Mobility of Heavy Metals in Soils and Wastewater from Landfill, Sarona, Raipur, Chhattisgarh, India

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Abstract: In modem culture, widespread use of heavy metals affects paths accompanied by fluxes on the earth's surface. The altered flow paths can be detrimental to the equilibrium between biological systems at various levels, micro-organisms, human beings and entire ecosystems, because their concentrations and chemical types decide the toxicity of heavy metals. The physicochemical parameters such as pH, Total Dissolved Solids(TDS), Electrical Conductivity and heavy metals like Iron (Fe), Zinc (Zn), Copper (Cu), Lead (Pb), Nickel (Ni) and Cadmium (Cd) were analyzed in this research in landfill leaches, surface water, and river water. Despite the low mobility of heavy metals in urban landfills, it was found that during the degradation of the waste, substantial transformations of the binding types of heavy metal occur within the waste mass. The formation of early digenetic solid phases, i.e. new secondary solid phases formed in the waste, appears to be closely related to these changes. Solid waste treatment plant in Sarona, District Raipur, Chhattisgarh, India. Finally, more than permissible limit of zinc, iron, cadmium, calcium, iron, nickel, copper and manganese heavy metals were primarily responsible for soil pollution. The geologist of the study said that these heavy metals are toxic to soil and water (ground water and surface waters)

Keywords: Heavy metals, Mobility, Elements, Landfill, Kharun river

1. INTRODUCTION

The biggest issue in the current decade is the massive disposal of Urban Solid Waste (MSW). In the rainy season, MSW creates thick leachate with waste water. The dissemination into soil minerals and water of significant metals depends on the emphasis and solvency of the metals present (Oyewo et al., 2020). Substantial metals can also be bio accessible, which is defined as the distribution of the small content of components that is broken down in the gas-trointestinal lot and accessible for transportation via the intestinal lumen (De Miguel et al., 2012). The waste material is the main source of inorganic elements in the soils. Only household waste is dumped in the area and there are no industrial sources of waste contamination present in the region. Accumulation and transfer of heavy metals from the polluted region of fly ash into soil and plants. They examined and discussed the deposition of heavy metals from a thermal power plant in fields polluted with fly ash and subsequent absorption into various sections of naturally grown plants (Singh et al., 2006). The waste material is the predominant source of inorganic elements in the soil. However, a number of studies have been conducted on the assessment of water quality and heavy metals in Chhattisgarh India (Swarnakar et al., 2016).

2.Materials and methods

2.1 Study area

The central region of India is Chhattisgarh. The Satpura Basin is situated in Chhattisgarh (Yadav et al., 2020). Raipur's rainfall comes from the south-western monsoon and it is 1348 mm on average. Raipur is Chhattisgarh's capital. Figure 2 and 3 are the Location map of Raipur district, Chhattisgarh state, India. The site's elevation is approximately 271 m above MSL and is situated on the south side of Raipur at 210 14 '48' N Latitude and 210 14 '1.00' E Longitude. Approximately 19.4 acres/78595 sq-m is calculated in an area of which 18 acres (approx.) of land is owned by Raipur Municipal Corporation and private property is the remaining area. Raipur Municipal Corporation manages and tracks everyday operations at the site. On a daily basis, waste collected from all 8 zones and 70 wards of Raipur City are transported to the Sarona dump site, located 11 km from the heart of Raipur City. Figure 3 and 4 display the location map and sampling map.

2.2 Sample Collection:

During the post-monsoon season, surface wastewater samples were collected near landfills, far from landfills and rivers (Fig. 1 and 2). Sediments and leaches were also collected.

Figure 1. Kharun River

Figure 2. Landfill Area

2.2.1 Soil sample collection:

In September 2018, a total of 15 soil samples were taken from the four separate trenching areas that are used for dumping waste. The soil samples were obtained using soil auger from topsoil at depths of 0-20 cm. five sub-sites were taken for random sampling from each of the four trenching sites, and five soil samples were randomly collected from each sample point in Figure 3 and 4. The climate status of the study site is listed below in Table 1. Finally, four soil bulk samples were transferred into polyethylene bags and transported to the laboratory, one from each of the listed areas. For one week, the samples were air-dried, ground with porcelain mortar and pestle, passed through a 0.5 mm sieve, and then held for further examination in clean polythene bags.

