CONTAMINATION OF HEAVY METALS IN SOIL OF MANDIDEEP INDUSTRIAL AREA, MADHYA PRADESH, INDIA

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1. ABSTRACT

A study has been conducted to assess the heavy metal contamination in soil of Mandideep industrial area of Madhya Pradesh, India. Total twelve locations and one control location were selected in Mandideep industrial area for soil quality monitoring w.r.t. heavy metals. The thirteen 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 2018 to March 2019. The present study is an attempt to visualize the heavy metal contamination with w.r.t. Contamination Index (CI), Pollution Load Index (PLI) study at selected locations in Mandideep industrial area. Over all Pollution Load Index of soil was found greater than one which shows polluted soil w.r.t. heavy metals at all selected monitoring locations in Mandideep industrial area of Madhya Pradesh, India during this study.
KEYWORDS: *Industrial Area, Soil, Heavy Metals, Contamination Index (CI), Pollution Load Index (PLI)*

2. INTRODUCTION

Heavy metals are accumulated in soils mainly due to dry and wet atmospheric deposition from various sources; the main and most important origin of heavy metals is related to industrial emissions (chemistry, mining, iron and steel industry, metallurgy, building and electronics industry, etc.), fuel combustion, and waste management and transport (automobile traffic, a fuel composition, road types etc [1]. Heavy metals can be transferred into the human body as a consequence of dermal contact, inhalation, and ingestion [2-4]. Industrialization has been accompanied by increased concentrations of metals and semimetals in soils. Some, such as lead and cadmium, are non-essential, being potentially toxic even in very low concentrations; essential ones, such as copper, nickel, zinc, and manganese, are fundamental for many metabolic activities, but become toxic for concentrations above a certain threshold [5]. Due to rapid industrialization, excessive application of metals and synthetic chemicals in the terrestrial environment coupled with deficient environmental management has led to large scale pollution in the environment. Soils contaminated by heavy metals from human activities have raised serious concern in recent decades regarding potential risk to human health through the direct intake, bioaccumulation through food chain, and their impacts on ecological system [6,7]. Furthermore, exposure to the high amount of heavy metals can cause serious problems to human [8]. Heavy metals can be derived from both local and distant sources of emissions, and therefore can be deposited in situ or, due to their ability to be bound by dust, can be transported over long distances [9-11]. Most anthropogenic pollutants are emitted into the atmosphere and then are deposited on the soil surface [12]. Accumulation of metals may also be supported by natural processes. Vehicular pollution is also participates in heavy metal pollution of soil ecosystem. In addition to this, soil is also considered as the major sink for airborne metals. All aspects stated above become responsible for accumulation of heavy metals in the soil by one or way and thus give rise to soil pollution [13].Therefore pollution load index w.r.t. heavy metals in soil of Mandideep industrial area was observed in this study.

## 3. METHODOLOGY

3.1. Study Area

Mandideep is a municipality in Goharganj subdistrict of Raisen district in the Indian state of Madhya Pradesh. It is situated between the latitude 22° 47' and 23° 33' north and the longitude $77^o21'$ and $78^o49'$ east and is bounded in the west by Sehore District, in the north by Vidisha District, in the east and southeast by Sagar District, and in the south by Hoshangabad and Sehore districts.

3.2. Monitoring Locations

Total twelve locations and one control location in Mandideep industrial area were selected for soil monitoring w.r.t. heavy metals is depicted in table no 1 and figure no 1.

