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Assessment of Heavy Metals in Fruits and Vegetables Collected from Bareilly Local Market, Uttar Pradesh State, India

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Abstract: Heavy metals are among the contaminating agents of our food supply, and the main source of metals or the media through which living beings get exposed to various toxic metals is food and water. The concentration of heavy metals in plants is essential for good health and growth of human and animals but should be within permissible limits. Various natural and anthropogenic factors are responsible for excess metal concentration in crops. Dietary heavy metals such as cadmium, lead, arsenic, mercury can be harmful to biota as their excessive accumulation in human body can lead to systematic health problems. Fruits and vegetables are main component in diet after cereals. Hence the present study aimed to determine Aluminium (Al), Arsenic (As), Cadmium (Cd), Lead (Pb) and Mercury (Hg) content in mostly consumed vegetables (onion, potato, taro root, spinach, taro root leaves, beans, jackfruit and pumpkin) and fruits (blackberry, mango and pears) during summers in Bareilly City, Uttar Pradesh. These food samples were collected from local vendors and shops from four different market sites of the city. The samples were analysed using atomic absorption spectrophotometer and the obtained results were compared with safe limits set by different national and international agencies. Based on the data we conclude that concentrations (mg/kg dry weight) of As, Pb and Hg for all samples and Al and Cd for most of the food stuffs were found exceeding the allowable limits causing potential health risk to consumers of present study area. Elevated levels of these metals in food stuffs might be due to various factors such as usage of industrial and disposal waste water for irrigation, municipal and urban runoff, fertilizers, pesticides, that contaminates the soil and hence crops absorb those metals. Some cultivation areas get exposed to atmospheric pollution found near highways, in form of metal containing aerosols. Other factors can be exposure to pollution during transportation and marketing. The prolonged consumption of unsafe concentration of metals is an alarming public health concerns, considering that metals can accumulate in organism and show negative effects by causing various disruptions of numerous biochemical processes and therefore leading to acute and chronic health outcomes. Such foodstuffs should be avoided in the diet and a regular monitoring is required to avoid the health risk among humans.
Keywords: heavy metal, contamination, concentration, food sample, human, toxicity

I. INTRODUCTION

Heavy metals ingestion through food chain among the population is gaining attention from public, researchers and as well as government agencies, as it has become an alarming public health concern in many countries particularly developing countries [35, 9]. Heavy metals are basically termed as group of metalloids or metals having an atomic number greater than 22 and specific gravity greater than 5; example are nickel, chromium, cadmium, mercury, arsenic, lead, zinc, copper [15]. Heavy metals accumulate in body through air, water and particularly by food chain. In India, due to faster growing rate of urbanization and industrialization in many states, these heavy metals are polluting the agricultural fields. Though these metals are present in the environment from these several years, but the human anthropogenic activities have increased their toxicity. Heavy metals runoff from industries, use of sewage and industrial effluents, mining, oil extraction; get accumulated in to the water bodies and thus affect the soil properties [49, 43, 54]. The treated and untreated industrial effluent are discharged into the rivers located near fields, some farmers also use polluted sediment to agricultural fields as organic matter supply during the dry season [22]. Air also gets contaminated like soil and water by these contaminants. Acid rain is a natural effect to this air pollution, and aerial deposition of metals from thermal power plants, use of pesticides in fields, on plants as small particles emitted from such industries are easily movable in the atmosphere due to their light weight [17, 24]. Once these metals are dispersed into the air, water and soil, they reach the crops and then consumed by animals and humans, and that is how it enters the food chain [34].

501

These are considered as essential elements among plants and animals for growth but many of them and their increased accumulation becomes toxic towards these living organisms [32].

Human diet constitutes fruits and vegetables as an important part as they provide carbohydrates, proteins as well as vitamins, minerals, and trace elements [2]. Fruits can accumulate high levels of heavy metals in their edible parts and vegetables in their edible and unedible parts [40, 37]. Higher amount of metals are accumulated in leafy vegetables than the fruits [44]. Metals accumulation in fruits and vegetables depend upon several factors as physiochemical properties of soil, plant metal uptake, transfer factor of soil to plants, plant species, state of surrounding environment or atmospheric deposition, assimilation capability, levels of sewage sludge amendments applied, irrigation water quality, harvesting process or growth condition, the climate and [33, 45] and during transportation, storage or at point of sale [19].

The consumption of such contaminated fruits and vegetables by humans will allow metals to enter human body and to exert influence at cellular, tissue and systematic level. These metals cause environmental hazards and are reported as exceptionally toxic elements [23, 8]. The intake of such food stuff may constitute major source of long term low level heavy metals accumulation in body; its detrimental effects becomes apparent only after several years of exposure and accumulation [5, 20].

