RJC
http://www.rasayanjournal.com

RASĀYAN *J. Chem.*
Vol.3, No.3 (2010), 539-544
ISSN: 0974-1496
CODEN: RJCABP

AN USEPA APPROACH OF HEAVY METAL ANALYSIS IN SOLID WASTE BY MULTIPLE EXTRACTION PROCEDURE USING SYNTHETIC ACID RAIN AS EXTRACTION FLUID

N.Raman* and D.Sathiyanarayanan
Research Department of Chemistry, VHNSN College, Virudhunagar-626 001, India.
*E-mail: drn_raman@yahoo.co.in

ABSTRACT

Solid waste samples collected from the Pallavapuram Municipal solid waste dump yard nearer to Pallavaram area in Chennai, were subjected to repetitive extraction using synthetic acid rain (60/40 w/w sulfuric acid and nitric acid) by multiple extraction procedure which reveals the highest concentration of each constituent that is likely to leach into the environment. The collected waste samples were extracted according to the Extraction Procedure Toxicity test method and analyzed for the constituents Pb, Cd, Cr, Ba and Ag and compared with the maximum concentration of contaminants for characteristics of Extraction Procedure (EP) Toxicity. In this method the solid portions of the samples which remained after application of the EP toxicity method were extracted nine times using synthetic acid rain extraction fluid and the extraction procedure was repeated until the concentration of constituent ceased. For finding out the metal concentration present in the extraction fluid, VARIAN 720 – ES ICP – OES was used for better accuracy.

Keywords: Pallavapuram Municipality; solid waste; toxicity; leaching; Chennai.

INTRODUCTION

Assessment of toxicity of heavy metals in the solid waste dumpsite by Multiple Extraction is a recent technique and it has been applied to the solid waste samples collected from Pallavapuram Municipality landfill in Chennai. The locales of Pallavapuram municipal dump yard nearer to Pallavaram were suffering equally from garbage dumping and leading to serious environmental threats to air, water and soil. The water samples in and around the dumpsite were heavily contaminated due to the impact of municipal solid waste dumping. In the rainy season the water from the surrounding places were stored here. Recently, a Japanese university carried out a study on human breast milk samples from three places, Perungudi which is just 4 km away from the Pallavapuram dumpsite area and two other places in Cambodia and Philippines. It is found that Perungudi sample topped in levels of dioxins in the breast milk collected from the vicinity of the dumping site. Another recent study shows the presence of 29 toxic chemicals in the area. A report of the Salim Ali Centre for Ornithology and Natural History (SACON) shows the presence of carcinogens such as 1,3-butadiene, benzene and chloromethane in alarming levels, much higher than considered safe by the US Environmental Protection Agency. A research survey of the Centre for Water Resources and Analysis says that the levels of metals like lead, mercury and copper have already crossed the limit prescribed by the Bureau of Indian Standards. Lead can affect children and pregnant women. An IIT study says that it can also cause blue baby syndrome. "The main problem in the Pallavaram dump yard is not 'house waste' but industrial and medical waste. In addition, unplanned dumping and burning of garbage pollute air, water and soil. This will create a lot of serious health problems in future. Highly leaded jewellary has been subjected to TCLP (Toxicity Characteristic Leaching Procedure) and it is found that it exceeds the regulatory limits of Lead[1]. In various countries the municipal solid wastes are incinerated and reused. The incinerator ash of municipal solid waste can be used as cement additives or road base[2]. Cement production can be a feasible alternative for municipal solid waste incinerator ash management and cement products conformed to the Chinese National Standard (CNS) of Type-II Portland cement[3]. In this work, five solid waste samples were collected and

the heavy metals present in the solid wastes were analysed by Multiple Extraction Procedure using synthetic acid rain as extraction fluid, using the method developed by the US Environmental Protection Agency (USEPA). The leaching behaviors of the pollutants in the zinc extraction residue were investigated using multiple extraction technique and successive extractions[4]. The examination of bottom ashes from medical incinerator were subjected to extraction technique and it is found that the heavy metals were present well below the limits of TCLP than the direct medical waste[5].

Pallavapuram dumpsite area nearer to Pallavaram area is located at 12.98° N 80.18° E. It has an average elevation of 16 m (52 feet). The Pallavapuram land filling dumpsite is in the beginning of Grand South Trunk road connecting Old Mahabalipuram road by 200 feet road. It is surrounded by residential areas in which they are heavily affected by both soil and water pollution through the leach out of hazards from the solid waste. Figure 1 shows the study area. Five solid waste samples were collected in the Pallavappuram landfill dumping site nearer to Pallavaram and they were marked as SW1, SW2, SW3, SW4 and SW5.

