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Assessment of heavy metal contamination in the evergreen tree *Mangifera indica* L. and soils near National Highway-47 in Thiruvananthapuram District, Kerala

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Abstract

The present study was carried out to assess the heavy metal contamination in the evergreen tree *Mangifera Indica* L. and soils near the National Highway-47 passing through Thiruvananthapuram District in Kerala State. The study showed that the concentration of heavy metals like cadmium, lead and zinc in the leaves and crops of *Mangifera indica* in the sampling stations of road sides were high compared to that of the control station in the study area. The presence of heavy metals were also detected in the soils of all selected study stations near National Highway-47, and the concentration of lead and cadmium were found high in the soils collected from the study stations, Thampanoor and Pallichal of Thiruvananthapuram district with high vehicular intensity. Therefore this study concludes that the *Mangifera indica* L and its crop 'mango' in the main road side areas of the capital city of Kerala were contaminated with heavy metals which may cause health problems in humans on daily consumption of the crop.

Key words: Heavy metals, Mangifera indica, Soils, pH, Organic matter

Introduction

Human activities such as mining, smelting, refining, energy production, industrial and vehicular emissions, agricultural operations, sewage discharge, and disposal of wastes are rapidly increasing environmental pollution. Heavy metals are present in all phases of the environment- air, water, and land. Emissions into the air constitute the greatest source of heavy metal pollution. Soils are described as the sink for metals. The metals being immobile in soils accumulate in the top soil, thus endangering crops and vegetables. Besides plants, other items in the food chain may also get contaminated (Athar and Vohora, 1995).

In many developing countries including India, the levels of air pollutants are increasing rapidly in urban and peri-urban areas (Agrawal *et al.*, 2003). Petrol and Diesel engine motor vehicles emit a wide variety of pollutants principally benzene, carbon monoxide, lead, organic compounds, oxides of nitrogen, sulphur dioxide, and other suspended particulate matter like smoke, metals (Cd, Co, Cu, Zn, etc.) and inert dust (Gajghate and Hasan, 1999). Metals may accumulate in our body and affect the central nervous system, causing heavy metal poisoning and acting as cofactors in many other diseases. There is increasing public concern about health effects resulting from ingestion of food containing toxic metals such as cadmium and lead. A wide range of metabolic disorders and neuropsychological deficits in children have been noted, and chronic exposure to cadmium has been linked to kidney failure and bone disease.

Plants have a higher capacity to take up metals from soils or atmosphere than their physiological needs. While this may not have any adverse effect on plant itself, it may expose the consumer to higher intake of concerned metals. Since plants are the major source of human food, a study of metal-content in plants and crops indicates the extent of heavy metal contamination in human beings by consuming them (Athar and Vohora, 1995). Air pollution has the potential to reduce yield and the nutritional quality of crop plants (Jager *et al.*, 1993). Chemical contamination from sources such as industries, vehicles and pesticides can affect the safety of food. Heavy metals are one

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of a range of important types of contaminants that can be found on the surface and in the tissue of fresh vegetables. Vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Zurera-Cosano *et al.*, 1989). It has been reported that nearly half of the mean ingestion of lead, cadmium and mercury through food is due to plant origin (fruit, vegetables and cereals).

The aim of the present study is to assess the heavy metal content in the leaves and crop of Mangifera indica, and in the soils near the road side areas of National Highway-47 passing through Thiruvananthapuram District.

Materials and Methods

Study Area and Location

The study area was Thiruvananthapuram District, the capital city of Kerala State. The National Highway-47 (NH-47), from Kanyakumari to Salem, is of 640 km total length, which is the major route for passenger and freight transportation in southern and central Kerala. Due to the commercial importance of Thiruvananthapuram city and also with various industries, there is heavy increase in vehicular intensity in the National Highway – 47 passing through this district. The present study was conducted in the evergreen tree, *Mangifera indica* L. cultivar "Kottoorkonam" variety grown in the road sides of NH – 47 (with length : 55 km) passing through Thiruvananthapuram District, and the soils in this area. For this, six stations were identified 9 km apart, from Attingal to Neyyattinkara and one control station was also selected near Kariavattom University Campus that is in a benign environment, 5 km away from road side area. The sampling stations selected for the study include : Station I – Attingal; Station II – Mangalapuram; Station III – Kazhakuttam; Station IV – Thampanoor ; Station V – Pallichal ; Station VI – Neyyattinkara ; Station VII -Control station. Soil samples were also collected from the selected sampling stations. The location of the study area and sampling stations were given in figure.1.

