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Long term Effect of Municipal Solid Waste Disposal on Soil Heavy Metal Contamination

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Abstract

A meticulous perceptive of soil heavy metals is very much desired in the developing countries like India due to the mounting pressure on the soil environment. Growing population and altering life styles is adding up waste materials of complex nature into the environment contaminating the soil fertility by increase of heavy metal concentration. The present swot is carried out to gauge the extent of soil heavy metal concentration of Fe, Co, Cu, Mn, Cd, Cr, Pb in an active dumpsite which can cause a significant damage to the environment and human health when surpass their tolerable levels.

Keywords: Municipal solid waste, Dumpsite, Soil, Heavy metals, Concentration of trace metals, Atomic absorption spectroscopy, Concentration of trace metals.

Introduction

Many studies on soil pollution indicated that municipal solid waste dumpsites within the urban local bodies contribute to increase in heavy metal concentration to a level toxic to both human and animals. This has become a niggling aspect in many developing countries due to the lack of stringent laws on methods of MSW disposal. Developing countries adapt methods that are most disturbing to the environment like open land filling of municipal solid waste, burning etc; resulting in a vulnerable and fragile ecosystems. The waste dumped typically contains trace metals in various forms and at different contamination levels. Some heavy metals like As, Cd, Hg and Pb are particularly perilous to plants, animals and humans[1]. Anthropogenic activities like burning of fossil fuels, industrial effluent discharge, fertilizers, solid waste disposal contribute to heavy metal pollution of the soils in the vicinity. These heavy metals are the metals or metalloids of potential toxicity. More specific definitions of heavy metals have been proposed but none have obtained widespread acceptance[2]. Although these metals have become increasingly important in view of pollution not until recently they are recognized and acknowledged as potentially dangerous environmental toxins[3]. Of many activities dumping of solid waste is considered as one of the major contributors' of heavy metals due the intricacy of waste materials dumped in landfill which generate leachate ultimately polluting soil and groundwater resources. This accretion of heavy metals in the soil is considered to be a serious risk at the environmental level[4]. Leachate from solid waste heaps is of concern due to transfer of metal ions into the surface, sub-surface through the lateral or vertical movement of leachate[5]. The assessment of heavy metal content and their sources in soils is a key element in many programs of environmental protection, including the establishment of regional-level quality standards to detect the sites affected by contamination[6,7]. In many developing countries the practice of using the municipal solid waste as a source of fertilizer to the cut the expenses on crop cultivation is observed which is catching the eye of many researches to analyze the composition of the soils augmented with this manure. In this milieu the investigation of heavy metals in soil is essential since even slight changes in their concentration above the acceptable levels, whether due to natural or anthropogenic factors, can result in serious environmental and subsequent health problems[8,9]. It became obvious that land filling and incineration have a noteworthy impact on the environment and thus cannot be considered a preeminent method to get rid of the huge amounts of waste generated[10]. Thus land filling method of waste disposal is not per recommended standards in most of the developing countries[11,12]. Therefore the present work is intended to probe the extent of dumpsite soil contamination and whether the heavy metal concentration in the soil of the study area is ample enough to affect the soil quality and health of inhabitants residing in and around the study area.

Methodology

Study Area: Greater Visakhapatnam is the second largest metropolitan city in the state of Andhra Pradesh known for its natural harbor and abode for industries. The city lies between 17^0 - 15' and 18^0-32' Northern latitude and 18^0 - 54' and 83^0 - 30' in Eastern longitude occupying 681.96 sq.km (proposed). The city has a spoon shaped topography bordered by the Bay of Bengal and the Eastern Ghats. The city is famous for its natural beauty and is often referred as the "*City of Destiny".* The present study is carried out in a dumpsite at Kapuluppada which is operational for more than 25 years in Visakhapatnam. The municipal dump yard lies between latitude $17^0$50'45 26"N and longitude 83^0 22' 03 27'E in Kapuluppada village located in Bheemunipatnam of Visakhapatnam district, Andhra Pradesh. The dump yard is located 25kms away from the city extending in about 100 acres. The city generates nearly 1000MT of waste which is unscientifically managed in about 85 acres in the dumping yard. The present work is carried out to assess the heavy metal concentration in dumpsite soils which may cause a cumulative effect to the in and around areas.