EXPERIMENTAL

The solid waste samples were collected from the Pallavapuram Solid waste dumpsite area nearer to Pallavaram. The entire areas of the solid waste dumpsite were divided into five different parts and the solid waste samples were collected at 1m depth from each part of the area as per the standard procedures. The entire samples were spread on a tray and placed beneath the dryer overnight. The dried samples were crumbled mechanically and passed through a sieve with 2 mm mesh and used for further analysis. The "Solid waste" samples were divided by the sample divider for getting the uniformity of the sample. The resultant samples were taken for the analysis.

The collected samples contained more than 65% of solids. Hence, the samples were directly subjected to Multiple Extraction after continuing the pH determination. Here the collected solid waste samples were subjected to multiple extractions with the synthetic acid rain as extraction fluid.

The solid phase of the sample was ground to pass a 9.5 mm sieve and extracted with deionised water which was maintained at a pH 5±0.2 with acetic acid. The solid portions of the samples remaining after the application were re-extracted nine times using synthetic acid rain extraction fluid. If the concentration of any constituent of concern increased from the seventh or eighth extraction to the ninth extraction, the procedure was repeated until these concentrations decreased[6].

The solid waste samples after subjected to the preliminary steps were subjected to Extraction Procedure (EP) test as per method 1310. The constituents of interest for the extract were analysed. The synthetic acid rain extraction fluid was prepared by adding the 60/40 weight percent sulphuric acid and nitric acid to distilled deionized water until the pH was 3.0 + 0.2. The solid phase of the sample remaining after the Extraction Procedure was weighed and added an aliquot of synthetic acid rain extraction fluid equal to 20 times the weight of the solid sample in the wet condition. The solid phase sample and acid rain fluid were combined in the same extractor as used in the EP and started the agitation. The pH within 5-10 min was measured after agitation has been started. The mixture was agitated for 24 h, maintaining the temperature at 20ºC-40ºC. The pH was recorded at the end of the 24 h extraction period. The Separation Procedure was repeated as described in Method 1310b[7].

The extract for the constituents of concern was analysed and repeated the above mentioned steps, eight additional times. After completing the ninth synthetic rain extraction, the concentration of any of the constituents of concern was increasing over that found in the seventh and eighth extractions, then the extracting with synthetic acid rain was continued until the concentration in the extract ceased to increase. The initial and final pH of each extraction and the concentration of each listed constituent of concern in each extract were reported.

RESULTS AND DISCUSSION

The preliminary evaluation before Multiple Extraction is the determination of percentage solids in the solid waste samples. Table 1 describes the maximum concentration of Multiple Extraction constituents as per the guidelines set forth in 40 CFR 261.4. Table 2 shows the pH, percentage moisture and percentage solids of the solid waste samples. In this study all the samples contain more than 65% of solids and no

liquid is forced out by an applied force. Then the study is preceded with direct Multiple Extraction using synthetic acid rain extraction fluid.

Table 3 shows the total metal concentration of the solid waste samples. If the total metal concentration of the solid waste exceeds the appropriate regulatory levels of the Multiple Extraction, then the Multiple Extraction is needed to be run for the determination of individual analyte present in the solid waste. Tables 4 to 8 show nine subsequent multiple extraction analysis of solid wastes using synthetic acid rain namely SW1 to SW5. In SW1, SW2, SW4 and SW5, the Pb values are higher than those of the regulatory level as mentioned in the Table 1 except that of the SW3 which has the maximum value of the Pb content (3.89 ppm). In all five samples of SW1 to SW5 the solid waste samples contain more than 1 ppm of Cd in the extracted samples which is more than that of the regulatory level, SW4 contains 3.25 ppm of Cd which is 3 times higher than that of the regulatory level and from the seventh extraction of the solid waste sample it is obtained like that. In all the samples chromium value exceeds the limit, in SW5 sample third extraction contains more Cr and in the sample SW3, in the first extraction it is just below the limit. In SW1 to SW5 samples, the Ba content exceeds the limit as compared to the regulatory level. In the sample SW1, the barium content is 121.3 ppm. Similarly the presence of Ag is also higher in all the samples and particularly in SW5 sample the concentration of Ag is maximum and it is 7.98 ppm.

