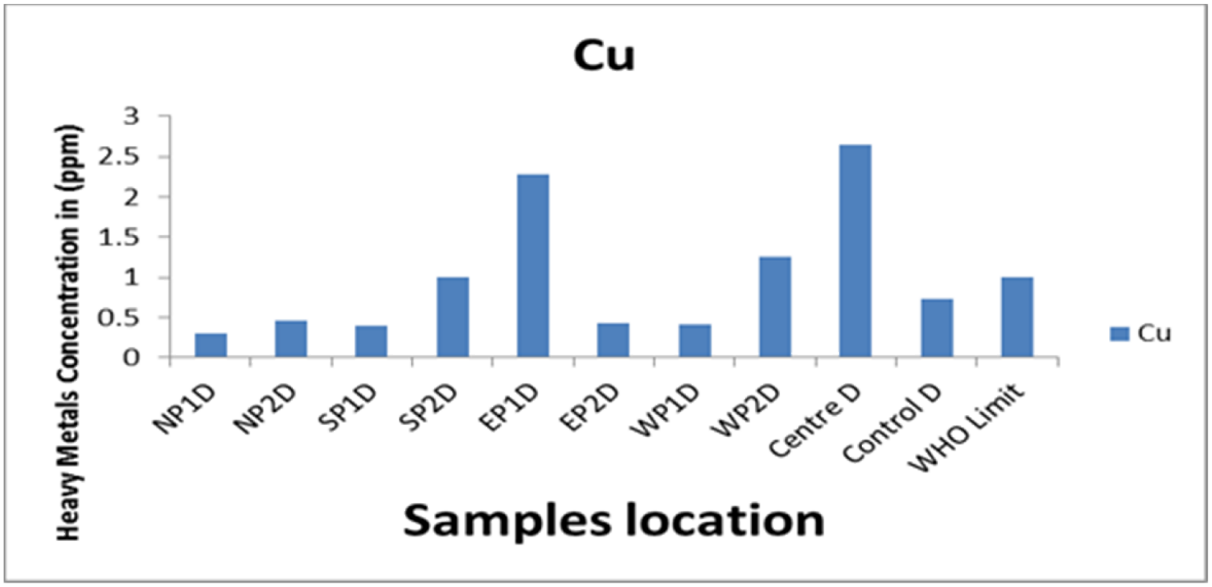


Fig 3.05 A plot of cupper concentration against sample location during dry season

