Section A-Research paper
ISSN 2063-5346

HEAVY METAL CONTAMINATION AND THEIR IMPACT ON HEALTH VIA CONSUMPTION OF LEAFY VEGETABLES GROWN NEAR ROAD SIDE AREAS OF BHOPAL

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DOI: 10.48047/ecb/2023.12.si4.1736

ABSTRACT

Heavy metals concentration in leafy vegetables or in any other edible products causes risk to the human health and long term use of that causes serious diseases concern to the heavy metals. Current research work shows the result related to the contamination and impact of the higher concentration of heavy metals on the health. So for the research work five heavy metals such as Pb, Zn, cd, Cu and Ni were used and their concentration were compared between the washed and unwashed leafy vegetables samples . Leafy vegetables such as spinach, amaranth leaves, wild spinach, fenugreek, cabbage, coriander, purslane and mustard were collected from the different site near to the roadside (location: hoshangabad , khajuri kalan, and ayodhya bypass).Different parameters of risk assessment were analysed in the samples , parameters like Pollution index , hazard ratio , average daily intake etc. All the result compared with the permissible limit of the heavy metals which were helpful in the detection of toxicity level. This study helped in determination of presence of concentration of heavy metals in the samples and as well as its toxicity level. This research work shows the comparative result which helpful in the measurement of the toxicity level.

INTRODUCTION

Heavy metals" are natural elements characterized by their rather high atomic mass and their high density. Although typically occurring in rather low concentration, they can be found all through the crust of our planet. Commonly, a density of at least 5 g cm^{-3} is used to define a heavy metal and to differentiate it from other, "light" metals. Other, broader definitions for "heavy metals" require an atomic mass higher than 23 or an atomic number exceeding 20; these definitions are highly error prone and confusing.[1]

The necessary heavy metals influence plants and animals' biochemistry and physiology. They are crucial parts of numerous essential enzymes and participate in a number of oxidation-reduction processes (World Health Organisation, 2020). Copper for example serves as an essential co-factor for several oxidative stress-related enzymes including catalase, superoxide dismutase, peroxidase, cytochrome c oxidases, ferroxidases, monoamine oxidase, and dopamine β-monooxygenase .[2,3,4]

In several industrial processes, cadmium is often employed. Cadmium is used in the manufacturing of alloys, pigments, and batteries, among other things .[5].The commercial usage of cadmium has decreased in industrialised nations due to environmental concerns, despite the fact that its use in batteries has increased significantly in recent years. Cadmium concentrations in human bodies can be significantly raised by consuming foods high in the metal. Nickel is essential in proper growth and development of the plants and has vital roles in a wide range of morphological and physiological functions, such as germination seeds and productivity. However, at high levels nickel alters the metabolic activities of the

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ISSN 2063-5346

plants inhibiting enzymatic activity, photosynthetic electron transport and chlorophyll biosynthesis Lead is a naturally occurring substance, human activities like burning fossil fuels, mining, and manufacturing cause significant amounts to be released into the environment.[6] Lead poisoning's most vulnerable victim is the neurological system. Early signs of the consequences include headache, low attention span, impatience, lack of memory, and dullness. Copper is one of the essential micronutrients, and is also necessary for a wide range of metabolic processes in both procaryotes and eucaryotes. [7]**.** Copper, an essential micronutrient for plants, animals, and humans, plays an irreplaceable role in the function of a large number of enzymes that catalyse oxidative reactions in a variety of metabolic pathways. [8] Excess Cu is toxic to plants and humans and disturbs a wide range of biochemical and physiological processes, such as photosynthesis, pigment synthesis, protein metabolism, and membrane integrity. And it is a very common substance that occurs naturally. Many foodstuffs contain certain concentrations of zinc.Zinc occurs naturally in air, water and soil, but zinc concentrations are rising unnaturally, due to addition of zinc through human activities.[9]Plants often have a zinc uptake that their systems cannot handle, due to the accumulation of zinc in soils.On zinc-rich soils only a limited number of plants has a chance of survival. [9]

Researchers have been investigating the mechanisms of contaminant absorption by plants. It might be used to optimise the elements for better plant absorption performance. The plants, in the opinion of **10** serve as both "accumulators" and "excluders". Even though they concentrate pollutants in their aerial tissues, accumulates persist. In their tissues, they biodegrade or bio transform the pollutants into inert forms. The excluders limit the amount of contamination that can enter their biomass. [11]

Even when present at low ppm levels, plants have developed very specialised and effective systems to absorb vital micronutrients from the environment. Plant roots may solubilize and absorb micronutrients from extremely low concentrations in the soil, even from practically insoluble precipitates, with the help of chelating compounds generated by plants, pH changes, and redox processes that plants cause. Material and Methods.[12]

