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Assessment of Heavy Metal Pollution Index (HPI) In The Vegetables Collected From The Local Markets, Fields and Beras in The Jodhpur City, Rajasthan (India)

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ABSTRACT
The research work mainly focuses on the assessment of some toxic heavy metals in the vegetables sold in the mandis, local market and by vendors in the Jodhpur city. Assessment of heavy metal ions concentration and heavy metal pollution index (HPI)) for six toxic heavy metals viz. Cu, Zn, Pb, Cd, Cr and Ni were done. Four different types of vegetable samples were collected from ten different sites of the Jodhpur city. Metal contamination order of vegetables was-tomato>cauliflower>spring onion>radish. The order of metal pollution at different sites was-site-1>site-9>site-10>site-8>site-2>site-5>site-4>site-6>site-3>site-7. Order of metal concentration with respect to the permissible limit was Pb>Cr>Cd>Ni>Cu>Zn. Three most toxic metals Pb, Cr and Cd were found in most of the samples in more than the permissible limits but Ni, Cu and Zn were within permissible limits. HPI was obtained maximum at site-9 in tomato (0.6712) which is near Jojari river area. Vegetables grown in the Jodhpur city are consumed by local people as well as these are supplied to close towns, so mass population is at the danger of heavy metal toxicity. We recommend continuous monitoring of these heavy metals in vegetables sold in the local market. People should be made aware about the health-related issues occurring from heavy metals consumption in the vegetables.
KEYWORDS: Contamination, Toxic metal ions, Waste water, vegetables, Irrigation, Concentration, HPI

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INTRODUCTION

We know that vegetables and fruits are very important part of our daily balanced diet. It provides many types of minerals and vitamins [1], which are essential for our body metabolism, but the truth is that these minerals and vitamins providers like vegetables and fruits are getting contaminated day by day with different types of toxic metals, which causes harmful side effects on human body.

According to WHO report [2] there should be at least 30 % fruits and vegetables in our daily diet according to age and weight of a person, because vegetables and fruits are main source of nutrients, but it's becoming curse on human health now a days.We know that about 60% of population of India are dependent on agriculture and contribute 16-17% of GDP of India [3].

The elements with metallic characteristics and an atomic number larger than 20 are classified as heavy metals[4]. Ni, Cd, Cr, Cu, Hg, Zn, and Pb are the most well-known heavy metal contaminants. Metals are a type of natural component that can be found in soil [5]. Some metals, such as Mn, Zn, Co, Ni, and Cu, are micronutrients and needed for plant growth, but others, such as Cd, Pb, and Hg, have unknown biological activities [6]. Metal contamination in vegetable samples is revealed by HPI. For four different vegetables, we estimated the Heavy Metal Pollution Index (HPI) at ten different locations. The HPI readings obtained were higher above the regular standard limits.

Metal contamination has a negative impact on living organisms' biological systems and does not degrade[4]. Toxic heavy metals such as Cr, Cu, Hg, Ni, Pb, Co, Cd, and others are distinct from other pollutants in that they cannot be biodegraded, yet they can accumulate in living organisms[4] and cause a variety of disorders even at low amounts [7]. Heavy metals stay for years in soil, causing several health issues for organisms. Heavy metals have also been shown to have a deteriorating impact on plant development, ground cover, and soil microbiota [8]. Because these heavy hazardous metals cannot be destroyed chemically, they must be removed by physical means or transformed into benign molecules.

MATERIAL AND METHODS

Sample Collection

Radish, cauliflower, tomato, and spring onion leaf samples were gathered from various locations around the sampling areas and agriculture farm and stored in marked sampling packets. They were taken to our chemistry department in our campus's chemistry laboratory. They were rinsed in water and dried in the oven. Finally, they ere ground into a homogeneous fine powder and digested in acids.