Table 1: Monitoring Locations at Mandideep Industrial Area

S.N	Code	Monitoring Points
1	S1	Near M/S Bansal Extraction & Exports Pvt, Ltd Mandideep
2	S2	Near M/S Bhaskar Industry, Mandideep
3	S3	Near M/S Proctor & Gamble, Mandideep
4	S4	Near M/S Mahindra Steel Service Centre, Mandideep
5	S5	Near M/S Dawat Food Industry, Mandideep
6	S6	Near M/S TMTL (Eicher Tectors), Mandideep
7	S7	Near M/S HEG, Mandideep
8	S8	Near M/S Lupin ltd, Mandideep
S	S9	Near M/S Vardhman Yarns, Mandideep
10	S10	Near Lalit Gitanjali Hospital, Mandideep
11	S11	Near AKVN, Mandideep
12	S12	Near M/S Crompton & Greaves, Mandideep
13	CS (Control Site)	Near St Chavara, H. S. School, New Satlapur Mandideep
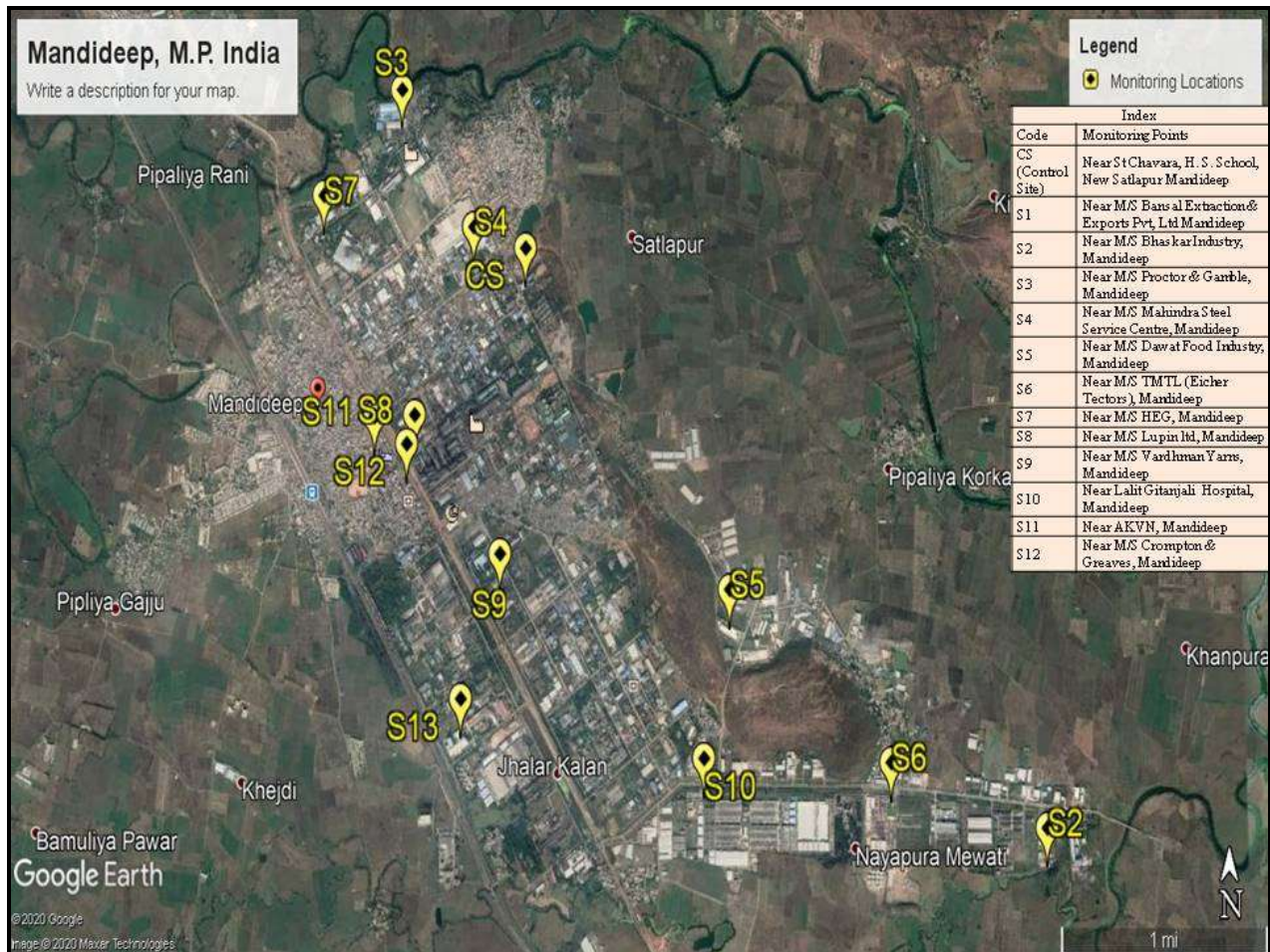
Figure 1: Monitoring Locations at Mandideep Industrial Area

3.3. Monitoring

All soil monitoring was done 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 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.

3.4. 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) [14] and analyzed by atomic absorption spectrophotometer (Perkin Elmer Pinnacle 900H).

3.5. 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.

3.5.1. Contamination Index (CI)

The contamination factors were derived by using the CI equation as defined [15]:

$$CF= Cn/Bn …………………………………… (1)$$

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 [16].

3.5.2. Pollution Load Index (PLI): The PLI gives a generalized assessment on the level of soil contamination. The PLI is obtained using approach as follows [17]:

$$PLI = [CF_1 \times CF_2 \times CF_3 \times \ldots\ldots \times C_n]^{1/n} \ldots\ldots (2)$$

Where, CF= contamination factor; and n = number of metals. PLI > 1 indicates pollution exists; PLI < 1 indicates no metal pollution [18]; and PLI = 1 indicates heavy metal loads close to the background level [19].

