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# Lead pollution in soil, water and plants due to automobile emission in urban environments in Coimbatore

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**Abstract: The soil, water and plants of urban and suburban of Coimbatore city showed high concentration of Pb. The soil samples from Coimbatore urban areas, especially along the road sides of National Highways, showed higher pH and EC. A high level (2.11 $dSm^{-1}$) of EC was noticed in Gandhi Park II location. Lead contents of soils also showed higher accumulation. A maximum of 141.2 mg $kg^{-1}$ was recorded at MTP Road VI location *viz.*, Goundampalayam Union Road. Water samples also showed higher pH and EC than the acceptable limits. An unusual high level of 2.87 $dSm^{-1}$ of EC was recorded at MTP Road III location. High concentration of Pb was observed in the water samples. Most of the samples exceeded the maximum permissible limit of Pb (0.1 mg $l^{-1}$) fixed for drinking water. Most of the predominant species of the plants were found to have accumulated higher amounts (up to 110 mg $kg^{-1}$) of Pb in Coimbatore urban.**

***Key words: Lead pollution, soil, water, plants***

## Introduction

Environment of this biosphere, be it physical, chemical and biological, is a gift of Mother Nature. Human advancements not only improved their modernized living but also had phenomenal negative impacts to their living environments. Now, there is an increasing awareness that environmental issues are no longer parochial or national concerns but global ones. In fact, environmental pollution is a by product of development and a price for progress. Of several causes, air pollution is most deleterious to the living beings on this biosphere. Automobile emission is the prime reason for air pollution now-a-days. The usage of many types of vehicles, fuelled by a variety of products emits varying amount of both simple and complex pollutants mainly at the ground level and dispersion is very limited.

Automobile emissions are the major source of lead pollution in the urban environment. Lead, a toxic heavy metal, is introduced into the environment mostly from petrol driven vehicles. The increasing use of lead is responsible for the alarming and threatening exposure to this toxic pollutant, globally. Lead comes in the category of those trace elements which are known to be toxic even when present in traces. It is one of the softest and heaviest metals available. Lead in the tetraethyl $[CH_3CH_2)_4Pb]$ form is used as an antiknock additive to gasoline to increase its octane number. The lead containing gasoline fumes from automobile exhaust constitute the chief and widespread source of lead contamination in the urban environment (Pratapa Mowli and Venkata Subbaya, 1989). Thus lead contamination in soil, plants and water becomes inevitable

**Table 1. Sampling (soil, water and plant) locations and landmarks on the road sides in urban and suburban areas of Coimbatore**

| Sample No. | Road location | Landmarks of sampling |
|---|---|---|
| 1 | Gandhi Park I* | Gandhi Park Entrance |
| 2 | Gandhi Park II | Gandhi Park Residential Area** |
| 3 | DB Road I | ING Vysya Bank Ltd. |
| 4 | DB Road II | Sabitha Hall |
| 5 | MTP Road I | Avinashilingam University |
| 6 | MTP Road II | Sri Kumaran Hospital |
| 7 | MTP Road III | Kumaran Kalyana Mandapam** |
| 8 | MTP Road IV | Ariyan Motors |
| 9 | MTP Road V | Bharat Petrol Bunk** |
| 10 | MTP Road VI | Goundampalayam Union Road |

* The Roman letters I, II… are used to denote the exact location from where the samples were drawn on the road sides.

DB Road- Diwan Bhagadur Road (Inner city Road)
MTP Road- Mettupalayam Road (National Highways Road)
Suburban Roads (State Highways Road)

** Water samples of these locations were collected from ditches and other samples were drinking water / bore well waters

**Table 2. Plant samples collected from urban and suburban areas of Coimbatore**

| S.No | Common Name | Botanical Name | Family |
|---|---|---|---|
| 1. | Curry leaf tree | *Murraya koenigii* (L.) Sprengel | Rutaceae |
| 2. | Green amaranth | *Amaranthus viridis* L. | Amaranthaceae |
| 3. | Desert horse purslane | *Trianthema portulacastrum* L. | Aizoaceae |
| 4. | Indian Doab | *Cynodon dactylon* (L.) Pers. | Poaceae |
| 5. | Castor oil plant | *Ricinus communis* L. | Euphorbiaceae |
| 6. | Coral creeper | *Antigonon leptopus* Hook Arn. | Fabaceae |
| 7. | Bitter weed | *Parthenium hysterophorus* L. | Asteraceae |
| 8. | Thorn apple | *Datura stramonium* L. | Solanaceae |
| 9. | Indian copper leaf | *Acalypha indica* L. | Euphorbiaceae |
| 10. | Paper flower | *Bougainvilla spectabilis* L. | Nyctaginaceae |