Fig.1-Sampling Sites

Preparation of samples

In a conical flask, 1 gm of a sample was weighed and digested with 15 ml of a triacid combination (70 percent high purity HNO3, 65 percent HClO4, and 70 percent H2SO4; 5:1:1) [9]. It was thoroughly combined with constant stirring for 30 minutes, on a hot plate at 250°C[10], until a translucent solution was obtained. Whatman no. 42 filter paper was used to filterate the digested material. The filtrate was poured into a volumetric flask with a capacity of 100 mL. It was diluted with distilled water until it reached the desired consistency. For each sample, we prepared blank solutions. For all metal ions, a 1000 ppm stock solution was created, and the necessary dilutions were performed. The concentration of all heavy metal ions was measured using AAS on samples and blank solutions [11,12].

Figure 2-packing and storage of samples

RESULTS AND DISCUSSION

Heavy metals persist in environment for long time and it cannot be degraded chemically and their removal is needed by physical methods or they should be changed into nontoxic compounds. In my research work 4 species of vegetables which were found contaminated with heavy metal ions are listed in below table no 1 . We collected 10 samples of each vegetable from 10 different sites of Jodhpur and then analyzed them for six heavy metals. All the concentrations are in ppm.

For determination of overall load of metals in each vegetable growing at each site, we calculated Heavy metal pollution index (HPI) for these concentrations of metal ions[13]. It was calculated as the geometric mean of concentation of all metals at a particular site in the edible part of plant. HPI was using equation given by Usero et al [14].

HPI = (Cf1× Cf2×Cf3×..........Cfn) ^1/n

Cf= Concentration of 'nth' heavy metal in vegetable samples [15]. So in our study n=6 , because we analysed the vegetable samples for six metals.

Table -1: List of vegetables which are collected from contaminated area of jodhpur city

S.NO.	NAME OF VEGETABLES	BOTANICAL NAME OF VEGETABLES	FAMILY NAME
1.	Radish	*Raphanus raphanistrum*	Brassicaceae
2	Cauliflower	*Brassica oleracea*	Brassicaceae
3	Tomato	*Solenum lycopersicum*	Solanaceae
4.	Spring Onion	*Allium cepa*	Amaryllidaceae

Table-2: Metal concentation and HPI values for 4 different vegetables at site-1 to site-5

Sites	Vegetable	Cu	Ni	Cr	Cd	Pb	Zn	HPI
Site-1	Radish	0.41	0	0.19	0.21	1.09	5.38	0
	Cauliflower	0.27	0.36	0.21	0.17	0.98	5.33	0.5125
	Tomato	0.27	0.45	0.27	0.09	1.09	5.05	0.5033
	Spring Onion	0.37	0.23	0.43	0.07	1.06	5.45	0.4955
Site-2	Radish	0.22	0.24	0.19	0.1	0.47	5.32	0.3686
	Cauliflower	0.31	0.27	0.18	0.12	0.87	3.35	0.4271
	Tomato	0.34	0.32	0.29	0.05	1.05	5.56	0.4578
	Spring Onion	0.33	0.37	0.32	0.12	0.98	5.76	0.5459
Site-3	Radish	0.18	0.23	0.37	0.13	0.43	3.27	0.3754
	Cauliflower	0.33	0.52	0.15	0.16	0.56	4.25	0.4626
	Tomato	0.33	0.35	0.16	0.11	1.11	4.67	0.4682
	Spring Onion	0.19	0.31	0.29	0.15	0.84	3.54	0.4436
Site-4	Radish	0.27	0.29	0.26	0.16	0.52	4.35	0.4411
	Cauliflower	0.19	0.26	0.24	0.09	0.78	3.41	0.3763
	Tomato	0.28	0.19	0.19	0.15	0.98	4.78	0.4384
	Spring Onion	0.29	0.28	0.33	0.09	0.94	4.48	0.4654
Site-5	Radish	0.42	0.28	0.2	0.13	1.95	3.41	0.5224
	Cauliflower	0.35	0.29	0.31	0.08	0.95	3.37	0.4478
	Tomato	0.4	0.37	0.45	0.23	0.69	3.91	0.588
	Spring Onion	0.4	0.16	0.27	0.17	1.02	4.51	0.488

Table :3 Metal concentation and HPI values for 4 different vegetables at site -6 to site-10

