

# Assessment of Heavy Metals' Risk on Human Health via Dietary Intake of Cereals and Vegetables from Effluent Irrigated Land Jaipur District, Rajasthan

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**ABSTRACT:** Soil pollution by untreated industrial effluent containing heavy metals is a ensuing threat to sustainability of ecological balance including humankind. The present study aims at determining human health risks associated with food chain contamination by heavy metals caused by industrial effluent irrigation. This study revealed the concentration of heavy metals in crops and vegetables (Carrot, Tomato, Wheat, Brinjal, and Barley) irrigated with effluent from textile and tanning industries in Jaipur district. The crops and vegetables analyzed are heavily contaminated with seven regulated elements namely Cadmium (Cd), Copper(Cu), Lead (Pb), Chromium(Cr), Nickel(Ni), Manganese(Mn) and Zinc(Zn) and Atomic Absorption Spectrophotometer was used to analyze the samples. The range of various metals present in the effluent irrigated plants varied from 8.537-14.372 mg/g in wheat, 8.234-15.271 mg/g in carrot, 10.361-13.313mg/g in Brinjal, 4.024-8.234 mg/g in tomato and 7.234-15.23 mg/g in barley. Nickel and lead found highest and Cadmium and copper found lowest in crops and vegetables. Irrigated water, soil and vegetables were analyzed for  $Cr^{+2}$ ,  $Ni^{+2}$ ,  $Cu^{+2}$ ,  $Pb^{+2}$ ,  $Cd^{+2}$ ,  $Mn^{+2}$  and  $Zn^{+2}$  transfer factor (TF), daily intake of metals (DIM) and health risk index (HRI) were also calculated.  $Cr^{+2}$ ,  $Zn^{+2}$  and  $Cd^{+2}$  in vegetables receiving effluent exceeded the permissible limits (WHO) while TF was lower for all metals except  $Cu^{+2}$ . The study highlights that children and adults consuming vegetables sourced from effluent-irrigated soils ingest significant amount of these metals. Continuous effluent irrigation of agricultural land has caused an ample build up of toxic metals in effluent irrigated soil as compared with the ground water irrigated soil.

**KEYWORDS:** Industrial effluent Irrigation, Heavy metals, Health risk, Transfer Factor

## I. INTRODUCTION

Western Rajasthan, particularly Pali, Balotra, Jaipur, Jodhpur and neighbouring areas have large number of textiles and dyeing industries, which discharge about 22 million litres of effluent per day. Due to lack of efficient economical treatments of the effluents, these are discharged into drains and rivers without any treatments and pollute the natural ecosystem of both land and water. Wastewater may contain various heavy metals including Zn, Cu, Pb, Mn, Ni, Cr, Cd, depending upon the type of activities it is associated with. Continuous irrigation of agricultural land with sewage and industrial wastewater may cause heavy metal accumulation in the soil and vegetables [11,12]. Heavy metals are generally not removed even after the treatment of wastewater at sewage treatment plants, and thus cause risk of heavy metal contamination of the soil and subsequently to the food chain [5]. Intake of heavy metals through the food chain by human populations has been widely reported throughout the world [10]. Due to the non-biodegradable and persistent nature, heavy metals are accumulated in vital organs in the human body such as the kidneys, bones and liver and are associated with numerous serious health disorders [3]. Individual metals exhibit specific signs of their toxicity. Lead, As, Hg, Zn, Cu and Al poisoning have been implicated with gastrointestinal (GI) disorders, diarrhoea, stomatitis, tremor, hemoglobinuria causing a rust-red colour to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia [9]. The nature of effects can be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic

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or teratogenic [4]. Vegetables, cereals and milk are major components of human diet, being sources of essential nutrients, antioxidants and metabolites in food items. In the present study, the concentrations of heavy metals in locally produced vegetables, cereals and milk were quantified throughout a year at a suburban area of Varanasi city of India, where treated and untreated wastewater has been used as a source of irrigation water for about 20 years [11]. The contamination levels in soil and vegetable/cereal crops were evaluated with respect to the prescribed safe limits of different heavy metals set under national and international norms. Milk is not directly contaminated by wastewater irrigation, but provides insight into the food chain transfer of heavy metals from fodder grass to the milk of animals. A number of standard measures were used to assess the health risks associated with the measured levels of heavy metal at the contamination sites.

