# Heavy Metal Contamination in Soil of Industrial Area, Dewas, Madhya Pradesh, India

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***Abstract—*** *A study has been conducted to assess the heavy metal contamination in soil of Dewas industrial area of Madhya Pradesh, India. Total eight locations and one control location were selected in Dewas industrial area for soil quality monitoring w.r.t. heavy metals. The nine soil samples were monitored for heavy metals such as Chromium (Cr), Manganese(Mn), Nickel (Ni), Copper (Cu), Zinc (Zn), Iron (Fe), Cadmium (Cd), Lead (Pb) and Cobalt (Co) analysis during different four quarters from April 2019 to March 2020. The heavy metal contamination with w.r.t. Contamination Index (CI), Pollution Load Index (PLI) study in selected locations in Dewas industrial area has been done. Over all Pollution Load Index of soil was found greater than 1 which shows polluted soil w.r.t. heavy metals at all selected monitoring locations in Dewas industrial area of Madhya Pradesh, India during this study*.

***Keywords— Industrial Area, Soil, Heavy Metals, Contamination Index (CI), Pollution Load Index (PLI).***

## I. INTRODUCTION

Heavy metals and trace elements are also a matter of concern due to their non biodegradable nature and long biological half-lives [1]. Soil pollution due to heavy metals, such as cadmium, lead, chromium, copper, and iron is a problem of concern. Although heavy metals are naturally present in soil, contamination comes from local sources: mostly industry, agriculture, waste incineration, combustion of fossil fuels, and road traffic. The most important sources of heavy metals in soil are the anthropogenic activities such as mining, smelting procedures, steel & iron industry, chemical industry, traffic, and agriculture as well as domestic activities [2–11]. Soil is a dynamic medium made up of many minerals, organic matter, water, air, living creatures including bacteria and earthworms. It was formed by changing due to physical factors; the parent material, time, the climate and organisms present in composition. Generally polluted water also pollutes soil as it percolate in it. Solid waste is a mixture of plastics, cloth, glass, metal and organic matter, sewage, sewage sludge, building debris, generated from households, commercial and industries establishments add to soil pollution. Fly ash, iron & steel slag, medical & industrial wastes disposed on land are important sources of soil pollution. Chemical and metallurgical industries are the most important sources of heavy metals in soil [12–14]. The problem of soil pollution due to toxic metals has begun to cause concern now in most of the major cities. Soil pollution in the environment with toxic metals has increased dramatically since the onset of the industrial revolution [15-16]. Heavy metals in soil plays important role in biological system but it can cause harm if it in higher concentration in any system of environment. Therefore concentration of Contamination Index (CI), Pollution Load Index (PLI) w.r.t. heavy metals in Dewas Industrial area in Madhya Pradesh, India is important.

## II. METHODOLOGY

### 2.1 Study Area

Dewas District in Ujjain Revenue Division, is situated on the Malwa plateau in the West-central part of Madhya Pradesh, India and lies between 20°17´ and 23°20´ North latitude and 75°54´ and 77°08´ East longitude. The district is bounded by Ujjain district in the north, Indore district in the west, West-Nimar district in the south-west, East Nimar district in the south, Hoshangabad district in the South East, Sehore district in the east and Shajapur district in the North-East.

### 2.2 Monitoring Locations

Dewas industrial area is consist of four industrial area i.e. Industrial Area 1, Industrial Area 2 & 3, Sia Industrial Area, Ujjain Road Industrial Area. Total eight locations and one control location in different industrial area in Dewas were selected for soil is depicted in table no 1 and figure no 1.