The toxicity of heavy metals mainly involves the brain and kidney but other organ manifestation also occur. Metals like arsenic, cadmium or lead are capable of causing different organ cancers. Some individuals with metal toxicity, even with acute or high dose, reveal some general symptoms such as headache, nausea, vomiting, weakness, tingling in hands and feet, lethargy, skin allergies, abdominal pain, memory loss, diarrhea, shortness of breath, developmental effects, slow growth, impaired senses, etc. Chronic exposure have effects like hypertension, delay in growth, developmental abnormalities in individual exposed to Pb, Hg or Al and renal toxicity in individual exposed to Cd, and can also occur in individual who have no symptoms [31]. Children are more susceptible to metal exposure and usually have weakened bones and delayed growth; pregnant women can have miscarriage or deliver prematurely.

Other effects can be blood acidity, developmental retardation, neurological disorders, nervous system disorders, skin lesions, immune system dysfunction, gastrointestinal, liver and kidney dysfunction, intestinal damage, anemia, and more.

In spite of the fact that these fruits and vegetables have nutritional values and consumer acceptance, it must be taken into consideration that they contain both essential and toxic elements over a wide range of concentration [53, 8]. Thus, food safety issue and public potential health risk are major environmental concern. Several national and international agencies on food quality have lowered maximum possible permissible levels of toxic metals to food chain contamination [38, 47]. Therefore, regular monitoring of these metals from effluents, sewage, markets sites, in vegetables, fruits and other food items is essential for preventing excessive build up of metals in food chain and human body. Several researches on heavy metals in soil, crops and different food items been conducted worldwide.

The objective of present study was to assess heavy metals viz. aluminum, arsenic, cadmium, lead and mercury in commonly consumed fruits and vegetables during summers collected from different market sites of Bareilly city, Uttar Pradesh state, India. The obtained results in dry weight basis were compared with the permissible levels set by different national/international agencies.

II. MATERIALS AND METHODS

A. Study Area and Sample Collection

Fruits and vegetable samples were brought from four local market area (north, south, east and west) of Bareilly city. Sampling was done from different local shops, retailers and vendors in these sites. Bareilly district is the northern Indian state of Uttar Pradesh, which lies between 28°20” to 28°54” and 78°58” to 79°47” E in western region of U.P. this area receives an average of 1032 mm of annual rainfall.

A number of industries such as Sugar mills, coca cola industry, katha factory, rubber factory, distilleries, IFFCO are situated within 30 km radius of this city. And they discharge their treated and untreated effluents into the Ramganaga River. This polluted water of river reaches to the fields and also contaminates the ground water.

After a dietary survey conducted in the month of May-June 2018, list of commonly consumed food items was gathered, and the mostly selective samples were listed out on the basis of daily and weekly consumption. These samples were analyzed with atomic absorption spectrometer for heavy metals (Al, As, Cd, Pb and Hg).

Selective samples of vegetables (spinach, taro root leaves, onion, potato, taro root, beans, jackfruit and pumpkin) and fruits (blackberry, mango and pears) (Table 1) were analyzed.

Table 1: Description of analyzed food samples

S. No.	Food samples	Scientific names	Edible parts
1.	Spinach	*Spinacia oleracea*	Leaves
2.	Taro root leaves	*Colocasia esculenta*	Leaves
3.	Onion	*Allium cepa*	Tuber
4.	Potato	*Solanum tuberosum*	Tuber
5.	Taro root	*Colocasia esculenta*	Tuber
6.	Beans	*Phaseolus vulgaris*	Leaf with seeds
7.	Jackfruit	*Artecarpus heterophyllus*	Fruit with seeds
8.	Pumpkin	*Cucurbitaceae*	Fruit
9.	Blackberry	*Syzygium cumini*	Fruit
10.	Mango	*Mangifera indica*	Fruit
11.	Pears	*Pyrus communis*	Fruit

B. Pretreatment of Samples

The edible portions of samples were cleaned not washed. Then the samples were cut into pieces with a stainless steel knife. They were dried in an electric oven at 80°C for several hours to obtain constant weight. After drying these samples were individually finely grounded into a powder and sieved through 2 mm sieve and stored in airtight clean zip lock polyethylene bags up to chemical analysis.

C. Digestion of Treated Samples

The samples (each of 0.5 g) were taken in a long glass tube and digested with tri acid mixture of HNO_3, H_2SO_4 and $HClO_4$ in the volume ratio of 5:1:1 keeping the temperature at 80°C on a hot plate, till the solution becomes transparent. The digested samples were then filtered by Whatman No. 42 filter paper and transferred into beaker to make it upto 50 ml with deionized water. Each treated sample after digestion was then used for metal analysis [3].

D. Analysis Of Heavy Metal In Digested Food Sample

Aluminium, arsenic, cadmium, lead and mercury were analyzed by using atomic absorption spectrophotometer (AAS) in the digested food samples. A GFS Furnace Autosampler – Thermo Scientific iCE 3000 SERIES AA Spectrometer was used for the analysis.

