

Heavy Metal Concentrations in Topsoil along National Highway – 12, Kota – Deoli (Tonk)

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ABSTRACT: With the increase in population, urbanization and advancement of technology, the public and commercial vehicles have increased manifold during the last two decades on Indian roads. National highways are the economic backbone of India carrying about 40% of the traffic. The national highways provide faster, easier and comfortable transportation but at the same time, they are creating environmental problems too. The emissions from vehicles include harmful gases and un-burnt hydrocarbons, which are a major source of green house gases. Heavy metals are also released from vehicle emissions and get mixed up with soil and underground water and hence pollute them. In the present study, an attempt has been made for the characterization of heavy metals in soil along the national highway-12 between Kota – Deoli (Tonk) by selecting ten sampling locations at a distance of about 10 – 12 Km between two consecutive locations for a period of six months from December 2015 to May 2016. The soil samples are analyzed for toxic metals like Lead (Pb), Manganese (Mn), Cadmium (Cd), Zinc (Zn), Iron (Fe) and other parameters like pH and electric conductivity (EC). It has been found that the concentrations of the heavy metals found in these samples along the national highway are beyond the permissible limits prescribed by the Indian Standards.

KEYWORDS: Heavy metals, topsoil, vehicle emissions, environmental pollution, national highway

I. INTRODUCTION

Rapid urbanization, industrialization and technological development have resulted in a considerable rise in number of vehicles during the recent years. Due to increase in number of vehicles over the years, the urban roads not only observe frequent traffic congestions but also affect the environment badly through vehicle emissions. Most of the vehicles use fossil fuels and hence transportation is one of the largest sources of greenhouse gases and air pollutants. The common pollutants emitted from vehicles are oxides of nitrogen, carbon monoxide, volatile organic compounds and fine particulate matters. These fine particles are able to penetrate deeply into the human respiratory tract and consequently constitute a risk for health by increasing mortality from respiratory infections and diseases, lung cancer and certain cardiovascular diseases. Traffic activities are one of the main sources responsible for heavy metal contamination in roadside soils due to their long-term accumulation. The increased exposure to traffic activities is the cause of enhanced incidences of a number of illnesses like asthma, chronic bronchitis, emphysema, pneumonia and heart diseases.

Heavy metals are responsible for direct harm to human health by entering the body through soil and dust, skin contact or breathing. The trace elements like cadmium, lead, zinc and copper found in the roadside soils coming from traffic activities may be transported through the food chain into the human body and hence be very toxic to humans. In agricultural areas, intake of heavy metals through the soil-crop system could play a major role in human exposure to heavy metals. Generally, the heavy metals with high concentrations in the environment result in health problems adversely affecting the nervous, blood forming, cardiovascular, renal and reproductive systems. The ill-effects of heavy metal pollution include reduced intelligence, attention deficit and behavioural abnormality as well as contribution to cardiovascular disease in adults. Some trace metals (such as Cu and Zn) are harmless in small amounts, but the others (like Pb, As, Hg and Cd), even at extremely low concentrations, are toxic and prove to be potential cofactors, initiators or promoters in many diseases, including increased risk of cancer.

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II. RELATED WORK

Heavy metal pollution from transport sector has attained much attention in the recent past. Khalid Farooq Akbar and Mohd. Akhtar (2006) carried out a research to study heavy metal contamination in roadside soils of northern England collecting 35 roadside soil samples and analyzed them for four heavy metals (cadmium, copper, lead, zinc). Their concentrations and distributions in different road verge zones (border, verge, slope, ditch) were determined. Lead concentration was found the highest in the soil while cadmium concentration was the lowest in the soil. All the four heavy metals exhibited a significant decrease in the roadside soils with the increasing distance from the road.

T. N. Nath (2015) found concentration of four typical heavy metals (Cd, Cr, Ni and Pb) in roadside tea cultivated soils close to national highway (NH 37) in the Dibrugarh district of Assam. A total of sixty soil samples were collected from both sides of the national highway. Results indicated that heavy metal concentration decreases in the order of Cr>Pb>Ni>Cd. Concentration of Cd, Cr, Ni and Pb of control site soil were found to be 1.06, 29.85, 20.56 and 24.02 mg/kg respectively. The concentrations of heavy metals in roadside tea cultivated soil were higher as compared to reference soil levels. It was suggested that automobiles were the major source of these metals in roadside soil.

