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HEAVY METAL ANALYSIS ON ROAD SIDE SEDIMENTS OF MUMBAI-PUNE NATIONAL HIGHWAY USING ATOMIC ABSORPTION SPECTROSCOPY (AAS) TECHNIQUE

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ABSTRACT

In this study road side sediments sample were collected in Mumbai-Pune National Highway for a stretch from Pnavel to Pune and subjected for heavy metals (Zn, Cr, Cd, Pb) analysis through Atomic Absorption Spectroscopy (AAS) Technique. Totally 25 sites were selected for sediments sample collection and sediment samples were collected as per standard methods. The concentration of heavy metals present in the road site sediments from the study area was determined by Atomic Absorption Spectrophotometer AAS7000. From the toxicity parameter results, it is observed that the contamination of the road site sediments in the study area by the metals Cd, Pb and Zn is mainly due to the anthropogenic activities (man-made activities) like industrial effluents, vehicular emission and wastages supplied to environment on the travel and uncontrolled input of sewage, garbage into the road side environment.

KEYWORDS: road side sediments, heavy metals, Atomic Absorption Spectrometer.

INTRODUCTION

Toxicity factors such as Contamination Factor (CF) and Geo-accumulation Index (Igeo) were calculated using average continental crustal values for heavy metals.[1,2] The term "heavy metals" refers to any metallic element that has a relative density greater than 4g/cm^3 or 5 times or more, greater than water.[3-9] Heavy metals include; Lead (Pb), Cadmium (Cd), Zinc

(Zn), Mercury (Hg), Arsenic (As), Silver (Ag), Chromium (Cr), Copper (Cu), Iron (Fe) and platinum (Pt) group elements. They are non-biodegradable and cause soil as well as environmental pollution.[10,11] The rapid increase in the use of vehicles for day to day transportation in most developing countries, coupled with lack of emission standards, has contributed a great deal of concern over vehicular pollution. Vehicular emission is at its peak when there is an increase in population, together with increase in the number of vehicles on roads. Most of the byproduct of automobiles comprise of different fraction particles. These fractions include the ultrafine particles which are formed in the engine and tailpipes; fine particle produces mainly by chemical reactions, and coarse particles which are form mechanically by the abrasion of road materials, tyres and brake linings.[11] Soil becomes contaminated by the accumulation of heavy metals produced from these traffic activities. Surveys on the distribution and concentration of heavy metals in the road side soil is important for planning management strategies to achieve better soil quality and to control the risk associated with the excessive intake of heavy metals.

EXPERIMENTAL SECTION

In this study it has been observed that deposition of metals in surface soils shows decreasing trend with increasing distance from the highway. Also the concentration of metals in the road side soil are influenced by meteorological conditions, traffic density and the kind of vehicle in traffic and soil parameters.

Mobility of heavy metals is mainly influenced by the soil factors such as pH, organic matter, ionic strength, CEC, texture, temperature, salinity amendments, Zn fertilization, rhizosphere, pH, phenolic substance and so on. Studies show that metals were sparingly soluble under alkaline conditions (pH=8) and metal solubility was higher under slightly acidic conditions (pH=5) and increase drastically when pH was kept at 3.3, soil organic matter act as a key for absorption phase for metals. Organic matter is important for the retention of metals by soil solids, thus decreasing mobility and bioavailability. A very strong correlation exists between decreasing grain size and the amount of heavy metal held by soil fraction. Heavy metals, in ionic form predominantly associate with smaller, higher surface area particles.

Road side soil contains high levels of heavy metals closer to the carriageway and contributes health risk to human and animal when plants-based food stuff grown in the area is consumed and also when metal contaminated soil particles are inhaled by the population.[12,13] Several health hazards are associated with exposure to polluted soil with children being more susceptible to the risk.

In this study, concentration of different heavy metals in road side soils and the influence of soil characteristics on metal binding were analyzed. The study area are selected was Mumbai-Pune national highway stretch starting from Panvel to Pune.

OBJECTIVES OF THE STUDY

1. To analyze the heavy metal composition of road side sediments collected from 20 selected locations over a stretch starting from Panvel to Pune in Mumbai-Pune national highway road.
2. To calculate some important toxicity parameters to know contamination level of the road side sediments.

MATERIALS AND METHODS

Heavy metals are natural constituents of the Earth's crust, but indiscriminate human activities have drastically altered their geochemical cycles and biochemical balance. Prolonged exposure to heavy metals such as cadmium, copper, lead, nickel, and zinc can cause deleterious health effects in humans. These metals are a cause of environmental pollution from sources such as leaded petrol, industrial effluents, garbage, wastages, and leaching of metal ions in addition to natural origin from earth crust. They exist in the road side sediments as a result of weathering, intrusion of contamination through the above said sources and subsequent deposition along the road sides from the waste streams.

