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Lead Deposits on the Leaves of Roadside Plants of Nashik Region- A Growing Concern.

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ABSTRACT

Consumption of plants and plant based food materials can be a source of essential elements or a route of human exposure to toxicants. Lead is easily accumulated in the edible parts of leafy vegetables as compared to grains or fruit crops. The accumulation of lead in agricultural soils is potentially hazardous to humans, livestock and plants species. The purpose of this study is to determine the lead deposited on the leaves of roadside plants with an attempt to find its interference in human comfort & health. The study area was different crowded locations in Nashik region. Dominant tree species *Magnifera indica*, *Ficus religiosa*, *Psidium guajava*, *Magnolia alba*, *Zea mays* were selected for screening from high traffic streets namely Dwarka circle, College road, Aurangabad Naka, Mumbai Naka and from outskirts of Nashik city namely Chandwad and Shinde palse gaon. Samples were collected in November- December. We collected leaves as they are most sensitive to pollution as well as least harmful to plants. The data collected was analyzed by ICP/MS technique and the results were obtained. The results of lead concentration of different samples of leaves collected were in the range of 0.36 mg/kg in *Zea mays* to 3.59 mg/kg in *Magnolia alba*. Higher concentrations of lead were observed in Nashik city heavy traffic zone as compared to low traffic routes in the outskirts of the city. The present study indicates that traffic volume may influence the concentration of lead deposited on the leaves of plants. Lead being a highly poisonous metal affecting almost every organ in the body its concentration in the consumed foodstuff of human beings should be monitored. This study emphasizes public to avoid feeding domestic animals and avoid the use of other agricultural food items grown close to this traffic zones which are high in lead concentration.

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Introduction

Plants are important bio indicators for heavy metal environmental pollution. The urban atmosphere like our Nashik region is enormously subjected to contaminants arising from automobiles and other sources. Owing to the increase in the number of vehicles in Nashik region the areas that are closer to the highways are subjected to pollution from traffic emissions. Studies have proved that the leaves and tissues of the roadside vegetation are polluted by heavy metals. Heavy metals may enter the food chain as result of their uptake by edible plants. Some of these metals have significantly toxic and hazardous effects on human health. The most potential hazard to human health among the heavy metals is lead. It is known that lead is an endangering metal for humans. Lead generally accumulate on the roadside soils and are absorbed by plants and vegetation grown on the roadside (Arjun *et al* 2015). It is a cumulative toxin present in the environment and being Non-biodegradable does not lose its toxicity by time. The main source of lead contamination is engine oil and fuel to which these roadside plants are mainly exposed. Its presence in the environment is undesirable as it is known to affect the health of the society.

The Ministry of Environment, Forest and Climate Change (MOEFCC), Government of India has passed a notification in November 2016 as;

"Regulation on Lead contents in Household and Decorative Paints Rules, 2016"

and prohibited manufacture, trade, import as well as export of household and decorative paints containing lead or lead compounds in excess of 90 parts per million(ppm). The government hence insisted on efforts to be made to create public awareness about precautionary measures to be taken to prevent lead poisoning. In this context our present study was initiated to determine the concentration of lead present on the roadside plants of Nashik region subjected to maximum exposure to this toxic heavy metal. In this study, leaves of roadside trees of Nashik region were collected and assessed for the presence of lead. Presence of lead and its concentration in plants of Nashik region have not been reported yet by any research worker.

Material and Methodology

Samples of plants were collected from different crowded areas of Nashik region which included high traffic zones like, Mumbai Naka, Dwarka Circle, College Road, Aurangabad Naka and also from outskirts of the city namely from Chandwad and Shinde Palse gaon.

The sampling was done between November-December 2019. The species taken for the study were *Ficus religiosa, Magnolia alba, Psidium guajava, Zea mays, Triticum asativum, Magnifera indica*. The parts of the plant taken for the study were leaves as they are most sensitive to pollution by such contaminants. After collection, the samples were dried, sealed, labelled and subjected to ICP-MS (Inductively Coupled Plasma-Mass Spectroscopy) analysis for determination of lead content. The results were obtained and then tabulated and the graphs were plotted accordingly.