**TABLE 1**
**MONITORING LOCATIONS AT DEWAS INDUSTRIAL AREA**

| S.N | Code | Industrial Area | Monitoring Locations | Latitude & Longitude |
|---|---|---|---|---|
| 1. | S1 | Industrial Area 1 | Near M/S White star milk and milk products , Dewas | 22.5754 & 76.2453 |
| 2. | S2 | Industrial Area 1 | Near M/S Tata International Ltd, Dewas | 23.1064 & 77.52432 |
| 3. | S3 | Industrial Area 1 | Near M/S Raj Pioneer Laboratories (India), Dewas | 23.07689 & 77.55652 |
| 4. | S4 | Industrial Area 2 & 3 | Near M/S Roca Bathroom Products Pvt Ltd (Parryware Industry) Dewas | 23.11448 & 77.51583 |
| 5. | S5 | Industrial Area 2 & 3 | Near M/S VE Commercial Vehicle Ltd unit 2 (Eicher), Dewas | 23.10886 & 77.51757 |
| 6. | S6 | Industrial Area 2 & 3 | Near M/S Navin Fluorine International Ltd, Dewas | 23.09844 & 77.52922 |
| 7. | S7 | Sia Industrial Area | Near M/S Krishna Food Products Ltd, Dewas | 23.08073 & 77.53493 |
| 8. | S8 | Ujjain Road Industrial Area | Near M/S Kriloskar Brother's Ltd, Dewas | 23.07719 & 77.54176 |
| 9. | CS (Control Site) | Ujjain Road Industrial Area | Near M/S Bank Note Press , Dewas | 23.07449 & 77.53204 |

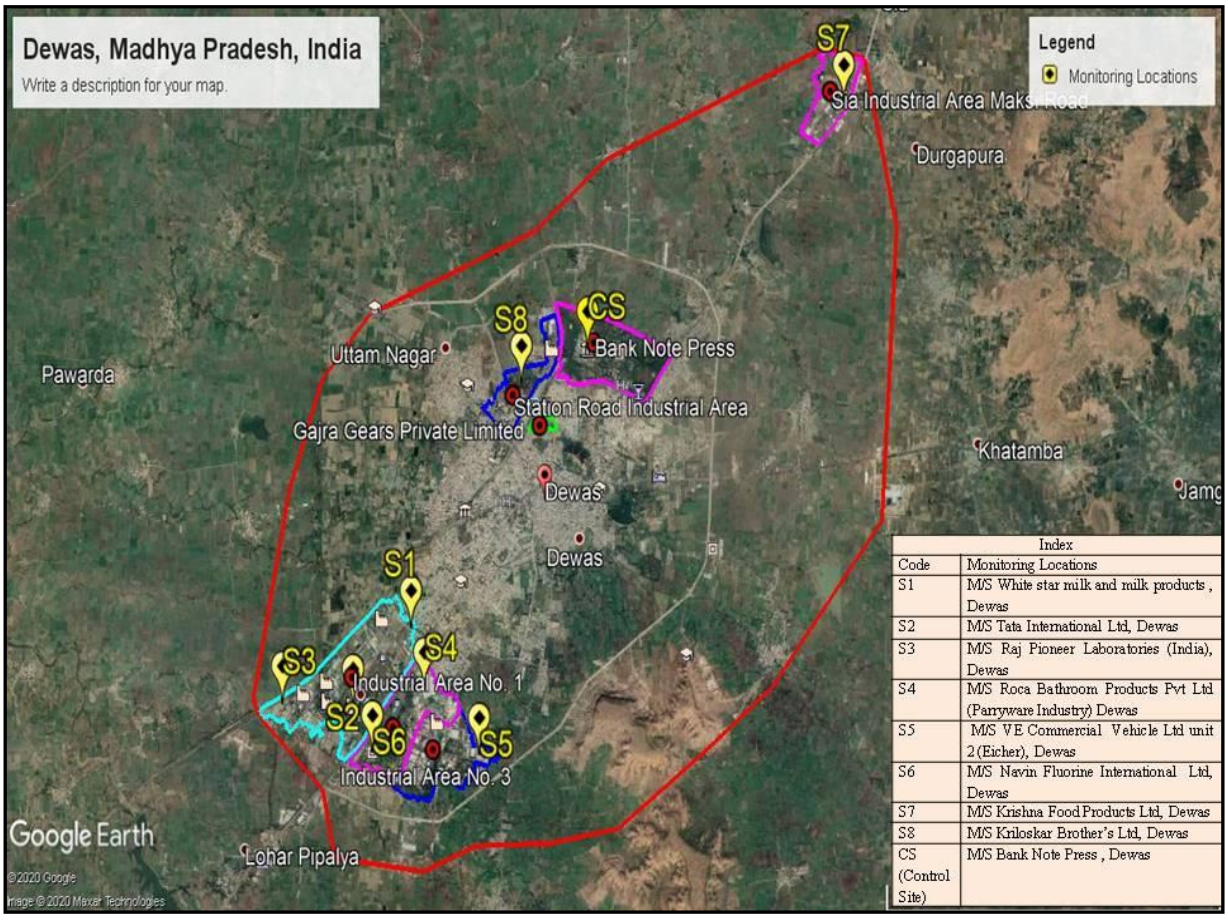


**FIGURE 1: Monitoring Locations at Dewas industrial area**

### 2.3 Monitoring

All soil samples were collected as per standard guidelines followed by Central Pollution Control Board. The aliquots of soil mixed together (unwanted matters to be separated manually before mixing of samples) during collection from the each selected sampling area. Out of this mixture, approx. 500 gm sample to be taken into polypropylene zip pouch, duly coded,

