INTERNATIONAL JOURNAL OF HIGHER EDUCATION AND RESEARCH
IJHER, Vol., 6(1), 2016, 16-.24.
www.ijher.com

IJHER
(ISSN 2277 260X)

CODEN: IJHER ORIGINAL ARTICLE

ENRICHMENT OF HEAVY METAL AND SOIL QUALITY OF MSW DUMPING SITE OF GUWAHATI CITY, ASSAM, INDIA

Reetashree Bordoloi and Sarbeswar Kalita
Department of Environmental Science
Gauhati University,Gopinath Bordoloi Nagar,
Guwahati -781014 ,Assam,India
E-mail: ritashree.100@gmail.com; Skalita53@gmail.com

Abstract : Soil samples from waste dumpsite of Guwahati city were analyzed for their Lead content and to determine the concentration and enrichment of the metal in the area. EF was found to be 11.9 which showed significant enrichment, the geo-accumulation indices indicated the area to be strongly polluted and pollution load index indicated strongly polluted. The soil pH, EC, OM, OC was found to be decreased with increase in soil depth. The analytical determination of major and minor oxides showed variations in their percentages. A significant correlation was found to occur between the physico-chemical parameters and concentration of Lead.

Key words : EF ,Geo accumulation index, pH ,EC, OM,OC

Introduction: Soil as described is a natural body of mineral and organic constituents, differentiated into horizons of variable depth differing from the material below in morphology, physical make up, chemical properties ,composition and biological characteristics(Joffe,1949). The quality of soil includes a inherent component determined by physic-chemical properties of soil. Evaluating and measuring the quality of soil resource was prompted by this increasing awareness that soil serves multiple functions in maintaining worldwide environmental quality (Dora & Parkin,1994).The soil waste dumped on regular basis can cause severe soil contamination eventually leading to detrimental changes in soil properties. High amount of heavy metals in solid waste can result in metal accumulation in surface soil (Gupta *et al.,1986*).Heavy metal viz, Pb in soil represent a major environmental and human health concern due to toxicity ,low bio degradability and cumulative tendency . The MSW is an inevitable by product and needs to be mechanically segregated. The dump site of Guwahati city is unsightly ,unsanitary and generally smelly .High risk is to the wetland adjacent and the groups of peoples residing thereby.

The paper involves the soil quality analysis of the dumping site. An attempt has been also made to investigate the heavy metal (Pb) concentration and status of the soil on the basis of EF, I_{geo} values and Pollution load index.

Methodologies:

Description of sampling site: Boragaon MSW dumping site is the only dumping site for the greater Guwahati city .A large amount of wastes are being dumped on regular basis. Located in

the South West corner of Guwahati city the site has not gained the status of safe waste dumping. Improper management seemed to be basically carried out of which probability of degradation of soil and metal accumulation is very high therein. With this motive in mind sampling sites were selected all around the dumping site.

Sampling and analysis: Sampling was carried out for the winter period in the month of February .Soils were sampled along different directions representing 0-15 cm & 15-30 cm respectively from each location. Soil samples were collected using auger and measuring tape kept in jip bags labeled properly and partially air dried at a temperature of about 25-35˚C. Digestion ,Standard stock solution for all parameters were prepared in the laboratory following the procedures as recommended by S.K Maiti (2002)

Instrumentation: Elemental composition in soil samples were determined using an X-ray fluorescence spectrophotometer, type Axios pananalytical .Its high level performance enables a very sensitive and accurate determination of trace and major oxides.It is a incessant instrument with a single geniometer based measuring channel covering the complete elemental array.

Enrichment Factor: A common approach to determine how much the soil has been affected by heavy metal incursion is to calculate the Enrichment Factor(EF) for metal concentration above and uncontaminated background level(Huu *et al.*,2010) .The EF for mean metal concentration in soil samples were calculated by-

$$EF = \frac{\left(\frac{X}{Fe}\right)sample}{\left(\frac{X}{Fe}\right)crust}$$

Where X is the metal studied and X/Fe is the ratio of the concentration of element X to Iron. Iron was chosen as the element of normalization because natural sources(98%) vastly dominate its input(Tippic,1984).The crustal abundance data of Bowmen (1979) were used for all EF value contamination categories based on enrichment factors are as follows-

EF<2 is deficiency to minimum enrichment
EF=2-5 is moderately enrichment
EF=5-20 is significant enrichment
EF=20-40 is very high enrichment
EF>40 is extremely high enrichment

Geo-accumulation Index(I_{geo}): I_{geo} was developed by Muller(1979).Muller's geo-accumulation index has been used in this study.