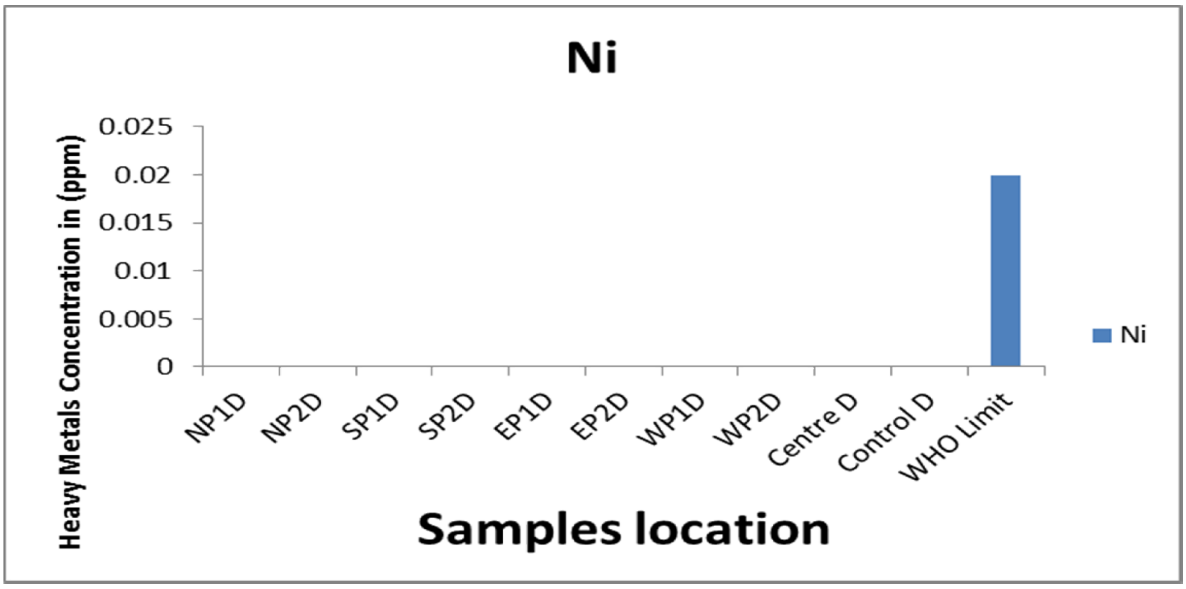


Fig 3.06 A plot of nickel concentration against sample location during dry season

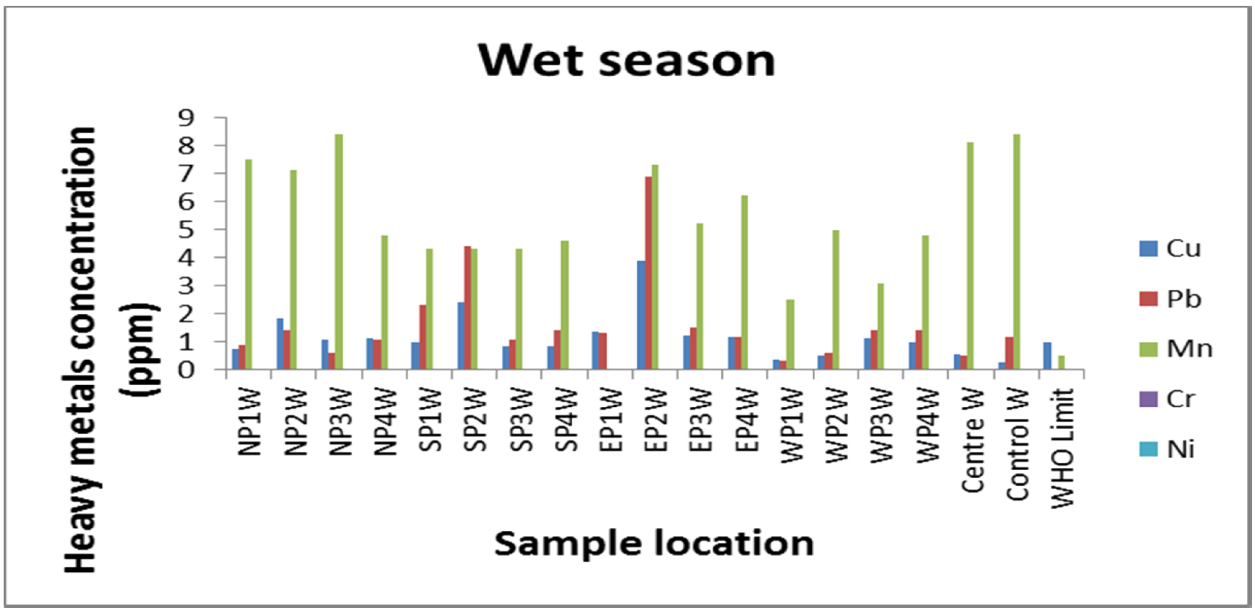


Fig 3.07 A plot of heavy metals concentration against sample locations of all metals during wet season.