4. RESULT & DISCUSSIONS

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: Metals Concentration in Soil

S.N.	Heavy Metals	Unit	CS	S1	S2	S3	S4	S5	S6
1	Cr	mg/kg	17	29	22	21	22	25	20
2	Mn	mg/kg	195	346	249	245	210	316	231
3	Ni	mg/kg	22	27	23	30	25	26	27
4	Cu	mg/kg	28	37	266	65	68	58	38
5	Zn	mg/kg	56	93	76	75	67	78	72
6	Co	mg/kg	16	29	23	24	28	27	26
7	Cd	mg/kg	2	3	2	2	3	3	2
8	Fe	mg/kg	2077	11867	7235	11260	9928	10340	7154
9	Pb	mg/kg	11	18	15	18	20	12	15

S.N.	Heavy Metals	Unit	S7	S8	S9	S10	S11	S12
1	Cr	mg/kg	18	24	27	26	19	18
2	Mn	mg/kg	209	269	230	219	361	312
3	Ni	mg/kg	25	28	26	28	33	23
4	Cu	mg/kg	32	56	63	63	32	31
5	Zn	mg/kg	63	50	62	59	57	76
6	Co	mg/kg	27	26	26	24	24	23
7	Cd	mg/kg	2	3	2	2	3	8
8	Fe	mg/kg	11885	7549	10429	11901	9450	4994
9	Pb	mg/kg	13	23	13	16	26	11

Table 3: Contamination index (CI) and Pollution load index (PLI) of Soil

Heavy Metal	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Cr	1.7	1.294	1.235	1.294	1.47	1.176	1.058	1.411	1.588	1.529	1.117	1.058
Mn	1.774	1.276	1.256	1.076	1.62	1.184	1.071	1.379	1.179	1.123	1.851	1.6
Ni	1.227	1.045	1.363	1.136	1.181	1.227	1.136	1.272	1.181	1.272	1.5	1.045
Cu	1.321	9.5	2.321	2.428	2.071	1.357	1.142	2	2.25	2.25	1.142	1.107
Zn	1.66	1.357	1.339	1.196	1.392	1.28	1.125	0.892	1.10	1.053	1.017	1.357
Co	1.812	1.437	1.5	1.75	1.687	1.625	1.687	1.625	1.625	1.5	1.5	1.437
Cd	1.5	1	1	1.5	1.5	1	1	1.5	1	1	1.5	4
Fe	5.713	3.483	5.421	4.779	4.978	3.444	5.722	3.634	5.021	5.729	4.549	2.404
Pb	1.636	1.363	1.636	1.818	1.09	1.363	1.181	2.09	1.181	1.454	2.363	1
PLI	**1.807**	**1.747**	**1.64**	**1.676**	**1.672**	**1.414**	**1.385**	**1.631**	**1.554**	**1.589**	**1.642**	**1.492**

Figure no 2 is showing that average concentration of Chromium (Cr) was found 17 mg/kg at control site (CS). Minimum average concentration was found 18 (S7 & S12) mg/kg and maximum average concentration was found 29 (S1) mg/kg during this study.
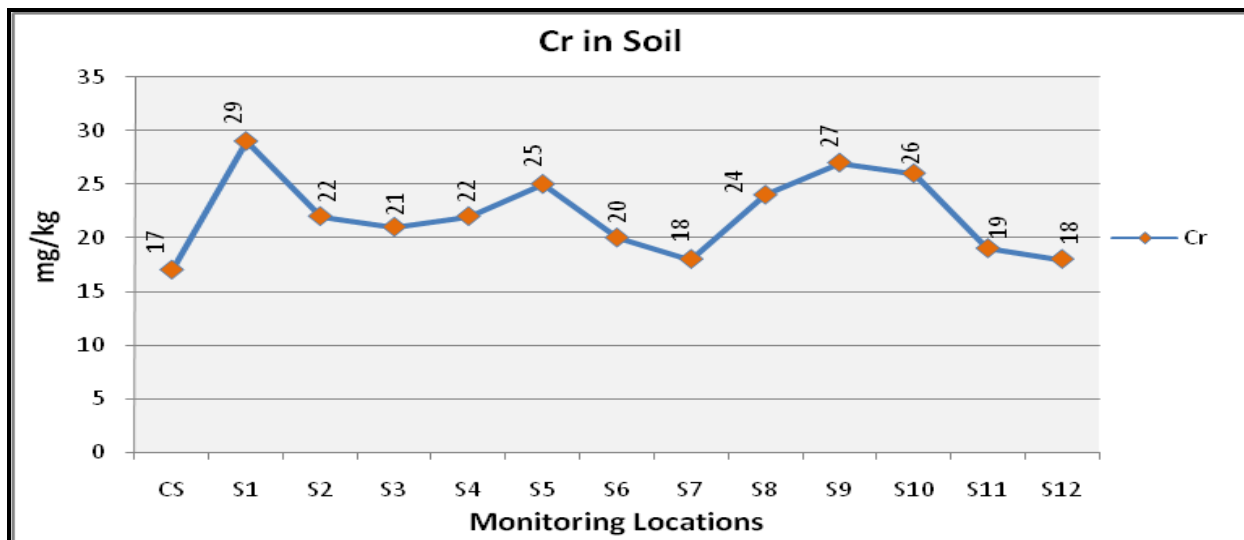