I_{geo} can be calculated using ,

$$I_{geo} = \frac{log\, 2Cn}{1.5\ Bn}$$

Where, Cn is the concentration of the examined metal in the soil and Bn is the geochemical background value. The factor 1.5 is introduced to minimize the effect of possible variations in the background or control values which may be a trait to lithogenic variations in the soil. According to Huu *et al.*,(2010)seven contamination classes are used to define the degree of metal pollutants in soils based on the increasing value of the index of geo-accumulation as follows –

$I_{geo}<0$ means unpolluted
$0\leq I_{geo}<1$ means unpolluted to moderately polluted
$1\leq I_{geo}<2$ means moderately polluted
$2\leq I_{geo}<3$ means moderately to strongly polluted
$3\leq I_{geo}<4$ means strongly polluted
$4\leq I_{geo}<5$means strongly to very strongly polluted
$I_{geo}>5$ means very strongly polluted

Contamination/Pollution Index: The contamination /Pollution index was defined by Lacatusu 2000.

C/P index = $\frac{Concentration \ \ of \ metal \ in \ soil}{Target \ \ value}$

The target value is the reference value of metals. C/P index value less than 1 define contamination ranges while greater than 1 define pollution(Lacatusu ,2000) as thus,

<0.1 –very slight contamination
0.10-0.25 –slight contamination
0.26-0.50 –moderate contamination
0.51-0.75 - severe contamination
0.76-1.00- very severe contamination
1.1-2.0- slight pollution
2.1-4.0-moderate pollution
4.1-8.0-severe pollution
8.1-16.0- very severe pollution
>16 –excessive pollution

Results and Discussions

A great variability in soil properties with depth was seen. The pH value depends on the experimental temperature and sample to water ratio .With increase in depth the pH was found to be in the range of 3.83-7.06 which is tending towards neutral or alkaline. The acidic nature of soil is mainly due to leaching of appreciable amounts of exchangeable bases and decomposition of organic and inorganic acid. The electrical conductivity value of soil depends on the dilution of the soil suspension. Conductivity value ranged from 247.50 -1970µS/cm. Conductivity value of 500µS/cm is perfectly safe and doesn't have any negative impact(Rao & Shantaram,1993). Organic Carbon and Organic Matter greatly affects the biology of the soil. Humus or organic matter present in the soil are complex in nature. Organic carbon content ranged from 0.06% - 5.34% while organic matter ranged from 0.10% - 9.20%. The organic waste deposited on the soil led to the enrichment of soil organic matter (Srivastava,2001).The high amount of organic content at the dumpsites may be mainly due to the presence of many organic wastes residues which add more organic content after they decay. Sodium and Potassium is of great importance for soil. Na ranged from 0.23mg/g -5.36mg/g and the values of K ranged from 13.98 mg/g - 96.78 mg/g .Magnesium metal is normally found along with calcium in all soils .In the present study the values of Mg were found to be less than those of calcium which corroborates with the findings of *Deka*,2007. Also the Ca and Mg values decreased with increase in depth corroborating the findings of *Eneje et al.*,2012.Ca and Mg on the higher side ranged 416.8 and 338 ppm respectively. The presence of Mg in the soil may be due to the disposal of construction waste along with MSW(Al Yaquot and Hameta,2003). Nitrogen in soil is contributed by inorganic and organic nitrogen and are most common constituents of organic wastes .Phosphorous is highly reactive and many of its compounds are not readily soluble. In the present study the value of Nitrogen ranged from 0.00%- 0.46% and the value of Phosphorous ranged from 0.00% -0.46%. Table 1 shows the physico-chemical parameters and indicates a significant variation with increase in depth. Leaching of appreciable amounts of exchangeable bases, decomposition of organic and inorganic acid, presence of ionic substances, soluble salts lead to the variations. Concentrations of Pb was found to be very higher than the background value . The total metal concentration of the selected heavy metal have been shown in the table 2. Observations, clearly indicate that the level of heavy metal contamination is higher at dumpsites