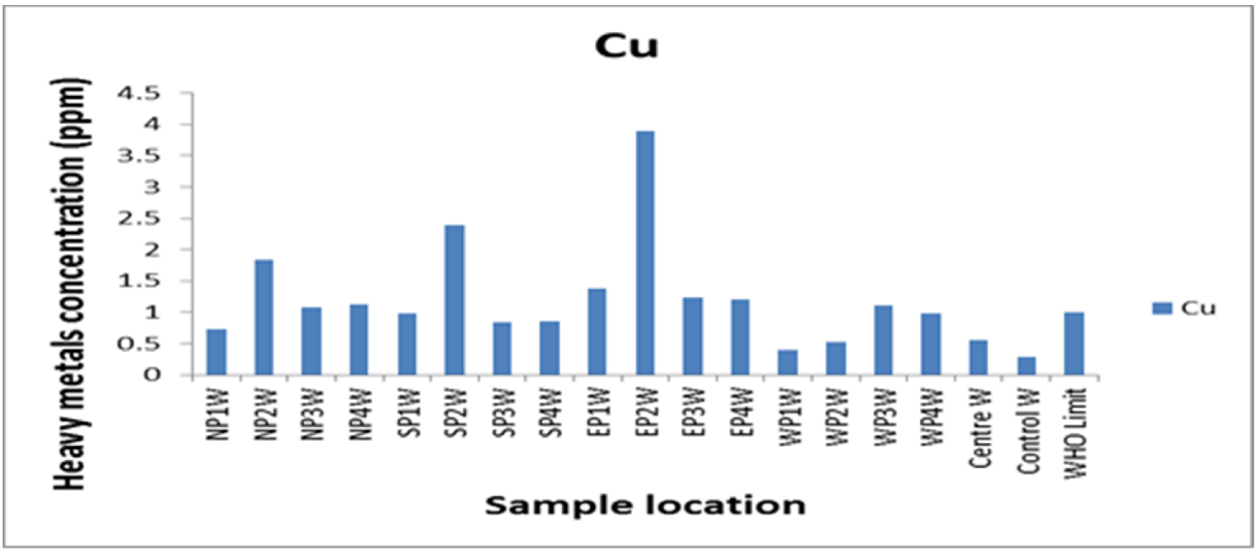


Fig 3.08 A plot of cupper concentration against sample location during wet season

