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Understanding the Soil Pollution Surrounding Municipal Solid Waste Landfill Site in Southwest Ahmedabad

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Abstract – *Improper management of municipal solid waste landfill sites and subsequent uncontrolled water and soil pollution surrounding landfill sites is posing threat to human and crop health. Soil pollution due to heavy metals has been an issue of great interest in the past few years because metals can impose harmful effect on soil ecosystem, agricultural production, ground water quality, food safety and human health through bioaccumulation across food chain (Yuan Chai, 2015). Agricultural, industrial, and urban developments have raised the possibility of metal accumulation in food crops and its risk to human health and well-being (Shahab Ahmadi Doabi, 2018). The study area has a complex polluting source like industrial activities, Pirana landfill leaching, tyre dust due to heavy traffic etc. The present work was carried out for soil pollution surrounding landfill area of Pirana site, a municipal solid waste dump site. For the study, surrounding area of the said landfill sites was divided into almost 100 spatial rectangular grids (~ 500 m x 500 m). Soil samples were collected from each such grid. A total of 100 surface soil samples were collected and analysed for metal concentration using atomic absorption spectroscopy (PinAAcle 900T, PerkinElmer). The results were used to infer concentration of various heavy metals present in the study area.*

Key Words*: *Heavy Metal, Soil Contamination, landfill, Atomic absorption spectroscopy, Surface soil

1. INTRODUCTION

With rapid economic growth and population size (Approx. 6 million) in Ahmedabad, the amount of municipal solid waste (MSW) generated in Ahmedabad is increased to 4,700 metric tonnes (AMC, 2017). The Pirana landfill has been city's major dumping yard since 1982 which is spreading over an area of 84 hectares. The landfill is characterised by three 75 feet (Approx. 22 meters) high massive mounds of garbage, each weighing 69 lakh metric tonnes (AMC, 2017). Landfill fire of MSW from non-engineered landfill in developing countries poses a risk of heavy metal pollution into soil (Willis Gwenzi et al., 2016). With comparison to incineration ash, it has only limited information on heavy metal leaching from open-burning ash and soil from non-engineered landfills (Willis Gwenzi et al., 2016). Heavy metals present in MSW evaporate during the landfill fire process and mainly transfer to the fly ash and flue gas (Weibel et al.,2017), and eventually accumulated in soil by wet and dry deposition (Rimmer et al., 2006). This leads to soil contamination and threatens food safety, posing a health risk to people living in the neighbourhood of MSW (Tepanosyan et al., 2017).

Heavy metal pollution is affecting the production and quality of crops as well as it also influences the quality of the atmosphere and water bodies, and threatens the health and life of animals and human being (Kumar, 2008). Influence of human activity as a major cause for metal contamination of the ecosystem is identified by several researches (Charlesworth et al., 2003; Tüzen, 2003; Al-Khashman, 2004; Banat et al., 2005; Chen et al., 2005). Metals are considering among the most dangerous environmental pollutants, because they do not disintegrate with physical processes and therefore remain for longtime period. They affect biogeochemical cycles and accumulate within living organisms, eventually making their way to humans through the food chain, where they can cause perturbation to biological reactions, long- lasting harm to vital organs or even death (Tiller, 1989).

Heavy metals (HMs) in dust and soil can be easily transferred into human body via three routes: ingestion, inhalation and dermal contact (Qing et al., 2015; Wu et al., 2015). Many investigations have confirmed that HMs accumulate in fatty tissues and then affect the functions of nervous system, endocrine system, immune system, cardiovascular system, urogenital system, normal cellular metabolism, etc. (Li et al., 2013; Wang, 2013) and significant negative effects on human health, ranging from acute reactions to chronic illnesses (Wang et al., 2015). The Chromium (Cr) is toxic or carcinogenic even at low concentrations when people are exposed for a long time (Khan et al., 2015; Zhang et al., 2015). The toxicity of Zn and Cu can change the function of the human central nervous system and respiratory system, and disrupt the endocrine system (Ma and Singhirunnusorn, 2012). Oral exposure to Ni can result in an increased incidence of allergic contact dermatitis, eczema, and respiratory effects in humans (ANL, 2001).

