



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH


IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 1, January 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**

 9940 572 462

 6381 907 438

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# Heavy Metal Contamination in Leafy Vegetables Grown Near Roadside Areas

Neelesh Agrawal<sup>1</sup>, Asha verma<sup>2</sup>

Research Scholar, Department of Chemistry, Dr. Shyama Prasad Mukherjee Gov. Science and Commerce College,  
Bhopal, Madhya Pradesh, India<sup>1</sup>

Professor, Department of Chemistry, Dr. Shyama Prasad Mukherjee Gov. Science and Commerce College, Bhopal,  
Madhya Pradesh, India<sup>2</sup>

**ABSTRACT:** Vehicular exhaust and non-exhaust are major source of heavy metal. These released heavy metals can easily accumulate on leafy vegetables growing near road side vegetable fields through anthropogenic sources. Heavy metals toxicity occurs more readily in leafy vegetables. These leafy vegetables take up metals through leaves as well as by absorbing them from contaminated soils. These heavy metals can easily deposit on the outside parts of leafy vegetables and later on absorbed by tissues. Heavy metals produced by vehicular exhaust and non-exhaust emissions can be easily deposited on road side growing leafy vegetables through anthropogenic sources. The contamination of leafy vegetables grown in road side by heavy metals is greatly affected by vehicle volume, speed and road. Regular intake of heavy metal contaminated leafy vegetables may pose a risk to the human health. This review concludes that leafy vegetables grown near road side are exposed to higher level of heavy metal contamination through vehicular exhaust and non-exhaust emissions.

**KEYWORDS:** Leafy vegetables, vehicular, heavy metals.

## I. INTRODUCTION

Leafy Vegetables are important part of daily diets in many households, forming an important source of vitamins and minerals required for human health. These not only strengthen the immune system of the body but also help in disease prevention. They also act as neutralising agents for acidic substance formed during digestion. Green leafy vegetables are valuable source of vitamin A and C, iron, calcium, folic acid, and dietary fibre. Heavy metal contamination of leafy vegetables is a great public health concern. One of the factors that influence the uptake and bioaccumulation of trace metals in vegetables is atmospheric deposition. Leafy 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. Leafy Vegetables plants that are exposed to atmospheric deposits from anthropogenic activities like vehicular emission, industrial emission and burning of all forms of wastes dumped along road sides should be contaminated with trace metals to a toxic level for consumer. Road traffic is one of the main sources of emission of heavy metals into the environment. Road traffic involves numerous potential sources of metals through combustion products from fuel and oil, wear products from tyres, brake linings, bearings and clutches, corrosion products of vehicle components and road construction material. The released heavy metals through traffic will easily find their way in leafy vegetables through anthropogenic activities by absorbing through their leafy tissues. Vehicle brakes release a significant amount of heavy metals in the form of wear particles. One of the most dangerous elements contained in brake pads is copper [1]. Due to traffic load the vegetables grown road side may contaminate with these copper emissions in the form of wear particles from brake pads through anthropogenic source. Vegetables grown on road side fields are exposed to atmospheric pollution in the form of metal containing aerosols through vehicular emissions. These metal containing aerosols may lead high accumulation of heavy metals such as Pd, Cd, Ni, Cu and Zn in leafy vegetables due to atmospheric depositions. The number of vehicles in operation increasing year by year and lengthening of trips have resulted in the emissions of larger amount of metals originating from brake, tyre, and road wear. Zn is the most abundant heavy metal from tire wear. Its high concentration resulted from the addition of ZnS to the tire during vulcanisation. The greatest Zn emission from tire occurs through abrasion in the form of tire dust during acceleration, braking, and cornering. Asphalt and sand paper like effects are significant sources of Ni in road dust. Concentration of Ni and Zn in road



bitumen were higher than in raw bitumen therefore the heavy metal concentrations in road dust are significantly affected by vehicle operation and road abrasion [2].

Heavy metals rank highest amongst the contamination in leafy vegetables. These leafy vegetables take up metals from deposits on leaves which are easily exposed to air as well as by absorbing from contaminated soils [1]. Cultivated areas near highways are also exposed to atmospheric pollution in the form of metal containing aerosols. These metal containing aerosols deposited on the leaves of vegetables and then absorbed. High accumulation of lead, Chromium and Cadmium in leafy vegetables are due to atmospheric decomposition of substances of such metals. Intake of heavy metal contaminated vegetables may pose a risk to the human health. The main objective of this research is to determine heavy metal contamination from leafy vegetables collected from road side heavy traffic areas of Bhopal district, Madhya Pradesh, India. As vehicular exhaust and non-exhaust heavy metal emissions occur more readily in leafy vegetables through anthropogenic pathway. Regular monitoring of these vegetables is essential for preventing excessive build-up of heavy metals in food chain.