III. RESULTS AND DISCUSSION

The results of present study showed that the consumers of this study area are at risk of consuming fruits and vegetables contaminated with heavy metals, which are beyond the legal permissible standard limits. The analyzed food samples were compared with the standard permissible limits [14, 7] as shown in Table 2, and results revealed that most of the samples were above the recommended levels of metal concentrations. The obtained mean concentration (mg/kg) results of five heavy metals in the selected food samples are summarized in Table 3.

Table 2: Standard permissible limits of heavy metals in selected food samples (mg/kg)

Food samples	Permissible limits (mg/kg) of heavy metals				
	Aluminum	Arsenic	Cadmium	Lead	Mercury
Spinach	1	0.05	0.2	0.2	0.01
Taro root leaves	1	0.05	0.2	0.2	0.01
Onion	1	0.05	0.1	0.1	0.01
Potato	1	0.05	0.1	0.1	0.01
Taro root	1	0.05	0.1	0.1	0.01
Beans	1	0.05	0.05	0.1	0.01
Jackfruit	1	0.05	0.05	0.1	0.01
Pumpkin	1	0.05	0.05	0.1	0.01
Blackberry	1	0.05	0.05	0.1	0.01
Mango	1	0.05	0.05	0.1	0.01
Pears	1	0.05	0.05	0.1	0.01

Table 3: Mean concentrations of heavy metals in food samples (mg/kg)

Food samples	Estimated mean concentrations (mg/kg) ± SD of heavy metals in analyzed food samples				
	Aluminium	Arsenic	Cadmium	Lead	Mercury
Spinach	2.300±0.100	1.500±0.100	1.180±0.010	1.100±0.100	0.200±0.010
Taro root leaves	1.460±0.010	1.340±0.010	1.260±0.010	0.410±0.010	0.500±0.010
Onion	0.900±0.010	0.290±0.010	0.220±0.010	0.150±0.010	0.370±0.010
Potato	1.300±0.010	1.203±0.015	0.010±0.001	0.800±0.010	1.200±0.010
Taro root	1.220±0.010	1.320±0.010	0.350±0.010	1.120±0.010	1.280±0.010
Beans	0.480±0.010	0.080±0.010	0.270±0.010	0.190±0.010	0.360±0.010
Jackfruit	1.280±0.010	1.200±0.010	0.490±0.010	0.360±0.010	1.120±0.010
Pumpkin	0.420±0.010	0.060±0.010	0.220±0.010	0.140±0.010	0.330±0.010
Blackberry	0.800±0.010	0.680±0.010	0.230±0.010	0.420±0.010	0.450±0.010
Mango	0.320±0.010	1.240±0.010	0.280±0.010	0.190±0.010	0.520±0.010
Pears	0.700±0.010	1.900±0.010	0.250±0.010	0.390±0.010	0.650±0.010

A. Aluminium

The aluminum concentration in food samples with comparison to their permissible limit (1 mg/kg) is shown in Figure 1. It is the third most abundant element in earth's crust and found basically in drinking water and food stuffs. It is considered as a neurotoxic agent; its toxicity increases the risk of Alzheimer disease, also interferes with Ca metabolism and regulation of iron levels, and causes cognitive damage, neurological diseases, and renal diseases [18]. Aluminium was found exceeding the permissible limits in sample of spinach (2.30 mg/kg) followed by taro root leaves (1.46 g/kg); potato (1.30 mg/kg), jackfruit (1.28 mg/kg) and taro root (1.22 mg/kg). Other samples were within the limits. Higher Al levels were recorded in spinach (27.47±38.74 mg/kg) and pears (9.68±6.88 mg/kg), potatoes (5.88±3.29 mg/kg) and onion (5.41±2.16 mg/kg) from a study in Spain [16] green vegetables (3.1 mg/kg) and potatoes (0.90 mg/kg) in USA [27] as compared with present study concentration.