labeled at field as per guidelines of Central Pollution Control Board. Soil samples were collected from the outer surface, i.e. 05–15 cm depth, after removing surface contamination. Sampling was carried out using a plastic spatula and the use of metal tools was avoided. The samples were collected in self-locking polythene bags and were sealed in double bags.

### 2.4 Digestion and Analysis:

Soil samples were dried for two days at room temperature. The dry soil sample was disaggregated with mortar and pestle. The sample was finely powdered to –250 mesh size (US Standard) using a swing grinding mill. All soil samples were digested by EPA Method 3050B (Acid Digestion of Sediments, Sludges and Soils) and analyzed by atomic absorption spectrophotometer (Perkin Elmer Pinnacle 900H) [17].

### 2.5 Soil Pollution Indices

Pollution assessment models are indicators used to assess the presence and intensity of anthropogenic contaminant deposition on soils. In this study, the following pollution assessment models were employed: Contamination Index (CI), Pollution Load Index (PLI) w.r.t heavy metals concentration present in soil.

#### 2.5.1 Contamination Index (CI):

The contamination factors were derived by using the CI equation as defined [18]:

$$CF = Cn/Bn \quad (1)$$

Where Cn = measured metal concentration and Bn = background concentration from control site. The concentration factor observe as; CF < 1 low; 1 < CF < 3 moderate; 3 < CF < 6 considerable, and CF > 6 as high contamination [19].

#### 2.5.2 Pollution Load Index (PLI):

The PLI gives a generalized assessment on the level of soil contamination. The PLI is obtained using approach as follows [20]:

$$PLI = [CF1 \times CF2 \times CF3 \times \ldots\ldots. \times C\ n]\ 1/n \quad (2)$$

Where, CF= contamination factor; and n = number of metals. PLI > 1 indicates pollution exists; PLI < 1 indicates no metal pollution [21]; and PLI = 1 indicates heavy metal loads close to the background level [22].

## III. RESULT & DISCUSSION

The observed concentration of heavy metals in soil is depicted in Table 2. Contamination index (CI) and Pollution load index (PLI) w.r.t. heavy metals in soil of all selected locations are presented in Table 3. All results are shown in figure no. 2 to figure no 11.

**TABLE 2**
**HEAVY METALS CONCENTRATION IN SOIL**

| S.N | Analytes | Unit | CS | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cr | mg/kg | 89 | 113 | 149 | 127 | 230 | 545 | 120 | 417 | 129 |
| 2 | Mn | mg/kg | 524 | 921 | 1301 | 927 | 771 | 1566 | 1105 | 891 | 1274 |
| 3 | Ni | mg/kg | 42 | 43 | 73 | 65 | 43 | 90 | 61 | 52 | 47 |
| 4 | Cu | mg/kg | 81 | 172 | 192 | 153 | 129 | 146 | 117 | 110 | 179 |
| 5 | Zn | mg/kg | 89 | 140 | 114 | 110 | 124 | 116 | 99 | 119 | 173 |
| 6 | Co | mg/kg | 30 | 36 | 42 | 38 | 34 | 39 | 38 | 32 | 42 |
| 7 | Cd | mg/kg | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 8 | Fe | mg/kg | 15323 | 46456 | 56801 | 48573 | 33429 | 52437 | 43657 | 27668 | 45858 |
| 9 | Pb | mg/kg | 59 | 63 | 118 | 93 | 89 | 93 | 102 | 72 | 116 |