## II. HEAVY METALS IN ROAD TRAFFIC

The major sources of non-exhaust vehicular emissions that leads to heavy metals in road dust are tire, brake and clutch wear, road surface wear, and other vehicle and road component degradation. Selected metals Cd, Cr, Cu, Ni, Pb, Zn, Fe, Se, Sr, Ba, Ti, and Pd were analysed using inductively coupled plasma-mass spectrometry, inductively coupled plasma (ICP)-optical emission spectroscopy, and atomic absorption spectroscopy on a range of size-fractionated road dust and brake lining dust (250 µm). The compositions of brake lining and tire dust were also investigated using scanning electron microscopy energy-dispersive spectroscopy [3]. The finest fractions of urban and motorway dusts were significantly contaminated with all of the investigated metals, especially with Ti, Cu, and Cr, which are well-recognized key tracers of non-exhaust brake wear. Diesel engines are a major source of nitrogen oxides and particulate, which mainly consist of soot and metals. The composition varies depending on engine type, operating conditions, fuel and lubricating oil composition and whether an emission control system is present. Recent studies have focused on the composition and toxicity of diesel exhaust (DE) and diesel particulate matter [4]. Biodiesel for the present experimental study has been made from rice-bran oil using the process of transesterification using methanol and basic catalyst (KOH). Out of metals studied in this research (Cr, Ni, Pb, Cd, Na, Al, Mg and Fe) Cr, Ni, Pb, and Cd are toxic metals having a limit of maximum allowable exposure. The acceptable ambient air concentration for Ni is 5 ng m<sup>-3</sup>, Pb is 1000 ng m<sup>-3</sup> and for Cd, it is 20 ng m<sup>-3</sup>. Fe, Al, and Mg are generally present in soil in the form of crust metals but excess of these metals in atmosphere is of concern [5].

## III. METHODOLOGY

Tri-acid mixture, 15 ml (70% high purity HNO<sub>3</sub>, 65% HClO<sub>4</sub> and 70% H<sub>2</sub>SO<sub>4</sub>; 5:1:1) were added to the beaker containing atmospheric deposits and heated at 80 C till the solution became transparent [14]. The resulting solution was cooled and filtered through Whatman no. 42 filter paper. The filtered solution was finally maintained to 50 ml using deionised water and kept at room temperature for further analysis of heavy metals. For the heavy metal analysis of dry vegetable, 1 g sample was taken into a 100 ml acid washed beaker and 15 ml of tri-acid mixture was added [14]. After cooling, the digested samples were filtered using Whatman no. 42 filter paper and the filtrate was diluted to 50 ml with deionised water [15].

**Heavy metal detection** - Determination of the heavy metals (Pd, Cd, Ni, Cu and Zn) in the filtrate of vegetables and atmospheric deposits was achieved by **Atomic absorption spectrophotometer** [16].

**FAO/WHO permissible limit of heavy metals in leafy vegetables (mg/kg)** [17].

Heavy metals	FAO/WHO Permissible limit in leafy vegetable (mg/Kg)
<b>Pd</b>	<b>0.3 mg/Kg</b>
<b>Cd</b>	<b>0.2 mg/Kg</b>
<b>Ni</b>	<b>67 mg/Kg</b>
<b>Cu</b>	<b>100 mg/kg</b>
<b>Zn</b>	<b>73 mg/Kg</b>

## IV. HEALTH RISK ASSESSMENT

The daily intake of metals was determined using the following equation [18]  $EDI \text{ (mg/kg bw/day)} = C_{\text{metal}} \times C_{\text{factor}} \times D_{\text{foodintake}} / B_w$ .  $C_{\text{metal}}$ ,  $C_{\text{factor}}$ , and  $B_w$  represent the mean concentration of each metal in vegetables (mg/kg dw), conversion factor, daily vegetable intake (kg/person/day), and body weight (bw, kg), respectively. In order to convert the fresh vegetable weight into dry weight, the conversion factor of 0.085 was used. The total intake of vegetables was obtained through a formal survey, in which a total of 438 healthy adults (199 males and 239 females) aged 18–54 years old were interviewed for their age, body weight, and daily consumption rate of vegetables. The 97.5th percentile (P97.5) of the estimated daily intake (EDI) levels was used to represent the high consumers [19]. To assess the health risk associated with heavy metal contamination of vegetables grown locally, estimated exposure and risk index were calculated. The results showed that both Cu and Cd contamination in vegetables had potential to pose health risk to the local population. Pb, however, may only pose risk through consumption of *B.oleracea*. Zn may not have any risk to the local population through consumption of these vegetables [20].