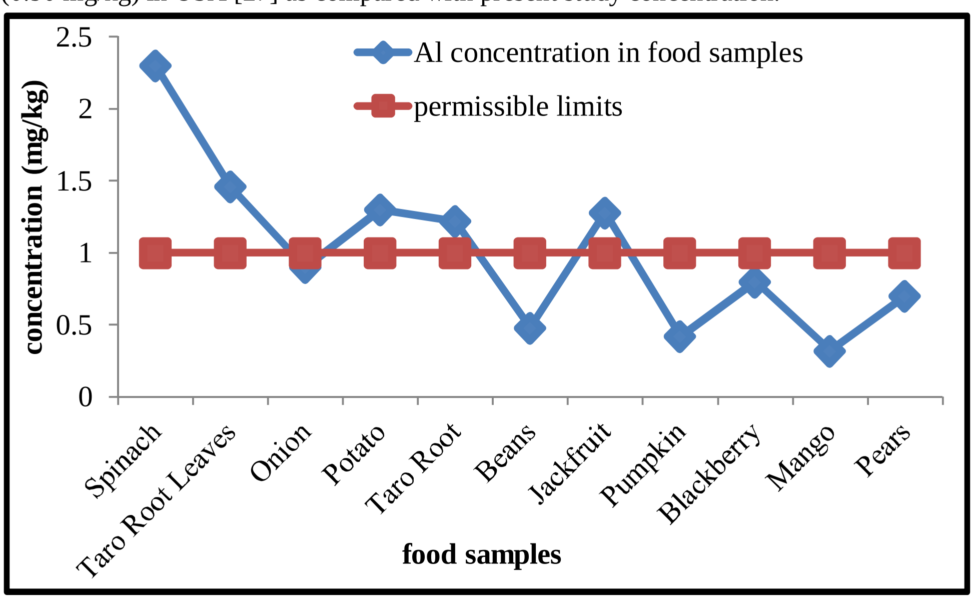

Figure 1: Mean concentration of As (mg/kg) in food samples with permissible limits

B. Arsenic

Arsenic is a metalloid, being the 20th most abundant element. Its toxicity on human health is termed as arsenicosis and can cause diarrhea, liver fibrosis, skin lesions, pigmentation, keratosis, anemia, hepatomegaly, lung diseases, polyneuropathy, gastrointestinal diseases, cardiovascular diseases, nervous system disorders, or cancers [30]. Figure 2 shows comparable values of obtained and permissible limits of arsenic in food samples. All food samples were above the allowable limits for arsenic. Among fruits samples, most contaminated sample with arsenic was pear (1.90 mg/kg) followed by mango (1.24 mg/kg) and blackberry (0.68 mg/kg). Green leafy vegetables were also high in arsenic concentration as spinach (1.50 mg/kg) and taro root leaves (1.34 mg/kg).

Other vegetable sample were also found contaminated with arsenic, taro root (1.32 mg/kg), potato (1.203 mg/kg), jackfruit (1.20 mg/kg), onion (0.29 mg/kg), beans (0.08 mg/kg) and pumpkin (0.06 mg/kg). Lower level in spinach (0.23 µg/g), potato (0.19 µg/) and onion (0.21 µg/g) were reported in a study in Varanasi [48], in potato (<0.1) [50]; lower arsenic reported in spinach (0.016 µg/g), onion (0.023 µg/g), potato (0.025 µg/g), pumpkin (0.053 µg/g) and beans (0.080 µg/g) from Sindh, Pakistan [1]; in vegetables (0.47±0.54 mg/kg) in Kolkata [12]; another study conducted in Bangladesh showed high values in bean (0.31 mg/kg) and jackfruit (0.16 mg/kg) and lower levels in potato (0.27 mg/kg), mango (0.17 mg/kg) and similar concentration (0.29 mg/kg) in onion [21]; in jackfruit (0.007 mg/kg), mango (0.013 mg/kg), bean (0.018 mg/kg), onion (0.008 mg/kg) and potato (0.006 mg/kg) in Bangladesh [46] as compared to current study levels. A study from Vadodara reported higher arsenic levels as compared to this study in spinach (5.0 ppm), onion (5 ppm) and potato (5 ppm) [10].

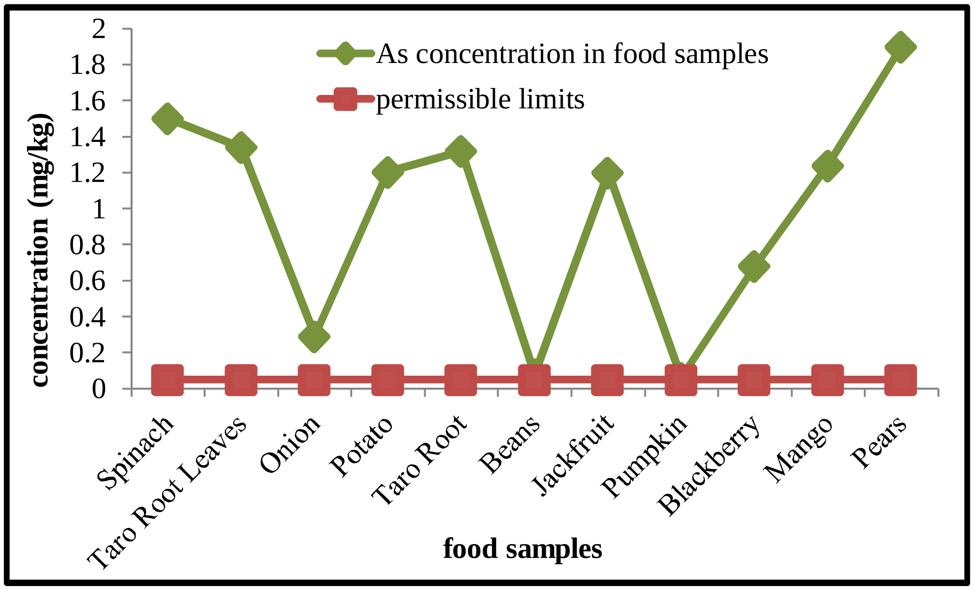

Figure 1: Mean concentration (mg/kg) of As in food samples with permissible limits