2. Material and Methods

2.1 Experimental site

All samples were collected from selected sites in Bhopal. The location of the sites is shown in **Table 1.** From where samples were collected in clean jute bags and brought to the laboratory for analysis. This study was carried out at the well-known city of Bhopal, Madhya Pradesh, India. The location of this research region is between 22°07 and 23°7 N and 77°10 and 78°25 E. The sub-humid climate of this city has hot, dry summers and freezing winters, with an average annual rainfall of 964 mm. On the basis of exposure to vehicular emissions from the whole research region, three sampling locations were selected for sample collection

Table 1: Location of the sampling sites

Site Name	Latitute	Longitude
Hoshangabad road	$22^0$744′38.788″N	$77^0$44′13.884″E
Khajurikalan road	$23^0$35′ 36.995″N	$77^0$39′ 14.984″E
Ayodhyabypass road	$23^0$18′ 99972″N	$77^{0.}$ 24′ 9.558″E

2.2 Collection of sample

The leafy vegetables samples were collected on the basis of availability in all farmers' fields at the same time. First of all, the samples were randomly collected in triplicate at a 0–15 cm depth using a spade from all selected sampling points. Then, the collected sub samples were mixed together to attain a 1 Kg of representative sample. Finally, samples were taken into labeled zippered polyethylene (PE) bags to prevent them from further contamination and immediately taken to the laboratory for further analysis. Details of vegetables samples are given in **Table 2**:

Table 2: List of the leafy vegetables

Sample Name	**Botanical Name**	**Hindi name**
Spinach	*Spinaciaoleracea*	Paalak
Amaranth Leaves	*Amranthusviridus*	Chaulaisaag
Purslane	*Portulacaoleracea*	Kulapha
Fenugreek	*Portulaca*	Methi
Coriander	*Coriander sativum*	Dhaniya
Cabbage	*Brassica oleraceavar.capitata*	Pattagobhee
Mustard	*Brassica junicea*	Sarso
Wild Spinach	*Chenopodium album*	Jangaleepaalak

2.3 Preparation of sample

The collected leafy vegetables were washed thoroughly with fresh tap water and rinsed three times with distilled water to remove surface pollutants and any items adhering to the surfaces. Samples were sliced into small pieces and open air dried on paper for about 2 hours to eliminate excess moisture. Each sample was weighed, dried in an oven at 80 °C for several hours and reweighed to constant weight. The dried sample was ground in a mortar until it could pass through a 0.2 mm mesh sieve and stored in clean and dry polyethylene bags. For the heavy metal analysis of dry vegetables, 1 gm sample was taken into a 100ml acid washed beaker and 15ml of tri-acid mixture was added. The mixture was then digested at 80^0C till transparent solution was achieved. After cooling, the digested samples were filtered using Whatman filter paper No. 42 and the filterate was diluted to 50 ml with the deionized water.

2.4 Heavy metal analysis

Concentrations of heavy metals Lead (Pb) , Cadmium (Cd), Nickel (Ni), Copper (Cu) and Zinc (Zn) were determined by using the Atomic Absorption Spectrophotometer The analytical procedure was checked against a known concentration of the standard reference material. The percentage recovery was between 94-105%. All chemicals used were analytical grade, including standard stock solutions of known concentration for each metal.[13]

2.5 Single Factor Pollution Index (PI):

The Pollution Index (PI) is the ratio of heavy metal content in a sample and the permissible limits imposed by international organizations such as the WHO, FAO, and US Environmental Protection Agency (US EPA):

PI = CV⁄CL

Where CV is the concentration of heavy metal in sample (mg kg−1) and CL is the regulatory limit by FAO/ WHO (mg kg−1). PI < 1 indicates samples have not yet been polluted, whereas a value of PI > 1 suggests contamination and PI = 1 indicates critical condition (require environmental monitoring) [14]

2.6 Sum of pollution index

The sum of pollution index (PI) previously described by **Qingjie, *et. al.*,2008** was used for the present application. [15]

SPI = PiFe +Pi*Cr* + PiPb+ PiCd

Where Pi = single factor pollution index of heavy metals

2.7 Average Pollution Index (PIA)

The average pollution index (PIA) of different foodstuffs samples was calculated as follows :16

PIAvg. =1 n

$\sum PIni$**=1**

Where PI is the single-factor pollution index and n is the number of heavy metal species studied. PIA > 1.0 suggests higher heavy metal contamination is evident in the sample [15]

2.8 Average daily intake (ADI)

The ADI of a heavy metal was calculated as a product of average vegetables daily consumption per person, percentage of dry weight of leafy vegetables, and average heavy metal concentration per dry weight vegetables as shown in the following equation:

ADI= Avconsumption × ٪ DWvegetables × Cheavy metal,

where ADI is average daily intake of heavy metal per person per day (mg/person/day), Avconsumption is average daily consumption of vegetables per person per day (g/day), % DWvegetables is percentage of dry weight of vegetables (% DW = [(100 − % moisture)/100]) and Cheavy metal is average heavy metal concentration of dry weight vegetables (mg/g). The average daily consumption of leafy vegetables suggested by WHO guidelines in human diet is 300 to 350 g per person. An average weight of person was considered to be 60 kg.[16]