According to numerous studies, the pollution sources of HMs in environment are mainly derived from anthropogenic sources. The anthropogenic sources of metals in urban areas include traffic emission (vehicle exhaust particles, tire wear particles, weathered street surface particles,), industrial emission (power plants, coal combustion, metallurgical industry, auto repair shop, chemical plant, etc.), domestic emission, weathering of building and pavement surface, atmospheric deposited (Doabi et al., 2018) and in agricultural areas include mining, waste disposal sewage, pesticides, fertilizers, and vehicle exhausts (Shahab Ahmadi Doabi et al., 2018). So, metal speciation is to find out that how strongly they are retained in soil and their easiest way to release into soil solution (Kaasalainen and Yli-Halla, 2003).

The main objective of this study was the characterization of soil samples issued around pirana landfill located in southwest Ahmedabad in relation to their content of heavy metals. The soil samples collected from the study area, one of the most complex polluting areas where metal processing, chemical, Textile, cement, food and wood industries are located with huge pirana landfill leaching and tyre dust pollution by heavy traffic issues due to National Highway. The current study aimed elaborate the following objectives: 1) to determine total concentrations distribution of Ten heavy metals (Zn, Cu, Ni, Co, Fe, As, Cd, Pb, Al, Cr. To our knowledge, this study is the first attempt to analyse of heavy metals present in surface soils of southwest Ahmedabad.

2. MATERIALS AND METHODS

2.1 STUDY AREA

The location of Ahmedabad city is on the banks of the river Sabarmati in the part of northern Gujarat and the western part of India at 23.03°N 72.58°E. The population of Ahmedabad Municipal Corporation (AMC) was 3.5 million with area 191 km2 in 2001 and the population of the Ahmedabad urban agglomeration was 4.5 million with area of 600 km2 (Census of India, 2001). Ahmedabad is having Hot and semi-arid type of climate (Köppen climate classification: BSh). It is having marginally less rain than required for a tropical savanna climate. There are three main seasons: summer, monsoon and winter. Except from the monsoon season, the climate is extremely dry during the whole period of year. The weather is hot from March to June with having average summer maximum is 43 °C (109 °F), and the average minimum is 24 °C (75 °F). From November to February, it is having the average maximum temperature is 30 °C (86 °F), the average minimum is 13 °C (55 °F), and the climate is extremely dry. The reason behind mild chill in January is Cold northerly winds. Business and commerce, transportation and communication, construction, and other services, has grown rapidly in the city and dominates to the pollution.

The study area is southwest zone in Ahmedabad which is around 4-5 km radius of pirana landfill site and is a typical rural-industrial zone in Ahmedabad. The area has the advantage of good transportation and has a National highway 64 (Narol - sarkhej road). Pirana landfill, Diverse industries and heavy traffic, which provide various heavy metal sources and made challenging to quantify the appropriate sources.