C. Cadmium

Cd is regarded as one which mostly accumulates in food chain. It is known causing nausea, vomiting, diarrhea, headache, abdominal cramps, and irreversible damage to several organs like bone, kidney or respiratory tract as renal nephropathy, skeletal lesions, Itai-itai disease or cancer, gastrointestinal problems, anemia [51, 4]. All the food samples except potato were found contaminated with cadmium metal (Figure 3). Highest Cd was found in leafy vegetable samples of taro root leaves (1.26 mg/kg) and spinach (1.18 mg/kg) followed by jackfruit (0.49 mg/kg), taro root (0.35 mg/kg), mango (0.28 mg/kg), beans (0.27 mg/kg), pears (0.25 mg/kg), blackberry (0.23 mg/kg), pumpkin (0.22 mg/kg) and onion (0.22 mg/kg). A higher level of Cd was reported in spinach (14.58 mg/kg) [17] in West Bengal, (15.24 mg/kg) in spinach from Allahabad [52]; in pears (3.85 and 7.58 µg/kg) and mangoes (2.14 and 16.9 µg/g) from two market areas of Bangalore city [28]; high Cd level in spinach (4.1 µg/g) and potato (2.50 µg/g) while a slightly high level in onion (0.20 µg/g), (1.96 mg/kg) in spinach from market site [47], another study reported high Cd concentration in spinach (1.60 ppm), potato (1.63 ppm) and onion (1.65 ppm) in Vadodara [10]; similarly from study in Varanasi showed slightly high values in onion (0.44 µg/g) and lower in spinach (0.94 µg/g) by [48] as compared to present study; high Cd values in (1.33 mg/kg) and (0.75 mg/kg). Other research reported lower value in spinach (0.37µg/g) and high value in beans (0.93µg/g) but Cd not detected in pumpkin [39]. Lower Cd levels (0.63 mg/kg) in spinach were reported in Rawalpindi [25]; in spinach (0.064 mg/l), potato (0.082 mg/l) and onion (0.073 mg/l) from Vellore district [42], in spinach (0.35 mg/kg) and pumpkin (0.045 mg/kg) were reported [26]; (0.22 mg/kg) in beans from South astern Nigeria [36]; low Cd values reported in jackfruit (0.097 mg/kg), mango (0.005 mg/kg), bean (0.08 mg/kg), potato (0.013 mg/kg) and onion (0.023 mg/kg) from Bangladesh [46]; lower Cd in spinach (0.087 µg/g), onion (0.079 µg/g), potato (0.040 µg/g), pumpkin (0.032 µg/g) and beans (0.029 µg/g) from Sindh, Pakistan [1] in reference to present study. Other study in Chhattisgarh concluded lower Cd levels in spinach (0.27 mg/kg) and high level in mangoes (5.143 mg/kg) in comparison to this study [41]. (0.41 mg/kg) Cd in pumpkin was found to be slightly higher than present study [13].

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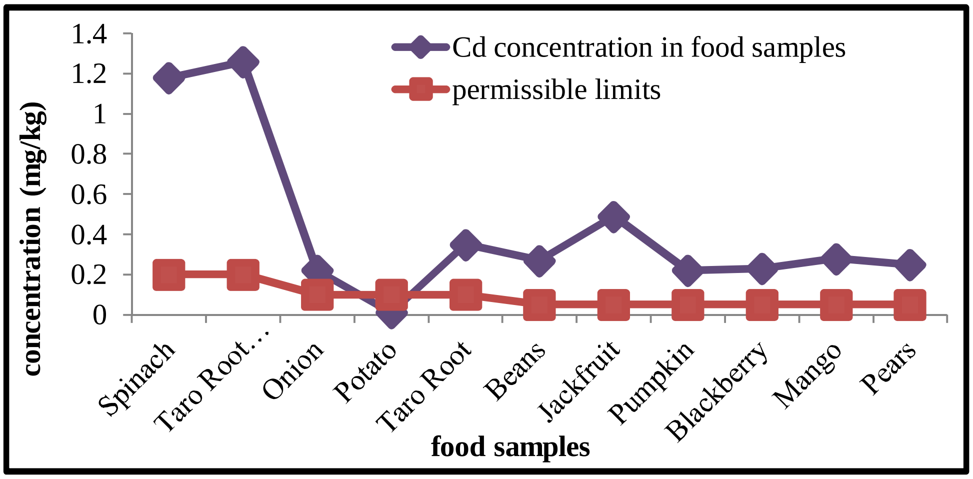

