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HEAVY METAL CONTAMINATION OF SOIL DUE TO VEHICULAR TRAFFIC: A CASE STUDY ACROSS NELAMANGALA-DABASPET SEGMENT OF NATIONAL HIGHWAY NO. 4

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ABSTRACT

Contamination of roadside soil and farmland with heavy metals due to traffic activities is an environmental hazard causing pollution, thereby affecting the eco-system. The present study is aimed to determine the impact of vehicular activity on soil and farmlands abetting the National highway 4 from Nelamangala to Dabaspet in the periphery of Bangalore city with contrasting traffic densities. The concentrations of heavy metals Titanium, Manganese, Iron, Zinc, Strontium and Zirconium across the highway were determined and the status of soil health due to traffic activity is presented.

Keywords: Heavy metals, vehicular traffic, soil, pollution

INTRODUCTION

Living in the 21st century where breakthroughs in science and technology has made life both comfortable and challenging, it cannot be denied that one of the perils of this modernization, urbanization and globalization is pollution. In this context, soil pollution in general and heavy metal contamination of soil in particular, is of utmost concern because these not only persist in soil for a long time, but can also enter the food chain[1-3] causing a potential health risk associated with intake of heavy metals[4-6]. Numerous studies link the presence of heavy metals in soil to industrialization[7-10].Apart from industries, roadways and automobiles are emerging as major contributors of heavy metal contamination in soil[11].It is now well established that a variety of motor vehicles introduce a number of toxic metals into the environment, most of which are released adjacent to roadways. Their concentration in the soil is a major concern because of their toxicity and threat to human life and the environment. Combustion of fuel, engine oil, wear and tear of brakes, tyres, leakage of oils etc. are some of the contributing factors for the contamination of soil[12, 13]. Certain heavy metals are harmless in small amounts where as certain metals; even in small concentrations are potential risk factors[14,15]. The effect of these metal ranges from inhibiting stomatal activity and a decrease of photosynthesis in plants[16], cardiovascular diseases, reduced intelligence and behavioral abnormalities[17]in humans as well as effects on enzyme activity[18].

While various arms of Government are concerned about the effects of exhaust emissions on the environment, information on road-side contamination with heavy metals due to vehicular emissions in India is limited. Hence, the present study is taken up to document the effects of vehicular exhausts on the health of soils adjacent to the highway with special reference to heavy metal accumulations.

Study Area

National Highway-4 region in the periphery of Bangalore city between Nelamangala to Dabaspet (Fig. -1) is undergoing industrial development at a faster rate during the recent past. Road construction has been an important activity in the development of industrial units. The study area consisted of 35-40 road-side sites across the National Highway-4 between Nelamangala and Dabaspet along both sides of the road. The geographical co-ordinates of the study area arefrom13° 6' 7" N (Latitude) and 77° 23' 23" E (Longitude) (Nelamangala) to 13° 13' 42" N and 77° 14' 30" E (Dabaspet), along both sides of the road. The road is one of the oldest tarmacs in this area and carries an average density of traffic. A typical road verge can be divided into four different arbitrary zones, Border, Verge, Slope and Ditch/hedge. The border is the narrow zone adjacent to the road and it is heavily disturbed. The verge is next to border and usually 1-3m wide. The slope, where present, is 1-3m in height with 30-35 degrees inclination. The ditch is the last zone and usually had a hedge along it. The soil sampling along the roadside verges was therefore carried-out according to the different zones. The main socioeconomic activity along this road is farming.

