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Heavy Metal Contamination of Surface Soil from E-Waste Recycling Sites of Informal Sector in Mumbai Urban

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Abstract:
E-waste is globally associated with environmental contamination and serious health issues due to its chemical constituents. The presence of elements like Copper, Lead, Zinc, Nickel, Mercury, Arsenic, Cadmium, Cobalt ,Total Chromium, etc make e-waste hazardous in nature. In Mumbai, large volumes of such waste is handled in the informal sector and recycled without any environmental safeguard which leads to heavy metals contamination of soil. In this study a total of 8 surface soil samples were collected four from each informal sector. Soil samples were analyzed for Copper (Cu), Lead (Pb), Zinc (Zn), Nickel (Ni), Mercury (Hg), Arsenic (As), Cadmium (Cd), Cobalt (Co) ,Total Chromium (TCr) using inductively coupled plasma optical emission spectroscopy (ICP- OES). Analysis revealed the levels of Copper (3166.81 to 12845.83), Zinc (1303.61 to 6205.16), Lead (1270.51 to 9802.08), Nickel (49.58 to 1286.02), Mercury (1.19 to 16.22), Cadmium (3.51 to 65.04), Cobalt (61.18 to 93.99), Arsenic (0.29 to 21.50), Total Chromium (18.27 to 124.67) mg/kg. The levels of Cu, Pb and Zn of all the samples were very high as compared to the standard limit. Soil results at both sites of informal sectors confirm changes in soil parameters as compared to the respective control samples and also if compared to standards. There is clear evidence of changes in soil characteristics at both recycling sites and this directly relates to the activities of the informal waste recycling sector.

Keywords: E waste, Heavy Metals, soil, recycling

I. INTRODUCTION

In the 20th Century, the information and communication revolution has brought massive changes in the way we organize our lives, our economies, industries and institutions. Electronics industry is the world's largest and fastest growing manufacturing industry [1]. Rapid growth, combined with rapid product obsolescence and discarded electronics is now the fastest growing waste stream in the industrialized world. The problems associated with e-waste in India started surfacing from 1990 after the first phase of economic liberalization [11]. Electronic Waste (e-Waste) comprises of waste electronic/electrical equipments (WEEE) which are not fit for their originally intended use. These include items such as computers, cellular phones, stereos, refrigerators, air conditioners, other consumer durables, etc. E-waste is not hazardous waste by itself [4]. However, the hazardous constituents present in the e-waste render it hazardous when such wastes are dismantled and processed, since it is only at this stage that they pose hazard to health and environment. Like hazardous waste, the problem of e-waste has become an immediate and long term concern as its unregulated accumulation and recycling can lead to major environmental problems cause danger to human health.

E-waste is varied and falls under 'hazardous' and 'non-hazardous' categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, printed circuit boards, ceramics, rubber and other items. Iron and steel are present in bulk quantity followed by plastics, non-ferrous metals and other constituents [2]. Precious metals like silver, gold, platinum, palladium are present in traces in the equipments. The presence of elements like mercury, lead, arsenic, cadmium, selenium, Hexavalent chromium, flame retardants, etc makes e-waste hazardous in nature [7]. Maharashtra state ranks first among top ten states generating WEEE in India. Among Indian cities, Mumbai ranks first among top ten cities generating WEEE in India. Mumbai is not only the port of import for new and used electronics; it is also home to a large user and manufacturer base, both generating large volumes of e-waste [9]. Of the total e-waste generated in India, approximately 1.5 percent is recycled by formal recyclers or institutional processing and recycling. Another 8.0 percent of the e- waste generated is rendered useless and goes to landfills. The remaining 90.5 percent of the e-waste is being handled by the informal sector [06]. This sector has been operational for many years and has been handling extensively large volumes of e-waste in improper way, which is harmful to the environment [8]. This sector does not use any safety measures which increase the risk to the health of the worker. Currently there is very little or negligible data generated from informal sectors recycling sites to understand the relationship between such activities and its impacts on the environment and human health [10]. With the above background in mind, the major objective of this paper is to quantifying the pollution levels (heavy metals concentration) generated from electronic waste activities from informal sector in and around Mumbai and their potentials impacts on the environment.

