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Study of heavy metal accumulation in Spinach irrigated with industrial waste water of Bhiwadi industrial area, Rajasthan

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Abstract

The concentrations of some heavy metals were determined in Spinach (*Beta palonga*) which were irrigated with treated and untreated waste water of Bhiwadi industrial area. Metal concentrations in the vegetable samples were determined using Atomic Absorption Spectroscopy (AAS).The levels of all the metals studied were higher than those recommended by Food and Agricultural Organization (FAO) and the World Health Organization (WHO).The high levels of these heavy metals thought to place the consumers of these vegetable crops grown within the study area at health risk with time unless an urgent step is taken by relevant agencies to address this issue. The study concluded that industrial waste water (untreated) and treated by common effluent treatment plant (CETP) is not suitable for irrigational purposes, in its present form. Spinach plants produced visible symptoms of toxicity and growth retardation, due to high accumulation of heavy metals when exposed to untreated industrial waste water .These responses of Spinach plants indicated its behaviour as a bioindicator of heavy metal pollution in waste water and may be helpful in research studies and phytoremedial approaches.

Key Words: AAS, FAO, IS, vegetables, WHO.
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Introduction

Rapid industrialization is one of the major cause of water pollution all over the world. Waste water disposal is becoming a problem in developing countries as large quantities of municipal wastes and industrial effluents are being produced due to increased urbanization and industrialization respectively (Alloway& Ayres, 1995).

Various industries like those producing pesticides, textiles, chemicals, fertilizers, pulp and paper, paints pharmaceuticals etc. discharge untreated and treated waste water. India falls amongst the first ten industrialized countries of the world. According to Shaffi et al (1981) about two tones of waste water is discharged into aquatic bodies annually from industries in India. Untreated sewage water and the industrial effluents are discharged directly into water channels or canals and the polluted water is used for growing crops particularly vegetables and fodder in the vicinity of big cities (Khan et al, 2003).

Fresh water sources are limited in Rajasthan .So due to easy availability, lesser expensive and lesser availability of fresh water, the industrial waste water has become an attractive source for crop irrigation especially in urban area where pollutant concentration is generally high. Industrial or municipal waste water are used commonly for irrigation purpose (Singh et al 2004,Figin et al 1991).Long term wastewater irrigation may lead to the accumulation of heavy metals in agricultural soils and plants.(Dohetry et al 2012, Zehra et al 2009)). Continuous use of wastewater for irrigation leads to the accumulation of heavy metals in the vegetables (Singh and Kumar, 2006; Sharma et al., 2006, 2007; Gupta et al., 2009).High levels of accumulation of heavy metals from soil by common garden vegetables have also been reported by many environmental researchers(Boon and Soltanpour, 1992; De Pieri et al., 1997; Xiong,1998, Lawal et al 2011).

Heavy metals are non-biodegradable and persistent environmental contaminants which may be deposited on the surface and then absorbed into the tissues of vegetables. They might accumulate in the food chain with risks to the health of animals and humans. Heavy metals are kept under environmental pollutant category due to their toxic effects to plants, animals and human beings (Sharma et al., 2006). Jimoh et al (2012) mentioned that these metals, due to their cumulative behaviour and toxicity have potential hazardous effects not only on plants but also on human health (Onianwa et al., 2001; Konofal et al., 2004; Kocak et al., 2005; Audu and Lawal, 2005).

Leafy vegetables are widely used for culinary purposes. They are used to increase the quality of soup and for dietary purposes (Sobukola et al., 2007). They are very important protective foods, useful for the maintenance of health, prevention and treatment of various diseases (D'Mello,2003). But these leafy vegetables become harmful for human health when they accumulate high amount of heavy metals due to irrigation of industrial waste water. Lettuce and radish were found to be more responsible than other vegetables for the accumulation of heavy metals in humans through the edible portion (Intawongse& Dean 2006).Ingestion of vegetables irrigated with waste water and grown in soils contaminated with heavy metals poses a possible risk to human health and wildlife (Otero et al., 2000; Mussarat et al., 2007; Rattan et al., 2005; Bhatti and Mussarat, 2006).The present work deals with the quantification of heavy metal concentrations in spinach leaves by long term irrigation of treated and untreated and ground water of bhiwadi industrial area of Rajasthan.