which may pose some serious concerns to their surrounding environment and organisms.(Tripathi and Misra ,2012). Depth wise variation of heavy metal concentration in the site are expected from several different sources ,including lead based exterior paint and automobile tail pipe emissions .Industrial emissions are also a source of soil contamination in some areas. The solubility of lead and absorption by soil and complexion by humus can further limit the lead concentration in surface waters and ground water. Enrichment factor, Geo –accumulation index and pollution load index for mean metal concentration of Lead in the sample of the study area were calculated and was found that Enrichment factor is moderately significant, Geo – accumulation index showed strongly to very strongly polluted and pollution load index showed the site to be strongly polluted which may be mainly due to the leaching of the elements from the soil into water bearing formations.

Statistically significant correlation was recorded among different quantitative variables shown in Table 3 .Pb showed negative correlation with soil organic content, Significant correlation was seen between Organic matter and EC Organic matter and CEC, positive correlation of Pb and EC was also found.

Summary and Conclusion: The present study on the soil quality revealed a clear picture regarding the deterioration of soil quality in the MSW dumping site of greater Guwahati city. Soil pH was found to be acidic which is one of the reasons for solubility of metals in soil environment. Variations are seen in the percentages and concentration of Organic matter, Organic Carbon, Ca, Mg ,K ,P, N with increase in depth.The percentage of the major and minor elements were all found to be in low concentration and high concentration when compared to the upper contienental crust average (Taylor & MC Lennan).The I_{geo} values, EF values, Pollution index values calculated for lead revealed that the intrinsic soil quality is not encouraging and Lead have relatively high availability.

Table 1: Soil quality parameters in MSW dumping site of Guwahati city.

Parameters	pH	EC (µS)	K (mg/g)	OC (%)	OM (%)	Ca (ppm)	Mg (ppm)	Na (mg/g)	P (mg/g)	N (%)
S1(0-15cm)	7.06	1.97	96.7	0.96	1.65	416.8	102.1	5.36	36.01	0.082
S1(15-30cm)	6.47	0.29	13.98	3.9	0.72	140.28	29.18	1.91	34.9	0.336
S2(0-15cm)	4.71	0.89	36.08	0.36	0.62	216.4	64.69	1.78	1.08	0.031
S2(15-30cm)	4.52	0.28	21.92	0.06	0.10	208.41	48.64	0.82	0.82	0.0005
S3(0-15cm)	5.75	0.55	79.75	5.04	8.68	192.3	304	1.5	4.99	0.434
S3(15-30cm)	5.52	0.73	69.2	4.68	8.06	104.4	299	0.23	2.43	0.403
S4(0-15cm)	3.83	1	21.87	4.5	7.7	296	143.4	1.44	5.04	0.385
S4(15-30cm)	4.37	0.34	58.98	3.84	6.62	164.3	192.1	2.37	2.08	0.331
S5(0-15cm)	5.06	0.31	26.09	0.6	1.03	292.5	277.2	0.59	3.34	0.051
S5(15-30cm)	5.01	0.25	15.65	0.48	0.82	264.4	50.09	0.58	3.17	0.041
S6(0-15cm)	5.77	0.65	85.57	5.34	9.20	228.46	87.55	0.65	4.3	0.46
S6(15-30cm)	5.71	0.24	83.51	4.32	7.44	164.3	338	0.67	1.21	0.372

Table 2: Analytical determination of Trace element (Pb) by XRF

Sample code	**Conc. of Pb in Soil**
S(0-15 cm)	351
S(15-30 cm)	481
World average shale (Turekian & Wedepohl,1961)	20

Calculated value of various factors

Enrichment Factor	**Geo –accumulation index**	**Pollution load index**
11.9 Significant enrichment	4.17 4 $\leq I_{geo} <$ 5 means strongly to very strongly polluted	20.8 > 16 means strongly polluted