Sites	Vegetable	Cu	Ni	Cr	Cd	Pb	Zn	HPI
Site-6	Radish	0.23	0.31	0.24	0.09	0.35	5.23	0.3759
	Cauliflower	0.29	0.33	0.25	0.1	1.08	4.28	0.472
	Tomato	0.37	0.48	0.36	0.07	0.77	3.37	0.4759
	Spring Onion	0.42	0.19	0.17	0.13	1.05	3.63	0.4344
Site-7	Radish	0.34	0.3	0.25	0.04	0.42	2.34	0.3164
	Cauliflower	0.44	0.22	0.29	0.18	0.85	2.29	0.4629
	Tomato	0.51	0.09	0.54	0.13	0.85	4.45	0.4797
	Spring Onion	0.33	0.25	0.23	0.08	1.09	5.35	0.4548
Site-8	Radish	0.38	0.24	0.28	0.19	0.48	4.44	0.4667
	Cauliflower	0.36	0.19	0.23	0.12	2.09	3.32	0.4855
	Tomato	0.56	0.18	0.43	0.16	0.94	5.34	0.5714
	Spring Onion	0.28	0.28	0.25	0.05	2.06	4.39	0.4549
Site-9	Radish	0.17	0.29	0.26	0.11	2.08	2.25	0.4331
	Cauliflower	0.42	0.25	0.26	0.22	2.05	5.21	0.6327
	Tomato	0.48	0.39	0.35	0.2	2.04	3.42	0.6712
	Spring Onion	0.25	0.32	0.24	0	1.51	5.53	0
Site-10	Radish	0.24	0.23	0.25	0.14	2.25	3.27	0.4922
	Cauliflower	0.26	0.29	0.28	0.2	0.79	4.36	0.4941
	Tomato	0.19	0.43	0.38	0.22	1.06	4.45	0.5641
	Spring Onion	0.17	0.35	0.31	0.15	1.73	5.47	0.5449

Table-4: Permissible limits of metal concentration in vegetables and HPI

Metals	Permissible limits in ppm for vegetables	Mean concentration of metal ions for all sites (ppm)	Increased Percentage (%)	Diseases caused by excess metal concentration
Cd	0.003	0.129	4200	It can cause cancer.
Cr	0.05	0.2787	457.4	Cardiac, neurological, gastrointestinal and reproductive disorders
Zn	5-15	4.28	Within limits	Vomiting, nausea diarrhea,
Cu	1	0.321	Within limits	Vomiting, jaundice, depression, fatigue
Ni	0.5	0.2845	Within limits	Headache, gastrointestinal and respiratory disorders
Pb	0.3	1.09	263.33	Muscular, skeletal and neurological disorders
HPI	0.2334	0.512	119.3	

So after comparison, it was clear that heavy metal ions concentration and HPI both were high in the vegetables collected from all the 10 different sites than normal standard limits.

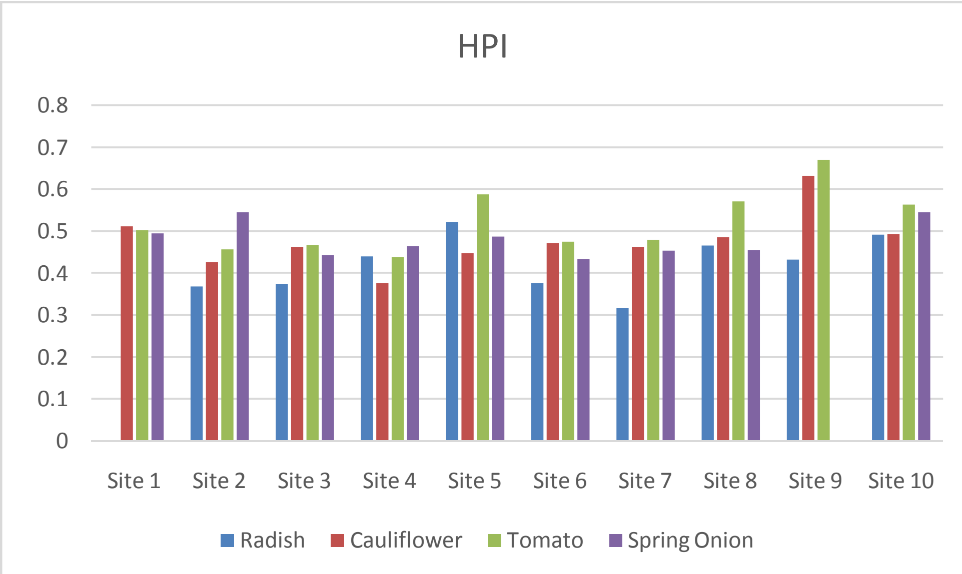

Fig.3-HPI of all the vegetable samples at ten different sites

Copper (Cu)