L. Sripathy et al (2015) determined the impact of vehicular activity on soil and farmlands along the national highway-4 from Nelamangala to Dabaspet in the periphery of Bangalore city with contrasting traffic densities. The concentrations of heavy metals like titanium, manganese, iron, zinc, strontium and zirconium across the highway were determined and it was concluded that there was no consistent trend in the concentration of heavy metals in the soils farther to the highway in comparison to those adjacent to the road.

III. STUDY AREA

The study area has been selected along national highway – 12, which runs between Jabalpur – Jaipur, from Kota to Deoli (Tonk) having a distance of about 90 Km. Initially a physical survey was conducted on this national highway for collection of topsoil samples from selected locations. The locations are selected in a manner that the total distance between Kota and Deoli is roughly divided into equal portions of about 8 to 12 Km. Total 10 sampling locations have been selected along this highway and at each location, 4 composite samples have been collected, one at the roadside, second at a distance of 20 m, third at a distance of 50 m and the fourth from the village soil at a distance of about 200 m in the perpendicular direction from the highway.

Table I: Sampling locations along the National Highway – 12 (Kota - Deoli)

S. No.	Sampling location	Symbol	S. No.	Sampling location	Symbol
1	Kota (NH Start point Km 0)	S – 1	6	Sathur	S – 6
2	Kota (near Gurunanak Public School)	S – 2	7	Hindoli	S – 7
3	Bargaon	S – 3	8	Deoli	S – 8
4	Taleda	S – 4	9	Sathali	S – 9
5	Bundi	S – 5	10	Bharnigaon	S – 10

The selected ten sampling locations have been given the symbols from S – 1 to S – 10 along the national highway.

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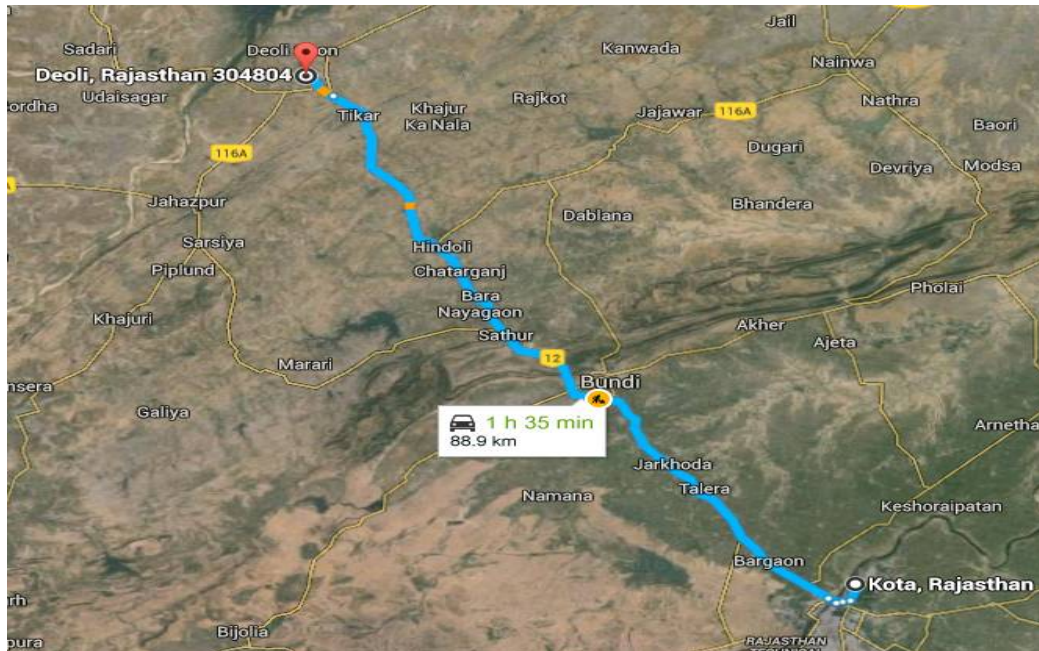


