ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

HEAVY METAL CONCENTRATION AND pH LEVELS IN SOILS OF THE MAIN DUMPSITE OF NAROK CENTRAL SUB-COUNTY.

Odhiambo O., Afullo A., Eunice G., Maghenda M.

Department of Environmental Studies, School of Tourism and Natural Resources, Maasai Mara University -Narok-Kenya.

Manuscript Info

Manuscript History:

Received: 15 June 2015
Final Accepted: 11 July 2015
Published Online: August 2015

Key words: Heavy metal concentration, pH, Environmental pollution

****Corresponding Author***

Odhiambo O

Abstract

Solid waste has been a major challenge in Narok town and its environs over the years causing pollution of water bodies such as rivers, blockage of drainage systems consequently leading to flooding that translates to loss of life and property. In this study soil samples were collected from the main dumpsite for heavy metal and pH analysis. They were analyzed for Lead (Pb), Cadmium (Cd), Chromium (Cr) and Zinc (Zn). This was done using Atomic Absorption Spectrophotometer (AAS-PG 990) and pH meter (HANNAH pH 211). These results indicate that these metals were beyond the levels at the reference sites for unpolluted soil 20m away from the dumpsite. The PH range was between 7.19±0.6 - 9.8±0.12 with a mean of 8.29±0.84 in the dump site during the dry season and 8.14±0.25 during the wet season. The mean pH during wet and dry season was not significantly different (P>0.05).The dumpsite was found to be about 50m from the Narok River while the recommended distance should be 500m. The results indicate negative effects of the dumpsite to the environment and therefore measures should be taken to ensure proper waste disposal and management. With the major dumpsite being near the river, this study recommends its relocation to prevent further water pollution, which may be a cause of human and livestock diseases.

INTRODUCTION

Waste disposal whether domestic, commercial or industrial is a growing problem in the world as a result of human civilization and no method of solid waste disposal so far is completely safe (Okeyode and Rufai,2011). Experience shows that all forms of waste disposal have negative effects on the environment, public health and local economies (Eddy *et al*., 2006). Waste dumps, leads to air pollution and sometimes results into temporary restriction on movements of people and consequently slowing of economic activities in urban areas (Elaigwu *et al*, .2007). It's doubtless to say that soil is the primary recipient of solid waste and that millions of tons of these wastes from various sources: Industrial, Domestic and Agricultural find their way into the soil (Nyles and Ray, 1999). Municipal solid wastes are known to increase nitrogen, ph, cation exchange capacity, percentage base saturation and organic matter of the receiving soil (Riziki, 2010). Municipal refuse dumps also form important feeding sites for pestiferous species including: birds, rats and stray animals thus contributing greatly to their sustenance and multiplication (Bellebaum, 2005).

Dumpsite is an old traditional method of solid waste disposal often established in disused quarries, mining or excavated pits away from residential areas (Abdus-Salam, 2009).Although metals are natural components of the environment especially soil, they are of great concern when they are added continuously; refuse dumping is one way in which elements are being added into the soil (Okeyode and Rufai, 2011). This continuous addition has adverse effects on the environment particularly leaching from the dumpsite when it contains potentially toxic heavy metals.

These metals are known to bioaccumulate in soil and have long persistence time through interaction with soil components and consequently enter food chain through plants and animals (Mohamed and Elsayed (2007);Rubio *et al*.,(2000). Heavy metals such as lead, cadmium, chromium, arsenics, nickel, cobalt and mercury are of concern because of their potential to harm soil organisms, plants, animals and human beings (Woodbury, 2005). In higher concentrations in the soil heavy metals have been reported to inhibit plant growth, nutrient uptake, physiological and metabolic processes resulting in chlorosis, damage of root tips and damage to enzymes (Baisberg-Pahlsson; Sanita di Toppi and Gabbrielli, 1999). In addition, Leachate from refuse dumpsite constitutes a source of heavy metal pollution to both soil and aquatic environment (Ebong *et al*., 2008). Like other environmental stressors heavy metals induce antioxidant enzyme activities increased in plants (Lannelli *et al*., 2002).
A study by Kimani (2010) in Kenya on the Dandora dumpsite in Nairobi showed high levels of heavy metals particularly lead (Pb), mercury (Hg), cadmium (Cd), copper (Cu) and chromium (Cr) in the soil samples obtained from the dump site. The current study set to determine the contribution of Narok municipal solid waste main dump site to heavy metals concentration in the soil in Narok municipal solid waste dumpsite. The main dumpsite is of concern due to the fact that it's the main dumpsite serving Narok town and its environs and again its proximity to Narok River which is the major source of water for residents of Narok County for domestic purposes.