Excess consumption of copper can cause low blood pressure, vomiting, jaundice, depression, fatigue, liver and kidney damage [16,17]. Copper concentation was maximum at site -9 in tomato, which was 0.48ppm. Minimum concentation of Cu was 0.17ppm at site -9 in radish and site 10 in spring onion.

Chromium (Cr)

Intake of excess amount of chromium in food can cause cardiac, neurological, gastrointestinal, kidney, liver[10] and reproduction disorders in humans. Cr concentation was maximum at site-7 in tomato, which was 0.54ppm. The minimum concentation of Cr was 0.15 ppm at site-3 in cauliflower.

Cadmium (Cd)

Cd is highly toxic non-essential metal ion and it does not have a role in biological activities in human health. Even trace amount is also harmful for human body. Cd is a carcinogenic metal also. Cd concentration was maximum at site-5 in tomato, which was 0.23ppm. The minimum concentration of Cd was zero at site-9 in spring onion.

Lead (Pb)

Lead is a toxic metal ion which causes muscular, skeletal, neurological effect. Its higher concentration reduces the growth. Lead concentration was maximum at site-10 in radish, which was 2.25ppm. Minimum concentration of Pb was 0.35 ppm at site-6 in radish.

Nickel (Ni)

Ni is required for enzymatic activities of body; the trace amount may be beneficial but higher concentration of this metal ion causes many side effects in human biological activities. Ni concentration was maximum at site-3 in cauliflower, which was 0.52ppm. The minimum concentration of Ni was zero at site-1 in radish.

Zinc (Zn)

Zinc is most essential element for all organisms and is useful in various biological activities but excess Zn intake can cause vomiting, nausea, diarrhea, body pain and cramps. Zinc concentration was found maximum at site-2 in spring onion , which was 5.76ppm. The minimum concentration of Zn was 2.25 ppm at site-9 in radish.

CONCLUSION

Six metal ions Ni, Zn, Cd, Cr, Cu, Zn and Pb were found in all the four vegetables sample in higher concentrations. They were well above the permissible limits given by the WHO and FAO.Three most toxic heavy metal ions Cr, Cd and Pb (which are dangerous for human health if consumed in above permissible limits) were found in all the four vegetables samples. HPI value was found maximum in tomato at site-9, which was 0. 6712.The range of HPI in radish, cauliflower, tomato and spring onion was between 0-0.5224, 0.3763-0.6327, 0.4384-0.6712 and 0- 0.6712 respectively. Site 9 samples were most toxic and highest levels of heavy metals were found in tomatoes among all the sites. Metal contamination order of vegetables was- tomato>cauliflower>spring onion>radish. The order of metal pollution at different sites was-site-1>site-9>site-10>site-8>site-2>site-5>site-4>site-6>site-3>site-7. Order of metal concentration with respect to the permissible limit was Pb>Cr>Cd>Ni>Cu>Zn. In our study Zn, Cu and Ni were found within limits, whereas Pb, Cr and Cd were found 3-10 times more in concentration than the prescribed limits. They can cause cancer and many neurological diseases, which are also reported by doctors at AIIMS Jodhpur[18].

Further most of the samples collected were from local venders near residential area, small shops, Jojari river farms and in local markets. This clearly confirms very high level of heavy metal toxicity amongst common people. This is a very serious issue. The government should immediately take action and stop use of untreated contaminated industrial waste water for irrigation. We also recommend regular sampling and testing of vegetables sold in the local markets and farm. Public should also be made aware of danger of eating cheap and toxic vegetables.

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CONFLICT OF INTEREST-

There is no conflict of interest and the main purpose of our research is to bring public awareness.

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