Figure1: Google map showing sampling locations along National Highway – 12

IV. METHODOLOGY

A sequential methodology has been adopted to carry out the study. The soil samples for analysis of heavy metals were collected from selected ten locations along the national highway – 12 between Kota to Deoli (Tonk) in a distance of about 90 Km. The study has been carried out for 6 months during December 2015 to May 2016 as per the following steps: 1) Survey of national highway – 12 (Kota to Deoli), 2) Selection of sampling locations, 3) Collection of soil samples, 4) Preparation of samples for analysis, 5) Digestion of samples, 6) Calibration of AAS, 7) Analysing the samples, 8) Comparison of results.

Collection, Preservation and Processing of Samples

The objective of sampling is to collect representative samples in which relative proportion or concentration of all relevant components is the same as in the material being sampled. Moreover, the same samples are handled in such a way that no significant changes in composition occur before the tests. Samples were collected once in a month for a period of 6 months, which gave a total of 40 samples. For collection of uniform samples, the gram composite sampling technique is used in which samples are taken on mass basis and not on weight basis.

Each soil sample is air-dried in the laboratory, pulverized with an agate mortar and pestle and then sieved through nylon sieve with diameter of ≤ 0.149 mm. Then 0.3 ± 0.0001 g sieved soil sample is mixed with 6 ml HNO_3 , 3 ml HCl and 0.25 ml H_2O_2 in a tetrafluoroethylene beaker and heated in a microwave digestion system. After that, the digested solution is diluted to 50 ml with ultra-pure water and filtered through $0.45 \mu\text{m}$ micro porous membrane. Finally 1.0 ml filtered solution is diluted to 10 ml for measurement of Pb, Cd, Cu and Zn by atomic absorption spectrophotometer. The various steps during study period are represented in Figure 2 to 7.



Figure 2: Sample collection



Figure 3: Sample collection



Figure 4: Sample preparation work in laboratory



Figure 5: Experimental work in laboratory



Figure 6: Experimental work in laboratory



Figure 7: Analysis of heavy metals with AAS

V. RESULTS AND DISCUSSION

The levels of toxic heavy metals like lead, cadmium, copper, zinc, iron and manganese were observed and analysed in the samples collected from roadside topsoil near National Highway-12, Kota to Deoli Rajasthan India, so that the impact of vehicular traffic on the heavy metal contamination of roadside soil can be documented in an indisputable way. Road traffic and maintenance induce chronic heavy metal pollution to the roadside soil and agriculture areas. A portion of these pollutants can be dispersed into the atmosphere or deposited on the roadside soils. Soil samples from 10 expected polluted sites near national highway have been collected. The analysis of heavy metals was carried out with the help of atomic absorption spectrophotometer and obtained results are shown in the following tables and graphs.

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Table II: Accumulation of Heavy metals along the roadside of national highway-12

S. No.	EC (ds/m)	pH	OC %	Cu (mg/Kg)	Mn (mg/Kg)	Fe (mg/Kg)	Pb (mg/Kg)	Cd (mg/Kg)	Zn (mg/Kg)
S-1	0.43	7.84	1.13	58	38	115	3.5	0.80	88
S-2	0.60	8.2	1.26	72	112	65	12.3	1.6	112
S-3	0.24	8.65	0.86	96	35	55	2.5	0.65	34
S-4	1.11	8.55	1.54	48	54	35	6.05	0.75	65
S-5	0.33	7.75	1.24	35	42	92	13.8	1.09	85
S-6	0.27	7.66	0.95	32	34	46	2.5	0.82	42
S-7	0.86	7.95	1.85	56	62	42	3.2	0.35	38
S-8	0.22	8.25	2.15	28	52	58	7.07	1.02	48
S-9	0.42	8.10	1.35	34	38	32	1.6	0.85	32
S-10	0.36	7.55	1.65	22	28	36	1.2	0.64	72