Figure 3: Mean concentration (mg/kg) of Cd in food samples with permissible limits

D. Lead

Lead is a slow poison, and can result into hazardous effects on human as disruption of biosynthesis of haemoglobin, kidney damage, high blood pressure, immunological, reduced fertility, miscarriage or abortions, bone damage, disruption of nervous system or cancers. Reports mention that children are more exposed to lead than adults, and often results in fatalities and diminished learning abilities [29]. Lead levels in food samples in comparison with allowable levels (0.01 mg/kg) are shown in figure 4, which shows that all the samples were found contaminated with lead. Lead was also highest in samples of taro root (1.12 mg/kg) and spinach (1.10 mg/kg) followed by potato (0.80 mg/kg), blackberry (0.42 mg/kg), taro root leaves (0.41 mg/kg), pears (0.39 mg/kg), jackfruit (0.36 mg/kg), beans (0.19 mg/kg), mango (0.19 mg/kg), onion (0.15 mg/kg) and pumpkin (0.14 mg/kg). In comparison to present study concentrations, highest Pb level was recorded in spinach (57.63 mg/kg) in a study in West Bengal [17]; in vegetables (32.11±36.50 mg/kg) in Kolkata [12]; other study in washed vegetable samples of spinach (30.48 µg/g), beans (1.127 µg/g) and pumpkin (7.16 µg/g) in West Bengal [39]; (16.20 mg/kg) in spinach [52]; in pears (9.52 and 26.13 µg/g) and mangoes (9.52 and 67.20 µg/g) from two areas and much higher levels in bottlegourd (74.07 µg/g), onion (22.22 µg/g) and potato (51.85 µg/g) in Bangalore city [28]; in spinach (27.7 µg/g), onion (4.4 µg/g) and potato (3.9 µg/g) in Andhra Pradesh [6], high concentration in spinach (4.95 mg/kg) in territories of Rawalpindi [25], (1.54 mg/l) in spinach, onion (3.91 mg/l) and potato (3.92 mg/l) in Vellore district [42]; in spinach (3.1 mg/kg) in sewage irrigated soil [11], and slightly high in spinach (1.44 mg/kg) [47], slightly similar values in spinach (1.08 µg/g), potato (0.37 µg/g) and onion (0.19 µg/g) in Varanasi [48] and (0.15 m/kg) in pumpkin in North Central Nigeria [13]. A reference study reported lower Pb in spinach (0.26 mg/kg) and higher value in mango (1.824 mg/kg) in Chhattisgarh state [41]. Another study showed lower Pb in jackfruit (0.017 mg/kg), bean (0.057 mg/kg), onion (0.027 mg/kg), potato (0.007 mg/kg) and high value in mango (0.642 mg/kg) in Bangladesh [46]; lower lead concentration in spinach (0.010 µg/g), onion (0.006 µg/g), potato (0.091 µg/g), pumpkin (0.065 µg/g) and beans (0.089 µg/g) from Pakistan [1] in respect to present study levels.

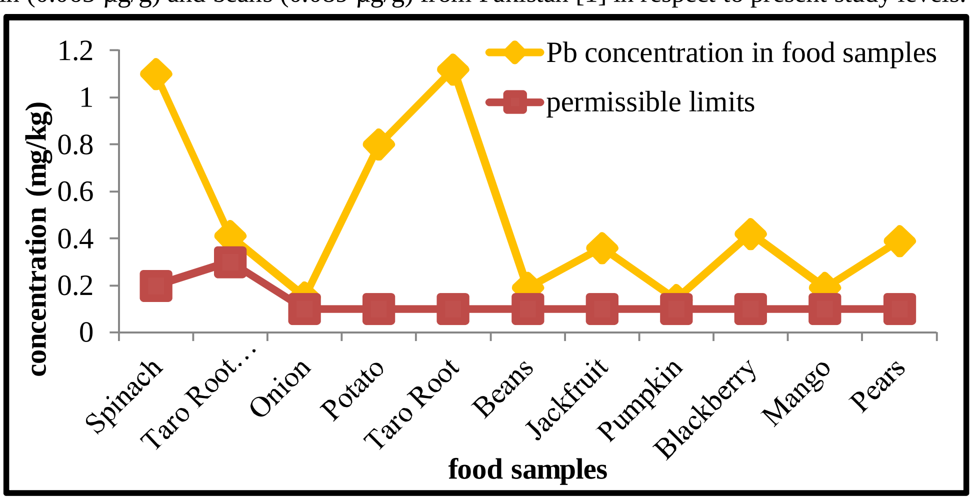

Figure 4: Mean concentration (mg/kg) of Pb in food samples with permissible limits