from the automobile exhaust. The inappropriate use of lead and its compounds has resulted in sporadic and silent outbreak of lead poisoning in the environment including human beings (Seema George, 2003). Hence, the present investigation was carried out to estimate the amount of vehicular lead in the urban environments of Coimbatore city to determine the nature of lead in soil, plants and water ecosystems.

## Materials and Methods

A study was undertaken to examine the lead pollution due to automobile emission in Coimbatore urban and suburban environments. The details of the materials used and methodology adopted are described in this chapter. Coimbatore, strategically located at the Coramandal coast, is at 10ºN, 77ºE and 426.72 m.s.l and is the second largest industrial centre in Tamil Nadu. It enjoys a salubrious climate as it is exposed to the Palghat gap of the Western Ghats. This has attracted a large number of textile mills to the region and Coimbatore is rightly called "The Manchester of South India". The region is also well known for the manufacture of varied goods which has earned it the title "The Detroit of the South". The minimum and maximum temperatures prevail between 21ºC and 34ºC. It receives an annual rainfall of 714 mm.

## Collection and Processing of Samples

*Soil*

The soil samples were collected during June-July 2007 at different locations over a length of 12 kilometers along the urban roads of Coimbatore city *i.e.* Coimbatore –Mettupalayam Road - a stretch from North Coimbatore over bridge to Goundampalayam Union Road; and the suburban roads from GCT on Thadagam Road to Kanuvai. The locations of the sampling sites are presented in Table 1. The samples were collected from 20 locations at a distance approximately 1-2 km. Replicated samples were collected from each location at 0-15 cm depth. The soil samples were air dried for 2 to 3 days at 25ºC and after grinding, passed through a 2 mm nylon sieve. The homogenized soils were stored in polythene bags until further analysis.

*Water*

The water samples were collected from ponds, stagnated surface water bodies, running waters, wells and bore wells of the urban and suburban road-sides motioned during June-July 2007. The samples were collected in new one litre polythene containers which were previously rinsed with sampling water before taking the samples. After measuring the pH and EC, the water samples were acidified with concentrated $HNO_3$ (2 ml $L^{-1}$) to a pH around 3.0 to stabilize the original valence state of Pb. The samples were stored at 4ºC and analyzed within a week.

*Plant*

The plant samples were collected from the above mentioned urban and suburban road-sides (adjacent to soil collection) during June-July 2007 (Table 2). The plant samples were collected from selected location and gently washed with 1% HCl, and dried in hot air oven at 70ºC for 8 hours and ground to pass a 0.425 mm screen using a stainless steel Wiley Mill. The samples were stored in plastic containers until further analysis.

## Chemical Analysis

*pH and electrical conductivity*

The pH and electrical conductivity (EC) of soil were measured in $H_2O$ (1:2.5) after one hour equilibration using ELTOP digital pH meter (3020) and Deluxe Conductivity meter-601 E, respectively. The pH and EC were directly measured in water samples immediately after collection.