Table III: Contamination of heavy metals in topsoil at 20 m away from NH-12

S. No.	EC (dS/m)	pH	OC %	Cu (mg/Kg)	Mn (mg/Kg)	Fe (mg/Kg)	Pb (mg/Kg)	Cd (mg/Kg)	Zn (mg/Kg)
S-1	0.65	8.10	0.65	24	21	23	1.2	0.43	26
S-2	0.86	7.65	1.10	18	38	32	0.48	0.36	18
S-3	0.28	7.77	0.84	15	22	20	0.32	0.82	12
S-4	0.42	7.10	0.55	06	16	24	0.16	0.45	21
S-5	1.10	8.15	0.38	16	14	18	0.34	0.12	16
S-6	0.64	8.24	1.15	12	06	16	0.16	0.34	12
S-7	0.86	7.86	0.85	08	2.8	12	0.21	0.24	18
S-8	0.48	7.95	0.65	22	07	09	1.34	0.16	08
S-9	0.36	7.65	0.45	18	12	14	1.06	0.18	06
S-10	0.22	8.1	1.09	09	16	12	0.2	0.2	14

Note: For electrical conductivity, 1 dS/m = 1000 µS/cm

Table IV: Contamination of heavy metals in topsoil at 50 m away from NH-12

S. No.	EC (dS/m)	pH	OC %	Cu (mg/Kg)	Mn (mg/Kg)	Fe (mg/Kg)	Pb (mg/Kg)	Cd (mg/Kg)	Zn (mg/Kg)
S-1	0.65	7.65	0.35	14	14	13	0.42	0.14	14
S-2	0.24	7.85	1.10	12	18	16	0.18	0.18	8.4
S-3	1.15	7.15	1.35	8.9	11.2	14	0.022	0.42	6.2
S-4	0.45	8.15	0.85	3.6	6.4	12.2	0.012	0.18	14
S-5	0.74	8.25	0.75	11	08	14	0.041	0.052	8.4
S-6	0.22	8.60	0.95	8.2	04	09	0.12	0.18	2.3
S-7	0.68	7.45	1.10	4.5	1.8	6.4	0.016	0.092	4.6
S-8	0.42	7.35	1.25	16	3.2	4.2	0.46	0.14	2.3
S-9	0.85	7.65	1.85	12	6.8	08	0.68	0.092	3.4
S-10	0.28	8.10	0.75	4.6	09	3.6	0.14	0.014	08

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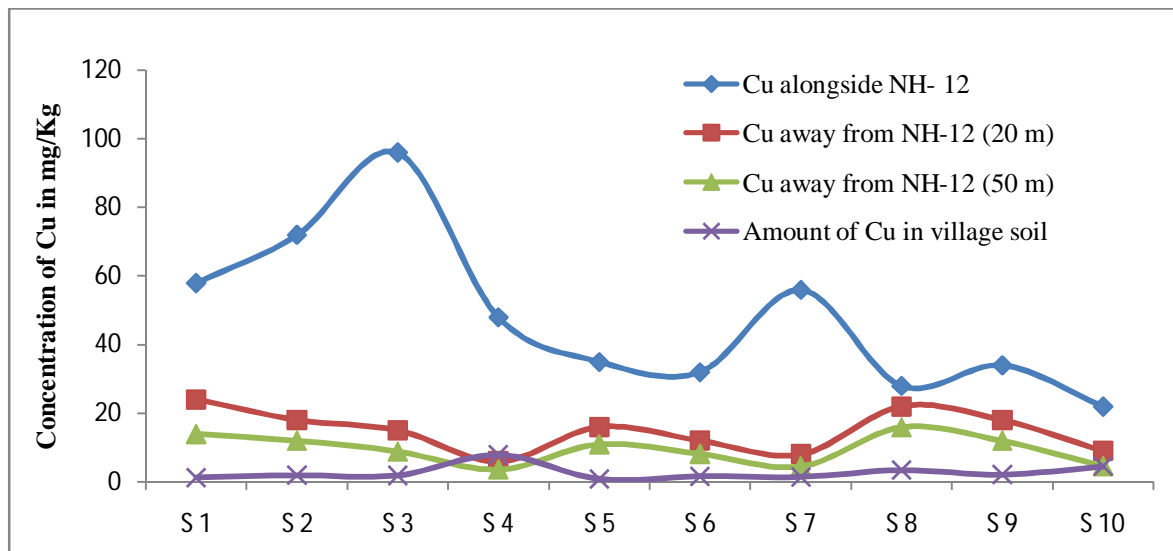
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Table V: Contamination of heavy metals in topsoil at 200 m away from NH-12 (i.e. in village)