2.9 Hazard Index

An exposure to more than one pollutant results in additive effects. Thus, hazard index (HI) is a vital index that assesses overall likely impacts that can be posed by exposure to more than one contaminant. When the HI is >1, this suggests that there are significant health effects from consuming pollutants contained in a foodstuff. The HI is calculated as an arithmetic sum of the hazard quotients for each pollutant as shown in the following equation

HI =$\sum THQni$**=1**

where i (= 1, 2……., n) = individual heavy metal present in the sample. The exposed population is deemed safe when HI < 1, whereas HI > 1 indicates a potential risk of ingesting contaminated food items. Thus, control measures should be applied .[17]

2.10 Hazard quotient

Hazard quotient is a proportion of the probable exposure to an element/chemical and level at which no negative impacts are expected. When the quotient is 1, it signifies there are potential health risks due to exposure .[18] The HQ was calculated as a fraction of determined dose to the reference dose as shown in the following equation:

Where ADI is the average heavy metal intake per day (mg/kg/day) and RfD is the oral reference dose of the metal (mg/kg/day). RfD is an approximation of daily tolerable exposure to which a person is expected to have without any significant risk of harmful effects during a lifespan. RfD for Pb, Zn, Cu, Cd, and Ni is 0.004,0.3,0.04,0.02 and 0.02 mg/kg/day, respectively (WHO/FAO, 2013).

HD=ADI/ R_fD

where, ADI= daily intake of food (kg/day), RfD = reference oral dose of metal (mg/kg of body weight/day) and

3 Result and Discussion

3.1 Heavy metal analysis

Lead, zinc, cadmium, chromium, nickel and copper concentration of the studied samples (leafy vegetables spinach, wild spinach, coriander, cabbage, fenugreek , amaranth, purslane and mustard leaf) were analyzed using Atomic Absorption Spectrophotometer (AAS).Analysis of the heavy metals concentration were calculated with the help of the AAS graph on the unwashed and washed sample of leafy vegetables. The permissible limit (mg/kg) for the heavy metals lead, cadmium, nickel, copper, and zinc, according to the FAO/WHO are 0.3 mg/kg, 0.2mg/kg, 67 mg/kg, 100 mg/kg and 73 mg/kg. As result of AAS shows AAS graph of heavy metals Cadmium shows the regression $R^2 = 0.9926$ and its equation was $y = 0.3591x + 0.0174$ at the wavelength 228.2 nm; Copper shows the regression $R^2 = 0.9982$and its equation was $y = 0.1595x + 0.0088$ at the wavelength 325.2 nm; Zinc shows the regression $R^2 = 0.999$and its equation was $y = 0.4049x + 0.0008$ at the wavelength 213.7 nm; Lead shows the regression $R^2 = 0.9992$and its equation was $y = 0.0257x + 0.0002$ at the wavelength 216.7 nm; Nickel shows the regression $R^2 = 0.9825$and its equation was $y = 0.0503x + 0.0096$ at the wavelength 231.7 nm and Cadmium shows the regression $R^2 = 0.9926$ and its equation was $y = 0.3591x + 0.0174$ at the wavelength 228.2 nm.