Figure-1
View at Dump yard

Figure-2
Burning of Waste dumped at dump yard

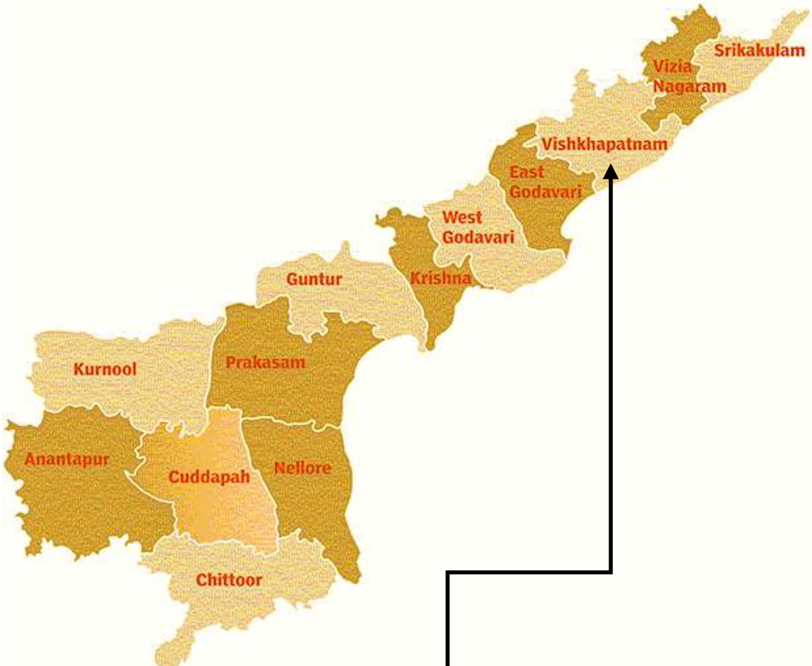

Figure-3
Location of Visakhapatnam District in Andhra Pradesh

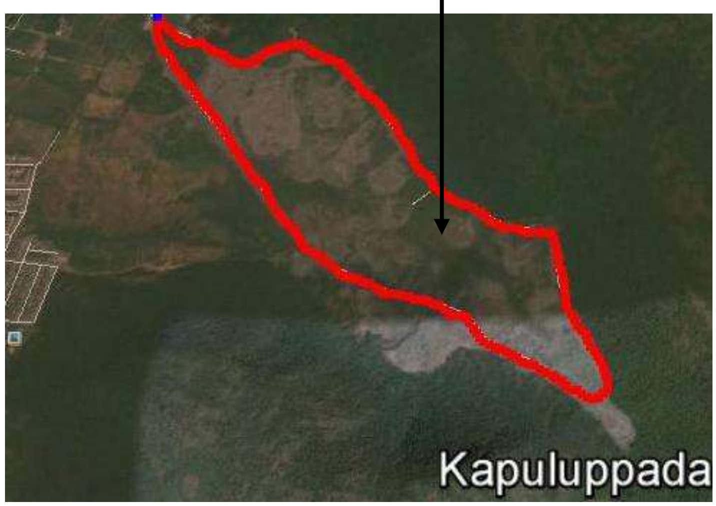

Figure-4
View of Dump yard

Sample Collection: Composite soil samples of 1kg were scooped and collected from a depth of 0-15cms randomly within the dumpsite. The samples were then transferred into clean polythene air tight bags to prevent any further oxidation of the organic matter. The soil samples were air-dried for 3 days at 25^0C temperature and pounded using mortar and pestle to obtain particle size of less than 2mm which were sieved through 2mm sieve prior to the heavy metal analysis.

Soil Sample Analysis: To get accurate reliable results for the soil samples, the soil extraction and analysis for heavy metals is carried out as per standard procedure specified by USEPA. The pre-sieved soil samples of less than 2mm size were digested according to USEPA Method, 3050B-Acid digestion of sediments, sludges and soils.

Soil Extraction Procedure: About 0.5 gm of sieved soil sample was placed in a 100ml beaker to which 5ml of concentrated HNO_3 acid mixture was added shaken well and allowed to stand quiescent for 5 min. To this 10 mL of 50 % HNO3 was added and the solutions were heated on hot plate at 95 °C±5 for 2 hrs until the volume reduces to 5ml. Then 2ml of ultrapure water and 3ml of 30% hydrogen peroxide was added. The solution in the beakers is further heated until the effervescences reduced.