Table 1. Description of the climate conditions of the study sites

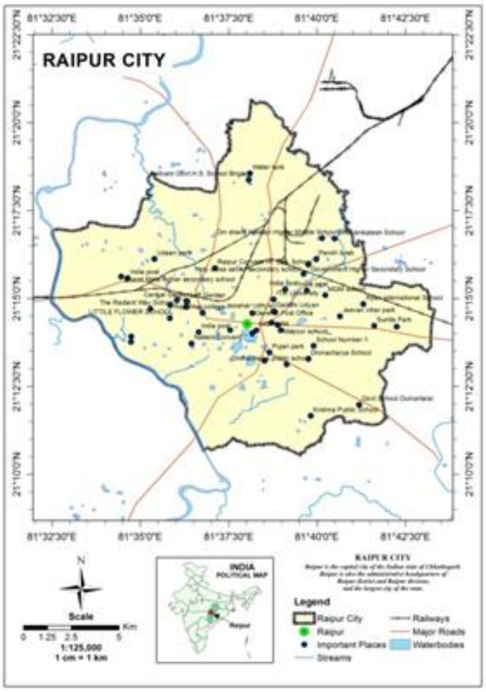
Location of Soil sample	Latitude	Longitude	Elevation (m)	Annual Temperature High / Low(°C)	Annual Rainfall (mm)
S 1	21°14′54.58’’N	81°32′50.69″E	271 m	32° / 24°	1318.9mm
S 2	21°14′54.58’’N	81°33′5.72″E	273 m	32° / 24°	1318.9mm
S 3	21°14′45.30’’N	81°33′5.72″E	275 m	32° / 24°	1318.9mm
S 4	21°14′45.30’’N	81°32′50.69″E	271 m	32° / 24°	1318.9mm

2.2.2Water sample collection:

The primary sampling point is in the surface water layer (0-5 cm from the surface) closest to the trenching ground (Fig.5) and (Table 2) for a total of 15 water samples obtained for water sampling. The top 1-2 cm of this surface layer, however, should be avoided so that floating dust, oil, etc. are not collected. In addition, if necessary to serve the purpose of the analysis, more samples can be obtained through the complete depth of the water column. The sampling point for lakes will be chosen after taking into account variables such as geography, whether there is fresh water (rivers or streams) or inflows of waste water, depth, tides, currents, etc. Before and after dumping, two samples are deposited in a river 100 m downstream. Buckets, open water grab samplers (a ladle or bottle at the end of a long pole) or vertical and horizontal triggered messenger samplers (such as Niskin bottles or Kemmerer water samplers) may be used for sampling.

Table 2. Location of Sampling

Locationof water sample	Latitude	Longitude	Elevation (m)	Annual Temperature High / Low(°C)	Annual Rainfall (mm)
W 1	21°14′54.58’’N	81°32′50.69″E	271 m	32° / 24°	1318.9mm
W 2	21°14′54.58’’N	81°33′5.72″E	273 m	32° / 24°	1318.9mm
W 3	21°14′45.30’’N	81°33′5.72″E	275 m	32° / 24°	1318.9mm
W 4	21°14′45.30’’N	81°32′50.69″E	271 m	32° / 24°	1318.9mm



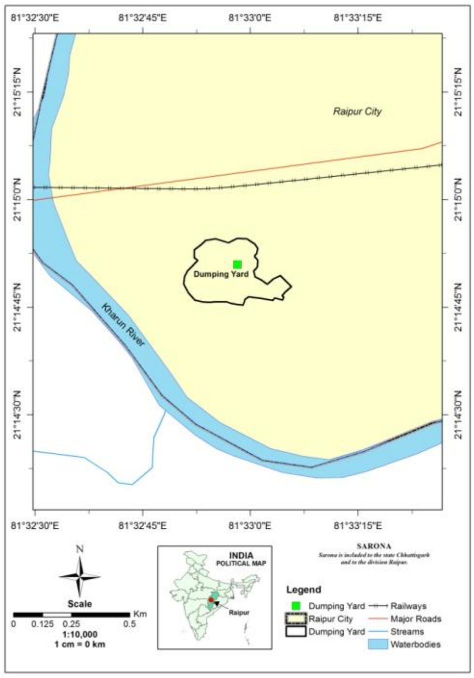


Figure 3. Location map of Raipur, Chhattisgarh, India **Figure 4**. Sampling map for study area

2.3 Method:

Mixing nitric acid (HNO_3) from the wastewater sample and taking the pH down to 2.0, was taken to the laboratory for heavy metal analysis. Wastewater quality assessed pH, temperature and conductivity and total dissolved solids (TDS) using EUTECH instruments. All air-dried, dry homogenised content sediment samples (passed 20-micron sieve) were weighted up to 1.00 gm. All sediments, as per USEPA 3050b method, are digested. The Atomic Absorption Spectrophotometer (AAS) was analysed for all diluted samples.