E. Mercury

Mercury toxicity have affects on several organ systems, leading to memory loss, Alzheimer like dementia, ataxia, impairment of hearing and vision, fatigue, sensory disturbances, deficit in memory and attention, decreased muscle strength, deceases immunity, multiple sclerosis, eczema, decrease in fertility rate of male and female, late growth in children, and many [55]. Similarly, all the analyzed food samples were exceeding the permissible Hg values (as compared in Figure 5). Mercury was found highest in sample of taro root (1.28 mg/kg), potato (1.20 mg/kg), jackfruit (1.12 mg/kg), pears (0.65 mg/kg), mango (0.52 mg/kg), taro root leaves (0.50 mg/kg), blackberry (0.45 mg/kg), onion (0.37 mg/kg), beans (0.36 mg/kg), pumpkin (0.33 mg/kg) and spinach (0.20 mg/kg). High Pb levels were reported in spinach (4.01 mg/l); potato (1.32 mg/l) and onion (1.71 mg/l) in Vellore district [42] and lower Hg level in potato (0.377±0.02) [50] as compared to present study. Much lower levels of mercury were recorded in spinach (0.009 µg/g), onion (0.009 µg/g), potato (0.001 µg/g), pumpkin (0.01 µg/g) and beans (0.008 µg/g) form Pakistan [1] in reference to current study.

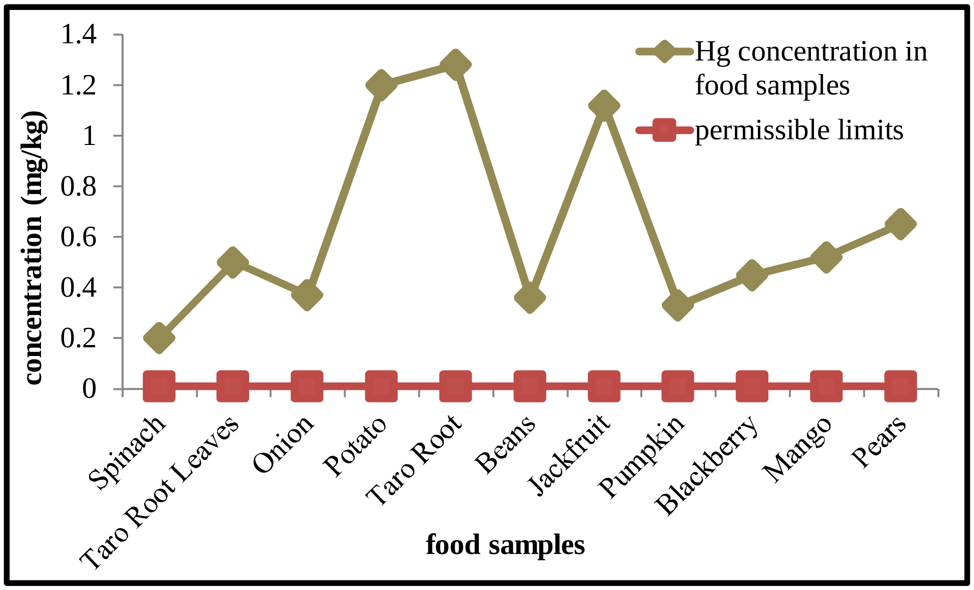

Figure 5: Mean concentration (mg/kg) of Hg in food samples with permissible limits

IV. CONCLUSIONS

The results from current study indicate that the food samples had higher content of As, Cd, Pb and Hg except for aluminium in some samples analyzed as compared to the values permitted by national/international bodies, which could be potentially health concern. Deposition of these metals from wide range of sources of industries (small/large scale), wastewater irrigation, excessive pesticides and fertilizers, fumigation or smelting, vehicular emissions, road side dust during transportation or during sale/marketing can be all the contributors to the contamination found in food samples. Among all the food samples, leafy vegetables and tubers were mostly contaminated by heavy metals and least was found in fruits. Maximum accumulation of metals was found in order of spinach (Al>Cd>As>Pb>Hg), taro root leaves (Al>As>Cd>Hg>Pb), taro root (As>Hg>Al>Pb>Cd), potato (Al>Hg>As>Pb>Cd), jackfruit (Al>As>Hg>Cd>Pb), pears (As>Al>hg>Cd>Pb), mango (As>Hg>Al>Cd>Pb), blackberry (Al>As>Hg>Pb>Cd), onion (Al>Hg>As>Cd>Pb) and pumpkin (Al>Hg>Cd>Pb>As). Maximum concentration of aluminium was found in spinach followed by taro root leaves, potato, jackfruit and taro root and minimum in mango. Arsenic in pears, spinach followed by taro root leaves, taro root, mango, potato, jackfruit, blackberry, onion and minimum in beans and pumpkin. Cd was maximum in sample of spinach and taro root leaves, and minimum in potato. Similarly, maximum Pb concentration was in taro root and spinach, and minimum in pumpkin and onion. Mercury level was maximum in taro root followed by potato, jackfruit, pears, mango, taro root leaves, blackberry, onion, beans and pumpkin and minimum in spinach. In contrast to other food samples, onion, beans, pumpkin, blackberry, mango and pears showed Al concentration within permissible limits. Cadmium was below detection limit in potato.