3.2 Unwashed leafy vegetables samples analysis

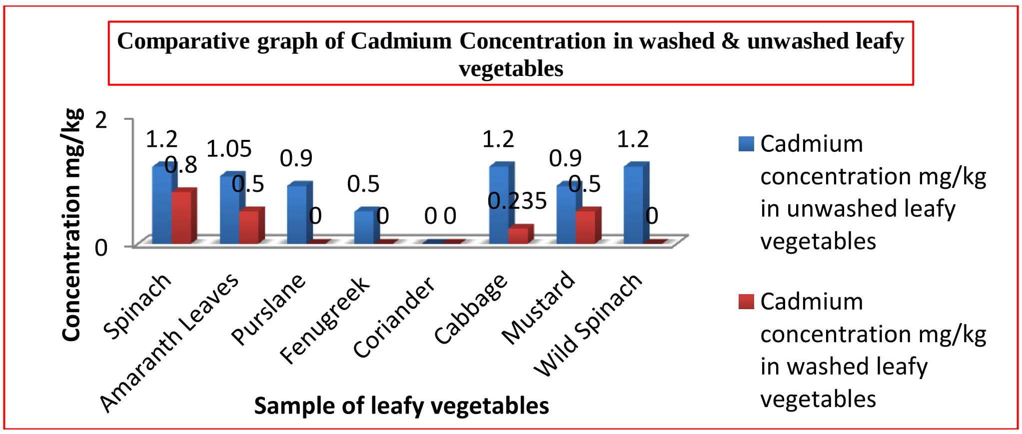
The concentration of cadmium in unwashed leafy vegetables samples shows that the spinach, cabbage, and wild spinach consisting of more cadmium concentration 1.2 mg /kg rather than the other like Amaranth shows 1.05 mg/kg , purslane and fenugreek shows 0.9 mg/kg and 0.5mg/kg. But the concentration of the cadmium in coriander was zero (spinach > cabbage> wild spinach> Amaranth > purslane>fenugreek> coriander) while Zinc concentration in samples shows that spinach had 80.65 mg/kg maximum concentration of zinc heavy metals than the other sample of leafy vegetables and fenugreek shows 70 mg/kg the lowest concentration of the leafy vegetables (Spinach (80.65mg/kg) > coriander(80mg/kg) = cabbage(80mg/kg) > purslane (78mg/kg) =mustard (78mg/kg) = wild spinach (78mg/kg) > Amaranth (75mg/kg) >, fenugreek (70mg/kg), on the other hand nickel concentration in unwashed leafy vegetables was zero. Not a single sample of unwashed leafy vegetables shows the presence of Nickel and the lead concentration in unwashed leafy vegetables samples show same concentration 0.45 mg/kg .Due to poisonous in nature they are not present in higher concentration. Copper concentration in the unwashed leafy vegetables sample resulted spinach having 185 mg/kg maximum concentration of copper heavy metals than the other sample of leafy vegetables and purslane shows 15 mg/kg the lowest concentration of the leafy vegetables (Spinach (185 mg/kg) > cabbage (58.5 mg/kg) > Amaranth leaves (28.5 mg/kg) > Wild spinach (22mg/kg) > Coriander (17 mg/kg) > wild spinach (78mg/kg) > Amaranth (75mg/kg) > fenugreek(70mg/kg)).

3.3 Washed leafy vegetables samples analysis

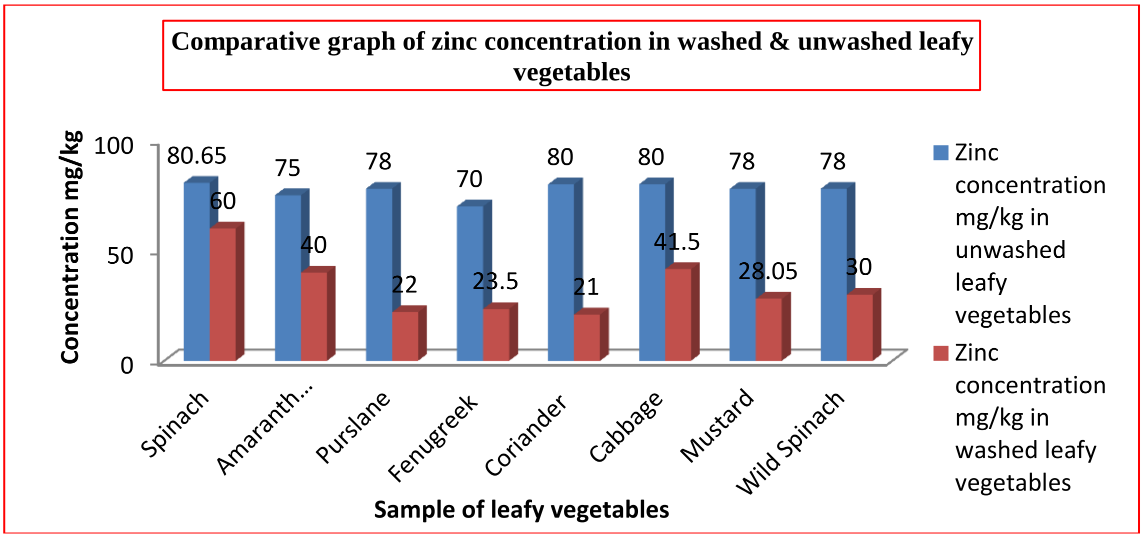
In washed leafy vegetables samples concentration of copper in spinach shows 13.25 mg/kg maximum concentration of copper heavy metals than the other sample of leafy vegetables and Corainder shows 6 mg/kg the lowest concentration of the leafy vegetables (Spinach (13.25 mg/kg) > Amaranth leaves (12 mg/kg) > fenugreek (11 mg/kg) > Cabbage(10.7mg/kg) > Purslane (9 mg/kg) > mustard (8.85mg/kg) > wild spinach (7.25mg/kg) > Corainder (6 mg/kg)), while the concentration of lead all the washed leafy vegetables were found out same and that was 0.45 mg/kg. The result was shown good because lead is the kind of heavy metal if present more than the reference values than it cause cancer detection similarly concentration of Nickel in all the washed leafy vegetables were found out same and that was zero concentration. And the zinc concentration in washed leafy vegetables shows that the spinach had 60 mg/kg maximum concentration of zinc heavy metals than the other sample of leafy vegetables and Corainder shows 21 mg/kg the lowest concentration of the leafy vegetables (Spinach (60 mg/kg) > Cabbage (41.5 mg/kg) > Amaranth leaves (40 mg/kg) > Wild Spinach (30mg/kg) > Mustard (28.5 mg/kg) > Fenugreek (23.5 mg/kg) >Purslane (22 mg/kg) > Coriander (6 mg/kg)) . Lastly the cadmium concentration In washed leafy vegetables samples shows spinach had 0.8 mg/kg maximum concentration of Cadmium heavy metals than the other sample of leafy vegetables and cabbage shows 0.235 mg/kg concentration of the leafy vegetables. And the washed leafy vegetables samples like purslane, fenugreek, wild spinach and coriander shows nil (0.0 mg/kg) concentration of cadmium.