CONCLUSION

Assessment of toxicity of heavy metals in the solid waste dumpsite by Multiple Extraction is a recent technique and it has been applied to the solid waste samples collected from Pallavapuram Municipality landfill in Chennai. Duo to the solid wastes that are dumped in the landfill which are highly polluted particularly by Pb,Cd, Ba ,Ag and Cr. The total metal concentration and the Multiple Extraction concentration of the metals indicate that they can be leached into nearby soils and ground water and getting polluted. The physical and chemical characteristics of solid waste are important to implement the waste disposal and management plan for the selection of resource and energy recovery potentials[8]. The fate of pollutants, transport mechanisms in soils and contaminant characteristics are parameters of significant importance for the design of remediation systems[9]. The method was developed by the US Environmental Protection Agency (USEPA) as the basis for the promulgation of the best demonstrated available technologies treatment standards under the land disposal restriction program[10]. There are some advanced technologies available to make use of wastes to minimize burden on landfill, such as the biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other biological processing for the stabilization of wastes[11]. The Pyrolysis character of Municipal Solid Waste is also a tool for disposal of the same[12].

ACKNOWLEDGEMENTS

The authors thank the Head, Department of Chemistry, the Principal and the Managing Board, VHNSN College Virudhunagar and Chennai Mettex Lab Private Limted (Formerly Mettex Laboratories of India), Chennai for their constant encouragement and providing research facilities.

REFERENCES

1. J.D.Weidenhamer., B.E., Newman, and A. Clever, *J. Hazard. Mater*., **177**, 1150 (2010).
2. C. Huang, W. Yang, H. Ma, and Y. Song, *Waste Manag*., **26**, 979 (2006).
3. J. R. Pan, C. Huang., J. Kuo, and S. Lin., *Waste Manag.*, **28**, 1113 (2008).
4. A. Ozverdi, and M. Erdem, *Hydrometallurgy*., **100**, 103 (2010).
5. L. Zhao, F. Zhang., M.Chen., Z.Liu, and D.B.J.Wu, *J. Hazard. Mater*., **173**,181 (2010).
6. USEPA. 1992 Method 1320, Multiple Extraction Procedure, Publication SW – 846: Test methods for Evaluating Solid Waste, Physical/Chemical Methods. Washington DC.
7. USEPA. 1992 Method 1310 b, Extraction Procedure (EP) Toxicity Test Method and Structural Integrity Test, Publication SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Washington DC.

8. T.B.Yousuf, and M. Rahman, *Environ. Monit. Assess*, **135**, 3 (2007).
9. W.Hogland, M.Mmarques, and S.Nimmermark, *J.Mater Cycles Waste Manag*, **6,** 119 (2004).
10. USEPA. 1992 Method 1311, Toxicity Characteristic Leaching Procedure (TCLP), Publication SW – 846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Washington DC.
11. Ministry of Environment and Forests (MOEF), Municipal Solid Wastes, Management and Handling Rules 2000, Schedule – II , Rules 6(1) and (3), 7(1) – Management of Municipal Solid Wastes.
12. J. Zheng., Y. Jin., Y.Chi., J. Wen., X. Jiang, and M. Ni., *Waste Manag*., **29**, 1089 (2009).

Table-1: Maximum concentration of contaminants for Multiple Extraction Procedure

S.No.	Contaminants	Regulatory Level (ppm)
1	Barium	100.0
2	Cadmium	1.0
3	Chromium	5.0
4	Lead	5.0
5	Silver	5.0

Table-2: Basic Properties of the Solid waste samples

Sample No.	pH (10 % suspension)	% Moisture	% Solids
SW1	7.98	21.54	78.46
SW2	8.65	20.76	79.24
SW3	7/98	23.45	76.55
SW4	7.65	21.23	78.77
SW5	7.09	21.45	78.55

Table-3: Total metal ion concentration Solid waste samples

Sample No	Total Pb (ppm)	Total Cd (ppm)	Total Cr (ppm)	Total Ba (ppm)	Total Ag (ppm)
SW1	11.6	5.65	70.7	435	20.7
SW2	12.6	6.45	65.7	342	23.8
SW3	11.9	5.76	72.8	365	22.9
SW4	12.5	4.87	69.0	324	24.8
SW5	13.2	5.23	78.6	345	26.9

Table-4: Solid Waste 1 – SW1

Element/Extraction	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}	7^{th}	8th	9^{th}
Pb	6.04	6.53	6.59	6.16	6.23	5.95	5.78	5.69	5.42
Cd	2.06	2.12	2.56	2.64	2.48	2.15	1.95	1.56	1.42
Cr	7.05	7.45	7.26	7.49	7.62	7.16	7.23	7.42	7.13
Ba	112.1	115.6	116.8	119.5	121.3	114.8	111.3	111.9	109.5
Ag	6.23	6.46	6.35	6.59	6.48	6.26	6.25	6.12	5.86