## II. STUDY AREA

Sanganer, Jaipur was selected as study area. It is famous for Tie dye and printing, waste paper recycling and blue pottery industries. Sanganer is located between 26° 49' to 26°51'N latitude and 75°46' to 75°51'E longitude . These industries discharge untreated waste water in Amanishah Nala(Earstwhile Dravyawati river) in Sanganer. A large number of small, medium and large scale textile industrial units are located in Sanganer. The untreated waste water which conatins chemical like anelin, caustic soda, acids, bleaching powder and heavy metals is utilizing in irrigating agricultural fields for growing vegetables and other crop plants.

## III. MATERIAL AND METHODS

### Heavy Metal Analysis By Atomic Absorption Spectrophotometer

Atomic absorption Spectrophotometer (AAS Model GBC 932) was used for analysis of heavy metals in water. The 25ml of the sample was digested in di acid mixture of HNO<sub>3</sub> and per chloric acid in the ratio of (10:1). The digestion was performed in 100 ml conical flasks and to facilitate complete digestion the samples in di acid mixture were kept overnight at room temperature .These flasks containing samples and di acid mixture were heated at hot plate until a clear solution was obtained .This was followed by a slow but complete evaporation of acids. Then, the volume of the digested samples was made up to 100 ml with the help of the double distilled water .Finally these solutions were analyzed by Atomic Absorption Spectrophotometer.

PLANT SPECIES	FAMILY	ENGLISH NAME	VERNACULAR NAME	PART USED
<i>Solanum lycopersicum</i>	Solanaceae	Tamoto	Tmatar	Fruit
<i>Daucus carota</i> L.	Apiaceae	Carrot	Gajar	Underground stem
<i>Triticum aestivum</i>	Poaceae	Wheat	Genhu	Fruit
<i>Solanum melongena</i>	Solanaceae	Brinjal	Bengan	Fruit
<i>Hordeum vulgare</i>	Poaceae	Barley	Jo	Seed

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## IV. DATA ANALYSIS

### 1. TRANSFER FACTOR (TF)

Soil to plant metal transfer was computed as transfer factor(TF), which was calculated by using the equation

$$TF = C_{\text{PLANT}} / C_{\text{SOIL}}$$

where, C Plant is the concentration of heavy metals in plants and C Soil is the concentration of heavy metals in soil.

### 2. DAILY INTAKE OF METALS (DIM)

Daily intake of vegetables in adult was calculated by data obtained during the survey through a questionnaire. DIM was calculated by the following equation

$$DIM = C_{\text{metal}} \times C_{\text{factor}} \times D_{\text{food intake}} / B_{\text{average weight}}$$

(Chary et al., 2008)

where,  $C_{\text{metal}}$ ,  $C_{\text{factor}}$ ,  $D_{\text{food intake}}$ ,  $B_{\text{average weight}}$  represent the heavy metal concentrations in plants ( $\text{mg kg}^{-1}$ ), conversion factor (0.085), daily intake of vegetables and average body weight, respectively. The average vegetable intake was calculated by conducting a survey where about 200 people (males and females) having an average body weight of 47 kg were asked for their daily intake of particular vegetables from sampling sites.

**3. HEALTH RISK INDEX (HRI) :** To assess the human health risk of heavy metals, it is necessary to calculate the level of human exposure to that metal by tracing the route of exposure of pollutant to human body. There subsist many exposures routes for heavy metals that depend upon a contaminated media of soil and vegetables on the recipients. Receptor population use the vegetables enriched with higher concentration of heavy metals which enters the human body leading to health risks [7]. In the present research work vegetables grown at the wastewater were collected from the study area and their metal concentration was used to calculate the health risk index (HRI). The health risk index of the present research work was compared with the one reported by Khan et al. [8] and Jan et al [6]. Results of HRI were found to be lower than those of Khan et al. [8] and Jan et al. [6]. Value of HRI depends upon the daily intake of metals (DIM) and oral reference dose ( $R_{fd}$ ).  $R_{fd}$  is an estimated per day exposure of metal to the human body that has no hazardous effect during life time [13]. The health risk index for Cr, Ni, Cu, Pb, Cd, Mn and Zn by consumption of contaminated vegetables was calculated by following equation [6]-

$$HRI = DIM / R_{fd}$$

where DIM represents the daily intake of metals and  $R_{fd}$  represents reference oral dose.  $R_{fd}$  for Cr, Ni, Cu, Pb, Cd, Mn and Zn is 1.5, 0.02, 0.04, 0.004, 0.001, 0.033 and 0.30 ( $\text{mg/kg bw/day}$ ) respectively [13].