**Table 3. pH, EC and Pb contents in soil and water samples along the road sides of urban area in Coimbatore**

| Sample No. | Location | Soil | | | Water | | |
|---|---|---|---|---|---|---|---|
| | | pH | EC ($dSm^{-1}$) | Pb ($mg\ kg^{-1}$) | pH | EC ($dSm^{-1}$) | Pb ($mg\ kg^{-1}$) |
| 1 | Gandhi Park I | 8.60 | 0.31 | 82.0 | 8.18 | 1.38 | 0.50 |
| 2 | Gandhi Park II | 7.39 | 2.11 | 24.6 | 7.20 | 1.49 | 2.42 |
| 3 | DB Road I | 8.15 | 0.86 | 65.0 | 8.62 | 1.56 | 0.28 |
| 4 | DB Road II | 7.91 | 2.20 | 122.0 | 8.30 | 1.48 | 0.35 |
| 5 | MTP Road I | 8.34 | 0.75 | 66.4 | 8.52 | 1.64 | 0.28 |
| 6 | MTP Road II | 8.27 | 0.31 | 86.0 | 8.40 | 1.46 | 0.48 |
| 7 | MTP Road III | 9.14 | 0.04 | 42.6 | 7.88 | 2.87 | 2.40 |
| 8 | MTP Road IV | 8.27 | 1.12 | 83.4 | 8.46 | 2.41 | 1.24 |
| 9 | MTP Road V | 9.13 | 0.21 | 76.0 | 8.02 | 2.31 | 4.40 |
| 10 | MTP Road VI | 8.49 | 0.25 | 141.2 | 8.18 | 1.35 | 4.10 |
| | **Mean** | **8.37** | **0.82** | **51.94** | **8.18** | **1.80** | **1.65** |
| | **S Ed** | **0.52** | **0.78** | **34.75** | **0.41** | **0.53** | **1.60** |
| | **CV** | **95.72** | **43.16** | **66.91** | **5.04** | **29.67** | **97.23** |

**Table 4. Lead contents of plants grown along the road sides of urban area in Coimbatore**

| Sample No. | Location | Plant species | Pb ($mg\ kg^{-1}$) |
|---|---|---|---|
| 1 | Gandhi Park I | Curry leaf tree | 3.70 |
| 2 | Gandhi Park II | Green amaranth | 72.0 |
| 3 | DB Road I | Desert horse purslane | 110.0 |
| 4 | DB Road II | Indian Doab | 52.0 |
| 5 | MTP Road I | Castor oil plant | 87.1 |
| 6 | MTP Road II | Coral creeper | 82.6 |
| 7 | MTP Road III | Bitter weed | 41.0 |
| 8 | MTP Road IV | Thorn apple | 29.0 |
| 9 | MTP Road V | Indian copper leaf | 25.0 |
| 10 | MTP Road VI | Paper flower | 17.0 |
| | | **Mean** | **51.94** |
| | | **S Ed** | **34.95** |
| | | **CV** | **66.91** |

*Lead in soil*

About one gram soil was digested with 10-15 ml freshly prepared aqua- regia (HCl : $HNO_3$ at 3:1) at 110ºC for 2 hours in a hotplate and made up to 50 ml using double distilled water. After filtration (Whatman No.42) and centrifugation (8000 rpm; 10 min), total Pb concentration was measured using an Atomic Absorption Spectrometer (Varian Spectra AA-200) with air-acetylene flame. The wavelength at 358 nm was used with a spectral slit width of 0.2 nm. Moisture factor was applied to express the results on oven dry weight basis.

*Lead in water*

The water soluble (or solution phase) Pb fraction was determined in the water samples after filtration through Whatman No.2 filter paper. To determine the total Pb content, the water samples were digested using aqua-regia at 1:2 ratio at 110ºC for about 2 hours, since the results of Mahimairaja *et al.* (1997) showed that the determination of heavy metals in undigested and filtered water samples recorded reduction in the recovery of total metal content. Acid digestion recovers metals both in solution and in colloidal particles. Therefore, water samples were subjected to acid digestion. After filtration and appropriate dilution, Pb was determined using Atomic Absorption Spectrometer (AAS).

*Lead in plant*

About 0.5 to 1.0 g of dried sample was digested with 15-20 ml aqua – regia at 110ºC for 2 hours, and made up to 50 ml. after filtration (Whatman No.6) the Pb content was determined in the extract using an Atomic Absorption spectrometer. Collected data were statistically analyzed for coefficient of variance.

**Results**

Pollution in this biosphere has become inevitable evil price of modernization of human culture. The changing scenario of human life style, day-by-day, especially the use of automobile increases exponentially. But the automobile exhaust let in this environment heavy deposition of lead on soil, water, plants and animals including human. The present study was under taken to investigate the extent of lead (Pb) contamination in the soil, water and plants along the road sides of urban and suburban areas of Coimbatore city. The locations of the sample collection were given in Table1. Results on the analysis of Pb in soil, water and plants and the discussions on the results of this investigation carried out are described in this chapter.