S. No.	EC (dS/m)	pH	OC %	Zn (mg/Kg)	Cu (mg/Kg)	Mn (mg/Kg)	Fe (mg/Kg)	Pb (mg/Kg)	Cd (mg/Kg)
S-1	1.2	7.94	0.32	0.68	1.22	2.68	0.65	0.014	0.032
S-2	0.22	8.14	0.38	3.34	1.90	4.21	1.42	ND	0.022
S-3	0.48	8.42	0.42	0.44	1.86	3.89	2.64	0.002	0.014
S-4	0.36	7.67	1.08	13.56	7.86	7.85	22.68	ND	ND
S-5	0.32	8.46	0.30	0.83	0.84	2.54	0.87	0.014	ND
S-6	0.42	8.21	0.44	2.01	1.6	1.24	1.6	0.008	0.014
S-7	0.28	7.92	0.32	3.23	1.44	2.64	2.42	ND	ND
S-8	0.22	8.45	0.42	3.52	3.42	1.86	1.86	0.016	ND
S-9	0.64	8.95	0.28	2.84	2.1	2.6	2.24	ND	0.002
S-10	0.32	7.96	0.30	0.86	4.5	4.32	2.65	0.008	ND

Note: Where ND stands for 'Not Detected'



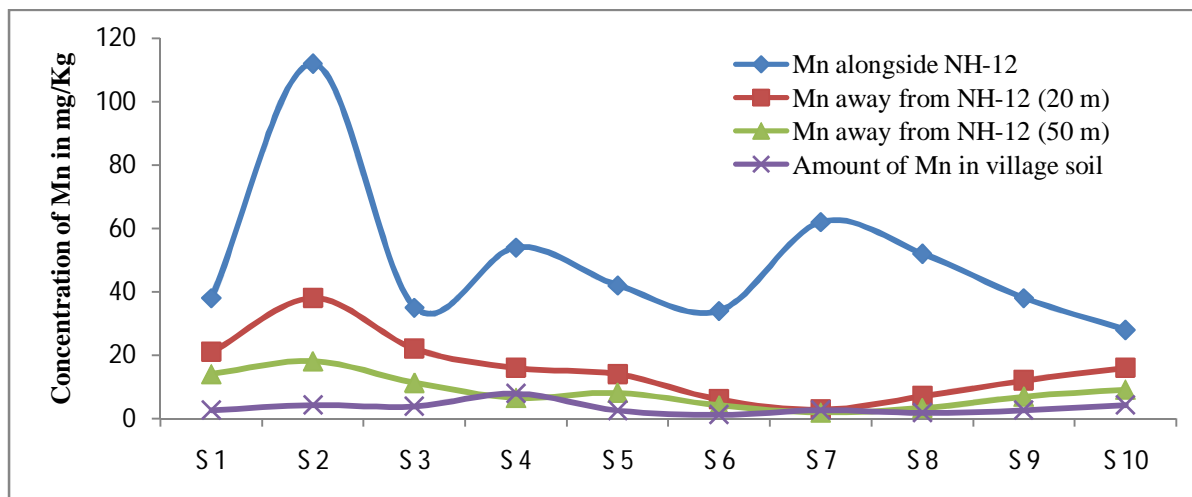
Graph I: Comparative concentration of Copper (Cu) in soil samples collected from roadside of NH-12, 20 m and 50 m away from NH-12 and from village soil

The maximum value of Cu is observed alongside the highway at location S-3 i.e. 96 mg/Kg while the least value 0.84 mg/kg is found at S-5 location of village sample which is in proximity of the national highway. The values of Cu concentration also show a declining trend with the increase of distance from the road i.e. maximum 96 mg/Kg alongside highway, 24 mg/kg at S-1 (20 m away from NH), 14 mg/Kg at 50 m away from the highway while in the village sample it is below permissible limit in some samples and observed least value in all samples is 0.84 mg/kg at S-5. The Cu concentration is higher near the roadside soil and gradually decreases as the distance increases. The possible accumulations of the roadside soil occur due to continual usage of the road by heavy traffic.