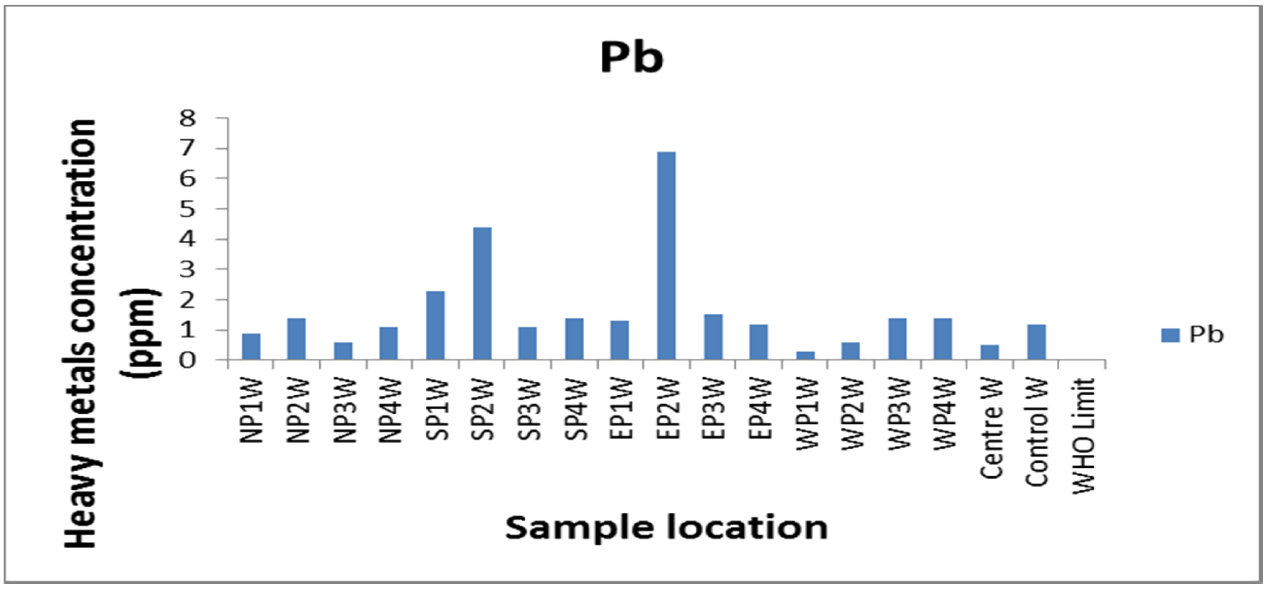


Fig 3.09 A plot of lead concentration against sample location during wet season

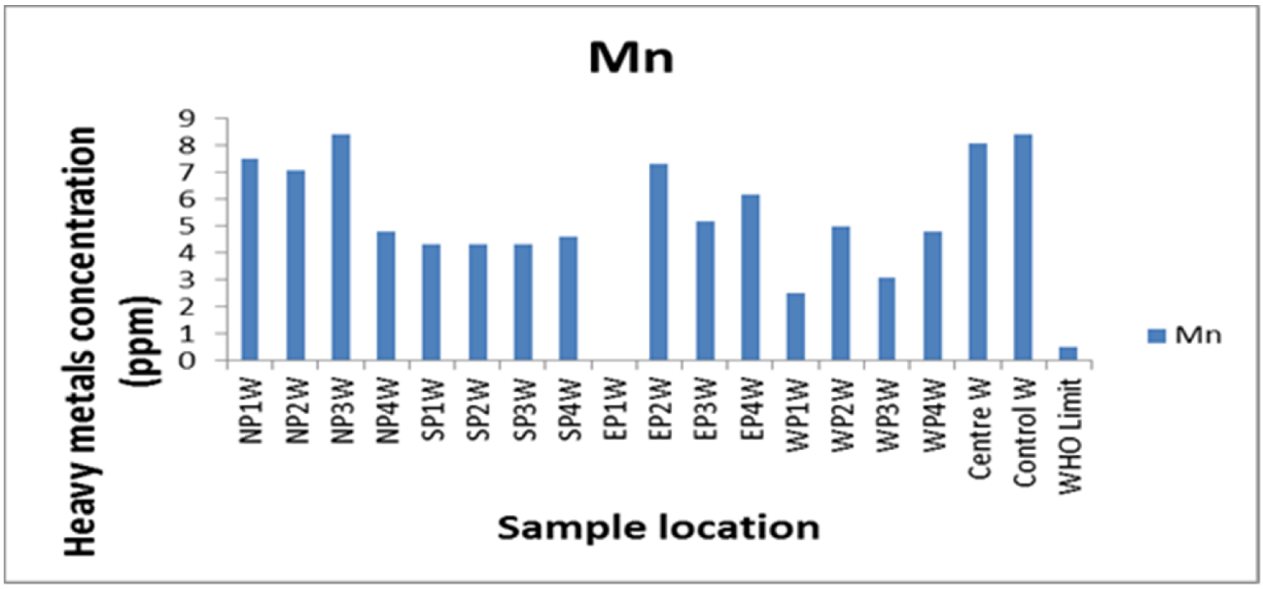


Fig 3.10 A plot of manganese concentration against sample location during wet season