Figure 2: Chromium (Cr) concentration in Soil

Figure no 3 is showing that average concentration of Manganese (Mn) was found 195 mg/kg at control site (CS). Minimum average concentration was found 209 (S7) mg/kg and maximum average concentration was found 361 (S11) mg/kg during this study.
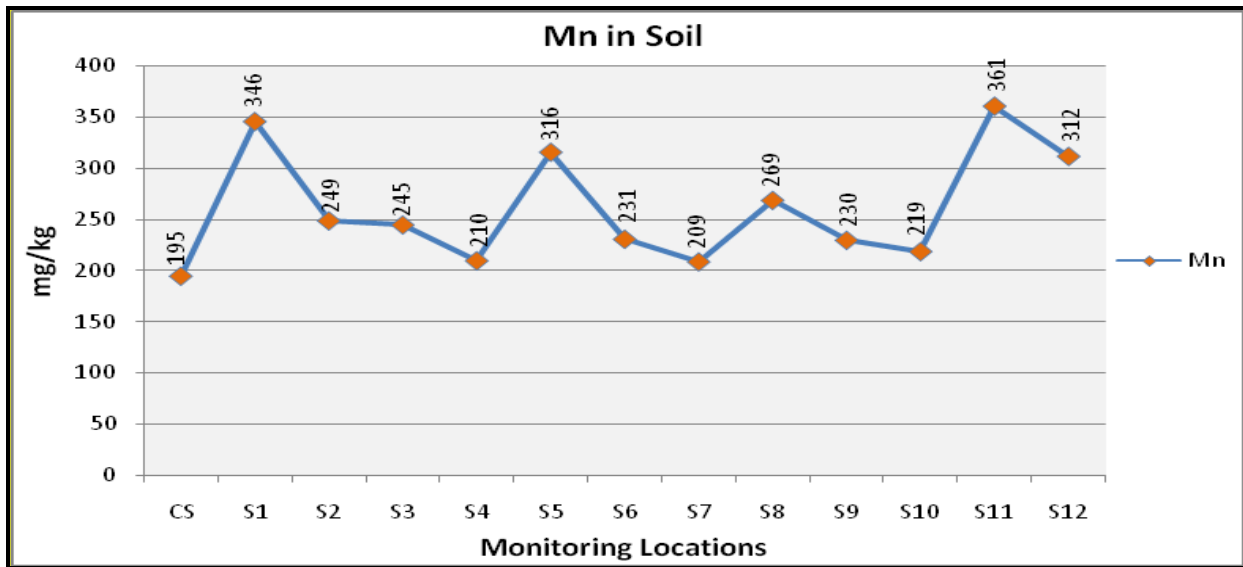
Figure 3: Manganese (Mn) concentration in Soil