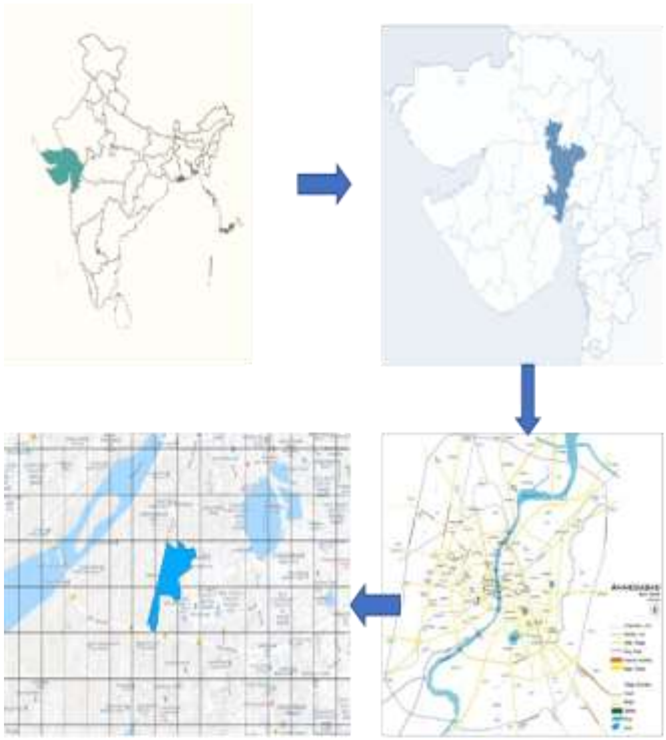

Fig-1: Study area

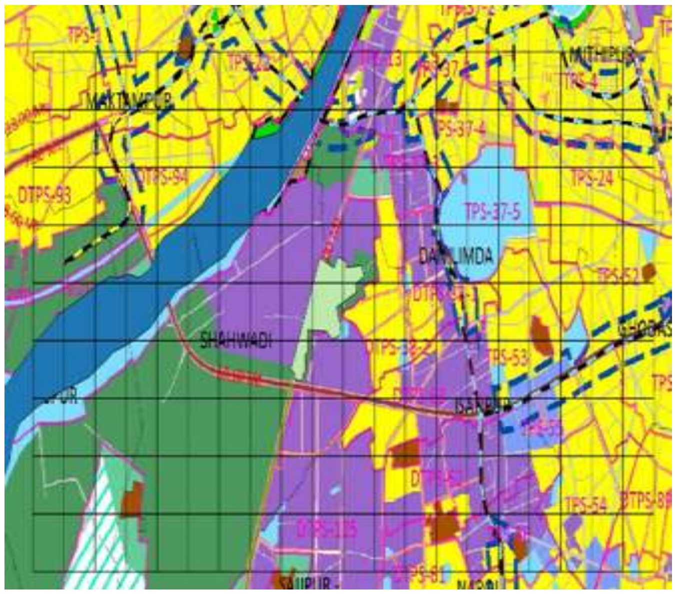

Fig-2: Study area with land feature

2.2 SAMPLE COLLECTION AND PREPARATION

2.2.1 SURFACE SOIL SAMPLING

Based on the predominant crop distribution, sizes of agricultural area, and probable sources of soil pollution, the whole study area has divided into 100 spatial rectangular grids (~500 m x 500 m). 100 surface soil samples (AS) were collected from 0 to 10 cm depth from the centres (almost) of the 500 mm grid squares in September-January 2018-19 across south waste Ahmedabad (Fig. 3). Each Sample was collected on single day from single grid on non-rainy days and average temperature was 15-20◦C in study area during sample collection. For every grid, major sampling points were selected near heavy traffic roads, landfill, industries and major polluting features. Each sample (about 100 gm dry weight) was collected from a designated location by composite of five subsamples from nearby sites (approximately 5-10 m apart) using glassware. These composite soil samples were tightly packed (to resist contamination) in polyethylene bags and transmitted to laboratory for chemical analyses. All soil samples were air-dried by using hot air oven (Spectra Labtech) at 100◦C for 30-60 minutes in laboratory. After removing the stones and other debris, samples were passed through 2 mm polyethylene sieve.

On each sampling point, the latitude, longitude, location ID, Type of area, date, day and timing of collected sample were noted.