*Soil*

The pH of the soils along the road sides of Coimbatore urban areas ranged from 7.39 to 9.14. The highest value was recorded at MTP Road III and the lowest at Gandhi Park II (Table 3). Of the ten locations, the pHs were found to show increasing trend at MTP Road III and MTP Road V and these two locations represent the sample near a *Kalyana Mandapam* and petrol bunk, respectively.

The EC of the soil adjacent to urban roads varied from 0.04 to 2.20 $dSm^{-1}$ (Table 3). The highest and lowest values were recorded at DB Road II and MTP Road III, respectively. The soils from Gandhi Park II and MTP Road IV had 2.11 and 1.12 $dSm^{-1}$ of EC, respectively.

The concentration of Pb in the soil samples collected along the urban road sides ranged from 24.6 to 141.2 mg $kg^{-1}$ (Table 3). More than 80 mg $kg^{-1}$ Pb was recorded at Gandhi Park I, DB Road II, MTP Road II, MTP Road IV, and MTP Road VI. These areas correspondingly represent a Park, Hall, Hospital, Motor Shop, and a Union Road; where more number of vehicles were parked and started. While starting a vehicle after parking the

combustion is associated with extra emissions. Hence, this might be the reason for higher deposition of Pb in soils.

*Water*

The pH of water samples collected along the urban road sides of Coimbatore city ranged from 7.20 to 8.62 (Table 3). DB Road I location had high pH followed by MTP Road IV, MTP Road I, MTP Road II, and DB Road. However, the mean value of pH 8.18 showed mild alkaline.

The EC as a measurable soluble salt content of water samples collected along the urban localities of Coimbatore city varied between 1.35 and 2.87 $dSm^{-1}$ (Table 3). These water samples showed higher levels of EC, especially at locations MTP Road III, MTP Road IV and MTP Road V (EC ranged from 2.31 to 2.37 $dSm^{-1}$).

Total Pb concentration in the water samples collected along the urban road sides varied from 0.28 to 4.40 mg $l^{-1}$ (Table 3). The higher levels of Pb were noted at Gandhi Park II (2.42 mg $l^{-1}$), MTP Road III (2.40) MTP Road V (4.40) and MTP Road VI (4.10) were associated with water samples collected from ditches of that locality. These locations represent residential area, *kalyana mandapam*, petrol bunk and a union road as high soil Pb deposition were noted. But WHO standard for allowable limit of Pb in water was 0.1 mg $l^{-1}$ while it was 0.05 mg $l^{-1}$ by USEPA standard. However, irrigation water can have Pb concentration from 5-10 mg $l^{-1}$. Other than ditch water samples the water samples of other location also showed higher magnitude of Pb deposition than the WHO standard.

*Plant*

The Pb concentration recorded in plants of urban areas of Coimbatore city ranged from 3.7 to 110 mg $kg^{-1}$ (Table 4). The curry leaves plant had low levels of Pb (3.70 mg $kg^{-1}$). But higher concentrations of Pb were recorded in *Portulaga* sp. (110 mg $kg^{-1}$). The species *Antigonan leptopus* (a common fence-creeper) also registered Pb @ 82.6 mg $kg^{-1}$. The castor, *Ricinus communis* also had higher levels of Pb (62.1 mg $kg^{-1}$) in this study. It was interesting to note that the species *Portulaga oleracea*, a weed plant could accumulate more (around 100 mg $kg^{-1}$) amounts of Pb than other plant species, and followed by *Antigonan leptopus*, *Ricinus commnnis* and *Cynodon dactylon*.

**Discussion**

Elevated concentration (122-276 mg $kg^{-1}$) of Pb was found in soils collected along the road sides of urban areas of Coimbatore city. Such accumulation of Pb in soil is attributed mainly due to the automobile exhaust (Brown, 1986; Seema George, 1999). However, the soils differed considerably in their Pb contents. This differential accumulation of Pb is related to traffic density, mode of vehicle operation, wind direction, rainfall, distance from the road, and characteristics of soil. Lead dominates the roadside environment because of its common usage in gasoline as an additive: lead tetraethyl.