Inductively Coupled Plasma-Mass Spectroscopy

Currently, the most established and widely used method for determination of metal concentrations in both biological and inorganic samples is inductively coupled plasma mass spectroscopy (ICP-MS). It is an Instrumental analytical technique in which liquid samples are first nebulised in the sample introduction system that results in fine aerosol which is subsequently transferred to high temperature ionisation source coupled to a mass spectrometer which atomises and ionises the sample. The generated ions are extracted through the interface region and into a set of electrostatic lenses called the ion optics which focuses and guides the ion beam into the quadrupole mass analyser. The mass analyser separates ions according to their mass-charge ratio (m/z), which are then measured at the detector (Wilschefski *et al* 2019).

A single quadrupole ICP-MS has six fundamental compartments which include the sample introduction system, inductively coupled plasma (ICP), interface, ion optics, mass analyser and detector as shown in figure (Fig. 1)

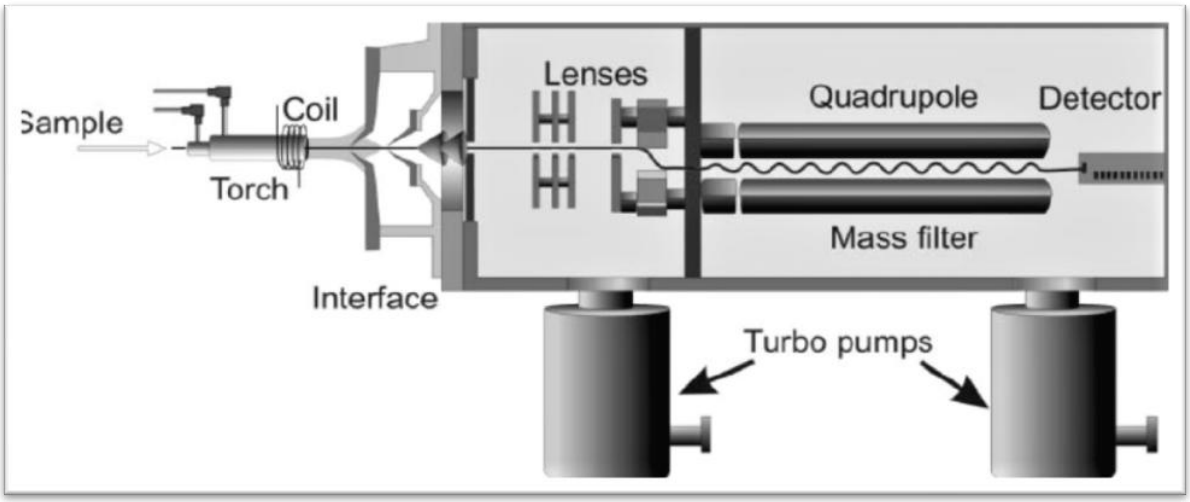

Fig. 1: Single Quadrupole ICP-MS

Sample Preparation-

ICP-MS instruments are primarily designed to analyse liquids. Therefore for this technique samples are diluted or thermally digested before analysis. Some common diluents used are dilute acids (e.g. nitric acid, hydrochloric acid) or alkali (e.g. ammonium hydroxide, tetramethylammonium hydroxide).

Sample Introduction-

For a uniform sample indroduction in the ICP the liquid samples are aerosolised by a nebuliser. Nebulizers convert the liquid sample into aerosol (finely dispersed liquid mist or spray suspended in gas) which aids in the stable operation of plasma. The most commonly used type of nebulizer is the pneumatic nebulizer.

Spray Chamber –

As the plasma is incapable of dissociating large droplets having diameter > 10μm so to filter out the larger aerosol droplets the sample enters the spray chamber where the nebulization 'pulses' produced by the pump are also smoothened out. Due to gravity the larger aerosol droplets exit the spray chamber at the end of the tube and are drained to waste and the smaller droplets with diameter roughly <10 are transferred to the plasma. Around 1-2% of the sample reaches the plasma. Thermoelectric cooling device or a water jacket is used to maintain the temperature of the spray chamber at 2°.

ICP – Plasma is a gas ionised by either heating or by subjecting it to a strong electromagnetic field. It consists of positively charged ions and unbound (free) electrons. In ICP-MS the plasma (ICP) is used to ionise the sample. An argon plasma preferred over helium in this technique.