Table-5: Solid Waste 2 – SW2

Element/Extraction	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Pb	5.86	5.98	5.99	6.12	6.23	6.12	5.90	5.89	5.70
Cd	1.96	2.02	2.15	2.03	2.15	2.18	2.19	2.15	2.01
Cr	6.23	6.25	6.39	6.45	6.48	6.59	6.60	6.56	6.41
Ba	108.9	107.9	108.7	109.2	111.4	109.5	108.4	108.6	106.2
Ag	6.13	6.23	6.15	6.19	6.23	6.25	6.15	6.19	5.95

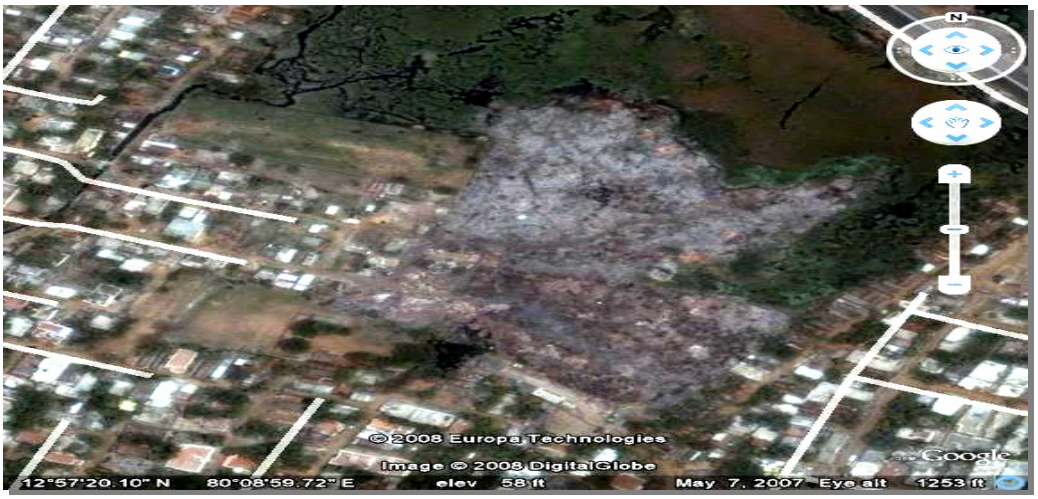

Fig-1: Map of the Pallavaram Landfill site area

Fig-2: The Pallavaram solid waste dumpsite area.

Table -6: Solid Waste 3 – SW3

Element/Extraction	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Pb	3.36	3.38	3.69	3.48	3.78	3.89	3.70	3.75	3.12
Cd	2.05	2.12	2.32	2.56	2.41	2.54	2.63	2.45	2.12
Cr	4.87	5.12	5.16	5.48	5.32	5.18	5.20	5.22	5.01
Ba	110.2	110.8	110.9	110.2	111.2	111.4	111.8	111.8	110.1
Ag	6.54	6.62	6.23	6.58	6.59	6.45	6.78	6.62	6.21

Table-7: Solid Waste 4 – SW4

Element/Extraction	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Pb	5.96	5.98	6.12	6.23	6.25	6.52	6.53	6.68	6.12
Cd	2.85	2.96	2.94	2.98	3.12	3.21	3.25	3.21	2.98
Cr	6.23	6.56	6.89	6.45	6.52	6.23	6.59	6.60	6.12
Ba	112.3	112.5	113.5	114.6	114.8	114.2	114.6	114.7	111.3
Ag	7.25	7.20	7.12	7.45	7.56	7.52	7.59	7.68	7.12

Table-8: Solid Waste 5 – SW5

Element/Extraction	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Pb	6.12	6.32	6.15	6.20	6.59	6.48	6.59	6.60	6.12
Cd	1.23	1.29	1.26	1.38	1.56	1.62	1.78	1.89	1.52
Cr	7.42	7.56	7.89	7.65	7.52	7.23	7.56	7.52	7.12
Ba	110.2	110.9	112.5	113.6	114.5	115.2	117.8	119.2	110.1
Ag	7.21	7.15	7.56	7.89	7.54	7.98	7.56	7.62	7.12

(Received: 21 August 2010 Accepted: 25 September 2010 RJC-532)