Description of the Study Area
The study was carried out in Narok town main dumpsite in Narok County, as shown in figure 1 and 2 below. It's located at an elevation of 1864 M above the sea level. Its coordinates are 1^0 15'0''N and 35^0 45'0''E in DMS (Degree Minutes seconds). Narok main dumpsite was selected for study since it borders river Narok which is the main river that serves the county. The dumpsite serves Narok main estates such as Lenana, Total, London, Riverview and Majengo among others. The dumpsite is hardly 100M from the river and this poses a health hazard during rainy season as the runoffs finds its way into the river.

Figure1: Location Map of Narok

Methodology
Materials and Reagents
Soil sampling
Soil were sampled from the edge of the Narok main dumpsite using the zigzag method (Dan *et al*., 2006). A total of 10 samples were collected for analysis at a depth of 15cm according to Remon *et al.*, (2005). They were stored in tightly sealed plastic bags before they were transported to the laboratory where they were air dried on the bench for 24 hours. The dried soil samples were then crushed using a motar and pestle and stored in plastic bags ready for chemical analysis.

Soil Analysis of heavy metals in the soil

0.1g of soil samples was measured in a beaker and 5 ml of tri acid mixture (Conc. $HN0_3$, $HClO_4$ and H_2SO_4) in the ratio 3:1:1 was added. The mixture was then heated on a hot plate at 105^oC until white fumes were observed (Lindsay and Norvell, 1978). The digested soil was then filtered using Whatmann Ashless filter paper No. 42 into 100ml volumetric flask and topped up to the mark with distilled water and two drops of 1% HNO_3 added for preservation (To avoid precipitation of elements). The digested samples were transferred into plastic bottles and analyzed for heavy metals using atomic absorption spectrophotometer (AAS) - PG 990 Model. The AAS was zeroed using the blanks. For each metal the working standard solutions were aspirated, starting with the least concentrated to the most concentrated. in the AAS fitted with the respective metal lamps and respective absorbance were recorded. The sample solution was then aspirated in the AAS fitted with suitable hollow cathode lamps and the respective absorbance was recorded. A blank measurement of the solvent was also made. The concentrations of the different elements were determined by analysis of the corresponding standard calibration curves for Cr, Zn, Pb and Cd.

Table 1: Concentration of Heavy Metals at the Dumpsite in Mg/Kg

SAMPLE SITE	CHROMIUM	ZINC	LEAD	CADMIUM
S1	0.002±0.005	1.692±0.045	0.101±0.001	0.218±0.015
S2	0.027±0.001	4.654±0.032	0.394±0.014	0.409±0.012
S3	0.025±0.002	4.432±0.026	0.801±0.001	0.602±0.006
S4	0.015±0.001	4.422±0.011	1.209±0.011	0.805±0.022
S5	0.075±0.004	3.476±0.023	1.607±0.013	1.005±0.015
S6	0.013±0.001	2.370±0.027	2.003±0.003	0.520±0.030
S7	0.009±0.001	2.058±0.007	1.309±0.012	0.925±0.029
S8	0.005±0.001	2.341±0.016	0.761±0.054	0.814±0.075
S9	0.020±0.001	3.433±0.008	0.869±0.071	0.105±0.006
S10	0.003±0.000	0.728±0.573	1.188±0.061	0.222±0.017
Control	0.001±0.000	0.531±0.0.27	0.021±0.001	0.09 ± 0.002

Discussion

The current study shows that zinc was the highest in concentration at the dump site followed by lead, cadmium and lastly chromium as shown in figure 3 above. The high level of Zinc could be attributed to organic waste. Zinc concentration ranged from 0.728 ± 0.573 to 4.654 ± 0.032mg/kg, these values were higher than the control sampled 20 metres from the dumpsite which had a concentration of 0.531 ± 0.27mg/Kg as shown in table 1 above. The results of this study were slightly higher as compared to a study by Lawan *et al*., 2012 on vertical migration of heavy metals in dumpsite soil at Maiduguri metropolis dumpsite, Nigeria that reported mean zinc concentration at 1.80 ± 0.01mg/kg but lower than the findings according to Leah and Jonny, 2014 at a dumpsite in Manila, Philippines that reported Zinc concentration of 53.283 mg/Kg.