The plasma is formed in the torch which consist of three concentric quartz tubes through which argon gas is passed. The sample is delivered to the plasma through an inner tube (injector) containing the aerosol sample along with the steam of argon.

Ionization-

After nebulisation, the aerosol (consisting of smallest droplets with diameter <10)is delivered to the plasma. Once the plasma reaches the required temperature the sample is desolvated, vaporised, atomised and ionised. Most of the ions are singly charged positive ions, some elements may also form a small fraction of double charged ions. This ionisation of the element depends on the temperature of the plasma and the ionisation potential of the sample. The Saha ionization equation is an expression that relates the ionization state of a gas in thermal equilibrium to the temperature and pressure. It states that at a given temperature , as the ionisation potential increases the degree of ionisation (%) in an argon plasma decreases declining to almost zero at values higher than the ionisation potential of argon itself(15.76 eV). However as most elements have a first ionisation potential much lower than argon, they are efficiently ionised in the plasma which makes it possible to measure nearly all elements in the table using ICP-MS.

Interface-

Interface is a pair of coaxial nickel (or platinum) cones (1^{st}- The sample cone 2^{nd} The skimmer

cone) that separates the plasma from the mass spectrometer vacuum chamber. A small orifice (~1 mm diameter) at the tip of the sample cone passes the ions, photons and neutral atoms or molecules from the plasma into the interface region. The interface pressure is maintained at ~150–300 Pa using a mechanical pump . In the interface region, the ions are forced into the vacuum chamber through a even smaller orifice (~0.45 mm diameter) of the skimmer cone. To keep the components from overheating a cooling fluid is continuously circulated between the RF coil and the interface cones.

Ion Optics-

Ion optics are a set of electrostatic lenses located behind the skimmer cone used to guide the ion beam toward the mass analyser and also to prevent photons and other neutral species (such as non-ionised matrix components) from reaching the detector.

Mass Analyser-

The ions arrive at the mass analyser after passing through the ion optics. The most common type of analyser used is the Quadrupole mass analyser. It is a mass filter that seperates ions based on their m/z ratio which is the mass divided by charge number ratio.

Detector-

An electron multiplier (EM) is the most common detector used in ICP-MS. An amplification cascade is generated by the emission of several electrons caused by the impact of the ions on the detector that sums up into a signal which is large enough to be measured by the detector as ion count. The limits of detection in ICP-MS are in nmol/L.

Result and Discussion

The analyses of collected samples for lead content were done and the result tabulated in Table 1.

Table 1: Concentration of Lead in Different Samples

Sr No.	Location	Species Collected	Lead Concentration (mg/kg)
1.	Mumbai Naka	*Ficus religiosa*	0.58
2.	Dwarka Circle	*Magnnolia alba*	3.59
3.	College Road	*Psidium guaiava*	0.76
4.	Aurangabad Naka	*Zea mays*	0.36
5.	Chandwad	*Triticum asativum*	0.44
6.	Shinde Palse	*Magnifera indica*	0.54