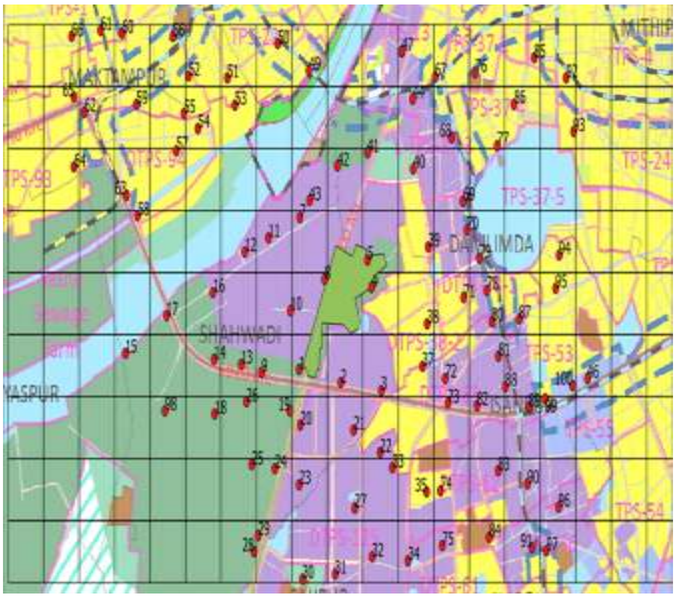

Fig-3: Sample collection points

3. CHEMICAL ANALYSIS

In order to measurements of heavy metals, an accurately weighted 0.5 gm of agricultural soil sample by using weighing machine (Radwag AS 220.R2) and were placed in a test tube. After that 10 ml typical mixture of concentrated 3:1 HCL/HNO_3 was added to each test tube having soil samples. Each test tube was covered with an air condenser and left at room temperature overnight (Approx. 24 hrs). On other day after 24 hrs samples were refluxed gently by using centrifuge (Remi R-8C) at 2000-3000 RPM for 10 minutes and then heated to 90-95◦C for 10 minutes in digester (KES 06L R TS, KELPLUS) After cooling, the solution was filtered through a Whatman 42 filter paper and stored in glass bottles. Based on the need, the sample was diluted to 50 ml volume with distilled water (Doabi et al., 2018; Sparks et al., 1996; Karimi et al., 2009). Digestion and analysis of all the soil samples were done by using method 3050A of the US Environmental Protection Agency (US EPA, 1998). The total concentrations of Zn, Cu, Ni, Co, Fe, As, Cd, Pb, Al, Cr and Hg were determined using an Atomic Absorption Spectrophotometer AAS (PinAAcle 900T, PerkinElmer). The Calibration curves were prepared for every single metal by using standard metal solution. Graphite Furnace atomic absorption (GFAA) was used for the analysis of heavy metal from soil. For the accuracy of concentration of heavy metals, three replicates were analysed and its mean is used further as metal concentration.

4. RESULTS AND CONCLUSION

4.1 HEAVY METAL ANALYSIS OF SOIL SAMPLES

The 100 examined sites in southwest Ahmedabad region are distributed in majorly 25 km^2 area of Ahmedabad around pirana landfill. As shown in Fig. 3 the examined sites are densely distributed in the southwest Ahmedabad with very small distances of 500m and obviously covered all industrial, commercial, residential and agricultural zones of region. The major industrial zone, Pirana landfill, Agricultural zone are included for sample collection and that is why the obtained dataset of this work has a good representation.

Heavy metal concentrations in surface soil samples showed significant variations between sites of each sample collection points. However, the sitewise variation was not significant for Cd, As, Zn, Cr and Pb. The mean concentrations (mg/kg) of heavy metals ranged 4.63 for Cu, 13.61 for Fe, 2.62 for Ni, 3.13 for Co, 17.95 for Al, 0.67 for As, 1.00 for Pb, 2.64 for Cr, 1.60 for Cd, 0.66 for Hg and 1.63 for Zn (Table.1). The concentration of heavy metals were ranged from 0-59.6 for Cu, 4.8-22.16 for Fe, 0-25.88 for Ni, 0-31.38 for Co, 0-144.58 for Al, 0-2.92 for As, 0-7.18 for Pb, 0.5 to 2.64 for Cr, 0-5.33 for Cd, 0-1.97 for Hg and 0-10.15 for Zn (Table. 1). The highest concentration was recorded for Aluminium (144.58 mg/kg) and the lowest was of chromium (5.01 mg/kg). Here we can compare the values of heavy metals to standard permissible limits given in figure 4. By taking permissible limits into consideration, Cu, Fe, Pb, As have high concentration for sampling sites nearer to pirana landfill, Narol-Sarkhej highway and industrial area. At some sites the concentration of metals were also observed zero except Fe and Cr. The contour maps were prepared in ArcGIS software showing the variation of concentration of different metal in the study areas. These maps help to determine the hotspots of the different heavy metals and eventually helps to find the sources emitting them accordingly.

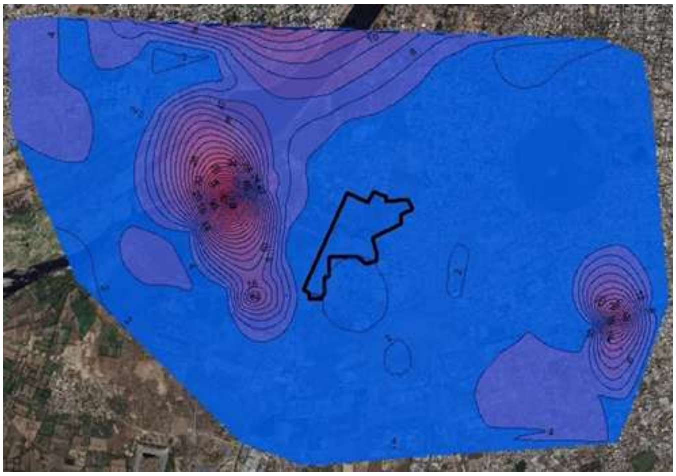

Fig-5: Copper Concentration (mg/kg)