3.STATISTICAL ANALYSIS

The permissible mean concentrations of heavy metals in the soil samples are shown in Table 3. The data revealed that all the analyzed metals accumulated by the soil at different concentrations.

Table 3. Permissible limit of various metals

METAL	Primary drinking Water mg/L	Secondary drinking water mg/L	Hazardous waste screening criteria mg/kg	Hazardous waste limit TCLP mg/kg	Common range in soils mg/kg	Livestock k water quality mg/L	Surface water quality mg/L	Land application of sewage sludge ppm
Aluminium (Al)	-	0.05-0.20	-	10,000-300,000	10,000-300,000	5.0	-	-
Arsenic (As)	0.05	-	100	1-50 1-40	1-50 1-40	0.5	0.04	75
Antimony (Sb)	0.006	-	-	-	-	-	-	-
Barium (Ba)	2.0	-	2000	100-3,000	100-3000	-	1.0	-
Beryllium (Be)	0.004	-	-	-	-	-	-	-
Cadmium (Cd)	0.005	-	20	0.01-0.7	0.01-0.7	0.5	0.02	85
Chromium (Cr)	0.1	-	100	1-1000	1-1000 5-3000	1.0	0.05	3,000
Copper (Cu)	1.3	1.0	-	2-100	2-100	0.5	1.0	4,300
Iron (Fe)	-	0.3	-	7000-550,000	7000-550,000	-	-	-
Lead (Pb)	0.015	-	100	2-200	2-200	0.05	0.10	840
Manganese (Mn)	-	0.05	-	20-3000	20-3,000	-	0.002	57
Mercury (Hg)	0.002	-	4	0.01-0.3	0.01-0.3	0.01	0.01	420
Nickel (Ni)	-	-	-	5-500	5-500	1.0	0.05	100
Selenium (Se)	0.05	-	20	0.1-2.0	0.1-2.0	0.1	-	-
Silver (Ag)	-	0.1	-	0.01-5.0	0.01-5.0	-	-	-
Zinc (Zn)	-	5.0	-	10-300	10-300	25	5.0	-

Compiled by: Brent L. Balentine 7/95 (Direction of Everett Wilson) Revised by: Everett Wilson and Carl Solomon. source; https://www.occeweb.com/og/metals-limits.pdf.

3.1 Remediation of heavy metal in soils:

3.1.1 Engineering remediation
Engineering remediation refers to using physical or chemical methods to control heavy metal contamination of soils.

3.1.2 Replacement of contaminated soil, soil removal and soil isolation
Contaminated soil replacement requires the addition of vast amounts of clean soil to the surface of the contaminated soil to cover or blend with the contaminated soil. Removing the soil refers to removing the polluted soil and renewing it with clean soil, which is appropriate for a limited area of severely contaminated soil.

3.1.3 Electro kinetic remediation
A modern, economically efficient technology is soil electro-kinetic remediation. The theory is that the DC-voltage is used on both sides of the electrolytic tank containing the polluted soil to form the electric field gradient; pollutants in the soil are moved to the processing chamber situated on the two polar sides of the electrolytic cell by means of electro migration, electrical filtration or electrophoresis, thus reducing contamination. The mechanism performs well in the soil with low permeability.

3.1.4 Soil leaching
The theory of soil leaching is to wash the polluted heavy metal soil with unique reagents and thus dissolve the complex and soluble heavy metal iron adsorbed on the particles of the solid phase. Heavy metals are removed from the soil by using this process, and heavy metals are then recovered from the solution being collected.

3.1.5 Adsorption
Adsorption method is based on the fact that almost all heavy metal ions can be fixed and adsorbed by clay mineral (bentonite, zeolite, etc.), a steel slag, furnace slag, etc.