The deposition of particulate Pb from automobile exhaust was influenced by the weather factors. Seema George (1999) observed maximum concentration of soil-Pb during winter and minimum during summer. But, Mooniaruck *et al.* (1996) inferred that concentration of suspended particulate Pb in traffic dense area was higher during summer than winter. The soils at high vehicular road recorded more Pb compared to low vehicular road. It was also evidenced in this study that the urban road was a high vehicular road which had higher levels of Pb in soil samples. Interestingly, Seema George (1999) stated that Pb concentrations were found higher during

winter in soils of National Highways, while the concentrations were higher during summer in soils of State Highways. The dynamics in the soil properties play important role in the accumulation of Pb in soil. Accord to Alloway (1995), the retention of added heavy metals to soils was often correlated with soil organic matter. The distribution of Pb in various fractions of soils in Coimbatore urban environment showed that Pb was mostly present in organic plus iron oxide bound fraction as extracted in EDTA (Seema George, 1999). Most of the Pb in soil was present as soluble precipitate or bound to soil solids. In most of soil solutions only a small fraction of Pb was present as free ionic species ($Pb^{2+}$) and most of the soluble Pb complexed with dissolved organic matter.

High amounts of Pb in water were observed in urban samples of Coimbatore city. But Pb contents of ditch water sample were higher than the drinking water samples. The reason for higher Pb content in ditch water might be due to accumulation of Pb from various sources, like soil, rain water, home and hospital waste water, *etc.* Surface runoff and leaching might also have contributed for high levels of Pb in ditch water. Seema George (1999) reported that the water Pb was low during summer and higher during winter. The reason being probably due to adsorption of Pb in soil or soil particles as it was found to be an important mechanism for reducing the heavy metal concentration in solution (Seema george, 2003). It is assumed that a significant portion of Pb in water samples was bound to form colloids either hydrous iron oxides or organic macromolecular depending on the composition of the water. Hart and Devis (1981) found that in the fresh water about 45 per cent of total Pb was present in particulate form. The calculated equilibrium distribution of ion-exchangeable species showed that $PbCO_3$ recounted for about 80 per cent with smaller contributions from $Pb^{2+}$ and Pb ($OH^{+}$).

However, the safer limit for Pb in drinking water fixed by Ministry of Health, Government of India (1971) is 0.1 mg $l^{-1}$. In the present investigation, all the samples of urban or suburban showed higher concentration of Pb content in drinking water samples. Also, the ditch water samples had very high levels (up to 4 mg $l^{-1}$). It is alarming that the Coimbatore urban and suburban drinking water samples exceeded the maximum permissible limit of Pb prescribed for drinking purpose too. Of course this drinking water might influence the higher animals including human.

Plants in the ecosystem play important role in recycling of organic and inorganic elements. In this study, about 10 plant species were collected to know the levels of Pb concentration in them to ascertain their importance and role in heavy metal bioremediation. In this study the presence of Pb was estimated in 10 plant species *viz.*, curry leaves, green amaranths, desert horse purslane, India Doab, castor, coral creeper, bitter weed, thorn apple, Indian copper leaf, and paper flower, in Coimbatore urban. Of the ten plants, the behaviour of the plants in accumulating the Pb from the environment especially from the automobile exhaust remains almost same. The plants namely *Saranai* (in Tamil Vernacular): Desert-horse purslane, *Trianthema portulacastrum* had accumulated more amounts of Pb in both urban and suburban environments followed by castor, coral creeper, green amaranthus and Indian Doab. Of the 10 plants, curry leaves had very low concentration of Pb. The reason for higher accumulation in some of the plant species might be attributed to their broad leaved nature, accumulating efficiency and absorption from the soil and also to some unknown physiological reasons. Seema George

(1999) stated that the Indian Doab, *Cynodon dactylon* recorded higher uptake of Pb during summer than winter. Lindbery and Haris (1981) demonstrated that Pb was absorbed internally by leaves or irreversibly adsorbed onto leaves. According to Thakre and Vitall (1985), the accumulation of Pb in vegetation through aerial deposition near highways varied with vehicular traffic density and distance from road. Lord *et al*. (1979) stated that the Pb entered the plants mostly through stomata.

It is summarized from the foregoing results that the automobile exhaust resulted in severe contamination of Pb in soil, water and plants urban environments of Coimbatore city. There is no doubt that the Pb will find its way to higher animals including human through soil, water and plants since their existence is in close proximity with them. Reports of Pb accumulation in human body have been very well documented elsewhere. This study also supports that the carry over of Pb accumulation from automobile exhaust to soil-water-plant system.

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