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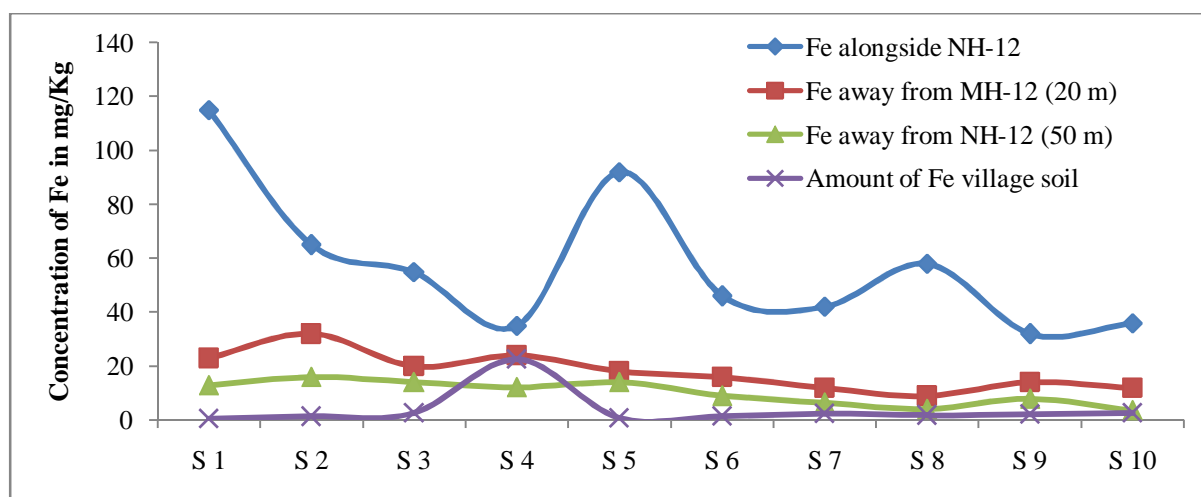
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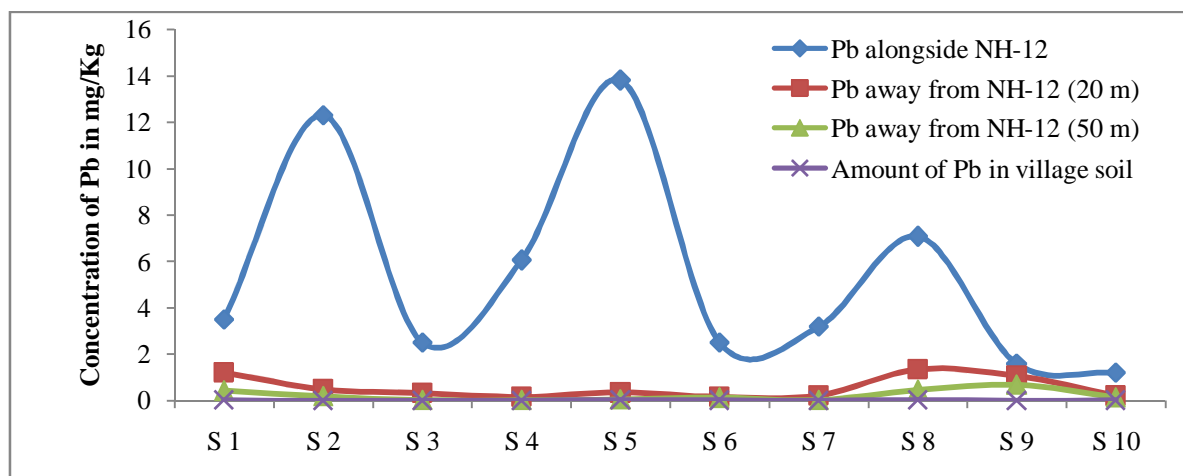
Graph II: Comparative concentration of Manganese (Mn) in soil samples collected from roadside of NH-12, 20 m and 50 m away from NH-12 and from village soil

Manganese (Mn) is one of the micronutrients all crops must have in small amounts for normal growth. During this study, the value of Mn has been noticed more than the permissible limits set by the Indian standards and it reaches up to 112 mg/Kg alongside the highway at S-1 while least value is observed in the village sample which is 500 m far from the national highway i.e. 1.24 mg/kg at S-6. The values of concentration show a declining trend with the increase of distance from the road.