**TABLE 3**
**CONTAMINATION INDEX (CI) AND POLLUTION LOAD INDEX (PLI) OF SOIL**

| Heavy Metal | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 |
|---|---|---|---|---|---|---|---|---|
| Cr | 1.269 | 1.674 | 1.426 | 2.584 | 6.123 | 1.348 | 4.685 | 1.449 |
| Mn | 1.757 | 2.482 | 1.769 | 1.471 | 2.988 | 2.108 | 1.7 | 2.431 |
| Ni | 1.023 | 1.738 | 1.547 | 1.023 | 2.142 | 1.452 | 1.238 | 1.119 |
| Cu | 2.123 | 2.37 | 1.888 | 1.592 | 1.802 | 1.444 | 1.358 | 2.209 |
| Zn | 1.573 | 1.28 | 1.235 | 1.393 | 1.3 | 1.112 | 1.337 | 1.943 |
| Co | 1.2 | 1.4 | 1.266 | 1.133 | 1.3 | 1.266 | 1.066 | 1.4 |
| Cd | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| Fe | 3.031 | 3.706 | 3.169 | 2.181 | 3.422 | 2.849 | 1.805 | 2.992 |
| Pb | 1.067 | 2 | 1.576 | 1.508 | 1.576 | 1.728 | 1.22 | 1.966 |
| **Pollution Load Index (PLI)** | **1.573** | **1.827** | **1.568** | **1.47** | **2.051** | **1.633** | **1.636** | **1.869** |

Figure no 2 is showing that average concentration of Chromium (Cr) was found 89 mg/kg at control site (CS). Minimum average concentration was found 120 (S6) mg/kg and maximum average concentration was found 545 (S5) mg/kg during this study.

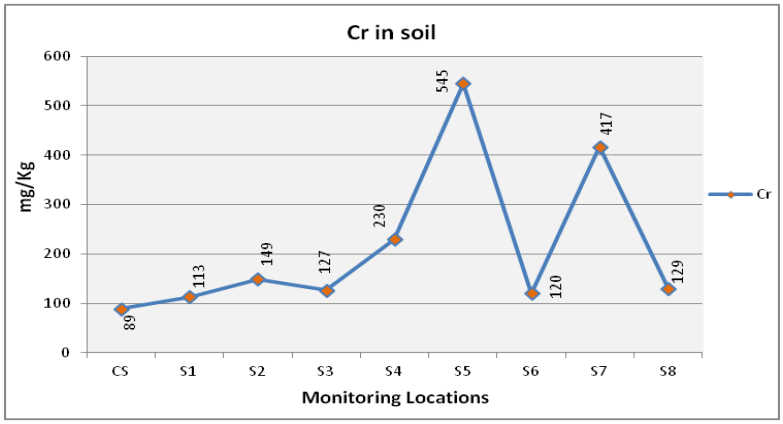


**FIGURE 2: Chromium (Cr) concentration in Soil**

Figure no 3 is showing that average concentration of Manganese (Mn) was found 524 mg/kg at control site (CS). Minimum average concentration was found 771 (S4) mg/kg and maximum average concentration was found 1566 (S5) mg/kg during this study.

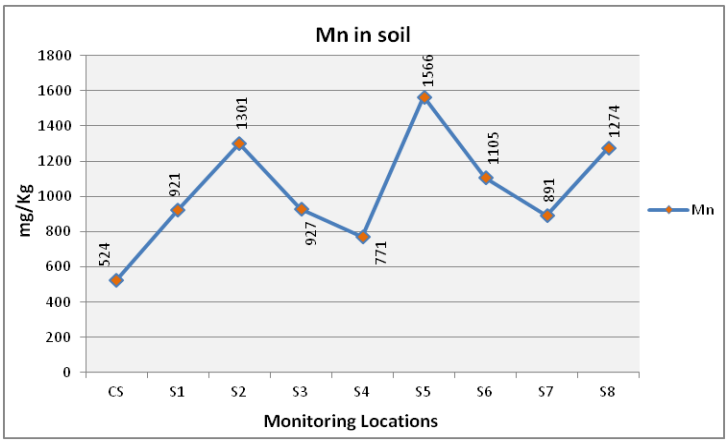


**FIGURE 3: Manganese (Mn) concentration in Soil**

Figure no 4 is showing that average concentration of Nickel (Ni) was found 42 mg/kg at control site (CS). Minimum average concentration was found 43 (S1) mg/kg and maximum average concentration was found 90 (S5) mg/kg during this study.