1ml aliquots of H_2O_2 were added till the disappearance of the effervescences and the solution turns clear. The heating of the solution is continued till the volume reduces to 5ml to which 10ml of HCl is added and heated for another 15mintues. The obtained final solution was filtered and made up to 50ml with the distil water which is analyzed for heavy metals in AAS.

Results and Discussion

The soil at the dump site usually contains multifaceted materials which has the potential to alter the soil physico-chemical properties interfering with various metabolic activities of flora and fauna dependant on it. The soil samples collected from the dumping yard were analyzed for seven heavy metals mentioned in the tabular form above. It is perceptible from the results that the soils analyzed recorded high metal concentrations which were above the permissible standards prescribed by the WHO. Out of the twenty soil samples analyzed Fe was found to be most dominant within the ranges reported by Akubugwo [13] with a concentration of 465.36 mg/kg in agreement with the WHO standards. (3000 to 250,000mg/kg) which was further confirmed by the statement given by Eddy [14] who suggested that pollution of the environment by iron cannot be conclusively linked to waste materials alone but other natural sources of iron must be taken into consideration. The result was in agreement with the study carried out in Akwa Ibom state Nigeria where considerably higher Fe concentrations recorded for soil. This was followed by Cu with 185.10 mg/kg above the WHO limit of 100mg/kg which may be due to scrap metals in dumpyard. Pb concentration in the soil samples was recorded with a maximum value of 102.03 mg/kg above the permissible limit proposed by WHO (50mg/kg) and a minimum value of 1.02 mg/kg. The high concentrations of Pb in soil might be due to the discarded paint materials, e-waste, printed wiring boards, and lead-acid batteries etc; which is extremely toxic to the children affecting their nervous system when enters the body through bioaccumulation. Ni was recorded with a maximum value of 21.40 mg/kg and minimum of 0.04 mg/kg which is in agreement with WHO limit of 50mg/kg. Co was recorded with a maximum value of 24.16 mg/kg and a minimum value of 0.006mg/kg which is in agreement with WHO limits of 50mg/kg. On the other hand toxicity of Co is quite low compared to other metals as the majority of Co is not in their bioavailable form which is in agreement with findings of A.Perez-Espinosa [15]. Cd recorded maximum value of 14.86mg/kg and minimum value of 0.02mg/kg above the WHO permissible limit of 3mg/kg dry soil for Cd in soil. All the soil samples analyzed recorded very less concentration of Cr with maximum value of 2.04 and minimum value of 0.001 mg/kg within the WHO range of 100mg/kg while most of the samples showed below detection limit. The least concentration of Cr for all the soil samples may be attributed to the unorganized sector of rag-pickers at the dump yard sorting the discarded stainless steel, dysfunctional electrical equipment which has Cr as anti-corrosive agents. While Ni concentration was found to be more than in the study reported by A. Mahmood, R. N. Malik [16] from Pakistan which ranged between 0.91 and 5.94mg/L. Thus the metals in soil were in sequence Fe>Cu>Pb>Ni>Cd>Co>Cr.

Table-1
Heavy Metal Concentration in Dumpsite Soils (mg/kg)