3.4 Comparative results of washed and unwashed samples

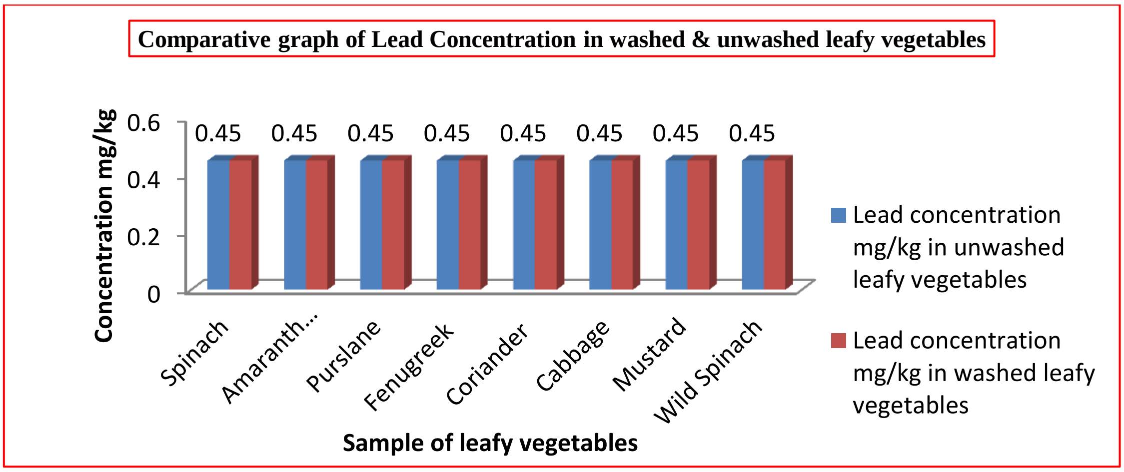
From the comparative study of cadmium heavy metal concentration in washed and unwashed leafy vegetables sample shows leafy vegetables spinach consisting of maximum concentration than the other sample and coriander shows least or nil concentration of cadmium **(Graph 1).** But on comparing the result of cadmium concentration in washed leafy vegetables with the permissible limit shows that spinach and mustard exceeded the permissible limit while the other sample of washed leafy vegetables not exceeded the limit and in unwashed leafy vegetables only coriander not exceeded the permissible limit because of absence of concentration of cadmium in that. But among the rest unwashed leafy vegetables sample spinach exceeded more than the other sample. From the rest heavy metals comparative result reveals that the zinc in washed and unwashed leafy vegetables sample shows that spinach in both type of sample shows presence of maximum concentration than the other sample and in unwashed leafy vegetables sample fenugreek shows the minimum concentration and in washed leafy vegetables coriander shows the minimum concentration of the cadmium**. (Graph 2)**. Zinc concentration in washed leafy vegetables samples with the permissible limit shows that from the entire sample of washed leafy vegetable not exceeded the permissible limit. But spinach showed near concentration to the permissible limit. On comparing the result of zinc in unwashed leafy vegetables samples with the permissible limit shows that only fenugreek not exceeded the permissible limit of concentration of zinc sample. But fenugreek shows the exceeded permissible limit of the zinc concentration. The comparing of the result concentration of lead in washed and unwashed leafy vegetables sample shows same concentration in both type of sample. **(Graph 3)** While the result of lead in washed leafy vegetables samples with the permissible limit shows that all the washed leafy vegetables exceed the 0.1mg/kg limit which was considerable. But if it was exceeded more than that than it causes health issues and in unwashed leafy vegetables samples with the permissible limit shows that all the washed leafy vegetables exceed the 0.1mg/kg limit which was considerable. But if it was exceeded more than that than it causes health issues**.** Copper concentration in both washed and unwashed leafy vegetables sample shows that spinach shows higher concentration in both type of sample than the other sample and in washed leafy vegetables sample coriander shows the minimum concentration and in unwashed leafy vegetables wild spinach shows the minimum concentration of the copper**. (Graph 4)**. And comparing the copper concentration in unwashed leafy vegetables samples with the permissible limit shows that only spinach exceeded the permissible limit rather than the other sample of lead concentration and in washed leafy vegetables samples with the permissible limit shows that all the samples not exceeded the permissible limit of copper concentration that means through washing and proper preservation of washed vegetables shows reduce in the concentration of heavy metals like copper. Nickel concentration in unwashed leafy vegetables samples with the permissible limit shows that all the samples not exceeded the permissible limit of nickel concentration because each samples shows the zero concentration of the nickel**. (Graph 5)** Comparison of Nickel in washed leafy vegetables samples with the permissible limit shows that all the samples not exceeded the permissible limit of nickel concentration because each samples shows the zero concentration of the nickel.