Figure no 4 is showing that average concentration of Nickel (Ni) was found 22 mg/kg at control site (CS). Minimum average concentration was found 23 (S2 & S12) mg/kg and maximum average concentration was found 33 (S11) mg/kg during this study.
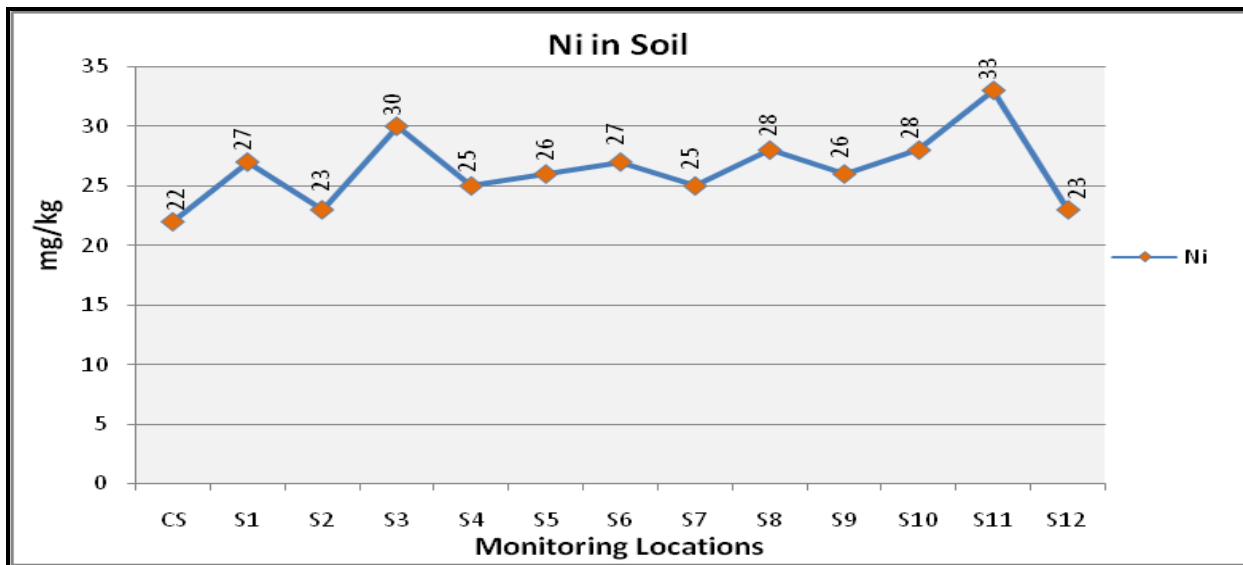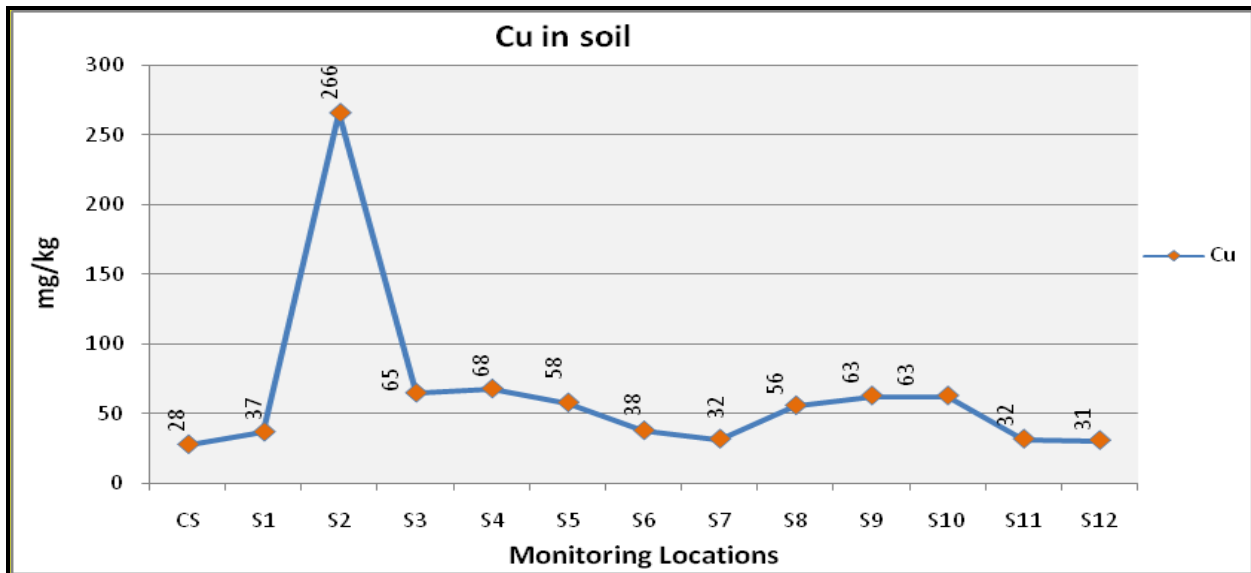

Figure 4: Nickel (Ni) concentration in Soil

Figure no 5 is showing that average concentration of copper (Cu) was found 28 mg/kg at control site (CS). Minimum average concentration was found 31 (S12) mg/kg and maximum average concentration was found 266 (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 56 mg/kg at control site (CS). Minimum average concentration was found 50 (S8) mg/kg and maximum average concentration was found 93 (S1) mg/kg during this study.
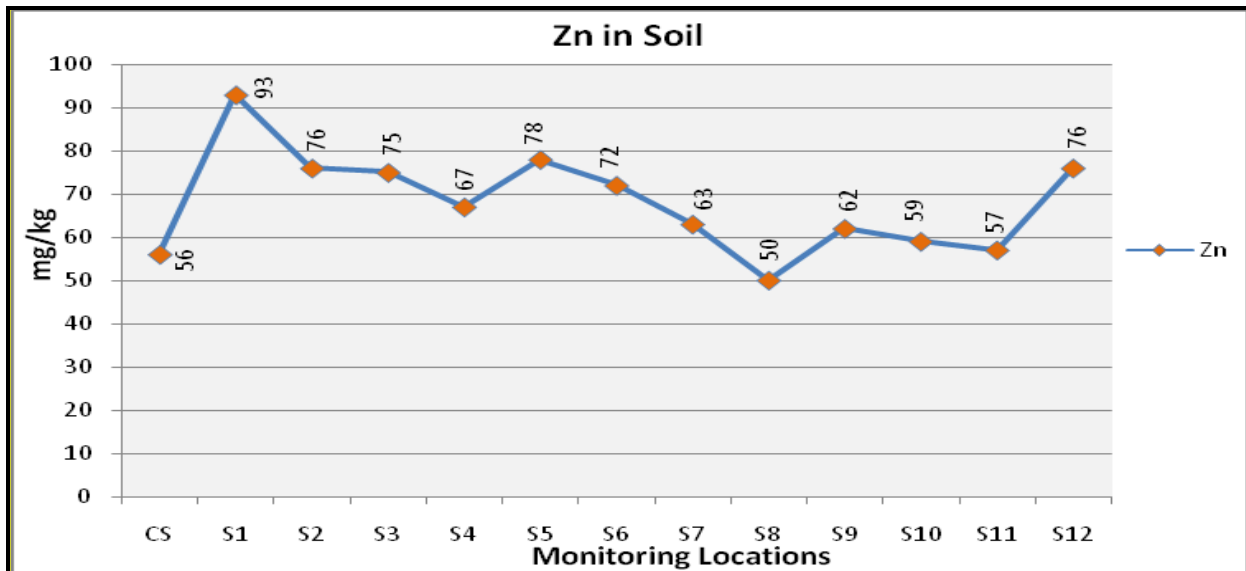