## V. DISCUSSION

The study revealed that washed and unwashed vegetables contaminated with Cr, Fe and Pb are above the WHO permissible limit whereas level of Mn, Cu, Zn and Ni in washed and unwashed vegetables was within the permissible limit of WHO. Vegetables take up metals by absorbing them from metal contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from anthropogenic activities. These vegetables are in high demand in local market and other areas within the locality because they are part of daily staple food. Continuous up taking of these vegetables will lead to several health consequences [21]. The results were high when compared with those of the control samples obtained in IkotEkang village about 10 km away from the study area. Some of these results were equally high compared with the WHO permissible limits for such trace metals in the bitter leaf. Hence, anthropogenic activities along the roads in Abak significantly contributed to the elevated levels of trace metal in atmospheric deposits and consequently in the leaves of roadsides *Vernonia amygdalina*. The elevated levels of Cu, Cd and Pb in the vegetable leaves could inevitably result to health consequences [22]. The highest mean levels of Pb, Cu, Zn, Co, Ni and Cd were detected in mango, melon, spinach, banana, mango, and mango fruits, respectively. The levels of these metals found in this study are compared with those reported for similar fruits and vegetables from some other parts of the world. The daily human intakes of Pb, Cu, Zn, Co, Ni, and Cd in a diet of fruits and vegetables in this region have also been estimated. Study shows that the results reported here confirm that the fruit and vegetables collected from chosen production and market sites in the Misurata area of Libya contained measured heavy metal contents within the safe limits prescribed by the WHO in 1999. This is an important result as human health is directly affected by ingestion of fruit and vegetables [23]. This study aimed to determine Pb and Cd toxicity in vegetables in five different agricultural sites in Pakistan. The Pb concentrations for leafy vegetables were higher than the fruiting and pulpy vegetables. The Pb concentrations exceeded the WHO permissible limit for leafy vegetables. Likewise, all vegetables except *Pisum sativum* contained high concentration of Cd with respect to WHO permissible limit in vegetable [24].

## VI. CONCLUSION

Leafy vegetables are important dietary source providing mineral nutrients. Due to heavy metal deposition in vegetables, metal contents of leafy vegetables need not only to be determined but also estimated health risk for revealing possible health effects on humans. Chinese cabbage was determined to be safe for the consumption of both genders. Based on the carcinogenic risk assessment, most of the vegetables examined in this study were categorized as moderately toxic. It was concluded from the given results that air borne pollution has increased the mineral contents of vegetables for both genders. The results obtained from this study were compared with international standards and will be concluded to the data available on international scale [25]. Due to heavy metal deposition in vegetables, metal contents of leafy vegetables need not only to be determined but also estimated health risk for revealing possible health effects on humans. Chinese cabbage was determined to be safe for the consumption of both genders. Based on the carcinogenic risk assessment, most of the vegetables examined in this study were categorized as moderately toxic. It was concluded from the given results that air borne pollution has increased the mineral contents of vegetables for both genders. The results obtained from this study were compared with international standards and will be concluded to the data available on international scale. [26]

Many vegetable samples contained very high levels of the investigated metals: cadmium, lead, nickel, and chromium. The content of the tested toxicity, cadmium, lead, nickel, and chromium in the selected vegetables changes considerably as a function of plant species and plant edible organs, as well as in production sites. The obtained results from this survey indicate that continuous up taking of locally grown vegetables potentially might be a health threat, due to the cumulative toxic effects of specific metals in plants grown in specific areas [27]. The green leafy Vegetables selected are *Basella alba* (spinach), *Trigonella foenumgraecum* (fenugreek) and *Coriandrum sativum* (dhania). These vegetables were tested with the help of Absorption Spectroscopy for Pb, Cd, Cr, Ni and Zn. This study shows that people and animals living in the urban area in Agra are exposed to metallic pollution and in turn the consumption of contaminated vegetables could lead to increased health hazards [28].

This review strongly demonstrates that Regular monitoring of heavy metal concentration in leafy vegetables is very necessary to control heavy metal toxicity in human dietary system.

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