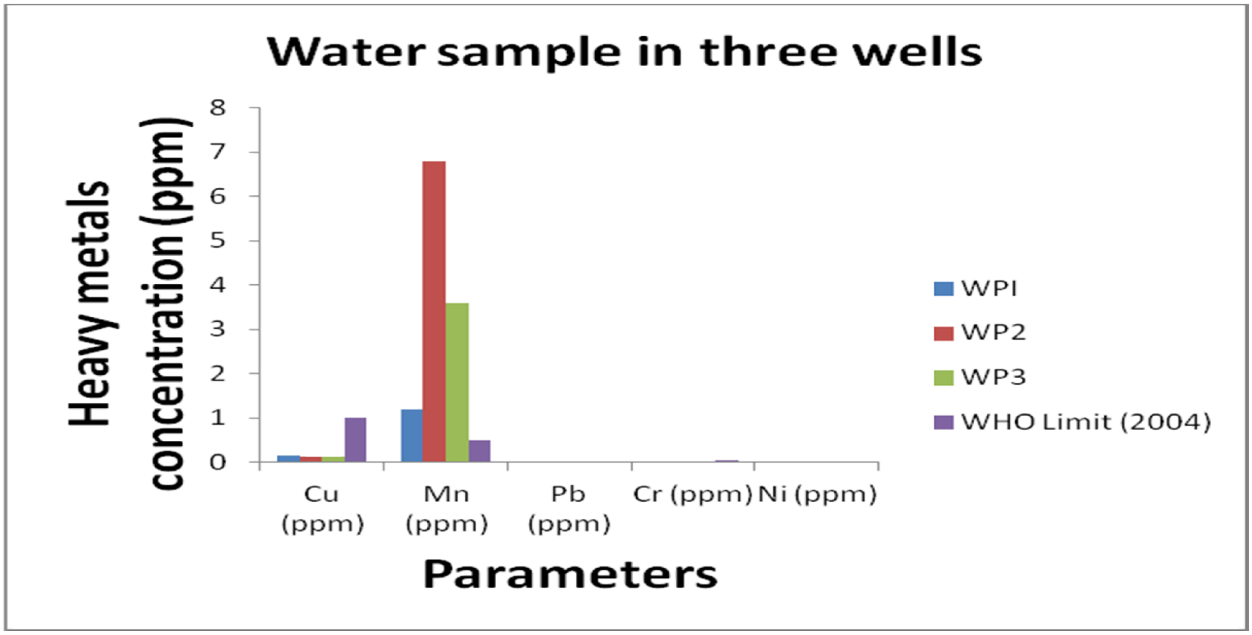


Fig 3.11 Plot of heavy metals against sample location three wells in Gosa dumpsite

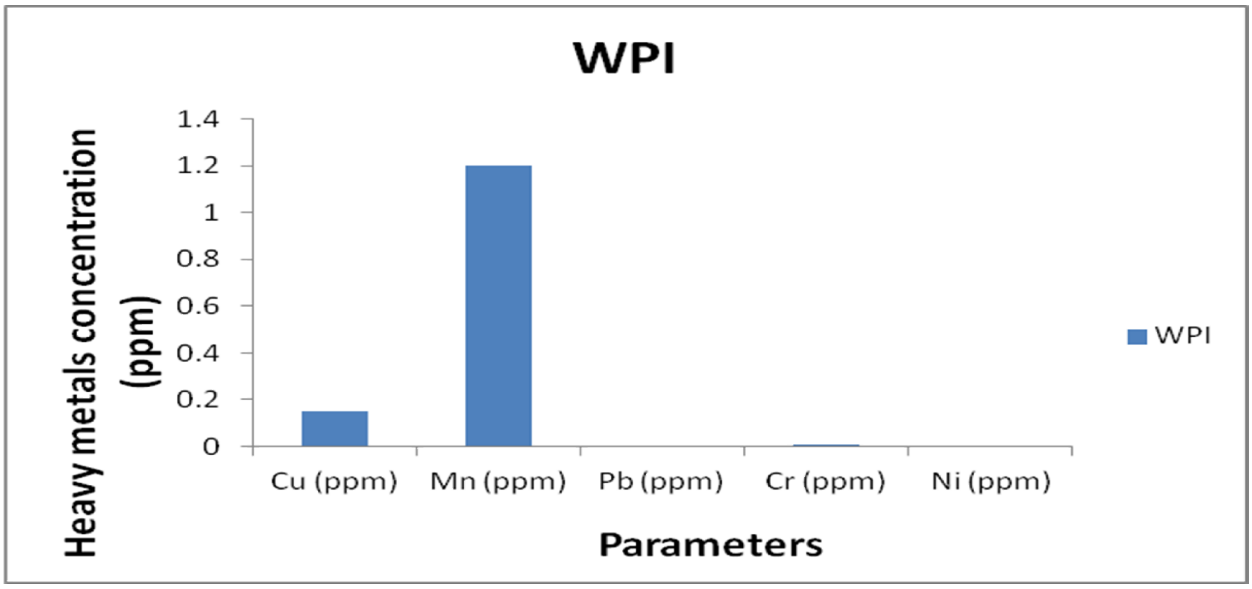


Fig 3.12 Plot of heavy metals concentration against well point one in Gosa dumpsite