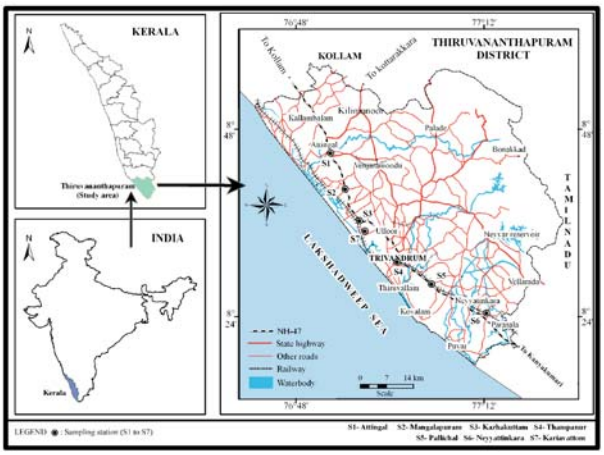


Fig. 1: Location map of study area showing sampling stations

Sampling and Analysis

The sampling of soils in the study area were conducted during the post-monsoon (Nov. 2005), pre-monsoon (March 2006) and monsoon seasons (July 2006). The surface soils (5-10 cm depth) from each study stations were sampled according to Cone and Quarter method (Carver, 1971). These samples were collected in labeled polythene bags. The leaves and mango were collected from *Mangifera indica* L. cultivar 'Kottoorkonam' variety in the selected stations during the pre-monsoon season (April-May 2006). The mature leaves and raw mangoes were plucked from the selected evergreen trees of almost same height and placed in labeled polythene bags. The diameter at breast height was taken as one of the criteria to bring out uniformity in age of trees. The collected samples were brought to the laboratory for detailed analysis. The soil samples, leaf and raw mango samples were dried in the sunlight and the heavy metals (Pb, Cd and Zn) content in the samples were estimated after diacid digestion (Gupta, 1999; Alloway, 1995) using an inductively coupled plasma atomic emission spectrometer (model IRIS intrepid II XSP). The soil physico-chemical parameters like pH, electrical conductivity, and organic matter were determined following the procedure of Saxena (1998).

Results and Discussion

Heavy metal content in Leaves and Mango

The heavy metal content in the leaves and 'mango', the edible crop of *Mangifera indica* was

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estimated and the results are given in table 1 and 2 respectively. The potential harm posed by the uptake of heavy metals such as cadmium and lead by plants is dependent on their abundance, mobility and bioaccumulation. The heavy metals, lead (Pb), Cadmium (Cd) and Zinc (Zn) are detected in the leaves of *Mangifera indica* in all the road side study stations. The cadmium was not detected in the leaves of *Mangifera indica* in the control station. The concentration of Pb and Zn was found to be more in road side plant leaves compared to that in the control station that is 5 km away from road side area. This increase in heavy metals in leaves of road side plants may be due to the accumulation of heavy metals from the contaminated soils and air of road side area. Soil represents a major sink for heavy metals ions, which can then enter the food chain via plants or leaching into groundwater (Bradl, 2005).

In the mango collected and analysed, the heavy metals Pb, Cd and Zn were detected. The heavy metal content was found to be high in the mangoes collected from the stations I, IV and VI. The concentration of the heavy metals, lead and cadmium in raw mangoes detected were beyond the permissible levels given by WHO (1993) for human consumption. Heavy metals may be present as a deposit on the surface of the vegetable, or may be taken up by the crop roots and incorporated into the plant tissue and the original source of the pollution may be from vehicular air pollution or contaminants deposited in soil. Prolonged human consumption of unsafe concentrations of heavy metals in food stuffs may lead to the disruption of numerous biological and biochemical processes in the human body.

It was also observed that the mangoes and leaves with increased heavy metal accumulation were collected from the *Mangifera indica* variety present in the study stations near NH-47, which are having high vehicular intensity (PWD Report, 1997). The present study showed that concentration of different heavy metals detected in *Mangifera indica* leaves and crop is in the order Zn > Pb > Cd. Phytotoxicity of heavy metals and other particles emitted from auto exhaust have been shown to accumulate and may cause damage and death of plant species growing along road side (Alfani *et al*., 1996).

Table 1: Heavy metal content in leaves of Mangifera indica (Values are mean of three replications ± SE).

Station	Heavy Metals (μg/gm dw)		
	Pb	Cd	Zn
I	8.57 ±0.074	4.07 ±0.156	38.33 ±0.882
II	9.04 ±0.163	3.55 ±0.115	28.00 ±0.577
III	9.51 ±0.122	4.09 ±0.137	32.00 ±1.039
IV	10.01 ±0.167	5.07 ±0.215	45.53 ±0.636
V	9.03 ±0.366	3.52 ±0.143	29.99 ±1.039
VI	8.51 ±0.215	3.54 ±0.254	35.57 ±0.852
VII	7.51 ±0.211	BDL	10.52 ±0.240

BDL - Below Detectable Limit

Table 2: Heavy metal content in Mango (Values are mean of three replications ± SE)

Station	Heavy Metals (μg/gm dw)		
	Pb	Cd	Zn
I	8.06 ±0.102	2.24 ±0.433	13.50 ±0.244
II	6.80 ±0.254	2.08 ±0.262	8.52 ±0.263
III	6.58 ±0.219	2.56 ±0.242	10.08 ±0.292
IV	7.51 ±0.172	3.09 ±0.415	12.51 ±0.244
V	6.51 ±0.155	2.50 ±0.213	11.06 ±0.297
VI	9.02 ±0.466	2.59 ±0.239	13.06 ±0.535
VII	4.31 ±0.426	2.01 ±0.055	10.01 ±0.315

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Changes in Soil Physico-chemical Parameters