Any metal species may be considered as "contaminant" if it occurs where it is unwanted, or in a form or concentration that cause a detrimental human or environmental effect. Some of the metallic contaminants include lead (Pd), cadmium (Cd), mercury (Hg), arsenic (As), Chromium (Cr), copper (Cu), selenium (Se), nickel (Ni), silver (Ag), and zinc (Zn) etc. other lesser common metallic contaminants include aluminum (Al), cesium (Cs), cobalt (Co), manganese (Mn), molybdenum (Mo), strontium (Sr), and uranium (U).[14]

SELECTION OF ROAD STRETCH FOR THE STUDY

Based on the analysis of samples collected from 25 sites of Mumbai-Pune national highway, the one with highest metal concentration and having considerable amount of traffic was selected as the stretch for detailed analysis.

COLLECTION OF SOIL SAMPLES

The present study area covers a total length of about 150 km from which 25 successive locations were selected and road side sediment samples were collected and numbered as S1 to S25. Each location is separated by a distance of 5 km to 6 km approximately. The sample from all site were collected manually from the top surface (0-6 cm depth) using plastic spade and packed in polyethylene bags during the period of June 2016 to February 2017. Stones and other impurities were removed and the collected samples were air dried at room temperature in open air.

SAMPLE PREPARATION

The collected samples were dried at 110 C suing hot air oven and stones and other impurities were removed. The dried sample were sieved using a sieve shaker to 250 µm grain size and the samples are packed for acid digestion and subsequent elemental analysis using Atomic Absorption Spectrophotometer.

ATOMIC ABSORPTION SPECTROSCOPY TECHNIQUE (AAS)

Atomic absorption spectroscopy (AAS) is a spectro-analytical procedure for the quantitative determination of chemical elements employing the absorption of optical radiation by free atoms in the gaseous state. The technique is used for determining the concentration of a particular element in a sample to be analyzed. Atomic absorption occurs when a ground sate atom absorbed energy in the form of light of a specific wavelength and is elevated to an exited state. The relation between the amount of light absorbed and the concentration of analytes present in know standards can be used to determine unknown sample concentration by measuring the amount of light they absorb.

RESULTS AND DISCUSSION

Distribution of Heavy Metals

The heavy metal (Zn, Pb, Cr, Cd) concentration obtained by AAS technique in the randomly selected 7 sampling sites is tabulated in the table 1.

Table 1: Heavy metal concentration of observed metals in the road side sediments under study.

Site No.	Heavy Metal Concentration in ppm			
	Zn	Pb	Cr	Cd
S1	61.33	132.05	29.03	1.140
S3	55.21	110.15	103.50	0.466
S8	88.45	68.55	50.10	0.906
S11	121.10	50.25	66.14	0.558
S15	128.03	95.03	250.05	0.604
S18	150.21	71.33	103.6	0.302
S22	69.08	126.51	41.10	1.024
Avg.	96.20	93.41	91.93	0.714
Max.	128.03	132.05	250.05	1.140
Min.	55.21	50.25	29.03	0.302

The minimum, maximum and average value of the elemental concentration are Compared with the crustal average as shown in the table 2.

Table 2: Statistical summary of measured heavy metals.

Site No.	Heavy Metals Concentration in ppm			
	Zn	Pb	Cr	Cd
Avg.	96.20	93.41	91.93	0.714
Max.	128.03	132.05	250.05	1.140
Min.	55.21	50.25	29.03	0.302
Crustal Average	65.00	13.5	103.0	0.280
Upper Continental Crust	48.00	18.23	34.00	0.105

From the above table, the average concentrations of heavy metals are in the order Zn> Pb> Cr> Cd. From the above values, toxicity parameter such as Contamination Factor (CF) and Geo Accumulation Index (Igeo) are calculated and the results are discussed.

ESTIMATING THE LEVEL OF TOXICITY

Contamination Factor (CF)

The sediment in the area are the indicator of anthropogenic changes and composition is controlled by the nature of substrate, conditions controlling the dissolution and precipitation of metals, pollution sites etc. sediments have the capacity to record the history and indicate the degree of pollution.[15,16]

CF is the ratio between the sediment metal concentration at a given site and the background value of the metal.[15] Contamination factor CF is an effective tool in monitoring the pollution over a period of time.

Contamination factor (CF) =Measured concentration of the metal/Background value of the metal.

Table 3: Contamination Factor values of observed metals in the road side sediments of the study areas.