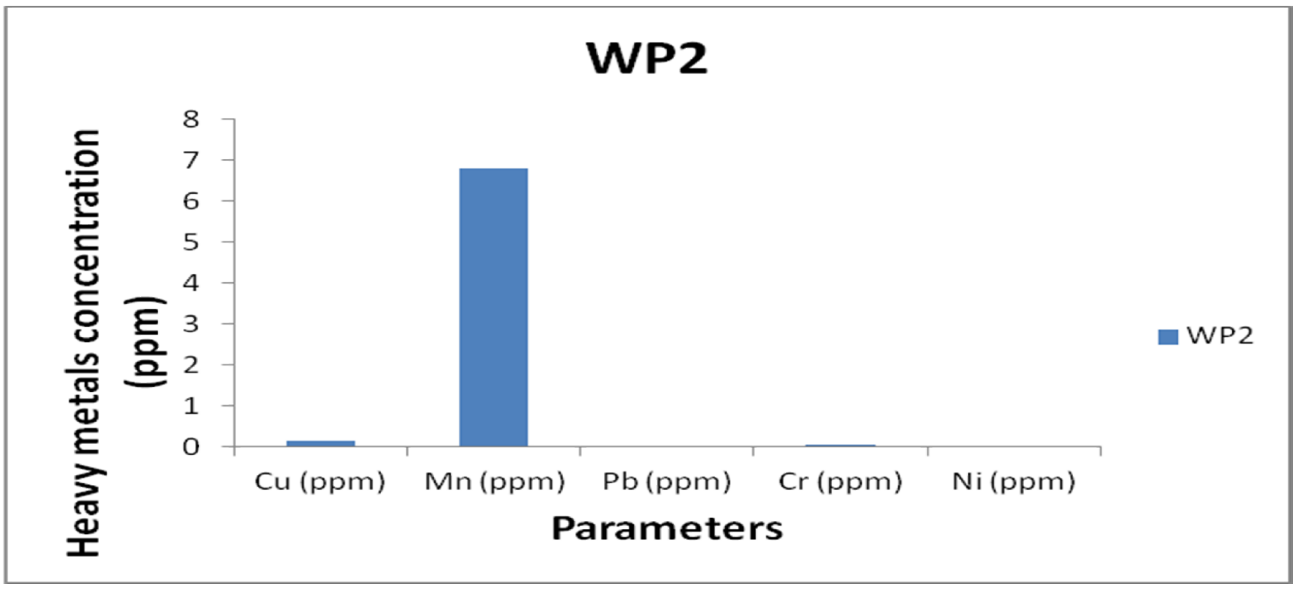


Fig 3.13 Plot of heavy metals concentration against well point two in Gosa dumpsite

