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Heavy metals contamination in vegetables and its growing soil

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Abstract
The present study was carried out to analyse the heavy metal contamination in soils and vegetable crops. Soil samples as well as vegetable samples were collected from commercially growing vegetable belts of Central Kashmir (Noorbah (Srinagar) and Narkara (Budgam) area of Jammu and Kashmir. The soils and vegetable samples were analyzed for Fe, Mn, Zn, Cu, Cd, Cr, Ni and Pb. The mean values showed slightly higher amount of the heavy metals in the soils of Noorbagh (Srinagar). Furthermore, the edible part of radish had higher amount of these heavy metals respectively compared to tomato owing to the excessive discharge of domestic sewage in the irrigation channels. The heavy metal concentration in both the vegetable crops were below the critical limits of Indian standards but continuous monitoring of these metals is necessary to ensure the good quality of vegetables for consumption.

Keywords: Heavy metals, vegetables, tomato, radish

Introduction
Heavy metals are hazardous contaminants in food and the environment and they are non-biodegradable having long biological half-lives [1]. The implications associated with metal (embracing metalloids) contamination are of great concern, particularly in agricultural production systems [2] due to their increasing trends in human foods and environment. Metals most often found as contaminants in vegetables include As, Cd and Pb. These metals can pose as a significant health risk to humans, particularly in elevated concentrations above the very low body requirements [3]. So, the metals must be controlled in food sources in order to assure public health safety [4]. Excessive amount of heavy metals in food cause a number of diseases, especially cardiovascular, renal, neurological, and bone diseases [5]. These metals could reach food chain through various biochemical process and ultimately biomagnified in various trophic levels and eventually threaten the health of human. The contamination of soil and vegetables by heavy metals is also a global environmental issue. They are ubiquitous in the environment through various pathways, due to natural and anthropogenic activities [6]. Under certain environmental conditions metals may accumulate to toxic concentration and they cause ecological damages [7, 8].
Source of anthropogenic contamination include the addition of manures, sewage sludge, fertilizers and pesticides to soils, several studies identifying the risks in relation to increased soil metal concentration and consequent plant uptake [9, 10]. Both commercial and residential growing areas are also vulnerable to atmospheric pollution, in the form of metal containing aerosols. These aerosols can penetrate the soil and be absorbed by vegetables, or alternatively be deposited on leaves and adsorbed. Analysis of vegetables grown in locations close to industry has reported elevated levels of heavy metals contamination [2, 11] studied the impact of atmospheric pollution from industry on heavy metal contamination in vegetables grown in Greece. The results of the study indicated significantly higher levels of metal accumulation in leafy vegetables as compared with root vegetables. This partitioning of Cd is well known, with accumulation of greater concentrations in the edible leafy portions of crops, than the storage organs or fruit [12, 13].
As the present study area is free from industrial pollution, the major sources of soil contamination with heavy metals might be due to the irrigation water, and agrochemicals. Excessive accumulation of heavy metals in agricultural soils through the use of agrochemicals and by other sources may not only result in soil contamination but also lead to elevated heavy metal up-take by vegetables and thus affect food quality and safety [14]. Heavy metals are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops [15]. Vegetables take up heavy metals and accumulate them in their edible [16] and inedible parts in quantities high enough to cause clinical problems both to animals and human beings when they consume these metal-rich plants [17].

Intake of toxic metals in a chronic level through soil and vegetables has adverse impacts on human, plants and the associated harmful impacts become apparent only after several years of exposure [16, 18]. However, the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body that are further responsible for decreasing immunological defenses, such as intrauterine growth retardation, impaired psycho-social facilities, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates [19, 20].

Materials and Methods

Collection of plant and soil samples

Soil and plant samples were collected from major vegetable growing belts of Noorbagh (Srinagar) and Narkara (Budgam) areas of Central Kashmir using surface water for irrigation purposes. Fifteen soil samples from each area were collected and fifteen samples of each vegetable crops Fifteen samples of each vegetable crop (tomato (*Solanum lycopersicum* L. variety: Local), radish (*Raphanus sativus* L. variety: Japanese long)) were collected from the same site from where soil samples were collected.

Digestion of soil and plant samples for heavy metal analysis

Heavy metals (Cd, Cr, Ni and Pb) from soil samples were extracted by the method of Jackson (1973) using di-acid digestion mixture (HNO_3:$HClO_4$, 4:1) and analyzed by Atomic Absorption Spectrophotometer (AAS).