II. MATERIALS AND METHODS

Sampling Sites

A preliminary survey of informal sector was conducted and covered using semi-structured interviews. The prime areas that handled with the major e-waste recycling practices in informal

sector in mumbai are Sakinaka (Teen No.Khadi) and Kurla (Kutubmandal). Sakinaka (Teen No. Khadi) is located on the Andheri Kurla Road close to Jari Mari Industrial Area. It is a low-income slum area with a large number of informal activities being carried out. The coordinates of the location (centre point) are 19^0 5' 26'' N and 72^0 52' 56'' E. Kurla (Kutubmandal) is situated along the bank of Mithi river beside the Kurla (W) bus depot. The coordinates of the location (centre point) are 19^0 4' 31'' N and 72^0 52' 33'' E. In this area various kinds of scrap activities carried out like iron, wooden, automobile scrap and e-waste [12].

Sample collection

Random surface soil samples were collected from each study site, (two informal sectors) at different location using a stainless steel spoon [14]. Descriptions of sample are described in Table I. All samples were stored in clean polyethylene bags (Ziploc) to minimize sample contamination and were kept in ice -filled coolers at approximately 4°C for transport to the laboratory, where they were transferred and wrapped in aluminium foil and stored at − 20°C. Soil samples were freeze dried; sieved (<1mm) to remove stones, roots, and coarse materials; and then stored in a desiccators prior to analysis [15]. Samples were analysed in MPCB laboratory and Trans Thane Creak Waste Management Association (TTCWMA) Laboratory.

Sample analysis

Soil samples were analyzed for Cu, Zn, Pb, Ni, Total Cr, Hg, Cd, Co and As using inductively coupled plasma optical emission spectroscopy (ICP- OES) by using method 3050 B Acid Digestions of Sediments, Sludges and Soils [13].

Statistical Analysis

Statistical analysis was performed by using Mean, standard deviation and coefficient of variation.

TABLE.I. DESCRIPTION OF SAMPLING SITES OF INFORMAL SECTOR

Sr.No.	Sampling site	Location	Sample	Description
1.	Sakinaka	Wire lane	Soil (SS-1)	Located near teen no. khadi wire ash stored in gunny bag Mixed with soil.
2.	Teen no. Khadi	Lane-2	Soil (SS-2)	Located in hill slum area last shop of lane-2 several Small burnt components and ash found beside road & in front of The shop.
3.	Teen no. Khadi	Aanis compound	Soil (SS-3)	Near hill open storage and dismantling of e waste. several Component of e waste area surrounded by open field.
4.	Teen no. Khadi	Lane-1	Soil (SS-4)	Located in hill slum area first shop of lane- Surface Heating of PWB , de-soldering seepage found in front of shop & beside the road.
5.	Kurla (Kutubmandal)	Lane-1	Soil (SS-5)	Located center of the market dismantling on open area several ewaste components mixed with soil.
6.	Kurla	Lane -2	Soil (SS-6)	Located in market s mall components of e waste and transformer core found beside the road.
7.	Kurla	Last lane	Soil (SS-7)	Located bank of the mithi river Several e waste and small wire parts found on the road.
8.	Kurla	Near bridge	Soil (SS-8)	Located Near bank of the mithi river discarded plastic and ewaste dumped.
9.	Ground	Kurla Andheri road	Soil (SS-9)	Control Sample

III. RESULTS AND DISCUSSION

The heavy metal concentrations measured in soil are shown in Table II. In this study, sample no. SS-9 was considered as the control sample. Data of other samples were compared with USEPA standards [5] [3] and control sample SS-9.

TABLE. II. CONCENTRATION OF HEAVY METALS IN SOIL COLLECTED FROM INFORMAL SECTORS

Sample No.	Cu	Zn	Pb	Ni	Total Cr	Hg	Cd	Co	As
SS-1	10914.40	1303.61	5972.83	49.58	37.08	BDL	3.51	BDL	7.8
SS-2	12845.83	6205.16	7144.54	1286.02	54.07	7.92	17.28	61.18	21.50
SS-3	3166.81	1602.93	5821.49	567.86	56.23	1.19	BDL	BDL	2.79
SS-4	7650.22	4638.45	9802.08	1112.32	18.27	1.65	BDL	93.99	0.29
SS-5	4265.86	3043.45	1270.51	153.06	124.67	16.22	65.04	BDL	BDL
SS-6	8218.91	3186.39	1540.61	309.41	97.23	3.58	16.08	BDL	BDL
SS-7	11605.82	4453.74	2416.75	366.69	86.06	14.08	49.43	BDL	BDL
SS-8	5554.71	2743.04	1685.99	490.44	81.88	3.23	26.34	BDL	BDL
Mean	8027.82	3397.10	4456.85	541.92	69.44	5.98	22.21	19.40	4.05
S.D.	3554.17	1636.27	3172.48	440.90	34.50	6.15	23.88	36.97	7.56
C.V. in %	44.27	48.17	71.18	81.36	49.68	102.83	107.50	190.60	186.74
SS-9 (control)	61.53	129.61	BDL	115.94	51.03	BDL	BDL	BDL	BDL