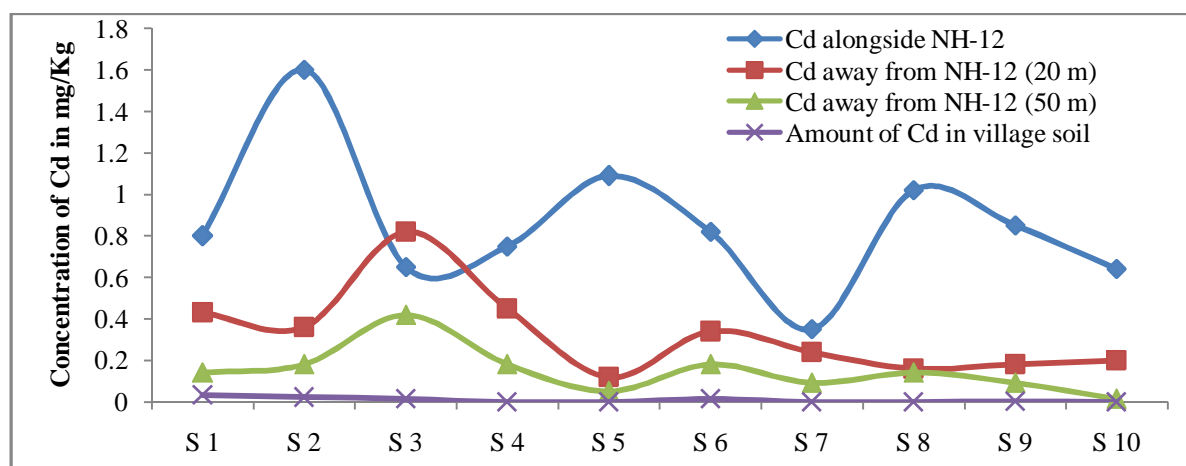
Graph III: Comparative concentration of Iron (Fe) in soil samples collected from roadside of NH-12, 20 m and 50 m away from NH-12 and from village soil

Iron is a common constituent in soils. The maximum observed value is 115 mg/Kg at S-1 location alongside the highway while least value observed alongside the highway is 35 mg/Kg at S-4 location. These both values are higher than the permissible limits of BIS. The minimum observed value for iron is 0.65 mg/Kg in the village sample which is 500 meter away from the highway. The values of iron concentration show a declining trend with the increase of distance from the road.



Graph IV: Comparative concentration of Lead (Pb) in soil samples collected from roadside of NH-12, 20 m and 50 m away from NH-12 and from village soil

The value of lead (Pb) observed in the study has reached up to a dangerous level. Alongside the highway it has been found more than the permissible limits of the BIS. Even, the presence of lead in atmosphere is a sign of the hazard to the human health. The maximum value observed alongside the highway at location S-5 due the heavy traffic load on that point is 13.8 mg/kg while the least value 0.016mg/kg is found at S-10 location of village sample. The values of lead concentration show a declining trend with the increase of distance from the road. The possible accumulations of the roadside soil occur due to continual usage of the road by automobile.



Graph V: Comparative concentration of Cadmium (Cd) in soil samples collected from roadside of NH-12, 20 m and 50 m away from NH-12 and from village soil