The changes in selected physico-chemical characteristics of the soil samples collected from different sampling stations in the study area are given in Table-3. In the post monsoon season, the soil pH in the study stations varies from 6.36 to 8.34 and electrical conductivity varies from 0.147 mS to 0.484 mS., but the soil pH was found to be alkaline (7.03 to 8.44) during the pre-monsoon season in all the stations. During the monsoon season, the pH is below neutral and it varies from 6.44 to 6.77 in different stations. The mean soil pH near NH-47 during the study period ranges from to 6.84 to 7.76. The pH is most influential to govern mobility and availability of metals and it is found that cation exchange capacity of a soil increases with a rise in pH (Brummer, 1986). Also the mobility and availability of heavy metals is considerably greater in acidic soils than in near neutral or alkaline soils (Lahermo, 1990). The electrical conductivity (E.C) of soils near NH-47 also varies in different seasons studied. The E.C in the soils of different stations ranges from 0.126 mS to 0.473 mS during post monsoon and it ranges from 0.218 mS to 0.434 mS during pre-monsoon. The variation in soil E.C in different stations during monsoon is from 0.101 mS to 0.225 mS. The mean electrical conductivity was found to be highest (0.347 mS) in station V and lowest in station II (0.168 mS). The soil with maximum electrical conductivity will have high concentrations of ions like sulphates, nitrates etc.

The changes in organic matter and heavy metal content in the soils of study stations are given in Table-4. The organic matter content was found to be highest (2.196 mg %) in station IV and lowest (0.225 mg %) in station VII i.e. the control station. In soils, high organic matter content helps in the high retention capacity for many pollutants (Gambrell, 1994). The concentration of heavy metals Pb, Cd and Zn were

Table 3: Changes in Soil organic matter and Heavy metal content (Values are mean of three replications ±SE)

Station	Organic Matter (mg%)	Heavy Metals (μg/gm dw)		
		Pb	Cd	Zn
I	0.561 ± 0.019	120.20 ±1.011	34.50 ± 0.978	28.22 ± 0.404
II	1.008 ± 0.062	120.42 ± 0.734	30.77 ± 0.436	30.56 ± 0.072
III	1.513 ± 0.070	110.33 ± 0.610	33.55 ± 0.940	35.38 ± 0.158
IV	2.196 ± 0.033	140.26 ± 0.999	38.23 ± 0.784	48.12 ± 0.466
V	0.784 ± 0.070	136.46 ± 0.764	37.53 ± 0.440	56.46 ± 0.174
VI	0.727 ± 0.040	132.69 ± 0.558	36.16 ± 0.491	52.01 ± 0.378
VII	0.225 ± 0.039	93.15 ± 0.934	28.89 ± 0.495	24.53 ± 0.609

Table 4: Changes in Physical characteristics of Soil (Average of three replications)

Station	pH				Electrical Conductivity (mS)			
	Post Monsoon	Pre Monsoon	Monsoon	Mean	Post Monsoon	Pre Monsoon	Monsoon	Mean
I	6.36	8.44	6.70	7.17	0.473	0.431	0.101	0.335
II	6.88	7.52	6.77	7.06	0.126	0.249	0.129	0.168
III	6.46	7.44	6.63	6.84	0.240	0.218	0.137	0.198
IV	8.34	8.49	6.44	7.76	0.147	0.233	0.141	0.174
V	7.4	7.40	6.53	7.11	0.434	0.434	0.173	0.347
VI	8.25	8.25	6.60	7.70	0.276	0.276	0.225	0.259
VII	7.05	7.03	6.59	6.89	0.484	0.396	0.104	0.328

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also found to be high in the soil of road side study stations compared to that of the control stations. The sequence of metal concentrations in the soil was Pb > Zn > Cd. The highest concentration of heavy metals, Pb (140.2 mg/gm soil) and Cd (38.2 mg/gm soil) were obtained in station IV i.e. Thampanoor, one of the highest vehicular intensity area near National Highway-47 passing through Thiruvananthapuram District in Kerala (PWD, 1997). Significant amount of cadmium was observed in most of the study stations and it may be from the wear and tear of vehicle tyres, lubricant oils and car washes from the service stations in the road side areas (Deepu and Jaya, 2002). Even though unleaded petrol is used in vehicles now-a-days, the high amounts of lead obtained in samples studied may be due to retention of early deposited lead in the soils for years.

Conclusion

The study conducted in road side trees and soils of National Highway-47 passing through Thiruvananthapuram district showed that the heavy metal content in the leaves and crops of the evergreen tree *Mangifera indica* in the sampling sites of road sides were high compared to that in the control station of Thiruvananthapuram District. Heavy metals were also detected in the surface soils of all selected study stations near National Highway-47, and the concentration of lead and cadmium were found to be high in the soils collected from the study stations, Thampanoor and Pallichal of Thiruvananthapuram district with high vehicular intensity. Therefore this study concludes that the *Mangifera indica* L. and its crop 'mango', and the soils in the road side areas of NH-47 were contaminated with heavy metals. The heavy metal contamination was found highest in Thampanoor, the study station with highest traffic density.

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