Table 4. Heavy metal concentration in wastewater and sediments

Name of Parameter	**W1**	**W2**	**W 3**	**S 1**	**S 2**	**S 3**
pH @ 25 °C	**7.4**	**7.7**	**7.3**	**8.1**	**8.3**	**8.5**
Conductivity	720µs/cm	2660µs/cm	384µs/cm	-	-	-
TDS	355 mg/L	320 mg/L	156 mg/L	-	-	-
Heavy metals (ppm)						
Nickel (Ni)	BDL	BDL	BDL	0.02	BDL	BDL
Cadmium (Cd)	0.012	BDL	BDL	BDL	BDL	BDL
Calcium (Ca)	60.0	95.0	54.0	45.0	47.0	5.2
Copper (Cu)	0.06	0.50	0.149	2.661	0.766	BDL
Zinc (Zn)	BDL	0.122	BDL	0.573	0.84	0.10
Iron (Fe)	0.301	1.112	0.20	12.2	10.65	9.31
Manganese (Mn)	0.05	0.49	0.139	2.109	0.65	0.41

4.Result and Conclusion

Based on the above results (Table 4), we conclude that the establishment of a solid waste plant for the processing and utilization of municipal solid waste at the Sarona site and the handing over of a recovered clean site after 20 years of cleaning and maintenance are based on the above results (Table 4). The construction period is 24 months and the concession period is 15 years. The total quantity of solid waste being dumped is around 4,00,000 to 5,00,000 T. It has been reported that the duration of service and maintenance is 20 years. The total full site area is approximately 78595 Sq-m, 19.4 acres. The bidder must take all precautionary steps and must ensure that fresh leachate is prevented from draining into the nearby Kharun River or polluting ground water. The presence of synthetic intragenic fertilizer, pigments in plastics, in dumping indicates that cadmium in wastewater samples.

The key objective of providing the correct way for power evacuation for either underground cable or transmission line from the forthcoming project to the current 132/33KV was indicated between 5 percent and 10 percent. The approval certificate for power evacuations was

authorized. In many respects, heavy metals are important for humans, especially in the manufacture of certain important products for human use, such as accumulators (lead), mercury arch lamps and thermometers (Hg), utensils and broad aluminum. The bio toxic effects might potentially be life-threatening when unduly exposed to them, so they cannot be ignored as these metals are invaluable in many respects, but precaution and proper industrial hygiene should be taken in handling them. The best solution is to avoid heavy metal contamination and eventual human poisoning, while heavy metal poisoning may be scientifically detected and medically treated. The dumping site of Sarona occupies 8.5 ha of land over 5, 20000 m2 of leading waste.
Nickel reveals the sample presence of nickel cadmium batteries, non-ferrous alloys and electronic waste products in sediments from table 4. The availability of limestone, which is a carbonate sedimentary rock, is shown by calcium. The copper value indicates the existence of electrical wiring, pigments, cooking utensils, fertilizer, and feed for animals. Due to the alloys, fungicides, batteries and rubber in the dump field, zinc remains present. Due to batteries, glass and fire operations in the dump sector, the Manganese are still present. That all these metals are diluted in river water is shown in Table 5. The values of heavy metals are subject to limitations. All residence is before 1 km of dump area and drinking water comes from government versatile, so as per local people, no illness due to drinking water found in this location.

Table 5. Concentration of heavy metals in Kharun river water (ppm)

Sample	Fe	Ni	Cd	Mn	Zn	Ca	Cu
Before 100 m dumping	0.21	BDL	0.001	0.031	BDL	55	BDL
After 100 m dumpling	0.28	BDL	0.001	0.041	BDL	58	0.02

The current situation at the dumping ground of Sarona:

Figure 6 shows the current situation at the dumping ground of study area as compare to figure 5. As the government order dumping landfill ground has moved from Sarona due to heavy smell, health problem and water contamination. Dumping has been closed since the last 1.5 years ago. The landfill is covered with soil and tree have been planted (Figure 6) with good arrangement of drip irrigation. There are numerous tree species, such as almonds, rosewood, mango, guava, blackberry, terminaliaarjuna, bombaxand other outdoor planted here.

Figure 5. Polluted Water beside landfill

Figure 6. Current situation in land fill

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