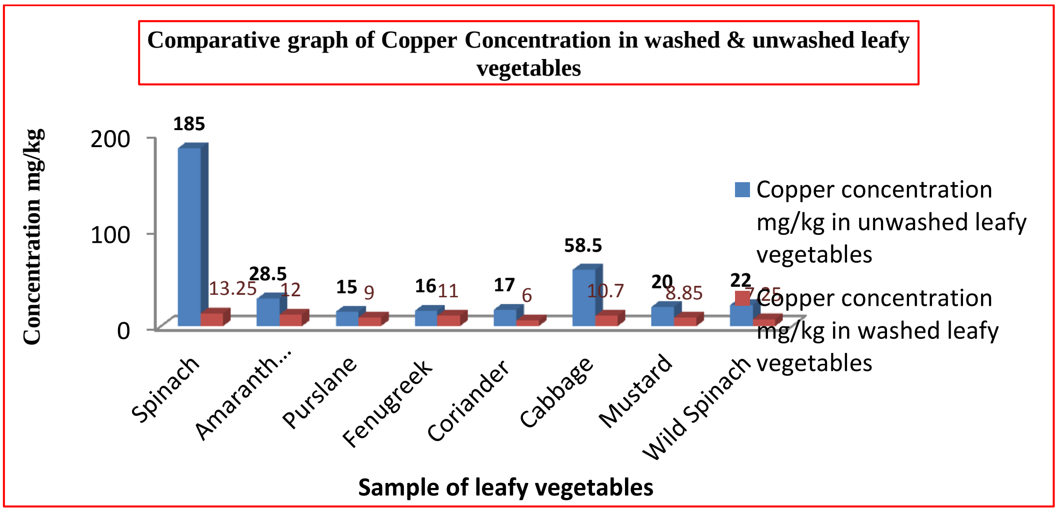
Graph 1: Comparative graph of Cadmium concentration in washed & unwashed leafy vegetables



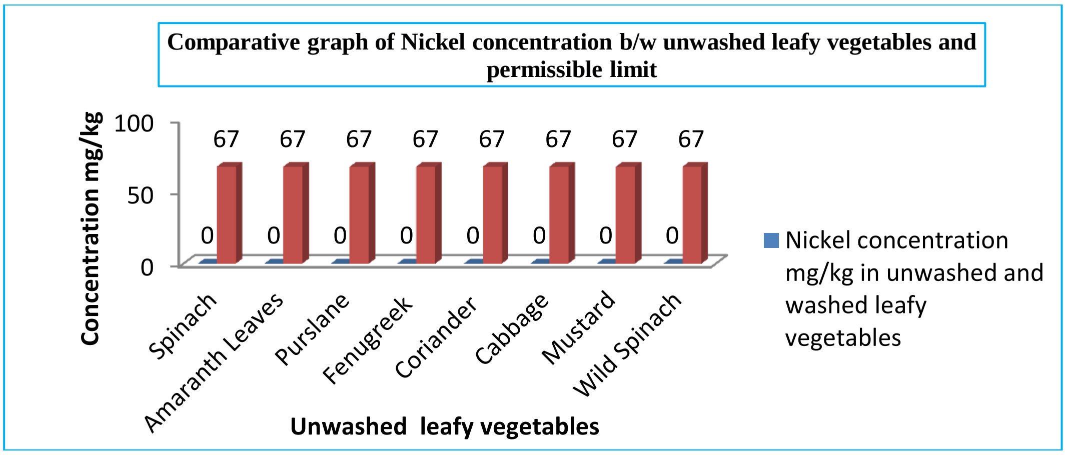
Graph 2: Comparative graph of concentration of Zinc in washed & unwashed leafy vegetables



Graph 3: Comparative graph of concentration of Lead in washed & unwashed leafy vegetables



Graph 4: Comparative graph of concentration of Copper in washed & unwashed leafy vegetables



Graph 5: Comparative graph of Nickel concentration b/w washed; unwashed leafy vegetables and permissible limit

3.4 Pollution Index for leafy vegetables

Different samples of unwashed leafy vegetables show various values of the single factor pollution index (PI). The Average PI of cabbage (2.688) shows more concentration of all the heavy metals and this due to the pollution occurred because of fuel consumption by vehicle and tyre wearing. All the result of samples resulted more in differed throughout the washed and unwashed leafy vegetables components examined in this study. **(Table 3)**

Different samples of washed leafy vegetables show various values of the single factor pollution index (PI). The Average PI of Spinach (1.29) shows more concentration of all the heavy metals and this due to the pollution occurred because of fuel consumption by vehicle and tyre wearing. All the result of samples resulted more in differed throughout the washed and unwashed leafy vegetables components examined in this study. **(Table 3)**

This ratio is known as the single factor pollution index (PI) **.**PI values below 1 show that the sample is not yet polluted, whereas PI values over 1 show contamination. However, PI=1 shows a critical condition, making the sample involved important for environmental monitoring .