All results are in mg/kg

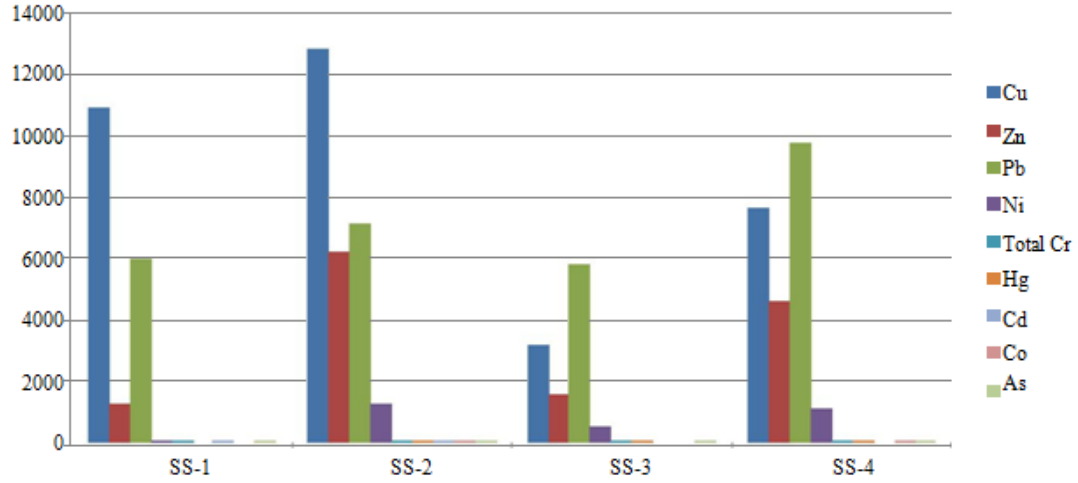

Figure.1. Concentration of heavy metals in soil from e-waste recycling site at teen no. Khadi

The observed copper levels varied from 3166.81 to 12845.83 mg/kg. All the samples were found highly exceeding as compared to the prescribed limit (100 mg/kg). Copper level in control sample (61.53 mg/kg) was found below limit. The highest copper level was almost 128 times higher than the USEPA standard. The mean copper concentration was found 8027.82 mg/kg. Leung *et al* 2008 reported mean concentration of copper in workshop dust was 8360 mg/kg and adjacent to road was 6170 mg/kg. This clearly indicates presenting of toxic metals in the soil at both informal sectors and can be directly linked to the ongoing crude recycling activity and presence of copper as an input material.

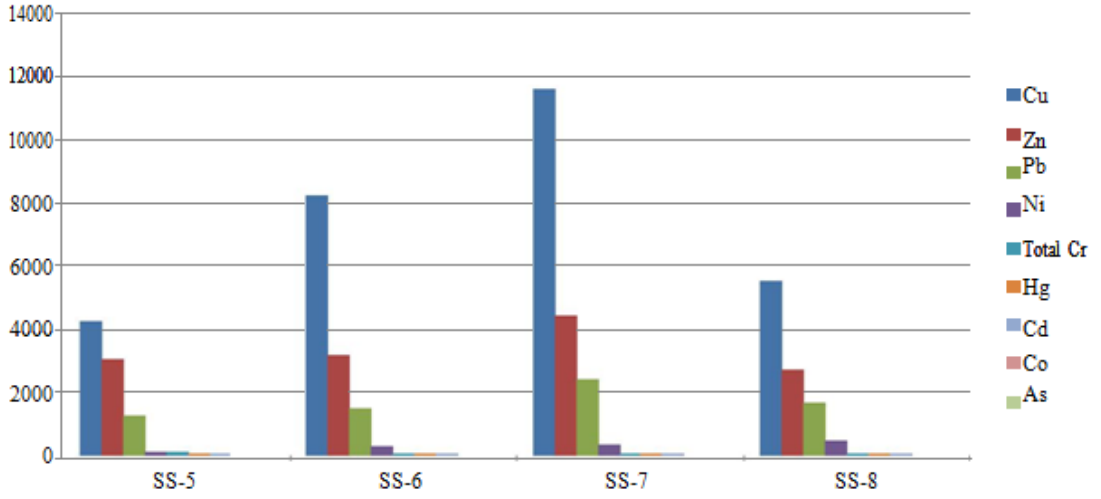

Figure.2. Concentration of heavy metals in soil from e-waste recycling site at kurla (kutubmandal).