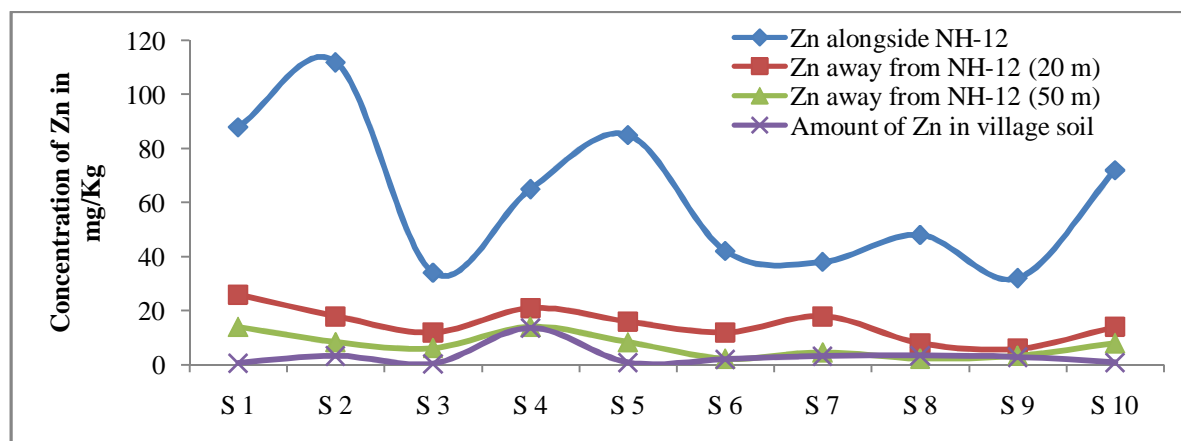
Cadmium (Cd)-The maximum value observed here alongside the highway on location S-2 due the heavy traffic load on that point reached up to 1.6 mg/kg while the least value .022 mg/kg found in S-2 location of village's sample which is in near proximity of national highway. the value of cadmium concentrations show a declining trend with the increase of distance from the road i.e. maximum 1.6 mg/kg alongside highway .82 mg/kg in controlled sample away from 20 meter, .014 at 50 m away from highway while in the village sample it is below detection limit in 5 samples & observed least value in all samples which is .022 mg/kg.. The heavy metal concentration is higher near the roadside soil and

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gradually decreases as the distance increases. The possible accumulations of the roadside soil occur due to continual usage of the road by heavy traffic.



Graph VI: Comparative concentration of Zinc (Zn) in soil samples collected from roadside of NH-12, 20 m and 50 m away from NH-12 and from village soil

The maximum observed value for Zn in all of the 40 samples is noticed as 112 mg/Kg at S-2 location alongside the NH. The most of the values of Zn are found more than the permissible limits as per the BIS. The least value of Zn is observed as 2.3 mg/Kg at S-8 location which is a distant village along the highway.

Table VI: Permissible limits of Heavy Metals prescribed by different agencies

S. N.	Parameters (Heavy metal)	Permissible limits (mg/Kg) as per the					
		Indian Standards			WHO	EU Standards	USEPA
		For Soil	For Plants	For Water	For Soil	For Soil	For Soil
1	Copper (Cu)	135 – 270	30	0.05	NA	140	50
2	Manganese (Mn)	NA	NA	0.1	NA	NA	80
3	Iron (Fe)	NA	NA	0.3	1.0	NA	NL
4	Lead (Pb)	250 – 500	2.5	0.1	70	300	300
5	Cadmium (Cd)	3 – 6	1.5	0.01	10	3	3
6	Zinc (Zn)	300 – 600	50	5.0	200	300	200

VI. CONCLUSION

The result of this work show that the concentration levels of heavy metals in the study area as a result of vehicular emissions has reached to an alarming level at the moment. The heavy metal concentration is higher near the roadside soil and gradually decreases as the distance increases. The possible accumulations of the roadside soil occur due to continual usage of the road by automobile. Heavy metal concentrations in soils show significant spatial and temporal variations. In the absence of any major industry in the sampling area, these observations suggest that motor vehicles on the roads may be sources of these metals. It is also concluded from the study that the location S-1, S-2 is having the most of the contamination while location S-9, S-10 showing the least observed values. The reason for this phenomenon is that S-1, S-2 is situated very near to Kota city and S-1 is heavily loaded with heavy vehicles due to Kota–Deoli expressway and toll tax on it where the vehicles stop for paying tax all around the clock. On the other hand, the endpoints of the study area S-9, S-10 show least amounts of contamination as they are far from the city and vehicles are continuously running here. Although the concentration of heavy metals are not beyond for soil as prescribed by the

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Indian Standards but lesser limits for plants and water have been prescribed as compared to the observed values. Therefore regular monitoring of heavy metals in soil is essential.

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