Table 3: Single factor pollution index, metal pollution index, and the sum of pollution index of unwashed and washed leafy vegetables collected from different three location of Bhopal (MP)

Sample	Single Factor Pollution Index for unwashed vegetables					Sum of PI	Avg. PI	Single Factor Pollution Index for washed vegetables					Sum of PI	Avg. PI
	Cd	Cu	Pb	Zn	Ni			Cd	Cu	Pb	Zn	Ni		
Spinach	6	1.85	1.5	0.821	0	10.171	2.034	4	0.13	1.5	0.821	0	6.451	1.29
Amaranth Leaves	5.25	0.285	1.5	1.02	0	8.055	1.611	2.5	0.12	1.5	0.547	0	4.667	0.9334
Purslane	4.5	0.15	1.5	1.06	0	7.21	1.442	0	0.09	1.5	0.301	0	1.891	0.3782
Fenugreek	2.5	0.16	1.5	0.95	0	5.11	1.022	0	0.11	1.5	0.321	0	1.931	0.3862
Coriander	0	0.17	1.5	0.821	0	2.491	0.498	0	0.06	1.5	0.287	0	1.5887	0.31774
Cabbage	6	5.85	1.5	0.09	0	13.44	2.688	1.175	0.107	1.5	0.568	0	3.35	0.67
Mustard	2.5	2.7	1.5	1.06	0	7.76	1.552	2.5	0.0885	1.5	0.384	0	4.4725	0.8945
Wild Spinach	6	2	1.5	1.06	0	10.56	2.112	4	0.13	1.5	0.821	0	1.9825	0.3965

3.5 Average daily intake (ADI)

The average daily intakes of five heavy metals (Pb, Zn, Cd , Ni and Cu) were estimated according to the mean concentration of each metal in each vegetable. The ADI and the permitted maximum tolerable

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daily intake (PMTDI) of studied metals from the consumption of five vegetables. The average values of ADI for Pb, Zn, Cd , Ni and Cu in each vegetable (mg/person/day), respectively, differed significantly from each other. According to the daily intake result of the samples unwashed leafy vegetables shows that the concentration of zinc was high according to the average in unwashed leafy vegetables. But the cadmium, copper lead and nickel shows the exceeded concentration according to the PMTDI.According to the daily intake result of the samples washed leafy vegetables shows that the concentration of zinc was high according to the average in unwashed leafy vegetables. But the cadmium, copper lead and nickel shows the exceeded concentration according to the PMTDI. **(Table 4)**

Table 4: Average daily intake of unwashed vegetables

Sample	Average daily intake (ADI) of unwashed vegetables mg/person/day					Average daily intake (ADI) of washed vegetables mg/person/day				
	Cd	Cu	Zn	Pb	Ni	Cd	Cu	Zn	Pb	Ni
Spinach	0.772	11.1	4.839	0.027	0	0.048	0.78	3.6	0.027	0
Amaranth Leaves	0.063	1.71	4.5	0.027	0	0.03	0.72	2.4	0.027	0
Purslane	0.054	0.9	4.68	0.027	0	0	0.54	1.32	0.027	0
Fenugreek	0.03	0.96	4.2	0.027	0	0	0.66	1.41	0.027	0
Coriander	0	1.02	4.8	0.027	0	0	0.36	1.26	0.027	0
Cabbage	0.772	3.51	4.8	0.027	0	0.0138	0.64	2.49	0.027	0
Mustard	0.054	1.2	4.68	0.027	0	0.03	0.531	1.6	0.027	0
Wild Spinach	0.772	1.32	4.68	0.027	0	0	0.435	1.8	0.027	0
AVERAGE	0.314	2.715	4.647	0.027	0	0.0655	0.58325	1.985	0.027	0
PMTDI	0.046	2.0	15	0.21	0.3	0.046	2.0	15	0.21	0.3

3.6 Hazard quotient and Hazard Index

The results in **Table 5** show that HI values of eight samples of vegetables. If Hazard indexes is greater than one, then it causes health risk but if it was lower than one than there were no issues with the health. Hazard quotient of an element represents the level at which no negative impacts are expected. When the quotient is less than 1, it is assumed no potential health effects are expected from the exposure. But when it is greater than 1, this means there are potential health risks. The rest have HQ values less than 1 which does not signify any potential health risk. The endings also showed that HQ values of Pb, Zn, Ni and Cu in all the vegetable samples were below 1 and they possess no potential health effects. But potential health risks may occur when HQ values of all the heavy metals in a vegetable are considered.