The Zinc levels varied from 1303.61 to 6205.16 mg/kg. In all the soil samples Zinc was highly exceeding as compared to prescribed limit (300 mg/kg). Zinc level in control sample (129.61 mg/kg) was found below the prescribed limit. The mean Zinc concentration was found 3397.10 mg/kg. The highest zinc level was almost 21 times higher than prescribed limit. Sinha *et al*, (2014) reported Zinc level 6258 mg/kg in mandolin area. Leung *et al* 2008 reported mean concentration of Zn 4420 mg/kg in workshop dust. The observed Lead levels varied from 1270.51 to 9802.08 mg/kg. In the soil of both the sectors Lead level are highly exceeding compared to the prescribed limit (200 mg/kg). The lead in the control sample was below the detectable limit. The highest Lead level was almost 49 times higher than the prescribed limit. The mean Lead concentration was found 4456.85 mg/kg. Sinha *et al*. (2014) reported lead level 3836 mg/kg in mandoli area. Leung *et al* 2008 reported mean concentration of Lead 22600 mg/kg in adjacent to road. This clearly indicates a change in characteristics of the soil in both the informal sectors and can be directly linked to the ongoing crude recycling activity and presence of lead as an input material. Exposure to its high levels can severely damage the brain, kidneys and ultimately cause death. The Nickel levels varied from 49.58 to 1286.02 mg/kg. Three samples (~38 per cent) recorded Nickel level exceeding as compared to the prescribed limit (500 mg/kg). In the control soil sample the Nickel was recorded below the prescribed limit (115.94 mg/kg). The highest nickel level was almost 3 times higher than the permissible limit. The mean Nickel concentration was observed 541.92 mg/kg. High level of nickel may cause skin problems and vomiting. The Total Chromium levels varied from 18.27 to 124.67 mg/kg. Total Chromium levels of all the soil samples were found below the prescribed limit (1000 mg/kg). The Mercury levels varied from 1.19 to 16.22 mg/kg. ~88 per cent of soil samples, that is, seven samples were found with high mercury levels as compared to the USEPA standard (0.3 mg/kg). Sample no. SS-1 including the control sample was found below the detectable limit. The highest mercury level was almost 54 times higher than the permissible limit. The mean concentration of mercury was found 5.98 mg/kg. Mercury has a tendency to remain in the environment for a long period of time. This variation in mercury concentration in soil is indicative of a mercury contamination of soil in the recycling sectors. Mercury is acutely poisonous and injurious to health on long term perspective. The cadmium levels varied from 3.51 to 65.04 mg/kg. In six soil samples, (SS-1, SS-2, SS-5, SS -6, SS-7, and SS-8) the cadmium levels were high as compared to prescribed limit (0.7 mg/kg). Two samples including the control sample were below the detectable limit. The highest cadmium level was almost 93 times higher than the permissible limit. The mean concentration of cadmium was observed 22.21 mg/kg. This leads to the abnormalities in soil characteristics due to high level of cadmium. Cadmium is acutely poisonous and injurious to health on long term perspective. The cobalt levels varied from 61.18 to 93.99 mg/kg; 25 per cent of soil samples, that is, two samples (sample nos. SS-2, and SS-4,) was found with high cobalt levels as compared to control sample. All other samples including the control sample were below the detectable limit. Mean concentration of cobalt was 19.40 mg/kg. This indicates the deposition of cobalt in soil characteristics due to recycling activity and presence of high level of cobalt. The Arsenic levels varied from 0.29 to 21.50 mg/kg; 50 per cent of soil samples, that is, four samples (sample nos. SS-1, SS- 2, SS-3 and SS-4) were found with less arsenic levels as compared to prescribed limit (50 mg/kg). Other samples including the control sample were below the detectable limit. Mean concentration of Arsenic was 4.05 mg/kg. Arsenic is acutely poisonous and injurious to health on long term perspective. Masnari *et al* 2011 reported arsenic level <50 to 1000 mg/kg.