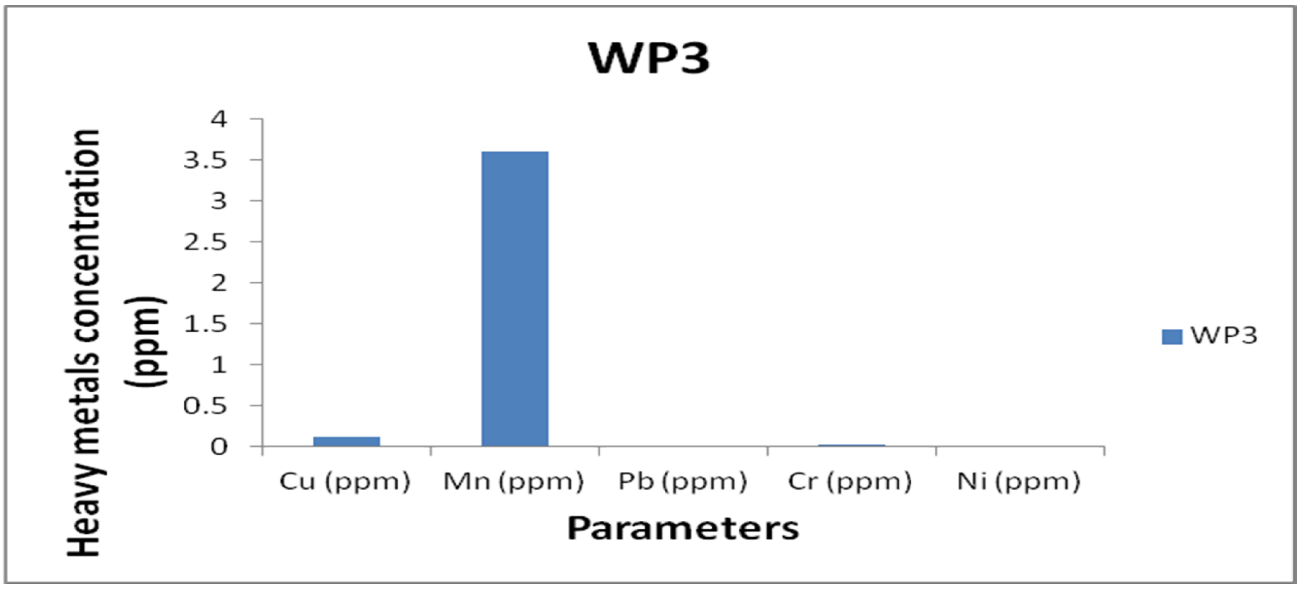


Fig 3.14 Plot of heavy metals concentration against well point three in Gosa dumpsite

4 CONCLUSION

The work on investigation of soil degradation resulting from migration in leachate in Gosa dumpsite, Abuja was successfully carried out. The concentration of heavy metals were obtained to be higher at some point within the dumpsite, but was recorded highest at the centre and control during wet season and highest in control sample during dry season. Out of the five heavy metals analyzed in Gosa dumpsite, only Pb and Mn concentration was found to have appreciable level and exceeds WHO standard. Cr and Ni was not detected in any case of the season, Cu concentration has two points in both season that exceeded WHO limit, while the rest points were below standard and fell within acceptable limit.

However, the results indicates that the dumpsite and Gosa community contains increased level of Mn and Pb ions, leaching of heavy metals but not to a level of contaminating underground water for people to drink and degrading the soil for farming activities. However, in years to come attention should be given to the site because if such activities continues at the dumpsite, there will be high level of leachate generation, heavy metals may increase above tolerance and may reach toxic levels through food chain which course for concern as these metals can accumulate to pollute the environment (soil and underground water).

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REFERENCES

[1] Adamu S., (2000), A brief history of Yauri emirate council, ABU press, Zaria, pp. 2- 8.
[2] Adefemi O.S, Awokunmi E.E (2009). The impact of municipal solid waste disposal in Ado Ekiti metropolis, Ekiti State., Nigeria Afr. J. Environ Sc. Tech, 3(8); 186 – 189.
[3] Adefolalu DO (2007). Nigerian eco-climatic atlas for North West zones, centre for climate change and fresh water resources. FUT Minna, Nigeria.
[4] Ademoroti, C. M. A., (1996), Environmental Chemistry and Toxicology, Foludex Press Ltd., Ibadan, Nigeria.
[5] Bouchez, T., Munoz, M.L., Vessigaud, S., Bordier,C., Aran, C., and Duquennoi, C., (2003), Clogging of MSW Landfill Leachate Collection Systems: Prediction Methods and in Situ Diagnosis, Proceedings Sardinia 2003, 9th International Waste Management and Landfill Symposium, S. Margherita di Pula, Cagliari, Italy, (CD-ROM).
[6] Bruinsma, J., (2003), World agriculture: towards 2015/2030: an FAO perspective: FAO: Earthscan: Rome; London.
[7] Eddy N.O, Ndibuke M. O, Ndibuke E.O., (2004), Heavy metals in sediment from Cross River at Oron., Afr. J. Environ. Pollut. Health, 3 (5): 21-26