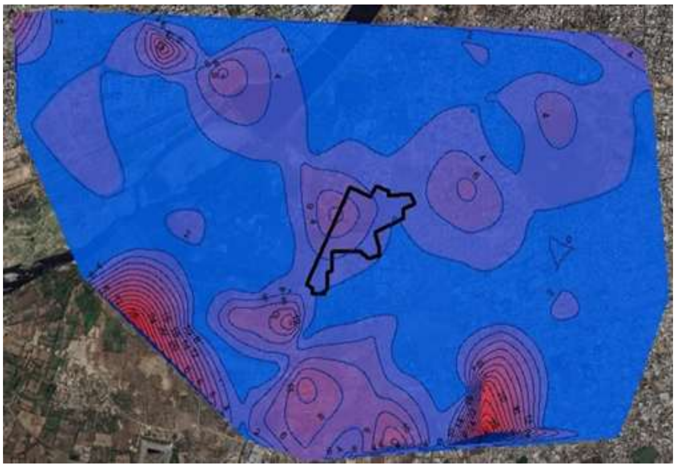

Fig-6: Cobalt Concentration (mg/kg)

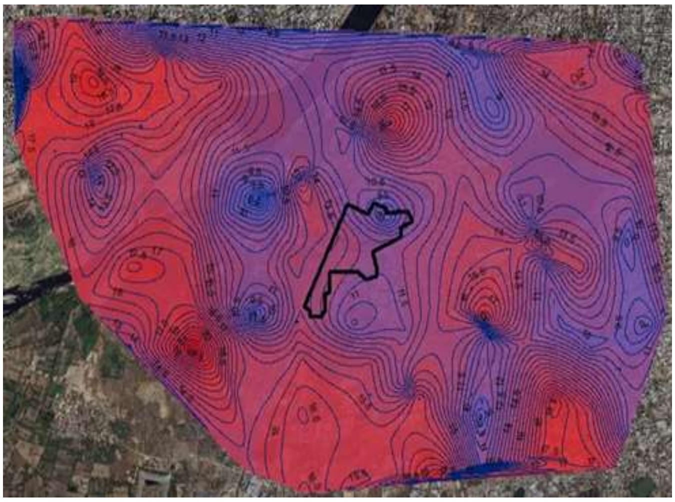

Fig-7: Iron Concentration (mg/kg)

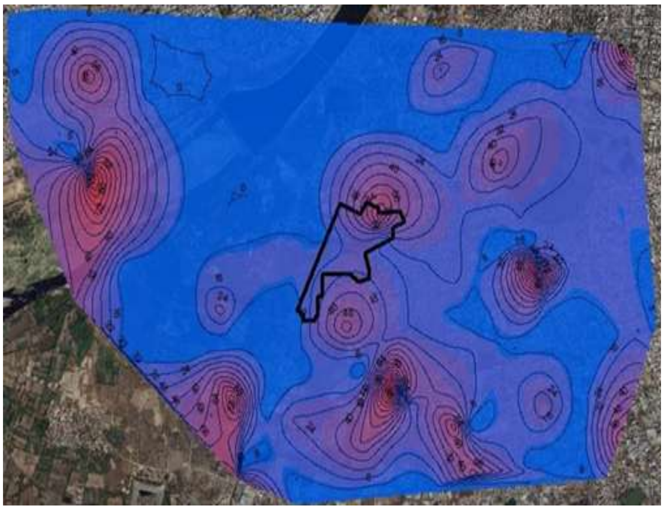

Fig-8: Aluminium Concentration (mg/kg)

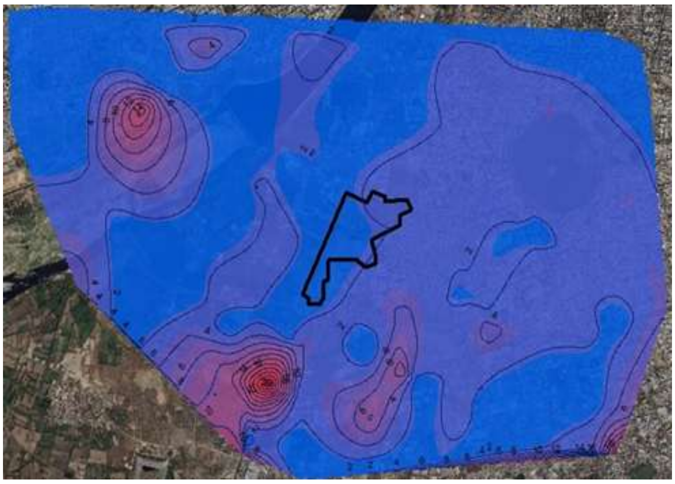

Fig-9: Nickel Concentration (mg/kg)