The concentration of chromium in soil at the Narok main dumpsite ranged from 0.002 ± 0.001 to 0.075 ± 0.004 mg/kg as shown in table 1 above. These levels were relatively high as compared to the control which had a concentration of 0.001 ± 0.000 mg/kg. This is a clear indication of build up or accumulation of heavy metals at the dumpsite. However the chromium levels in this study were lower compared to a study by Oladuni *et al*., 2013 around an electronic waste dumpsite in Nigeria which revealed high levels of chromium in the soil between (0-15cm) ranging from 22.34 ± 0.01 to 46.58 ±0.02mg/kg which was attributed to electronic waste. A similar study by Adekelan and Alainode, 2011 on contribution of municipal refuse dumps to heavy metal concentration in soil profile in Ibadan Nigeria also showed high levels of chromium in surface soil ranging from 15.30 – 62.75 mg/kg. This high concentration of chromium was linked to deposited waste which contained high concentration of chromium.

Cadmium concentration ranged from 0.105 ± 0.06 to 1.005 ± 0.015 mg/kg as shown in table 1 above. Cadmium concentrations for this study were above the levels from the control site which was 0.09 ± 0.002 mg/kg. This difference is attributed to the solid waste at the dumpsite. A study by Amadi and Nwankwoalae, 2013 reported concentration of Cd between 0.18- 2.60 mg/kg with a mean concentration of 1.40mg/kg these results were almost similar to the findings in this study. However, these values were lower compared to a study by Anietie and Labunmi (2015) that reported Cd Concentration ranging from 28.56 ± 17.95mg/kg to 40.17 ± 18.21 mg/kg.

Lead concentrations at the dumpsite ranged between 0.101 ± 0.001mg/kg and 2.002 ± 0.003mg/kg as shown in the table 1, these results were high compared to the control at 0.021 ± 0.005mg/kg 20m away from the dumpsite. This is also a clear indication of buildup of heavy metal at the dumpsite. The finding of this study agree with that of Amadi and Nwankwoala,2013 who reported a range of 0.24-2.15mg/kg with a mean concentration of 1.08mg/kg from Enyimba dumpsite in Aba, Nigeria. However these findings were much lower compared to a study by Riziki, 2010 along Mtoni dumpsite bordering the Indian Ocean in Dar Es Salaam, Tanzania with a mean concentration of 223.80 ± 146.73mg/kg. Other measurements at 50, 100, 150, 200m from the edge of the dumpsite were 25.19 ± 13.99mg/kg, 15.17 ± 1.20 mg/kg, 13.77 ± 2.96 mg/kg and 7.63 ± 0.83 mg/kg respectively.

pH of The Soil at The Dump Site

Table 2: Means and Standard Deviations of PH and Temperatures during Dry and Wet Seasons

Sampling point	**Mean ph**		**Mean temp.**	
	Dry	**Wet**	**Dry**	**Wet**
S1	9.80±0.12	8.80±0.13	22.2±0.00	24.0±0.00
S2	8.20±0.08	8.10±0.01	22.3±0.01	24.0±0.01
S3	8.60±0.08	7.92±0.03	22.2±0.06	23.1±0.00
S4	8.05±0.30	8.12±0.01	22.2±0.03	24.1±0.00
S5	8.41±0.01	8.50±0.06	22.1±0.03	24.4±0.01
S6	9.15±0.12	8.21±0.03	21.9±0.02	23.1±0.00
S7	7.19±0.06	7.91±0.01	22.0±0.17	23.5±0.00
S8	8.33±0.01	8.43±0.06	22.3±0.10	24.2±0.00
S9	8.43±0.13	8.00±0.15	22.0±0.00	23.3±0.04
S10	8.22±0.11	8.21±0.01	21.8±0.00	24.0±0.00