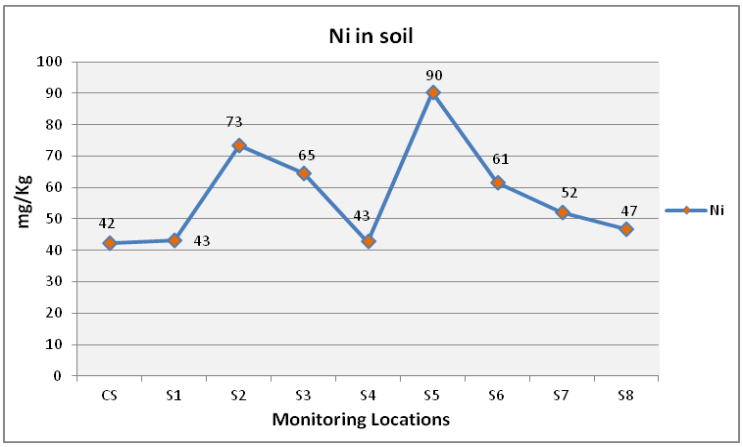


**FIGURE 4: Nickel (Ni) concentration in Soil**

Figure no 5 is showing that average concentration of copper (Cu) was found 81 mg/kg at control site (CS). Minimum average concentration was found 110 (S7) mg/kg and maximum average concentration was found 192 (S2) mg/kg during this study.

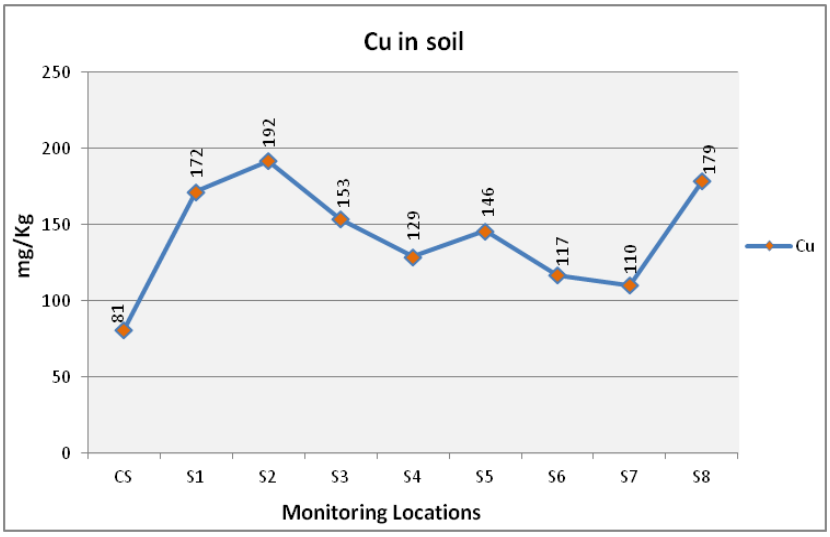


**FIGURE 5: Copper (Cu) concentration in Soil**

Figure no 6 is showing that average concentration of zinc (Zn) was found 89 mg/kg at control site (CS). Minimum average concentration was found 99 (S6) mg/kg and maximum average concentration was found 173 (S8) mg/kg during this study.

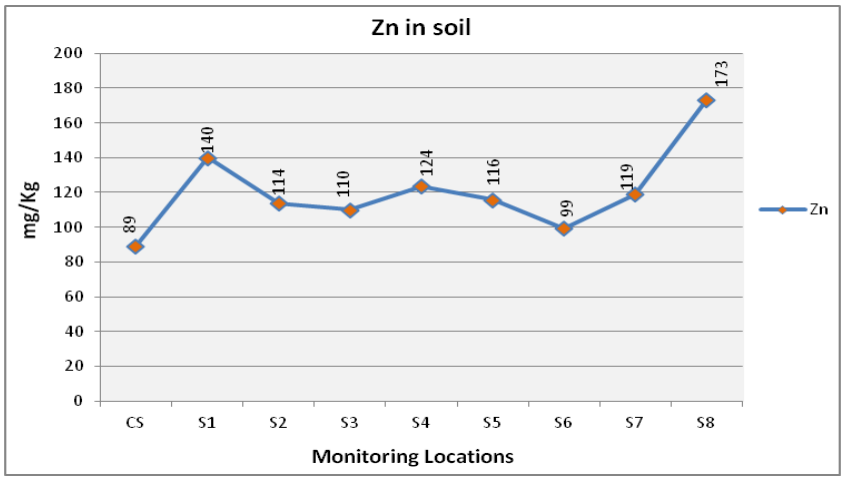


**FIGURE 6: Zinc (Zn) concentration in Soil**

Figure no 7 is showing that average concentration of Cobalt (Co) was found 30 mg/kg at control site (CS). Minimum average concentration was found 32 (S7) mg/kg and maximum average concentration was found 42 (S2, S8) mg/kg during this study.