[8] Federal Environmental Protection Agency (FEPA) (1995). Corporate profile, Metro prints Ltd, Port Harcourt.
[9] Freeze, R.A., Cherry, J.A. 1979. Groundwater. Prentice-Hall, 479 pp.
[10] Good, D. H. and Reureny R. (2006). The fate of Easter Island: the limit of resources management Institutions. Ecological economics, 58(3) : P473
[11] Hazra T., Goel S., (2008), Solid waste management in kolkota, Journal of waste management, In Press.
[12] Hawkes J. S., (1997). Heavy metals, J. Chem. Educ. 74(11): 1374.
[13] Lenntech water treatment and purification (2004). Water Treatment, Publish by Lenntech Rotterdamseweg, Netherland.
[14] Miroslav R. and Vladimir N. The Royal Society of chemistry, 1999. Milton Road, Cambridge, Uk.
[15] Rowe, R.K and VanGulck, J.F. (2004) Filtering and Drainage of Contaminated Water, 4th International Conference on GeoFilters, Stellenbosch, South Africa, October, pp1-63.
[16] Rowe, R.K., and McIsaac, R. (2005) Clogging of Tire Shreds and Gravel Permeated with Landfill Leachate. *Journal of Geotechnical and Geoenvironmental Engineering*, 131(6): 682-693.
[17] World Health Organisation (WHO) (Ipcs) (2011). Environmental Health Criteria 171; Diesel fuel and Exhaust Emission. WHO Geneva. 389 pp, 2004.
[18] Scherr, S. J. (1999). Social degradation: A threat to developing-country food security by 2020? International Food Policy Research Institute: Wastington DC.
[19] Abida, B., Ramaih, M., Harikrishma, I., and Veena, K., (2009), Analysis of heavy metals concentrations in soils and litchens from various localities of Hosur road, Bangalore, India. E-Journal of Chemistry, 6(1): 13-22
[20] Agunwamba, J. (1998). Solid waste management in Nigeria: problems and issues. Journal of Environmental Management, 25 (2), 849-856.
[21] Ali, M., Cotton, A. and Westlake, K. (1999). Down to earth: solid waste disposal for low-income countries. Journal of Environmental Management, 2 (12), 745-751.
[22] Allen, A. (2001). Containment landfills. Journal of Engineering Geology, 60 (4), 3-19.
[23] Bagchi, A. (2004). Design of landfills and integrated solid waste management, Journal of International Waste and Enviromental Management, 11 (31), 1121-1128.
[24] Barrett, A. and Lawlor, J., (1995), The economics of waste management in Ireland. Journal of Economic and Social Research, 12 (9), 121-126.
[25] Campbell, D. (1993). Environmental management of landfill sites, Journal of International Waste and Enviromental Management., 7(2), 170 - 173.
[26] Chifamba, P. (2007). Trace metal contamination of water at a solid waste disposal site at Kariba, Zimbabwe. African Journal of Aquatic Science, 32 (1), 71-78.
[27] Diwekar, U., (2005), Green process design, industrial ecology, and sustainability, Journal of Environmental Management, 44 (6), 215-235.
[28] Fergusson, J. (1990). The heavy elements: chemistry, environmental impacts and health effects. London, UK: Pergamon Press
[29] Christensen, T.H., Cossu R., Stegmann, R. (Eds.), Proceedings Sardinia 03, Ninth International Waste Management and Landfill Symposium, (pp. 77). London, UK: CISA Publisher.
[30] Madumelu, P., Okafor, J. and Akoma, O. (2001). The Effect of some Additives on the Physical and Organoleptic Quality Characrteristics of Fermented Cassava, Polymath Journal, 2 (1), 3-4.
[31] McIsaac, R., and Rowe, R. (2006) Effect of Filter-Separators on the Clogging of Leachate Collection Systems. Canadian Geotechnical Journal, 43(7): 674-693.
[32] Scherr, S. J., (1999), Social degradation on dumpsite., Journal of International Food Science International., 4 (2), 99-104.
[33] www.unep.org/cpi/briefs/2008May14.doc
[34] World Health Organisation (WHO) (Ipcs) (2011). Environmental Health Criteria 171; Diesel fuel and Exhaust Emission. WHO Geneva. 389 pp, 2004.
[35] Standard Organisation of Nigeria (2007).