Site No.	Contamination Factor			
	Zn	**Pb**	**Cr**	**Cd**
S1	0.119	0.895	0.082	11.40
S3	0.107	0.746	0.295	4.66
S8	0.171	0.464	0.143	9.06
S11	0.235	0.340	0.188	5.58
S15	0.248	0.644	0.714	6.04
S18	0.291	0.483	0.296	3.02
S22	0.134	0.857	0.117	10.024
Avg.	0.186	0.633	0.262	7.14
Max.	0.248	0.895	0.714	11.40
Min.	0.107	0.340	0.082	3.02

GEO-ACCUMULATION INDEX (IGEO)

The geo-accumulation index (Igeo) defined by Muller [17] is also a measure of the metal pollution in aquatic sediments [15]. The geo accumulation index is given by

$$\mathbf{Igeo = log_2\,(Cn/1.5Bn)}$$

Where Cn is the measured elemental concentration and Bn is the background value of the same element.

The factor 1.5 is used because of possible variation in background values for a given metal in the environment. In the present study, Igeo was used to understand heavy metal concentration in the road side sediments in the selected location along Mumbai Pune national highway, stretch starting from Panvel to Pune under study. The world average concentrations of these elements were taken as the background values.

The calculated geo-accumulation index (Igeo) value for the observed metals in the road side sediments along the selected site of the national highway road under study are calculated and tabulated in table 4.

Table 4: Geo-accumulation index values of observed metal in the road side sediments of the study areas.

Site No.	Geo-accumulation Index (Igeo)			
	Zn	**Pb**	**Cr**	**Cd**
S1	-0.398	2.301	-1.010	2.925
S3	-0.321	2.211	0.981	1.635
S8	0.180	-0.015	-0.069	2.595
S11	0.799	-0.097	0.333	1.895
S15	0.812	0.952	2.351	2.010
S18	0.901	0.035	0.986	1.010
S22	-0.121	2.251	-00.353	2.771
Avg.	0.195	0.921	0.0995	2.25
Max.	0.812	2.301	2.351	2.925
Min.	-0.321	-0.097	-0.353	1.010

DISCUSSION

Contamination Factor (CF)

According to Pekey[18] and Jayaprakash,[19] if the CF ≥ 1, it shows a low contamination factor. The value limit 1≤ CF < 3 shows moderate contamination factor. The CF value limit 3 ≤ CF < 6 show considerable contamination factor. If the CF is greater than or equal to 6 it shows very high contamination factor.

The average contamination factor values given in the table 3 exhibits the CF of the observed metal in the road side sediments are found to be in the order: Cd > Pd > Cr > Zn. Since the average CF value observed for Cd lies between 3 and 6 and for Pb is more than zero, it may be concluded that the road side sediments in the study area along Mumbai-Pune national highway is moderately contaminated by the metal Cd and very less contamination due to Pb. This is due to the factor that the study area is contaminated by the industrial effluents from the nearby industries and vehicular emissions. Further the sediments are very feebly contaminated by Zn and Cr. The above contamination may be due to anthropogenic activities like releasing of industrial wastage and sewage to the environment. These moderate and feeble contaminations due to Cd and Pb may impose hazardous health effects to human beings as discussed earlier.

GEO-ACCUMULATION INDEX (IGEO)

In this study, Igeo was calculated using background values for world crustal average metal concentrations.

The value of geo-accumulation index explains the heavy metal enrichment with respect to the background values as given below table 5:

Table-5.

Igeo	Nature of Contamination
<0	Unpolluted
0-1	From unpolluted to moderately polluted
1-2	Moderately polluted
2-3	From moderately polluted to strongly polluted
3-4	Strongly polluted
4-5	From strongly polluted to extremely polluted
>5	Extremely polluted

The average value of Igeo given in the table 4 exhibit the strong pollution of road side sediments in the study area by the metal Cd and Pb. The Igeo Values for Zn and Cr lie between 0 to 1 and this shows the moderate pollution of the sediments by the respective elements. Negative Igeo values exhibit unpolluted condition of the road side sediments by the concern metal.

The negative Igeo values represent relatively the lithogenic contamination. However, for Cd, Pb and Zn, the values are much higher than the average contamination crust in the study area and attribute for the enhanced result for enrichment and contamination factors.

CONCLUSION

The heavy metal concentration in the road side sediments of Mumbai-Pune national highway road side study area was determined by Atomic Absorption Spectrophotometer AA7000. Toxicity factor such as Contamination factor (CF) and Geo-accumulation Index (Igeo) were calculated using average continental crustal values for heavy metals. From the toxicity parameter results, it is observed that the contamination of the road side sediments in the study area by the metals Cd and Pb with Zn is mainly due to the anthropogenic activities (man-made activities) like industrial effluents, vehicular emission and wastages on the travel and uncontrolled input of sewage, garbage to the road side environment.

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