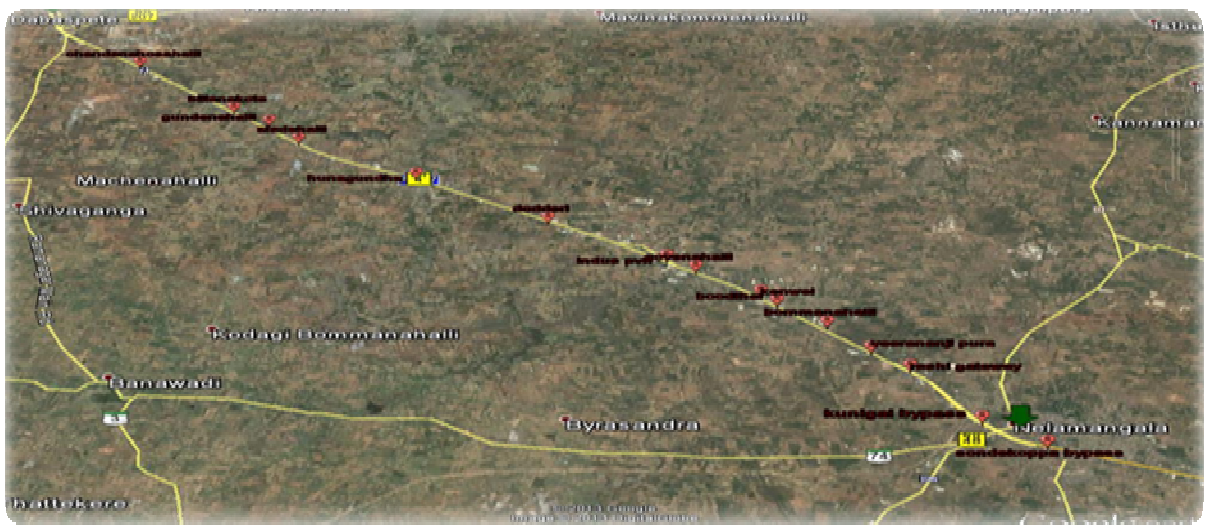

Fig.-1: Map of the study area

Soil Sampling and Chemical Analysis

Soil samples were collected from 35-40 sites abetting the Nelamangala to Dabaspet region of National highway 4. At each site, two samples of soil were collected at two different zones; one at a distance of 10m and other at a distance of 200m from the edge of the road. Soil samples were collected with the aid of stainless steel ditch auger at a depth of 0-10cm and 10-20cm from the surface of the soil and samples were air-dried before chemical analysis.

The air-dried soil samples were gently ground using an acid washed porcelain pestle and mortar and then passed through a 0.2mm nylon sieve and stored in plastic bags until analysis. The soil samples for metal analysis were digested using concentrated Nitric acid. The heavy metals Titanium, Manganese, Iron, Zinc, Strontium and Zirconium levels were analysed by X-Ray fluorescence spectrometry (XRF MODEL-α-4000) in the samples from different zones across the highway.

RESULTS AND DISCUSSION

The results of the present study clearly establish the presence of heavy metals Titanium, Manganese, Iron, Zinc, Strontium, and Zirconium on the road side soil along the National Highway-4 from Nelamangala to Dabaspet and their concentration in the soil were in the order of Fe>Ti>Zr>Mn>Zn>Sr. The concentration range of six heavy metals in roadside soils, taken from 35 sites, at 10m and 200m distance from the main road is presented in Table-1.

The results indicate considerable heavy metal accumulations in the soils at 10m and 200m from the edge of the road on both sides and these accumulations could be from engine wear, bearings or bushings and from vehicular emissions. The soils across the highway have shown significant differences in the concentration of all the heavy metals studied. The concentration of Titanium was 1541ppm to 5186ppm at 10m away from the road and 1899ppm to 7044ppm at 200m away from the road. Manganese was 115ppm to 488ppm at 10m away from the road and 0ppm to 464ppm at 200m away from the road. Iron varied from 11019ppm to 36078ppmat 10m away from the road and 16047ppm to 45200ppm at 200m away from the road.

Table-1: Concentration of heavy metals in roadside soil on either side of highway at different distances (range in ppm).

Sampling site distance from road	Ti	Mn	Fe	Zn	Sr	Zr
10m	1541-5186	115-488	11019-36078	34-248	40-247	111-574
200m	1899-7044	0-464	16047-45200	25-68	30-190	112-1974
Average	3378.8	268.86	26308.07	52.6225	116.37	411.83

Table-2: Concentration of heavy metals (ppm) in the soil samples across 10m Southeast of the road (Left side from Nelamangala to Dabaspet highway)

Sample	Ti	Mn	Fe	Zn	Sr	Zr
L.S-1	4248	488	23840	107	130	574
L.S-2	1541	264	15096	72	162	237
L.S-3	2965	387	31778	46	87	299
L.S-4	2376	413	21530	70	122	464
L.S-5	2161	451	21048	67	98	185
L.S-6	1872	191	13218	34	208	208
L.S-7	2719	294	36078	248	107	276
L.S-8	3829	236	20696	43	159	329
L.S-9	2376	216	14662	52	202	194
L.S-10	4140	309	15660	83	246	233
L.S-11	2366	197	15753	42	168	191
L.S-12	1581	115	11019	35	179	312
L.S-13	5186	371	28064	61	247	405

Table-3: Concentration of heavy metals (ppm) in the soil samples across 200m Southeast of the road (Left side from Nelamangala to Dabaspet highway)

Sample	Ti	Mn	Fe	Zn	Sr	Zr
L.S-3(a)	2951	392	34256	32	32	328
L.S-4(a)	2604	243	22728	54	82	341
L.S-5(a)	2997	288	27331	65	114	231
L.S-6(a)	1899	193	16047	59	108	112
L.S-7(a)	5362	366	42759	39	35	204
L.S-8(a)	6150	464	36436	67	86	487
L.S-9(a)	2105	325	27311	35	48	220
L.S-10(a)	4113	396	32664	68	190	456
L.S-11(a)	3457	259	34528	41	120	581
L.S-12(a)	4868	284	26823	26	91	824
L.S-13(a)	4023	297	38167	36	64	385