Figure 6: Zinc (Zn) concentration in Soil

Figure no 7 is showing that average concentration of Cobalt (Co) was found 16 mg/kg at control site (CS). Minimum average concentration was found 23 (S2 & S12) mg/kg and maximum average concentration was found 29 (S1) mg/kg during this study.
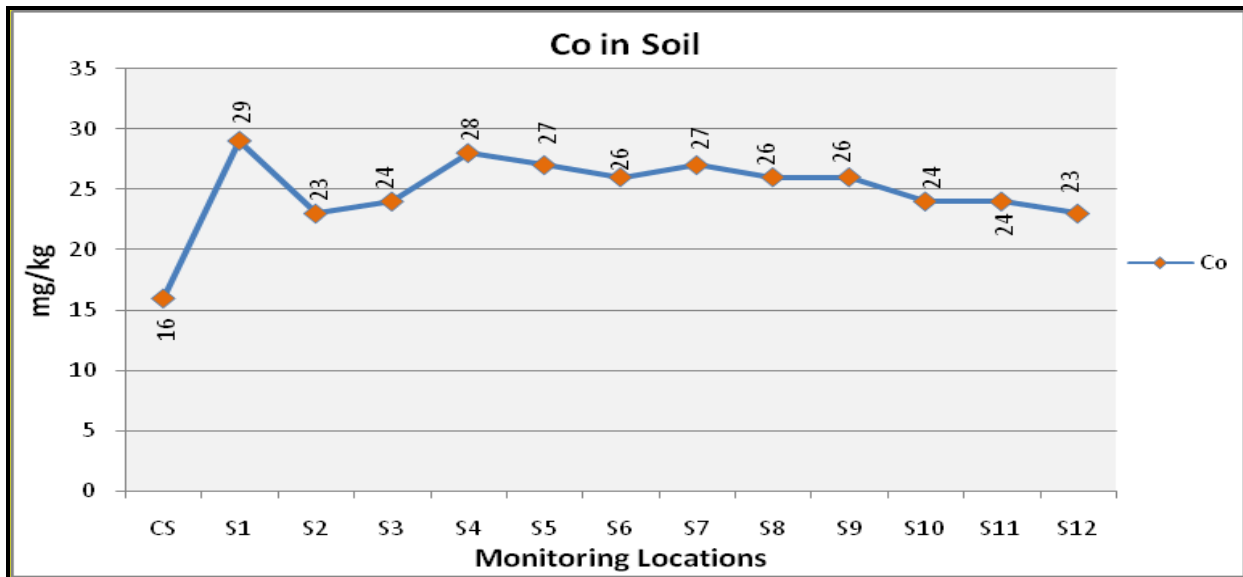
Figure 7: Cobalt (Co) concentration in Soil

Figure no 8 is showing that average concentration of cadmium (Cd) was found 2 mg/kg at control site (CS). Minimum average concentration was found 2 (S2, S3, S6, S7, S9 & S10) mg/kg and maximum average concentration was found 8 (S12) mg/kg during this study.
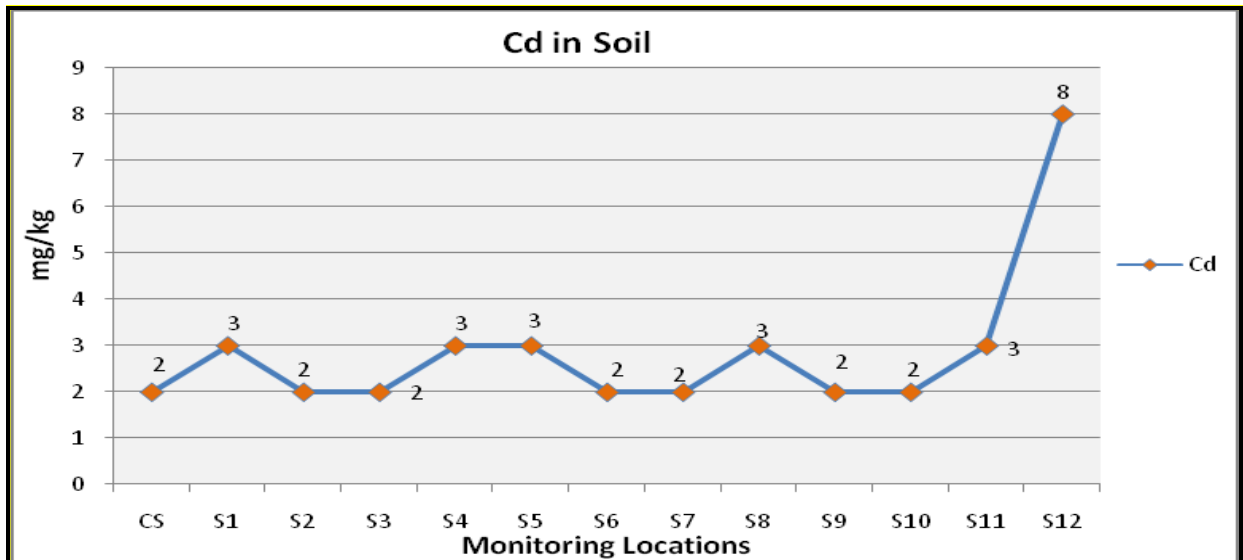