## V. RESULT

### HEAVY METALS IN SOIL

Continuous wastewater irrigation has changed the soil physicochemical properties. Ni was found in highest amount

#### HEAVY METALS IN SOIL

	Ni	Pb	Cu	Cd	Cr	Mn	Zn
Site 1	21.536±0.27	19.386±0.23	12.77±.014	14.37±0.26	17.772±0.16	18.446±0.18	18.774±0.16
Site 2	21.278±0.12	19.068±0.13	12.406±0.14	14.068±0.12	17.57±0.12	18.236±0.13	18.582±0.10
Site 3	21.212±0.14	18.968±0.12	12.268±0.11	13.984±0.14	17.48±0.10	18.008±0.13	18.45±0.11
Site 4	21.054±0.13	18.85±0.10	12.16±0.10	13.846±0.10	17.33±0.10	17.81±0.12	18.36±0.12
Site 5	20.892±0.13	18.684±0.11	12.032±0.11	13.714±0.10	17.176±0.11	17.64±0.09	18.162±0.10

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### HEAVY METALS IN VEGETABLES-

#### Tomato

	Ni	Pb	Cu	Cd	Cr	Mn	Zn
Site 1	7.618±0.20	8.23±0.21	4.3±0.18	4.342±0.20	6.348±0.16	4.97±0.15	6.136±0.15
Site 2	7.53±0.18	8.168±0.16	4.246±0.18	4.314±0.19	6.312±0.15	4.92±0.18	6.048±0.16
Site 3	7.44±0.16	8.116±0.12	4.178±0.16	4.25±0.17	6.272±0.12	4.838±0.15	5.95±0.16
Site 4	7.37±0.17	7.828±0.20	4.086±0.15	4.136±0.16	6.246±0.12	4.78±0.15	5.87±0.17
Site 5	7.32±0.20	7.704±0.20	4.024±0.14	4.048±0.15	6.154±0.10	4.654±0.04	5.778±0.15

#### CARROT

	Ni	Pb	Cu	Cd	Cr	Mn	Zn
Site 1	15.418±0.18	14.832±0.12	8.934±0.14	10.104±0.11	14.88±0.11	12.644±0.10	13.528±0.12
Site 2	15.382±0.17	14.744±0.11	8.668±0.15	9.92±0.12	14.782±0.11	12.412±0.11	13.312±0.12
Site 3	15.342±0.17	14.656±0.13	8.554±0.12	9.772±0.14	14.56±0.13	12.216±0.13	13.088±0.12
Site 4	15.308±0.17	14.524±0.11	8.394±0.12	9.636±0.15	14.31±0.12	11.966±0.11	12.89±0.12
Site 5	15.27±0.19	14.24±0.13	8.23±0.21	9.17±0.15	13.954±0.18	11.786±0.11	12.804±0.11

#### WHEAT

	Ni	Pb	Cu	Cd	Cr	Mn	Zn
Site 1	14.372±0.17	13.604±0.24	8.664±0.19	8.778±0.14	11.548±0.13	10.578±0.15	9.884±0.12
Site 2	14.358±0.17	13.562±0.14	8.632±0.19	8.73±0.14	11.51±0.13	10.53±0.15	9.818±0.11
Site 3	14.314±0.18	13.518±0.14	8.596±0.18	8.69±0.14	11.47±0.14	10.486±0.14	9.774±0.12
Site 4	14.252±0.17	13.476±0.14	8.564±0.18	8.646±0.13	11.432±0.13	10.438±0.13	9.718±0.11
Site 5	14.174±0.15	13.422±0.13	8.532±0.19	8.592±0.11	11.39±0.12	10.396±0.12	9.676±0.09