Table-4: Concentration of heavy metals (ppm) in the soil samples across 10m Northwest of the road (Right sidefrom Nelamangala to Dabaspet highway)

Sample	Ti	Mn	Fe	Zn	Sr	Zr
R.S-1	1584	181	11747	44	158	111
R.S-2	3957	177	34459	43	107	390
R.S-3	1920	204	11422	41	210	167
R.S-4	2686	343	29446	36	40	286
R.S-5	2239	209	15578	36	137	313

Table-5: Concentration of heavy metals (ppm) in the soil samples across 200m northwest of the road (Right side from Nelamangala to Dabaspet highway)

Sample	Ti	Mn	Fe	Zn	Sr	Zr
R.S-1(a)	4592	253	26940	25	108	349
R.S-2(a)	4012	<LOD	26037	32	91	532
R.S-3(a)	3530	288	25925	67	125	573
R.S-4(a)	3401	318	42047	58	30	145
R.S-5(a)	7044	298	45200	64	67	1974

Zinc was 34ppm to 248ppm at 10m away from the road and 25ppm to 68ppm at 200m away from the road. Strontium was 40ppm to 247ppm at 10m away from the road and 30ppm to 190ppm at 200m away from the road and Zirconium was 111ppm to 574ppm at 10m away from the road and 112ppm to 1974ppm at 200m away from the road. Road-side soil often shows a high degree of contamination that can be attributed to motor vehicles. Vehicular discharge of numerous gases and trace metal contaminants due to incomplete combustion of petroleum fuel, adversely affects the microbial population and their activities in the soil. Mineral filler materials in road surfaces contain different heavy metal species, including Titanium, Manganese, Iron, Zinc, Strontium and Zirconium which can be transported into the road-side soils by atmospheric precipitation or road runoff. The bio-availability and environmental mobility of the metals are dependent upon the form in which the metal is associated with the soil.

Heavy metals can directly harm public health by entering the body via soil and dust and through the food chain. The typical elements, including Titanium, Manganese, Iron, Zinc, Strontium and Zirconium in roadside soils coming from traffic activity, can be transported through the food chain into the human body and thus be very toxic to people. In agricultural areas, intake of heavy metals through the soil, crop system could play a predominant role in human exposure to heavy metals. In general, heavy metals with a high concentration in the environment result in health problem adversely affecting the nervous, cardiovascular, renal and reproductive systems. The consequences of heavy metal pollution include reduced intelligence, attention deficit and behavioural abnormality as well as contributing to cardiovascular diseases in adult. However, it is not easy to remove heavy metals from the soils because of their irreversible immobilization within different soil components.

Road-side heavy metal concentration is influenced by multiple factors, including traffic properties, highway characteristics, road-side terrain, road-side distance, rainfall and wind direction, etc. Normally, the heavy metal content in roadside soils has a belt-shaped distribution in terms of distance to the road edge, increasing/decreasing exponentially with distance from the road. The concentration of heavy metals Titanium, Manganese, Iron, Zinc, Strontium and Zirconium as analysed by X-Ray fluorescence spectrometry in the soil samples collected on the roadside are given in the Tables-2, 3,4 and 5.

CONCLUSION

1. The risk posed by heavy metals to food safety and the environment is of great concern to governments and society in many countries. Heavy metal pollution in agricultural soil is becoming serious with rapid industrialization and urbanization in developing countries and it is also influenced by the continuous increase in traffic of vehicles on the highways as observed presently in the soils

across NH-4. The cumulative contamination effect of long-term exposure to traffic activities cannot be neglected, more importantly the road-side farmland soil, which is associated with the food chain and public health.

2. There is no consistent trend in the concentration of heavy metals in the soils farther to the highway in comparison to those adjacent to the road. The results presented in the paper highlight the impact of vehicular exhausts leading to contamination of soils with heavy metals.
3. As per International Agricultural soil standards, no guideline value is set for Iron. The permissible limit for Manganese is given as 500mg/Kg and for Zinc it is 250mg/Kg. From the present study, both Manganese and Zinc were found to be in the permissible limits. Titanium is said to be non-toxic even in large doses, however a correlation between titanium and Yellow nail syndrome has been reported[19]. Strontium is said to behave chemically like Calcium in biological systems. Certain studies indicate a lack of any undesirable side effects of Strontium[20-21]. Zirconium is also considered to have low systemic toxicity.

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