Table 3: Major & Minor element oxides

Soil Depth	Element Oxides									
	SiO_2	Al_2O_3	Fe_2O_3(T)	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5
S(0-15cm)	61.89	16.51	8.62	0.087	1.19	0.72	2.32	3.55	1.79	0.46
S(15-30cm)	62.08	16.76	7.93	0.094	1.09	0.53	2.30	3.29	1.74	0.32
Upper continental crust average (Taylor & Mc Lennan)	65.89	15.17	4.49	0.07	2.20	4.19	3.89	3.39	0.50	0.20

Table 4: Correlation matrix of the soil parameters in the dumping site

	pH	EC	Mg	Ca	Organic Carbon	Organic Matter	Ex-chan-geable Na	Total Nitrogen	Avail-able P	Ex-chan-geable K	Pb
pH	1.00										
EC	0.32	1.00									
Mg	-0.04	-0.16	1.00								
Ca	0.20	0.77**	-0.16	1.00							
Organic Carbon	0.06	-0.10	0.44	-0.43	1.00						
Organic Matter	0.06	-0.10	0.44	-0.43	1.00**	1.00					
Exchangeable Na	0.42	.78**	-0.27	0.55	-0.20	-0.20	1.00				
Total Nitrogen	0.06	-0.10	0.44	-0.43	1.00**	1.00**	-0.20	1.00			
Available P	0.06	-0.10	0.44	-0.43	1.00**	1.00**	-0.20	1.00**	1.00		
Exchangeable K	0.47	0.44	0.47	0.14	0.44	0.44	0.34	0.44	0.44	1.00	
Pb	0.00	0.56	0.02	0.57	-0.02	-0.02	0.30	-0.02	-0.02	0.23	1.00

Acknowledgement

Author is thankful to the Head, Department of Environmental Science, Gauhati University for providing facilities during the MSc. Dissertation work. She is also thankful to Bidyut Bikash Sharma and classmates for their help and cooperation during the course of study.

Open uncontrolled pathetic condition of the dumpsite

REFERENCES

Alhassan ,M. (2012). Effect of Municipal solid waste on Geotechnical properties of soils.*International Journal of Environmental Science ,Management and Engineering Research* Vol.1(5),pp.204-210.

Adaikpoh & Edwin O. (2013). Distribution and Enrichment of Heavy metals in Soils from waste dump sites within Imoru and Environs, South West Nigeria, *Journal of Environment and Earth Science*, Vol 3 No.14.

Aderemi (2011). Assessment of ground water contamination by leachate near a Municipal solid waste landfill, *African Journal of Environmental Science and Technology* Vol5(11), pp.933-940.

Baishya, P. & Mahanta, D.K (2013). Improvised segregation of recyclable materials in Guwahati City, India: A case study, *The Clarion* Vol-2, No.-2, PP 46-52.

Deka ,G.(2007),Impact of textile mill on soil and water quality .A case study at Rangia ,Assam (India) ,Ph.D Thesis.

Debnath, P., Sahu ,S.S.,Das,A.C., Halder ,M.,Kulluru,P. & Mukherjee,D.(2004)

Potentiality of substrates in composting.

Eneje, R. C. & Lemoha Kelechi, T.(2012). Heavy metal content and physicochemical properties of Municipal Solid waste dump

soils in Owerri Imo State, *International Journal of Modern Engineering Research (IJMER)* Vol.2, pp. 3795-3799.

Gillham, E.W.F. & Simpson, D.T. (1973). U.K. Central Electricity Generating Board, Report, SSD/MID/R2/73

Greenland, D.J. & Hayes, M.H.B. (1981). The Chemistry of soil processes. John Wiley and Sons Ltd., pp. 593 – 699.

Goswami, D. & Choudhury ,B.N (2013). Chemical characteristics of Leachate contaminated Lateritic soil ,*IJIREST*,Vol.2,Issue 4.

Goswami,U. & Sarma ,H.P.,(2008). Study of the impact of Municipal Solid Waste dumping on soil quality in Guwahati City,*Poll Res* .27(2):327-330.

Hoque, R. R., Goswami, B.C. Kusre., K.P. Sarma (2010). Distribution and solid phase speciation of toxic heavy metals of bed sediments of Bharali tributary of Brahmaputra River, *Environment Monit Assess*. (2011). 177: 457- 466.