The plant samples were digested in a di-acid mixture consisting of HNO_3 and $HClO_4$ to the known amount of plant material (1g) 5ml of conc. HNO_3 was added and kept overnight. Next day 12 ml of di-acid mixture (HNO_3:$HClO_4$, 3:1) was added and digested on hot plate. The digestion process begins with the evolution of reddish brown fumes (NO_2 gas) and the plant samples slowly begin to dissolve and digested in a di-acid mixture. After few hours the plant samples dissolved completely in the digestion mixture and the solution was then evaporated until only 2 ml was left in the flask [21]. The remaining digested material was diluted to 25 ml with distilled water and was then analyzed for the presence of heavy metals Cd, Cr, Ni, Pb, Fe, Mn, Zn and Cu by Atomic Absorption Spectrophotometer.

Result and Discussion

Heavy metal Content in Soil

Heavy metal concentration (Fe, Mn, Zn, Cu, Cd, Cr, Pb and zn) of soils of Noorbagh Cu was found slightly higher than in soils of Narkara (table 1). The heavy metals followed the increasing trend of Ni> Pb> Cr> Cd>Fe >Mn >Cu >Zn in both the areas. The mean concentration of Fe in Noorbagh soils was 32.52±0.83 $mgkg^{-1}$ ranging of 28.33-39.00 $mgkg^{-1}$ and that of Narkara soils the concentration of Fe was 28.73±0.76 $mgkg^{-1}$ ranging from 23.92-33.12 $mgkg^{-1}$. The mean concentration of Mn was 9.43±0.62 $mgkg^{-1}$ in soils of Noorbagh and 8.75±0.22 $mgkg^{-1}$ in soils of Narkara. Zn in Noorbagh soils was found as 0.90±0.05 and 0.88±0.08 $mgkg^{-1}$ in Narkara soils. The mean concentration of copper was 3.71±0.12 and 2.98±0.16 $mgkg^{-1}$ in soils of Noorbagh and Narkara respectively. The mean concentration of Cd, Cr, Ni and Pb in Noorbagh soils was found as 0.14±0.03, 0.33±0.04, 0.91±0.07 and 0.65±0.10 $mgkg^{-1}$ respectively and in Narakara soils the concentration of these metals was found as 0.12±0.03, 0.30±0.004, 0.82±0.07 and 0.59±0.09 $mgkg^{-1}$ respectively. Furthermore on comparing with the safe limits of Indian Standards the concentration of these metal were found well below the safe limits and hence are excellent for growing vegetables commercially.

Table 1: Heavy metal concentration of soils in Central Kashmir

Parameters ($mgkg^{-1}$)	Noorbagh		Narkara		Safe limits (Awashthi, 2000)
	Mean±S.E	Range	Mean±S.E	Range	
Fe	32.52±0.83	28.33-39.00	28.73±0.76	23.92-33.12	--
Mn	9.43±0.62	4.66-13.20	8.75±0.22	7.21-10.22	--
Zn	0.90±0.05	0.67-1.20	0.88±0.08	0.27-1.52	300-600
Cu	3.71±0.12	2.66-4.20	2.98±0.16	2.00-4.10	135-270
Cd	0.14±0.03	0.03-0.47	0.12±0.03	0.03-0.42	3-6
Cr	0.33±0.04	0.06-0.64	0.30±0.04	0.05-0.58	--
Ni	0.91±0.07	0.34-1.55	0.82±0.07	0.31-1.40	75-150
Pb	0.65±0.10	0.11-1.41	0.59±0.09	0.10-1.27	250-300

The higher heavy metal concentration in soils of Noorbagh are due to excessive use of poultry manures which contain higher amounts of heavy metals like Cd, Cr, Ni, Pb, Fe, Cu, Mn and Zn. Besides, fertilizers and pesticides used in the area contain some trace metals as impurities or active ingredients which can lead to the build of micronutrients in the soil [22]. Moreover, some trace metals bind strongly to carbonates, clay particles, Fe and Mn oxides and organic matter and additionally soil pH, cation exchange and redox potential can also regulate the mobility of metals in soil. Quality of groundwater sources are affected by the characteristics of the media through which the water passes to the ground water zone of saturation, thus, the metals discharged by vehicles, municipal wastes, hazardous waste sites as well as from fertilizers for agricultural purposes can result in a steady rise in contamination of ground water and its subsequent use for irrigation leads to buildup of trace metals in soil [23].