Hazard index of the unwashed leafy vegetables samples shows that the cabbage exceeded the limit which was 3.077 (HI). This value of HI of cabbage exceeded the value one which shows the potential health issue. If taken on regularly basis. While Hazard Quotient of the heavy metals of all the unwashed leafy vegetables shows the variation in the concentration and all the heavy metals individually not shows the concentration more than one that means, the sum of the concentration of five heavy metals increases the value while the single concentration not exceeded.

Hazard index of the washed leafy vegetables samples shows that not a single sample exceeded the limit that is more than 1 (HI). While Hazard Quotient of the heavy metals of all the unwashed leafy vegetables shows the variation in the concentration and all the heavy metals individually not shows the concentration more than one that means, the sum of the concentration of five heavy metals increases the value while the single concentration not exceeded.

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Table 5: Hazard index and hazard quotient of heavy metals in unwashed vegetables

Sample	Hazard Quoteint (HQ) For unwashed vegetables					Hazard Index (HI) Σ HQ	Hazard Quotient (HQ) For washed vegetables					Hazard Index (HI) Σ HQ
	Cd	Cu	Zn	Pb	Ni		Cd	Cu	Zn	Pb	Ni	
Spinach	0.0154	0.444	1.4517	0.0081	0	1.9192	0.00016	0.00312	1.08	0.0018	0	1.08508
Amaranth Leaves	0.0126	0.0684	1.35	0.0081	0	1.4391	0.0006	0.0288	0.72	0.0018	0	0.7512
Purslane	0.0108	0.036	1.404	0.0081	0	1.4589	0	0.0266	0.396	0.0018	0	0.42278
Fenugreek	0.006	0.0384	1.26	0.0081	0	1.3125	0	0.0264	0.423	0.0018	0	0.44958
Coriander	0	0.0408	1.44	0.0081	0	1.4889	0	0.0144	0.378	0.0018	0	0.3942
Cabbage	0.0154	0.1404	1.44	0.0081	0	3.077	0.00276	0.0256	0.747	0.0018	0	0.77716
Mustard	0.0108	0.048	1.404	0.0081	0	1.4709	0.0006	0.0212	0.48	0.0018	0	0.5036
Wild Spinach	0.0154	0.0528	1.404	0.0081	0	1.4803	0	0.0174	0.54	0.0018	0	0.5592

4 CONCLUSION

The contamination of leafy vegetables with heavy metals due to vehicular exhaust and non exhaust emission poses a threat to human dietary system. Therefore, its regular monitoring is necessary to control the toxic level of heavy metals in our food chain that occurs through consumption of leafy vegetables collected from roadside areas. The whole research on the sample of unwashed and washed leafy vegetables concluded that:Selected roadside areas (Hoshangabad road, Ayodhya bypass road and khajuri kalan road) suffer heavy traffic density, the airborne copper particles produced by brake wear easily deposited on leafy vegetables through anthropogenic sources and then later on absorb by tissues of leafy vegetables , therefore the concentration of copper in leafy vegetables collected from different site shows higher concentration in the washed and unwashed leafy vegetables sample of spinach leaves (unwashed sample shows : 185mg/kg and washed shows 13.25 mg/ kg)Release of zinc from tyre wearing in atmosphere which added the rate of increase in contamination of the environment. So on comparing the permissible limit of zinc if the concentration of zinc exceeded than it causes increase in the toxicity level. As from the study of washed and unwashed leafy vegetables concentration of zinc not exceeded their permissible limit. So no sample shows toxicity regarding zinc.As per the comparative study between washed and unwashed leafy vegetables shows that the concentration of the five heavy metals lead (Pb), copper (Cu), Zinc (Zn), Nickel (Ni) and Cadmium (Cd) were higher in the samples of unwashed leafy vegetables than the washed leafy vegetables. From the vehicle tail pipe emission which contains all the five heavy metals shows the more deposition of the on the sample of leafy vegetables which consisting of the large leaves than the other samples like spinach , wild spinach and amaranth leaves. Spinach, wild spinach and amaranth leaves washed and unwashed samples show the more concentration of heavy metals due to the large surface area which absorb more heavy metals from the environment. Result shows that only spinach exceed the limit while other not.

This research conclude that if heavy metals concentration in leafy vegetables not exceeded the permissible limit, then the consumption of these leafy vegetables was not toxic and not causes any risk to the human health, but they absorb heavy metals and traces of these heavy metals shown in the result of washed and unwashed leafy vegetables which reveals that it may cause the health risk if grown near the roadside and also sold on the roadside. Consequently, this study encourages environmentalists, administrators, and public health workers to create public awareness to avoid the consumption of vegetables grown in contaminated soils, hence reducing health risks.

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