#### Brinjal

	Ni	Pb	Cu	Cd	Cr	Mn	Zn
Site 1	13.316±0.10	12.85±0.10	10.36±0.10	10.408±0.12	10.85±0.10	11.26±0.11	11.982±0.13
Site 2	13.116±0.11	12.77±0.11	10.256±0.09	10.316±0.10	10.742±0.12	11.21±0.10	11.882±0.10
Site 3	13.062±0.14	12.716±0.10	10.156±0.10	10.214±0.10	10.628±0.12	11.16±0.10	11.798±0.12
Site 4	12.972±0.16	12.636±0.08	10.068±0.11	10.118±0.12	10.552±0.10	11.066±0.12	11.686±0.14
Site 5	12.8±0.12	12.432±0.11	9.984±0.11	10.026±0.12	10.464±0.10	10.924±0.11	11.584±0.10

#### Barley

	Ni	Pb	Cu	Cd	Cr	Mn	Zn
Site 1	15.236±0.11	15.052±0.10	7.236±0.12	7.28±0.12	13.498±0.12	13.118±0.16	11.346±0.18
Site 2	15.182±0.13	14.96±0.09	7.163±0.12	7.206±0.12	13.418±0.13	13.082±0.16	11.278±0.17
Site 3	15.062±0.11	14.866±0.093	7.062±0.11	7.122±0.13	13.386±0.14	13.03±0.15	11.224±0.18
Site 4	14.984±0.10	14.778±0.10	6.96±0.11	7.034±0.14	13.346±0.12	13.008±0.16	11.15±0.15
Site 5	14.858±0.10	14.686±0.12	6.89±0.14	6.942±0.13	13.316±0.10	12.972±0.16	11.064±0.15

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### TRANSFER FACTOR , DAILY INTAKE OF METAL AND HEALTH RISK INDEX:-

#### Tomato

Heavy metals	Average concentration	Transfer factor	H.R.I	D.I.M
Ni	7.455	0.350	0.05	0.001
Pb	8.009	0.421	0.25	0.001
Cu	3.566	0.289	0.375	0.015
Cd	4.218	0.301	12	0.012
Cr	6.266	0.358	0.009	0.014
Mn	4.832	0.268	0.303	0.010
Zn	5.956	0.322	0.04	0.012

#### Carrot

Heavy metals	Average concentration	Transfer factor	H.R.I	D.I.M
Ni	15.344	0.720	3.05	0.061
Pb	14.599	0.768	14.5	0.058
Cu	8.556	0.694	8.525	0.341
Cd	9.720	0.695	3.89	0.389
Cr	14.497	0.830	0.039	0.058
Mn	12.204	0.676	1.484	0.049
Zn	13.124	0.710	0.173	0.052

#### Barley

Heavy metals	Average concentration	Transfer factor	H.R.I	D.I.M
Ni	15.06	0.707	2.95	0.059
Pb	14.872	0.783	15	0.060
Cu	7.062	0.572	0.7	0.028
Cd	7.116	0.508	29	0.029
Cr	13.392	0.766	0.035	0.053
Mn	13.042	0.723	1.575	0.052
Zn	11.212	0.607	0.146	0.044

#### Brinjal

Heavy metals	Average concentration	Transfer factor	H.R.I	D.I.M
Ni	13.053	0.613	2.6	0.052
Pb	12.679	0.667	12.5	0.050
Cu	10.164	0.824	1.025	0.041
Cd	10.216	0.729	48	0.048
Cr	10.647	0.609	0.028	0.042
Mn	11.124	0.911	1.363	0.045
Zn	11.786	0.638	0.156	0.047

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### Wheat

Heavy metals	Average concentration	Transfer factor	H.R.I	D.I.M
Ni	14.294	0.611	2.85	0.057
Pb	13.516	0.711	13.5	0.054
Cu	8.609	0.698	0.85	0.034
Cd	8.687	0.620	35	0.035
Cr	11.47	0.656	0.03	0.045
Mn	10.485	0.581	1.24	0.041
Zn	9.774	0.529	0.13	0.039