Figure 8: Cadmium (Cd) concentration in Soil

Figure no 9 is showing that average concentration of iron (Fe) was found 2077 mg/kg (CS) at control site. Minimum average concentration was found 4994 (S12) mg/kg and maximum average concentration was found 11867 (S1) mg/kg during this study.
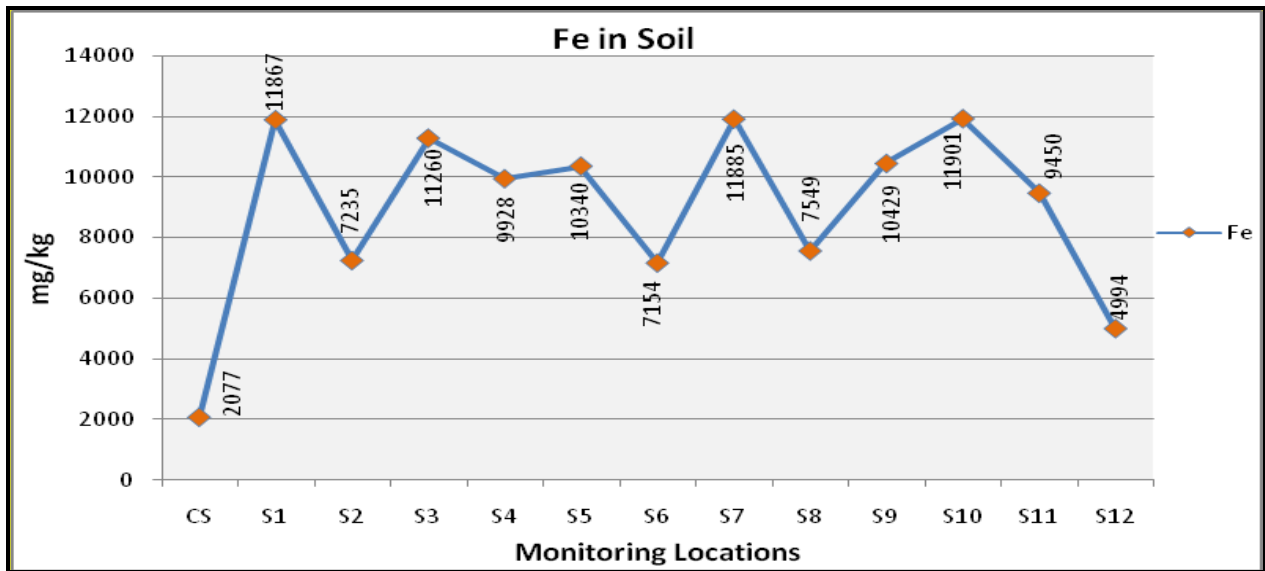
Figure 9: Iron (Fe) concentration in Soil