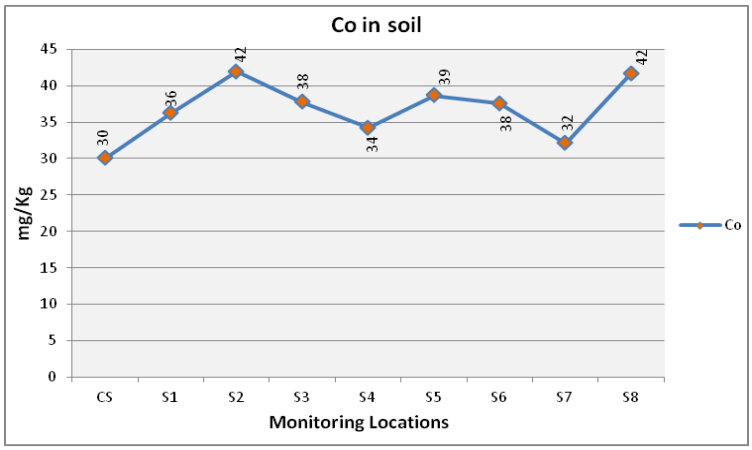


**FIGURE 7: Cobalt (Co) concentration in Soil**

Figure no 8 is showing that average concentration of cadmium (Cd) was found 1 mg/kg at control site (CS). Minimum average concentration was found 1 (S2, S3, S4, S5) mg/kg and maximum average concentration was found 2 (S1, S6, S7, S8) mg/kg during this study.

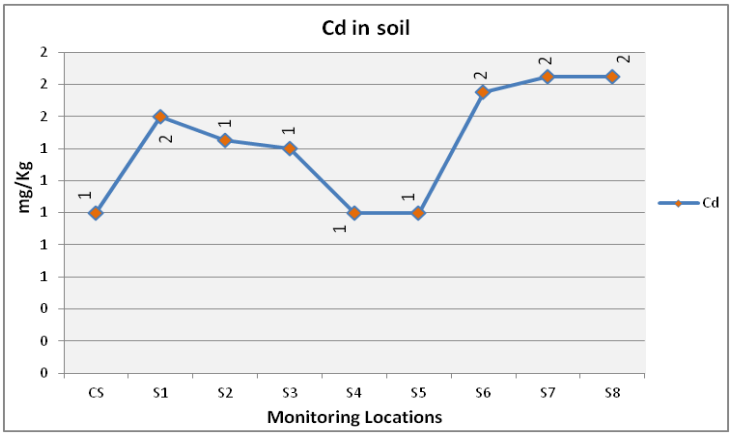


**FIGURE 8: Cadmium (Cd) concentration in Soil**

Figure no 9 is showing that average concentration of iron (Fe) was found 15323 mg/kg at control site (CS). Minimum average concentration was found 27668 (S7) mg/kg and maximum average concentration was found 56801 (S2) mg/kg during this study.

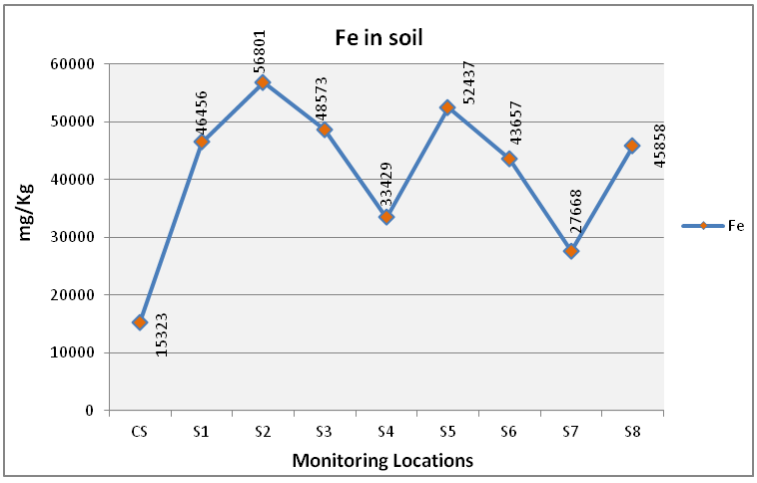


**FIGURE 9: Iron (Fe) concentration in Soil**

Figure no 10 is showing that average concentration of lead (Pb) was found 59 mg/kg at control site (CS). Minimum average concentration was found 63 (S1) mg/kg and maximum average concentration was found 118 (S2) mg/kg during this study.