## VI. RESULT AND DISCUSSION

### CONCENTRATION OF HEAVY METAL IN PLANT AND SOIL SAMPLE-

Concentration of heavy metals in vegetables on a dry weight basis grown in wastewater. Results revealed that the heavy metal concentration was significantly higher in vegetables. Concentration of Ni<sup>+2</sup> and Pb<sup>+2</sup> was highest in all vegetables and Cu<sup>+2</sup> was in lowest concentration, but all the metals were above the permissible limit of WHO and USEPA. Ni was highest in carrot (15.344mg/kg) and Pb was highest in barley (14.872mg/kg) . Among heavy metal concentration in vegetables grown at industrial waste water the trend appeared as Ni<sup>2+</sup> > Pb<sup>2+</sup>>Cr<sup>3+</sup> >Cd<sup>2+</sup> >Cu<sup>2+</sup> >Zn<sup>2+</sup> >Mn<sup>2+</sup>

Concentration of heavy metals in soil obtained from different agricultural sites of Salawas was found to be significantly high. The concentration of heavy metals in soil were above the safe limits set by USEPA , WHO and Indian standards Awashthi [1]. The concentrations of heavy metals(mg/g) in agricultural soil collected from different crop production sites ranged from a minimum of 12.327 for Cu<sup>2+</sup> to a maximum 21.284 for Ni<sup>2+</sup>.

### TRANSFER FACTOR(TF), DAILY INTAKE OF METAL(DIM) AND HEALTH RISK INDEX(HRI)-

Transfer factor for tamato ranges from 0.268 (Mn<sup>2+</sup>) to 0.421 (Pb<sup>2+</sup>) , for carrot from 0.676 (Mn<sup>2+</sup>) to 0.830(Cr<sup>3+</sup>), for wheat from 0.529 (Zn<sup>2+</sup>) to 0.711 (Pb<sup>2+</sup>), for brinjal from 0.911(Mn<sup>2+</sup>) to 0.609(Cr<sup>3+</sup>) and for barley it ranges from 0.508(Cd<sup>2+</sup>) to 0.783(Pb<sup>2+</sup>). Plants uptake the heavy metals from soil and then it accumulate in different parts of plant.

Formal interviews conducted in the study area to detect the average consumptions of tamato, carrot, wheat , brinjal, barley. Values of DIM calculated for adults (average age 47 years), are presented in this. These data revealed that the values of daily intake of metal were high for vegetables grown at different five agricultural sites. The trend for DIM in vegetables grown was in the order of Ni<sup>2+</sup> > Pb<sup>2+</sup>>Cr<sup>3+</sup> >Cd<sup>2+</sup> >Cu<sup>2+</sup> >Zn<sup>2+</sup> >Mn<sup>2+</sup>. The highest value of DIM for Ni was in carrot (0.061) and lowest in tomato (0.001). In Mn it ranges from 0.10 (tamato) to 0.052 (barley)

To assess the health risk associated with heavy metal contamination of plants grown locally, estimated exposure and risk index were calculated. The results showed that Cd, Pb and Ni contamination in plants had greatest potential to pose health risk to the consumers . Although cereal crops (wheat ) have lesser concentrations of metals than vegetables, but the health risk index was higher. This may be due to higher proportion of cereals in diet, which consequently increased the health risk index. HRI was maximum for Cd<sup>2+</sup> in carrot(389) and minimum or out of danger for Cr<sup>2+</sup>.

## VII. CONCLUSION

The present study has generated data on heavy metal pollution in and around an Indian city and associated risk assessment for consumer's exposure to the heavy metals. Continuous wastewater irrigation to the

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agricultural land has caused an ample build up of toxic metals. food items should be performed in order to prevent excessive build up of these heavy metals in the human food chain. Variations in the heavy metal concentrations between the test vegetables/cereal crops reflect the differences in uptake capabilities and their further translocation to the edible portion of the plants. Ni, Pb and Cd concentrations were above the national and various international permissible limits in all the vegetables and cereal crops. Heavy metals have a toxic impact, but detrimental impacts become apparent only when long term consumption of contaminated vegetables occurs. The health risk index of cereals was higher than vegetables due to higher proportion of cereals in the diet. Consumption of foodstuff with elevated levels of heavy metals may lead to high level of accumulation in the body causing related health disorders. It is suggested that an urgent attention is required for the implementation of proper means to monitor and regulate the industrial and municipal effluents.

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