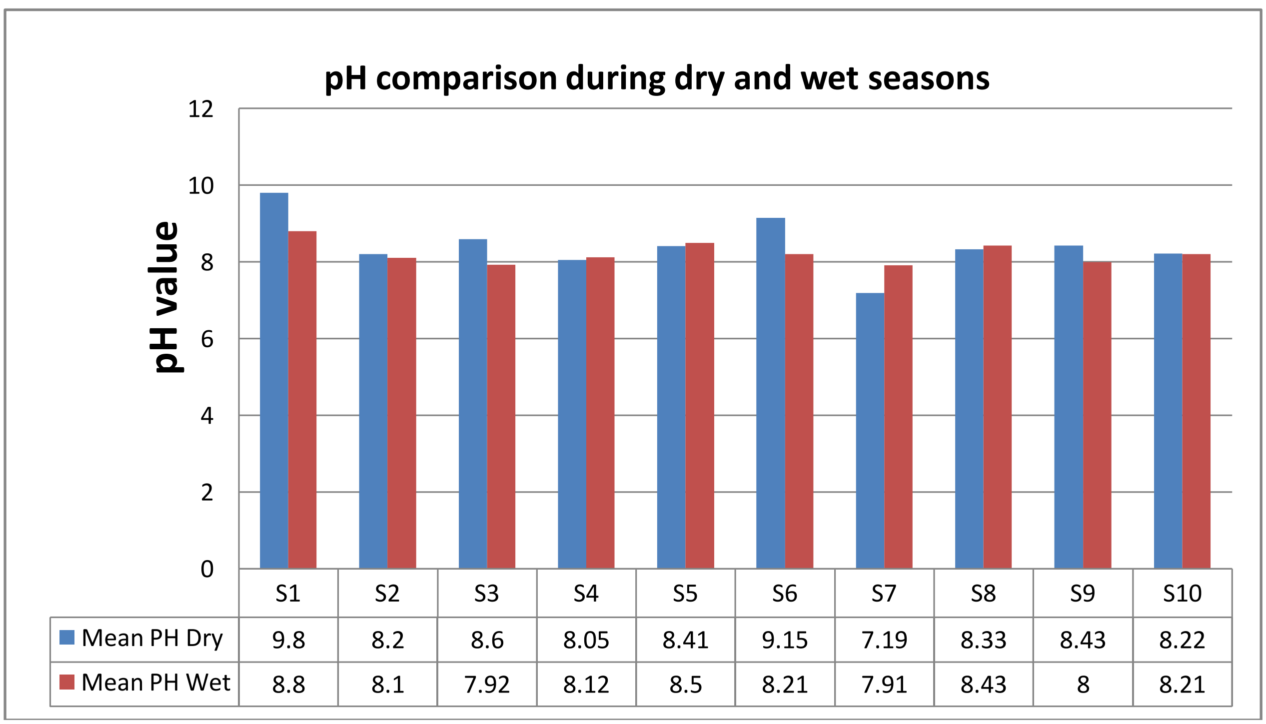

Figure 2: PH comparison during dry and wet season

The pH values of the study sites were mostly alkaline. The PH range was between 7.19±0.6 - 9.8±0.12 with a mean of 8.29±0.84 in the dump site during the dry season and 8.14±0.25 during the wet season. This pH was slightly lower than the findings of a similar study in Cameroon 8.55-9.40, Adjia *et al*., (2008). This might be as a result of the sorption of metals in the soil according to Lee (2003). These PH values were however higher than those obtained from a similar study done on soils of municipal waste dumpsites at Allahabad, India, which reported acidic PH. This acidic PH could be attributed to the presence of metal scrap, waste materials in the dumpsites and other human activities taking place around the dumpsites according to (Srivastava, 2012).

The highest pH of 9.8±0.12 was obtained from sample S1 and the lowest pH of 7.19±0.6 was obtained from sample S7. However for most of the sampled sites, the PH tended to remain the fairly the same. A neutral pH of 7.19±0.6 - 7.92±0.03 was obtained for Sample site 3 and 7. The neutral pH at this dumpsite could be as a result of anthropogenic activities, which could introduce some liming materials overtime to the soil. The results indicate high levels of pollution and the immobilization of the heavy metals may be attributed to alkaline pH as obtained in this study. However, there was no significant difference in pH between wet and dry seasons P> 0.05.

Conclusion and Recommendation

This current study shows that Zinc was the highest in concentration at the dump site followed by lead, cadmium and lastly chromium. There is a growing concern on the gradual build up of toxic heavy metals at the dumpsite and there is likelihood of contamination of the Narok river posing a health hazard to the local residents. These toxic heavy metals will become available to the plants and ground water over geological time whereby they will be biomagnified in the food chain hence heath risk. In addition the alkaline pH could lead to immobilization of the heavy metals hence the buildup.

Its recommended that the county government should consider relocating the dumpsite away from the Narok river which is the main source of drinking water since this study realized that the dumpsite is 50M away from the river instead of the recommended 500m.

References

Abdus-Salam N. (2009). Assessment of Heavy Metal Pollution in Dumpsites in Ilorin Metropolis. Ethiopian Journal of Environmental Studies and Management. Vol 2. No 2.2009.

Adjia R., W.M.L. Fezeu J.B. Tchatchueng' S. Sorho,G. Echevarria and M.B. Ngassoum (2008). Long Term Effects of Municipal Solid Waste Amendment On Soil Heavy Metal Content of Sites Used For Periurban Agriculture In Ngaoundere, Cameroon. African Journal Of Environmental Science And Technology, 2(12):412-421.

Amadi A.N. & Nkwankwoala H.O. (2013). Evaluation of Heavy Metal in Soil from Enyimba Dumpsite in Aba, South Eastern Nigeria. Energy and Environmental Research; Vol.3, No.1; 2013.