Heavy metal contamination among the most commonly consumed fruits and vegetables has pose a threat to the people in the Bareilly city

The daily dietary intake of food items could be much less at present than concentration but the situation can change in future after a long term consumption and amount of contaminants added in the diet. Studies have also reported that Pb, As and Cd are in food items might be carcinogenic to consumers and Al, Hg leads to slowed growth and development of children.
Therefore, continuous monitoring and assessment of heavy metal concentration in food items is required to prevent excessive take up of these metals in consumer food. Consumer should be made aware and attentive towards the metal toxicity.

V. ACKNOWLEDGEMENT

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VI. CONFLICT OF INTEREST

No conflicts.

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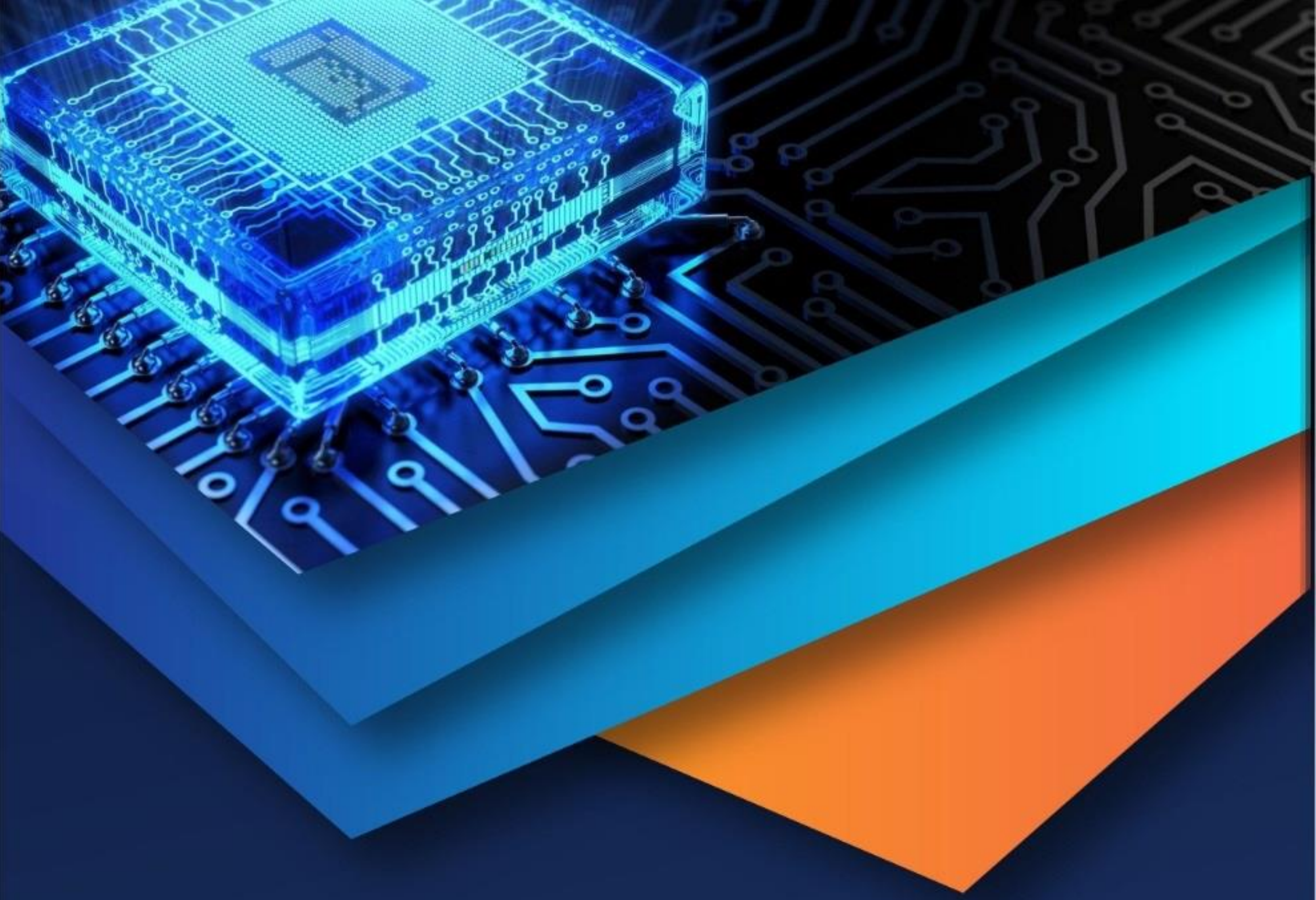
509



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