Jenkinson, D.S. & Ladd, J.N. Microbial Biomass in soil: Measurement & Turnover. In: Paul EA, Ladd, J.N., Editors . Soil Biochemistry Vol. 5. New York : Marcel Dekker; 1981. pp. 455 -471.

Jaynes, D.B., J.M. Novak, T.B. Moorman and C.A. Cambardella, 1995. *J. Environ. Qual.*, 24: 36-41.

Jackson ,M.L.,(1974) ,Soil Chemical analysis ,Englewood Cliffs, N.J. Prentice Hall.

Jeevan, R. K. and Shantaram ,M.V.,(1993) Characteristics of garbage, A review.*Agril.Rev.* 14(2),P.102 -108.

Kanmani, S. & Gandhimati, R. (2013). Assessment of heavy metal estimation in soil due to leachate migration from an open dumping site. Appl: Water Science (2013) 3: 193-205.

Karim,R.,Kuraoka ,M.,Higuchi ,T.,Sekine ,M.,Imani ,T., (2014). Assessment of Heavy metal contamination from Municipal Solid Waste Open Dumping sites in Bangladesh, *Journal of Hydrology and Environment Research*, Vol 2, N.1

Kashyap A., Kalita J., Kalita S and Majumdar K., 2010. Present Scenario of solid waste with special reference to plastic and other non-biodegradable solid waste and its management for the sustainable urban poor development in Guwahati City, Assam, India, *Ne BIO Vol.* 1(1), PP-18-26.

Mahajan, S. & Billore, D. (2014). Assessment of phsico chemical characteristics of the soil of Nagchoon Pond Khandwa, MP, India,

Research Journal of Chemical Sciences, Vol 4(1), pp. 26-30.

Manahan, Stanley E., Toxicological Chemistry. 4th edn. 1991, Chap.5, Toxic elements.

Musa, A. (2012). Effect of Municipal Solid Waste on Geotechnical properties of Soils, *International Journal of Environmental Science, Management and Engineering Research.* Vol.1(5), pp.204-210.

Parth, V., Murthy, N.N., Saxena (2011). Assessment of heavy metal contamination in soil around hazardous waste disposal sites in Hyderabad city. (India): Natural and anthropogenic implications, *E 3 Journal of Environmental Research and Management* Vol 2(2), pp. 027-034.

Pillai (2014). Soil pollution near a Municipal Solid Waste Disposal Site in India, International Conference on Biological, civil and Environmental Engineering (BCEE-2014) March 17-18 Dubai(UAE).

Raman, N. & Narayanan, D.S. (2008). Impact of Solid Waste effect on Ground water and soil quality nearer to Pallavaram soild waste landfill site in Chennai, Rasayan J. Chem, Vol 1. No.4, pp.828-836.

Sharma ,S.,Shah ,K.W.,(2005)Generation and disposal of solid waste in Hoshangaba.In:Book of proceedings of the 2nd international congress of chemistry and environment .Indore,India.pp:749-751.

Sahani, A. & Gautam, A.(2010). Assessment of Heavy metal toxicity in Soils nearby Municipal Solid Waste Dumping site, Mathuradaspur, Jaipur, *Asian J. Exp. Sci*, Vol 25.

Sharma, B.K. (2001). Environmental Chemistry, Goel Publishing House, Meerut.

Shekdar ,A.V. ,Krishnawamy ,K.N.,Tikekar ,V.G.,Bhide ,A.D.,(1992)Indian urban solid waste management systems-jaded systems in need of resource augmentation. J Waste Manag 12(4) :379-387.

Stevenson, F.J. (1986). Carbon balance of the soil and role of organic matter on soil fertility. In: Cycles of Soil – Carbon, Nitrogen, Phosphorus, Sulphur and micro nutrients. John, Wiley & Son, New York. pp. 45 -47.

Tripathi, A, Mishra D. R(2012). A study of physico-chemical properties and heavy metals in contaminated soils of municipal waste dump sites at Allahabad, India, *International Journal of Environmental Sciences*, Vol-2, No 4

Turekian, K.K. & Wedepohl, K. 11(1961), Distribution of the elements in some major units of the earth's crust. *Bulletin of the Geological Society of America*, 72, 175-192.

Van der Perk, M. And Van der Gaans, P.F.M., 1997, *Water, Air and Soil Pollution*, 96, pp.107-131.