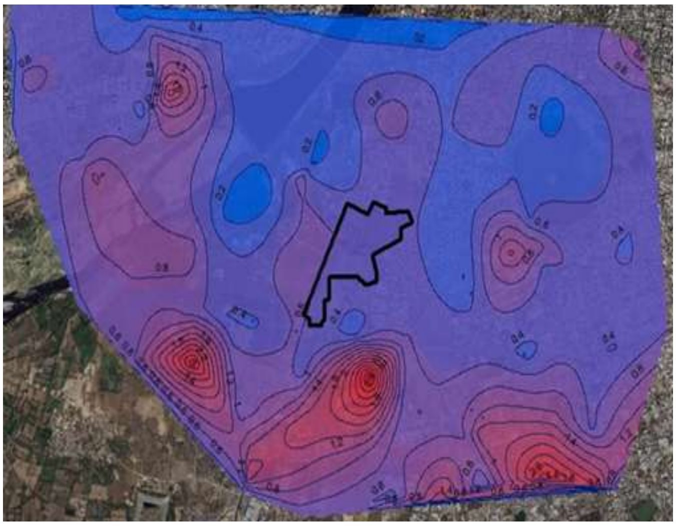

Fig-10: Arsenic Concentration (mg/kg)

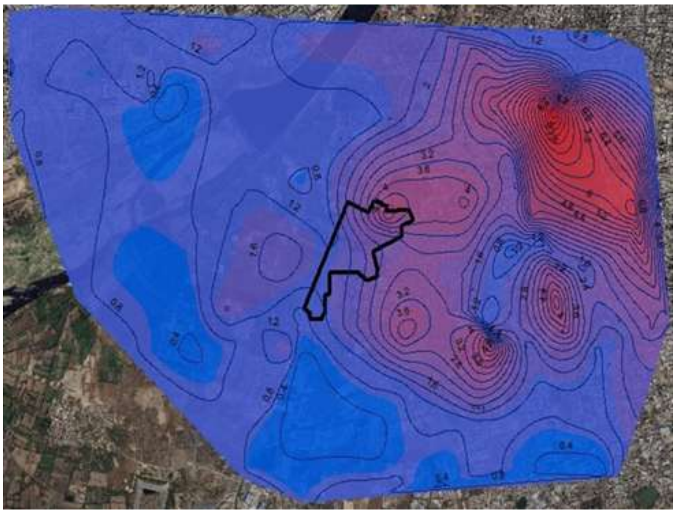

Fig-11: Zinc Concentration (mg/kg)

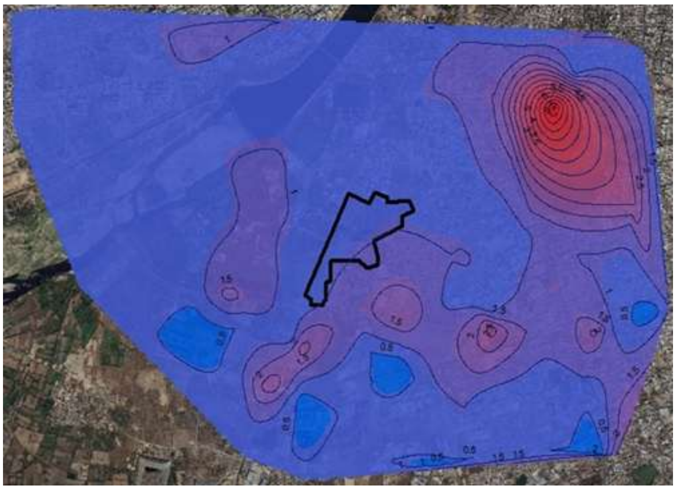

Fig-12: Lead Concentration (mg/kg)