Figure no 10 is showing that average concentration of lead (Pb) was found 11 mg/kg at control site (CS). Minimum average concentration was found 11 (S12) mg/kg and maximum average concentration was found 26 (S11) mg/kg during this study.
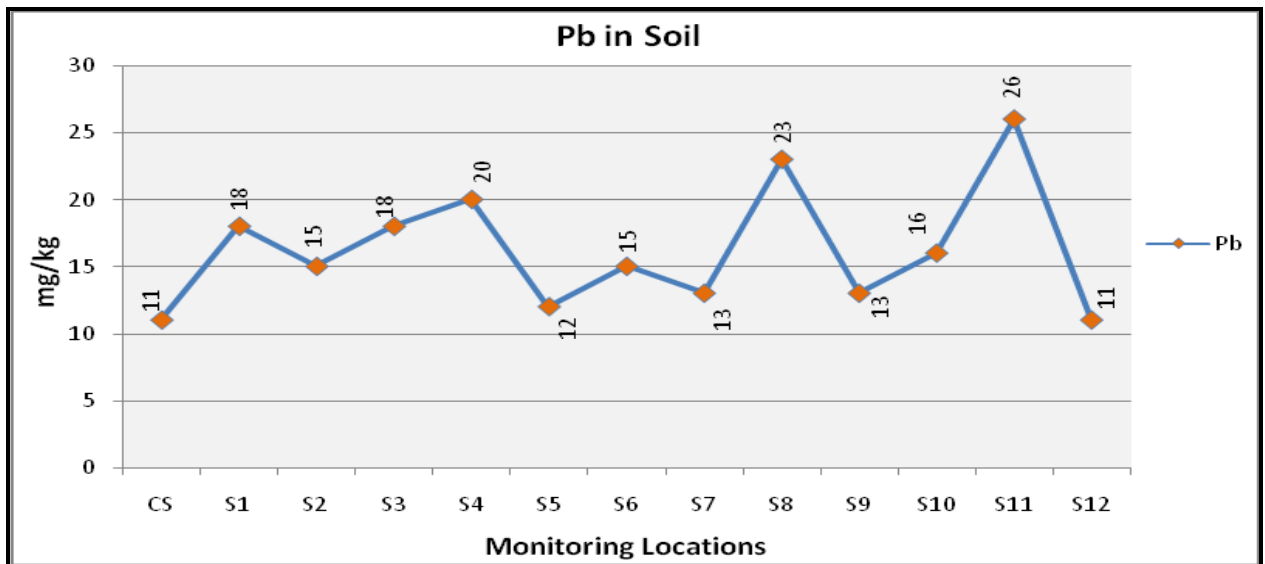

Figure 10: Lead (Pb) concentration in Soil

Figure no 11 is showing that minimum Pollution Load Index was found 1.385 (S7) and maximum Pollution Load Index was found 1.807 (S1). Over all Pollution Load Index was found greater than 1 which show polluted soil w.r.t. heavy metals under study at all selected monitoring locations during this study.
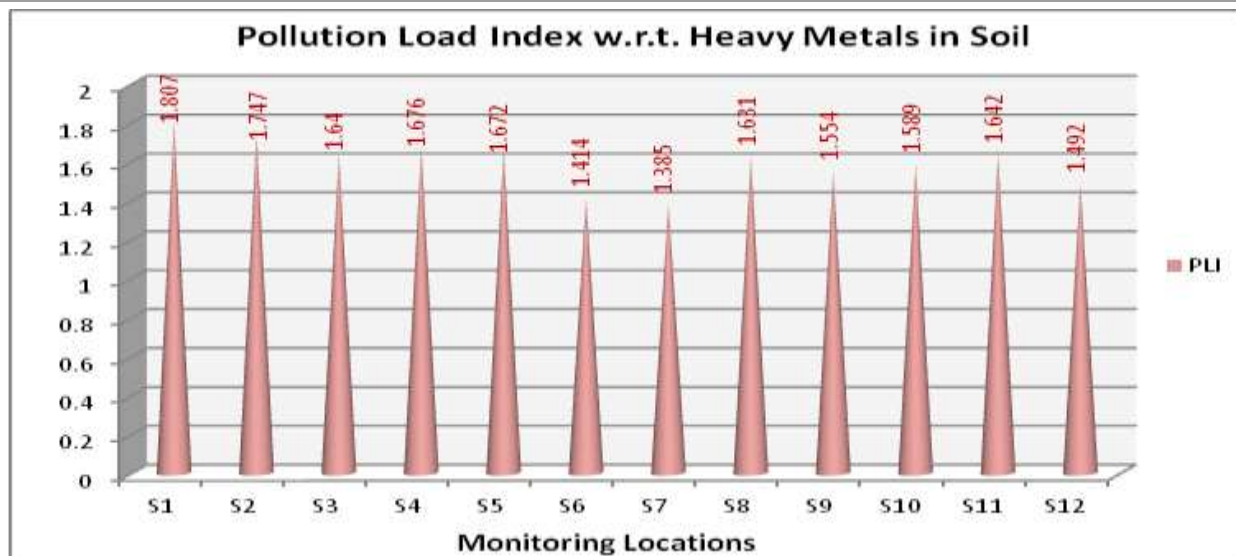
Figure 11: Pollution Load Index w.r.t. Heavy Metals in Soil

5. CONCLUSION

Mandideep is fast developing industrial area near Bhopal, the capital of Madhya Pradesh. The present study is an attempt to visualize the heavy metal contamination with w.r.t. Contamination Index (CI), Pollution Load Index (PLI) study at selected locations in Mandideep industrial area. Over all Pollution Load Index of soil was found greater than 1 which shows polluted soil w.r.t. heavy metals under study at all selected monitoring locations in Mandideep industrial area of Madhya Pradesh, India during this study.

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