Sample	**Elements**						
	Fe	**Cu**	**Co**	**Ni**	**Cr**	**Cd**	**Pb**
S-1	465.36	23.68	0.02	1.11	**BDL**	0.86	2.58
S-2	31.42	104.2	1.02	2.08	0.10	1.04	20.10
S-3	34.76	117.1	0.006	1.20	1.21	0.60	12.06
S-4	47.26	29.42	0.14	0.18	**BDL**	2.41	8.02
S-5	99.48	33.02	0.02	1.06	0.45	1.69	1.02
S-6	64.10	64	**BDL**	0.88	2.04	1.84	4.24
S-7	124.03	45.24	0.82	1.01	0.01	0.24	28.24
S-8	326.36	79.21	**BDL**	0.92	**BDL**	3.6	18.30
S-9	98.45	26.86	1.26	0.67	**BDL**	0.14	7.53
S-10	254.26	6.66	0.74	3.06	0.03	0.02	5.86
S-11	63.34	185.10	0.32	2.26	0.42	0.53	42.97
S-12	106.04	14.9	1.18	1.48	**BDL**	1.06	54.33
S-13	101.44	35.70	4.42	14.00	**BDL**	14.86	10.44
S-14	64.18	31.10	**BDL**	1.44	**BDL**	0.12	102.03
S-15	122.78	96.48	0.10	19.70	**BDL**	3.89	41.62
S-16	4.43	50.40	1.23	21.40	0.06	4.64	1.64
S-17	6.09	73.84	1.45	**BDL**	0.40	0.56	2.58
S-18	52.48	42.24	0.26	0.04	1.01	0.18	74.56
S-19	134.76	101.4	24.16	1.06	1.13	1.26	14.08
S-20	78.12	101.03	1.12	3.41	0.001	2.14	20.12

S- Sample Code, **BDL**- Below detection level.

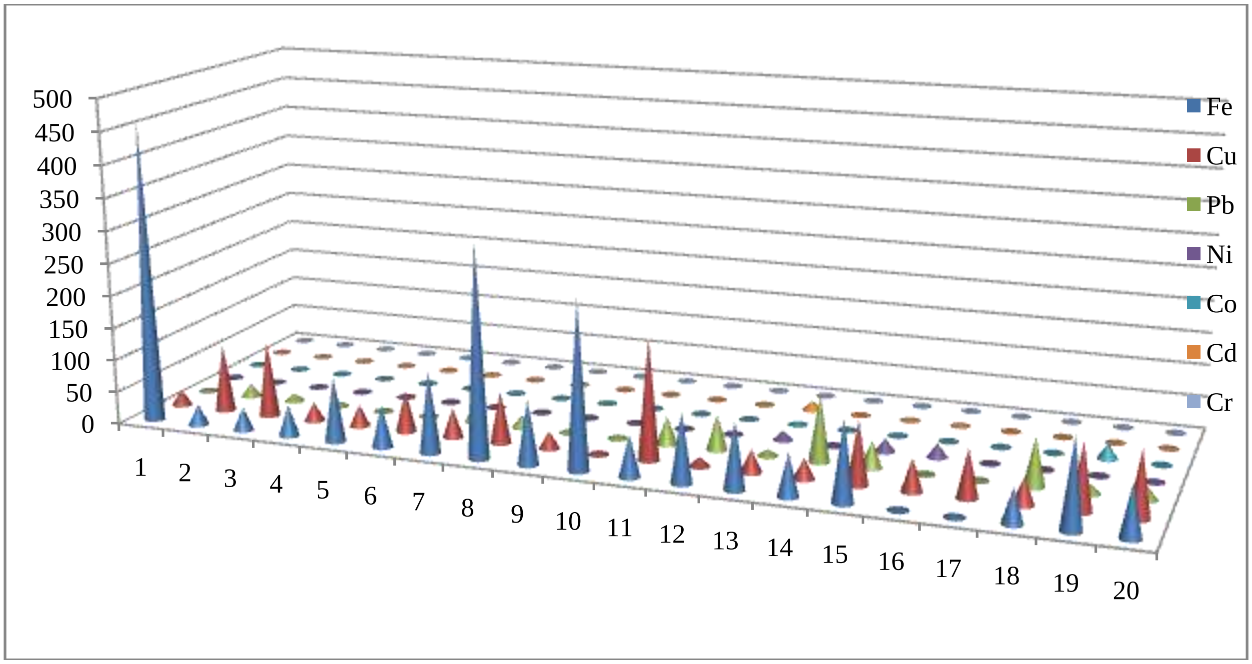

Figure-5
Representation of Heavy Metal concentration in samples

Conclusion

The present study of the dump yard soils revealed Pb, Cu and Cd beyond the limits of WHO while the remaining four were within the recommended ranges. Yet all the soil samples reported metals above the limits for agriculture. Since the study area is surrounded by cultivable fields it has become mandatory to assess the extent of soil contamination and presage the populace around the dump yard. Thus the study highlights a further intensive soil investigation due to the changing nature of waste generated and the potential of dumpsites in contaminating the groundwater sources and contiguous agricultural fields.

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