Anietie O.V. & Labunmi L. (2015). Surface Soil Pollution by Heavy Metals: International Journal of Scientific & Technology Research Vol.4.

B.A. Adelekan and A.O. Alawode (2011). Contribution of Municipal Refuse Dumps to Heavy Metal Concentrations in Soil Profile and Ground Water in Ibadan Nigeria. J. Appl.Biosci.2011.

Bellebaum J. (2005). Between The Herring Gull Larus Argentatusn and the bulldozer: Blach-headed Gull Larus Ridibundus Feeding Sites on a Refuse Dump. Ornis Fennica.82:166-171.

Dan P., Thomas Y. and Jeff B. (2006). Soil Sampling Design. CRC press Tailor and Francis group LLC.

Ebong G.A., Akpan M.M. and Mkpenie V.N. (2008). Heavy Metal Contents of Municipal and Rural Dumpsite Soils and Rate of Accumulation by *Carica papaya* and *Talinum tringulare* in Uyo, Nigeria.E.J. Chem.5(2):281-290.

Eddy N.O., Odoemelem S.A. & Mbaba A. (2006). Elemental Composition of Soil in Some Dumpsites. Electron J. Environ Agric Food Chem. (EJEAF Che) pp 1349-1365.

Elaigwu S.E.,Ajibola V.O. & Folaranmi F.M.(2007). Studies on The Impact of Municipal Waste Dump on Surrounding Soil and Air Quality of two Cities in Nothern Nigeria. Jounal of Applied sciences.7(3):421-425.

Lannelli M.A.,Pietrini F.,Flore L., Petrilli L. and Massacci A.(2002). Antioxidant Response to Cadmium in *Phragmitesaustralis* plants. Plant. Physiol. Biochem.40(11):977-982.

Lawan I.B.,Stephen S.H.,Goni A.D. and Muhammad T.(2012). Study of Vertical Migration of Heavy Metals in Dumpsites Soil. ARPN Journal of Science and Technology. Vol 2.No.2, March 2012.

Leah A.S. & Jonny A.C. (2014). Heavy Metal Concentration of Dumpsite Soil and Accumulation in *Zea Mays* (Corn) Growing In A Closed Dumpsite in Manila, Philippines. International Journal of Environmental Science and Development, vol.5, No.1, February 2014.

Lee M.K. and J.A. Saunders, (2003). Effects of Ph on Metal Precipitation and Sorption: Field Bioremediation and Geochemical Modeling Approaches.Z.J. Vadose 2:177-185.

Lindsay W.L and Norvell W.A., (1978). Development of a DTPA soil test for Zinc, Iron, Manganese and Copper. Soil Sci.Soc.Amer. J-42: 421-428.

Mohamed R. and Elsayed A.S. (2007). Dispersion and Deposition of Heavy Metals Around Two Municipal Solid Waste (MSW) Dumpsites ,Alexandria, Egypt American-Eurasian J. Agric. & Environ. Sci., 2 (3):204-2012, ISSN 1818-6769.

Oladunni B.O., Tejumade A. and Otolorin A.O. (2013). Heavy Metal Contamination of Water, Soil, and Plants around an Electronic Dumpsite, Nigeria.Pol.J.Environ. Stud.Vol.22, No 5, 1431-1439.

Okeyode I.C. & Rufai A.A. (2011). Determination of Elemental Composition of Soil Samples From Selected Dumpsite Abeokuta, Ogun State, Nigeria. International Journal of Basic & Applied Sciences IJBAS-IJENS Vol.11: No: 06.

Remon E., Bouchardon J. L., Cornier B., Guy B., Leclerc J. C. & Faure O., (2005). Soil characteristics, heavy metal availability and vegetation recovery at a former metallurgical landfill: Implications in risk assessment and site restoration. *Environmental Pollution*, *137*(2), 316-323.

Riziki S.S. (2010). Heavy Metal Concentration in Soils and Leachetes of Mtoni Dumpsite Bordering The Indian Ocean In Dar es Salaam, Tanzania. Scientific Research and Essays Vol.5 (16), pp.2143-2147.

Sanita di Toppi L. and Gabbrielli R. (1999). Response to Cadmium in Higher Plants, Environ. Exp. Bot. 41(2):105-130.

Srivastava K.P. and Singh V. K. (2012). Impact of Air-Pollution on pH of soil of Saran, Bihar, India, *Res. J. Recent Sci.*, **1(4),** 9-13 **(2012)**

Woodbury P.B. (2005). Municipal Solid Waste Composting: Potential Effects of Heavy Metals in Municipal Solid Waste Compost on Plant and the Environment. Cornell University, New York, USA.