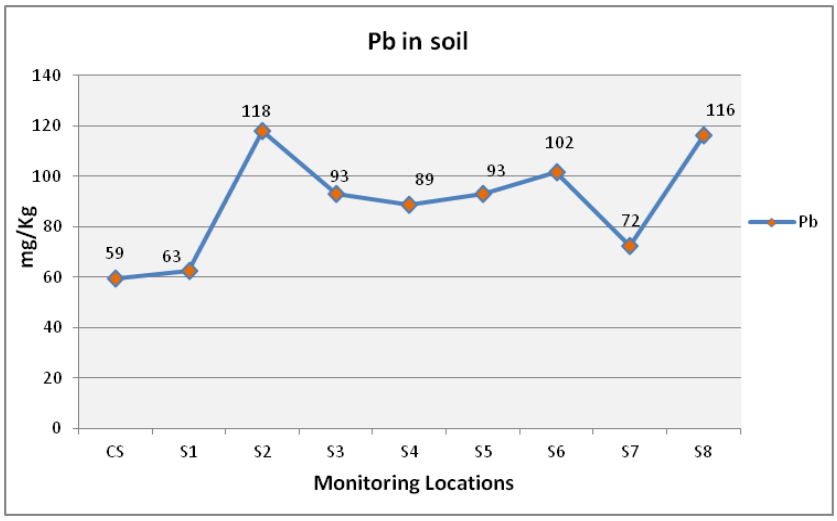


**FIGURE 10: Lead (Pb) concentration in Soil**

Figure no 11 is showing that Pollution Load Index (PLI) was found 1.47 (S4) and maximum Pollution Load Index was found 2.051 (S5). Over all Pollution Load Index was found greater than 1 which shows polluted soil w.r.t. heavy metals at all selected monitoring locations during this study.

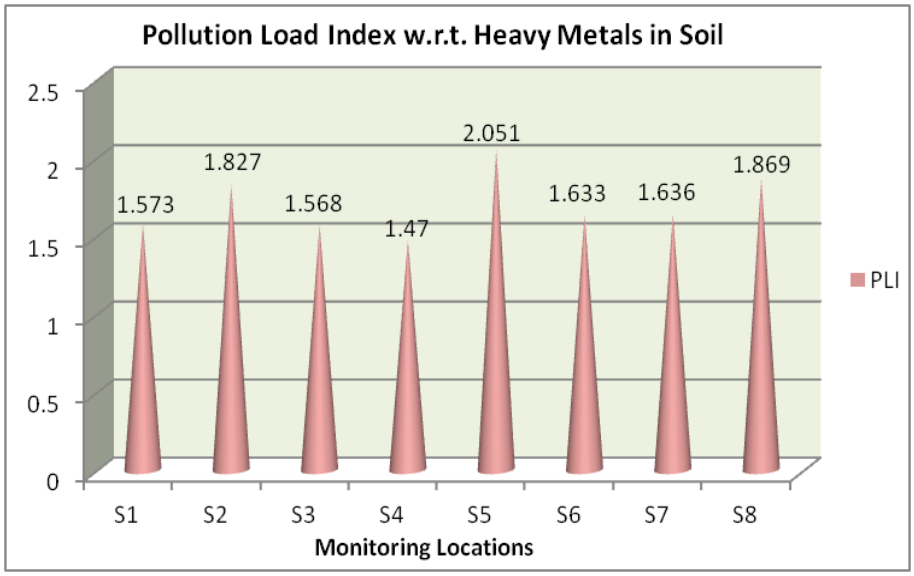


**FIGURE 11: Pollution Load Index w.r.t. Heavy Metals in Soil**

## IV. CONCLUSION

Almost three fourths of the area in the Dewas district is covered by black cotton soils, which is occupied by Deccan Basalts. The southern part has red yellow mixed soils derived from sandstone, shale, gneiss. The heavy metal contamination with w.r.t. Contamination Index (CI), Pollution Load Index (PLI) study in selected locations in Dewas industrial area has been done. Over all Pollution Load Index of soil was found greater than 1 which shows polluted soil w.r.t. heavy metals at all selected monitoring locations in Dewas industrial area of Madhya Pradesh, India during this study.

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