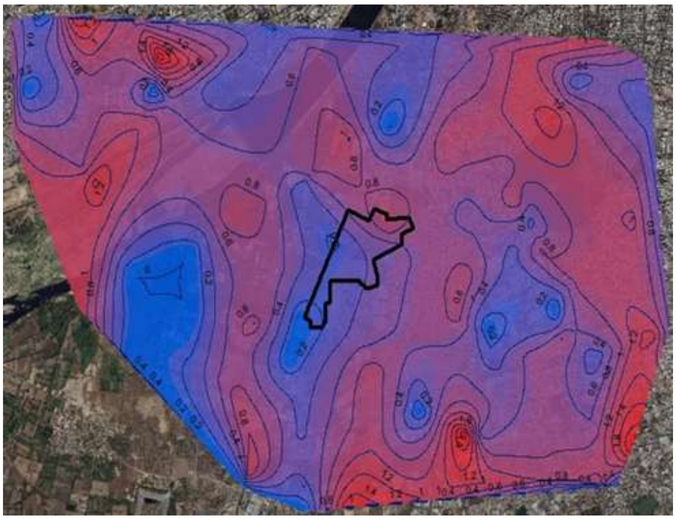

Fig-13: Mercury Concentration (mg/kg)

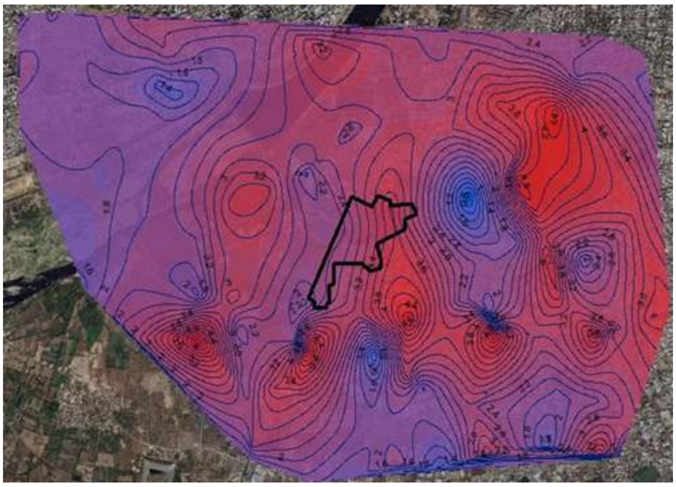

Fig-14: Chromium Concentration (mg/kg)

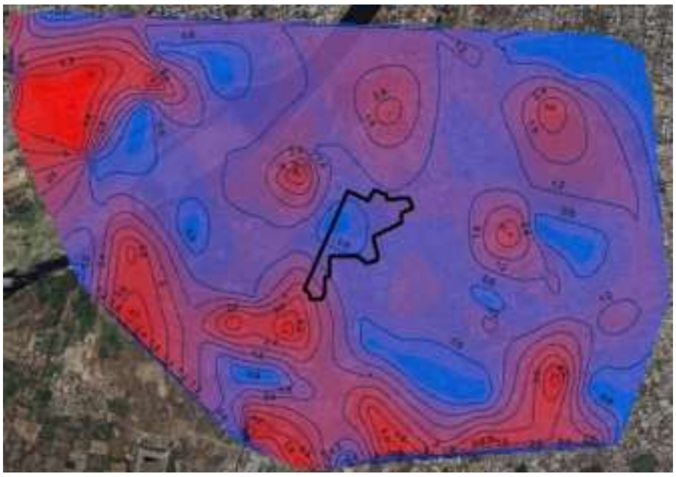

Fig-15: Cadmium Concentration (mg/kg)

5. CONCLUSIONS

Soil pollution is increasing from several local sources in Ahmedabad. Available studies suggest that rapid urban growth has led to emissions and stationary sources in Ahmedabad. In this study, the concentration of total 11 heavy metals were analyzed.

This study has shown that the study area has high concentration of Al between the range of 0-144.58 mg/kg but it is majorly a natural source and at two or three sites it is from steel industry around. The mean conc. of Cu, Fe, Ni, Co, Al, As, Pb, Cr, Cd, Zn and Hg is 4.63 mg/kg, 13.61 mg/kg, 2.62 mg/kg, 3.13 mg/kg, 17.95 mg/kg, 0.67 mg/kg, 1 mg/kg, 2.64 mg/kg, 1.60 mg/kg, 1.63 mg/kg and 0.66 mg/kg respectively.

The results of this study conclude that the concentration of heavy metal Cu, Fe, Pb, As and Cd is higher than standard permissible limits at sampling sites nearer to pirana landfill and industrial area. Also, the regular monitoring of heavy metal pollution and certain steps should be taken up in the study area as soon as possible to minimize the rate, and extent of future pollution problems.

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