Heavy metal content in vegetable crops

Table 2: Heavy metal uptake in vegetable crops in Central Kashmir

Parameters (mg kg^{-1})			Fe	Mn	Zn	Cu	Cd	Cr	Ni	Pb
Tomato	Noorbagh	Mean±S.E	60.32±1.81	58.33±3.56	24.58±1.40	12.93±0.74	0.06±0.01	0.11±0.02	0.08±0.01	0.11±0.05
		Range	46.69-68.58	38.25-77.14	17.35-36.82	8.88-18.32	0.01-0.11	0.03-0.29	0.02-0.20	0.01-0.74
	Narkara	Mean±S.E	58.74±1.76	56.80±3.47	23.93±1.36	12.59±0.72	0.06±0.01	0.10±0.02	0.08±0.01	0.10±0.05
		Range	45.46-66.78	37.24-75.11	16.89-35.85	8.65-17.83	0.01-0.11	0.03-0.29	0.02-0.19	0.01-0.72
Radish	Noorbagh	Mean±S.E	75.44±2.26	71.84±4.39	30.27±1.72	15.92±0.91	0.07±0.01	0.12±0.02	0.09±0.02	0.12±0.05
		Range	58.39-85.76	47.10-95.00	21.36-45.35	10.94-22.56	0.01-0.13	0.03-0.33	0.02-0.23	0.01-0.84
	Narkara	Mean±S.E	71.66±2.15	68.25±4.17	28.76±1.64	15.13±0.87	0.07±0.01	0.11±0.02	0.08±0.01	0.12±0.05
		Range	55.47-81.47	44.75-90.25	20.30-43.08	10.39-21.43	0.01-0.12	0.03-0.32	0.02-0.21	0.01-0.80
Safe limits (Awashthi, 2000)			-	-	50	30	1.5	20	1.5	2.5

Heavy metal concentration of both the vegetable crops in both the areas followed the increasing trend of Ni> Pb> Cr> Cd>Fe >Mn >Cu >Zn (table 2). The concentration of heavy metals grown in Noorbagh area was found higher than the vegetable grown in the soils of Narkara area. In Noorbagh the mean concentration of Fe, Mn, Zn, Cu, Cd, Cr, Ni, and Pb in tomato was 60.32±1.81, 58.33±3.56, 24.58±1.44, 12.93±0.71, 0.06±0.02, 0.11±0.02, 0.08±0.01 and 0.11±0.05 mg kg^{-1} and in Narakara the concentration of these metals in tomato was 58.74±1.76, 56.80±3.47, 23.93±1.36, 12.59±0.72, 0.06±0.02, 0.10±0.01, 0.08±0.01 and 0.10±0.05 mg kg^{-1} respectively. Among vegetable crops the concentration of these metals was higher in radish than in tomato. In Noorbagh the concentration of Fe, Mn, Zn, Cu, Cd, Cr, Ni, and Pb in radish was 75.66±2.26, 71.84±34.39, 30.27±1.72, 15.92±0.91, 0.07±0.01, 0.12±0.02, 0.09±0.02 and 0.12±0.05 mg kg^{-1} in Narkara the concentration of these metals was 71.66±2.15, 68.25±4.17, 28.76±1.64, 15.13±0.87, 0.07±0.01, 0.11±0.02, 0.08±0.01 and 0.12±0.05 mg kg^{-1} respectively. Furthermore the concentration of these micronutrients were found well below the safe limits of Indian standards and hence are fit for consumption purposes.

Elevated levels of heavy metals in soil have been shown to increase the metal uptake tendency in the plants [24]. The metal accumulation in crop tissues is generally a function of metal concentration in soil and soil texture but the level of absorption differ according to crop species and tissue. Plants are one of the principal sinks of accumulated heavy metals. Zinc is the most bioavailable metal in polluted soils and absorption of Copper by plant roots is among lowest for essential elements. The variations in the concentrations of the heavy metals in vegetables may be ascribed to the heavy metals concentrations in soil, air and water used for irrigation. Moreover, Heavy metal uptake by plant depends upon soil pH, plant species, cultivars, form of metal in water and application rate (Saraswat *et al*., 2005) [25].

Conclusion

The Noorbagh soils and vegetables contained relatively higher amounts of heavy metals than Narkara, wherein the edible part of radish had higher amount of Fe, Mn, Zn, Cu, Cd, Cr, Ni and Pb compared to tomato. The higher content of heavy metals in soils and vegetable crops of Noorbagh was higher owing to the excessive discharge of domestic sewage in the irrigation channels. The metal concentration in soils as well as in the vegetable crops were below the critical limits of Indian standards but continuous monitoring of these metals is necessary to ensure the good quality of vegetables for consumption.

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