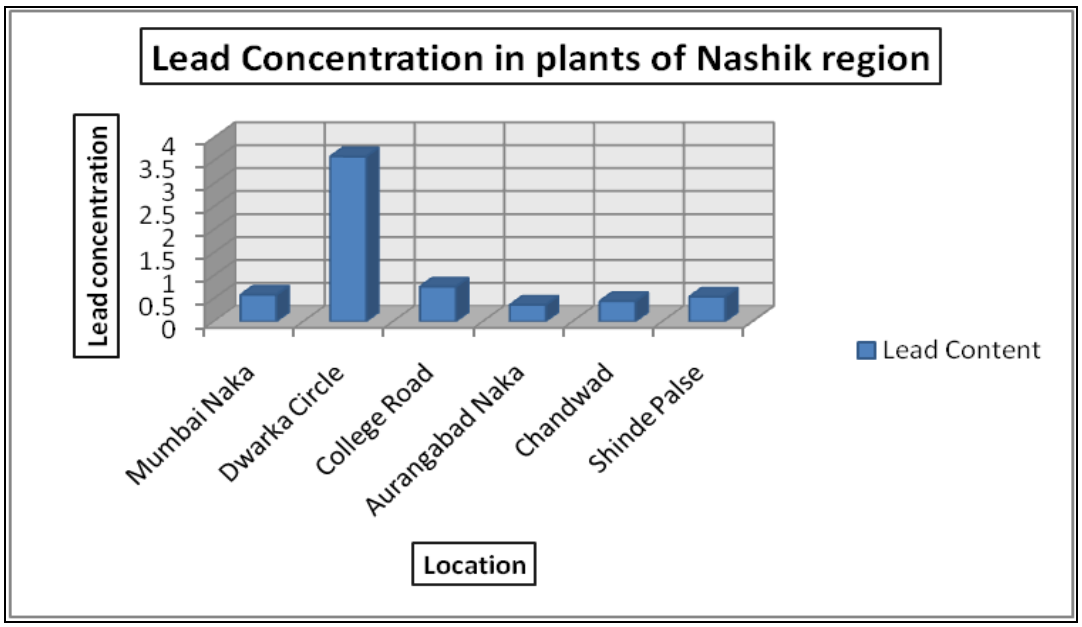

Fig. 2: Lead Concentration of Plants in Nashik Region.

The lead concentration in the collected samples range from 0.36mg/kg in *Zea mays* to 3.59mg/kg in *Magnolia alba*. The plants near high traffic zones like Dwarka circle and College Road contains higher lead concentration than the plants collected from the outskirts of Nashik region like Chandwad, Shinde Palse Gaon. Lead deposition in or on the surface of the leaf can directly or indirectly interfere with human welfare and animal activities. (Arjun, *et al.*, 2015) Although the samples collected did not show the presence of lead in significant amount, being collected at their very early stage of development. Till their complete growth the enormous exposure of these plants to the toxic pollutant may considerably increase the amount of lead deposition in it. Various factors can affect the levels of lead in plant which includes traffic density, presence of industry or more specifically the smoke produced from these industries, air pollution etc. (William, *et al.*, 2012, Chisom, *et al.*, 2013; Naveed, *et al.*, 2010). The presence of lead in high amounts is therefore an alarming situation.

Lead Toxicity in Plants (Sharma, *et al.*, 2005).

The accumulation and absorbtion of lead on different plant parts via the leaves depends on the extent of lead absorbed by the leaves from aerial sources. Rapid inhibition of root growth, stunted growth of the plants and chlorosis are some of the visual symptoms caused by increased levels of Pb. Even small amounts of Pb produce adverse effects on the physiological processes of the plants. Excess absorption of Pb in plants leads to inhibition of enzyme activities, changes in mineral nutrition, hormonal status and membrane permeability and water imbalance. There is a reduction in growth rate and changes in branching pattern. It affects the respiration and ATP content of photosynthetic organisms. A decline in transpiration rate in tissues is seen in plants growing under Pb exposure.

Lead Poisoning

WHO states that, "There is no level of exposure to lead that is known to be without harmful effects. '' i.e There is no known 'safe' blood lead concentration level. Multiple body systems and particularly children are affected by the harmful effects of lead. A high level of Pb exposure to children affects the brain and the central nervous system which can cause coma, convulsions and even death. It causes mental retardation and behavioural disorders. Anaemia, hypertension, renal impairment, immunotoxicity and toxicity are some of the other harmful effects caused by exposure to high level of lead.

Conclusion

Lead concentration was shown to be high on road side leaves of high traffic route of Dwarka circle in Nashik city (Fig. 2). Higher concentrations of lead were observed in Nashik city heavy traffic zone as compared to low traffic routes in the outskirts of the city. The present study indicates that traffic volume may influence the concentration of lead deposited on the leaves of plants. Lead being a highly poisonous metal affecting almost every organ in the body, its concentration in the consumed foodstuff of human beings should be closely monitored. Of all the organs, the nervous system is the mostly affected target in lead toxicity. This study emphasizes to create awareness among the public regarding lead as a potential hazardous contaminant and poses a gentle urge to the public to avoid the use of vegetables grown on roadside parts, stop feeding domestic animals with roadside fodder and strictly avoid the use of other agricultural food items grown close to these traffic zones which may be high in lead concentration.

Conflict of Interest

The authors declare no conflict of interest.

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