IV. CONCLUSIONS

E-waste is globally associated with environmental contamination and serious health issues due to its chemical constituents. The areas of kurla (Kutubmandal) and sakinaka (Teen no. khadi) both, on prime location of Mumbai, support extensive e-waste recycling where untrained workers carry out the crude and primitive methods without personal protective equipment (PPE), which are detrimental not only to their health but also to the environment. The results of soil samples collected from E-waste recycling sites gives a better awareness of hazardous implications of E-waste recycling on environment. The data of both sites of informal sectors confirm the contamination of soil by heavy metals as compared to the control site. The levels of heavy metals in soil are very much higher in both the sites as compared to control sample. Level of heavy metals Cu, Pb, Ni, Co and As in soil are much higher in the Sakinaka (Tenn no. khadi) area as compared to Kurla (Kutubmandal) and another metals like Hg and Cd are less level in the sakinaka (Teen No. Khadi).

V. RECOMMENDATIONS

1. An urgent need for better monitoring and control of the informal recycling sector and include the informal sector into formal WEEE recycling systems instead of trying to eliminate the informal sector.
2. Industrial space for e-waste dismantling and recycling in the existing and upcoming industrial park and industrial clusters should be allocated.
3. There must be a large scale awareness programme and industrial skill development activities among the workers involved in dis mantling and recycling.
4. Strict implementation of the E-waste (Management and Handling) rules, 2011 and E-Waste (Management) Rules, 2016.

VI. REFERENCES

[1].(2011).E-Waste in India. Report published by Rajay Sabha

[2].A.W. Leung, N .D. Duzgoren, K.C. Cheung and M. Wong, 2008.Heavy Metals Concentrations of Surface Dust from e-Waste Recycling and Its Human Health Implications in Southeast China. Environ. Sci. Technol., 42:2674–2680.

[3].C. J.,Vincient, A.P.singh, A. R. Supate and N. S. Desai, 2016. Comparative study of heavy metals contaminations at common biomedical waste treatment and disposal sites in Mumbai, Maharashtra, India. International J. of health sciences and research.

[4].C. Michael and R.W. Sugumar., 2013. Studies on leaching of heavy metals from E-waste. Orient. J. Chem., 29(3), 1149-1154.

[5].E M. Joan and B.E.Bledsoe (1992). Behaviour of metals in soils united state.

[6].http://www.attero.in/about-us.html.

[7].M., Otsuka, Itai, T., Kwadwo, A. Asante, M. Muto and S. Tanabe,2011. Trace Element Contamination around the E-waste Recycling Site at Agbogbloshie, Accra City, Ghana Interdisciplinary Studies on Environmental Chemistry—Environmental Pollution and Ecotoxicology

[8].Raghupathy l.,C.Krüger, A.Chaturvedi, R.Arora, M. P. Henzler,2012. E-Waste Recycling in India – Bridging the Gap between the Informal and Formal Sector. 12p

[9].Report on Assessment of Electronic Wastes in Mumbai-Pune Area; www.mpcb.gov.in

[10].Ruqianaziret al.,(2015). Accumulation of Heavy Metals (Ni, Cu, Cd, Cr, Pb, Zn, Fe) in the soil, water and plants and analysis of physico- chemical parameters of soil and water Collected from Tanda Dam kohat. J. Pharm. Sci. & Res. 7(3): 89-97.

[11].S., Sinha K. Wankhade and D.Sinha, 2007. Mumbai choking on E waste a study on status on E waste in Mumbai. www.toxicslinks.org

[12].S., Suresh, R. D., Patil, (2011).SPM characterization for heavy metals concentration. Report published by Central Pollution Control Board Bhopal, 25p.

[13].USEPA (1994) Method 3050B revision acid digestion of sediments, sludges, soils, and oils. www.epa.gov/ epaoswer/ hazwaste /test/main.htm.

[14].USEPA (1996) Method 3540C revision 3, soxhlet extraction. www.epa.gov/epaoswer/hazwaste /test/main.htm.

[15].USEPA (1996) Method 8270C revision 3, semi volatile organic compounds by gas chromatography/mass spectrometry (GC/MS).www.epa.gov/epaoswer/hazwaste /test/main.htm.