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Materials and methods

Experimental plant

Beta palonga (Basu and Mukharjee) (Spinach).

Study area

Bhiwadi is called gateway of Rajasthan. It is located in Tijara tehsil of AlwarDistt.. It comes under Delhi NCR region .It is 55 km away from Indira Gandhi International airport ,Newdelhi and 200 km from Jaipur. It is an industrial hub. It has 1850 small and large industries including MNC industrial units and steel ,furnance, engineering, pharmaceuticals ,textiles etc.

Collection of plants and water samples

The study was conducted with waste water released from industries at Bhiwadi, Alwar. Three categories of water samples were collected. (i) Waste water samples were collected at the main outlet point of combined effluents from all the industries is being disposed and is termed as untreated water/ inlet of CETP . (ii) Second category of samples were collected from the water treated by CETP (common effluents treatment plant) and termed as outlet samples. (iii) The third category water samples of ground water were collected from bourwell of bhiwadi and as termed as GW samples.

Three plots of 6.5 × 4.5 m2 size were prepared. Genetically uniform seeds of spinach were sown in each plot.Uniform irrigation schedule was followed at all the three plots to maintain similar moisture condition throughout the growth of plants. Names of the 3 plots were given as inlet,outlet and GW plot respectively. Plant samples collected were washed with distilled water to remove dust particles. Samples were air dried and then grounded into fine powder, sieved and stored in polythene bags.

Experimental

Methods of metal digestion in water and plant samples :

The standard method for metal digestion in water samples described by CPCB (Central Pollution Control Board) and in the handbook of methods in environmental studies (Maiti 2001) was followed. The acid preserved samples were treated with HNO_3 and used for metal determinations. (Erwin and Ivo's 1992) method of metal digestion in plant samples was followed for metal estimation in plant organs. Here concentrated H_2SO_4, concentraeted $HClO_4$ and concentrated HNO_3 acid in the ration of 1:4:40 Used for digestion .(Fig-3)

All water and plants samples are analyzed by (AAS) Atomic Absorption Spectrophotometer (GBC, Avanta).Standard solutions of heavy metals (1000 mg/l) Chromium (Cr), zinc (Zn), manganese (Mn) and iron (Fe)of varying concentrations were prepared by diluting the standards Solutions.Allsmaples of water and plants are analyzed by atomic absorption spectrophotometry (GBC ,Avanta).Standard solutions of heavy metals (1000 mg/l) Chromium (Cr), zinc (Zn), manganese (Mn) and iron (Fe)of varying concentrations were prepared by diluting the standards solutions.

Results and Discussion

Charles et al 2011 mentioned that waters used for irrigation is normally obtained from urban streams, wells and rivers which have often been reported to be polluted by heavy metals that can as well be the source of heavy metals accumulations in agriculture products (Othman, 2001; Bilos et al., 2001; Islami et al., 2007).

Results revealed that all the three categories of water samples are not suitable for irrigation purpose because water samples contained high amount of heavy metals .The levels of metals is higher than the permissible limits of (Indian Standards) IS for

Irrigation water and when these of metals in plant parts.This is the agreement with the preveious reports showing elevated levels of heavy metals in edible parts of food crops with continous waste water irrigation(khan et al,2007) ;(Liu et al, 2005).

Levels of heavy metals in Spinach leaves irrigated with untreated water, treated water and ground water are Fe 5.313±0.101,5.273 ±0.257,7.923±0.627 ; Mn 2.513±0.129, 1.950±0.244,1.90±0.219; Cr 0.312±0.0131,0.295±0.040,0.393±0.0195; Zn 1.346±0.0919,1.273±0.0176,0.509±0.0185 respectively (table :2)

The concentrations of heavy metals in samples were higher than the FAO/WHO guideline values of 0.1-0.2 mg/kg Cr; 0.3mg/kg Fe; 0.1 mg/kg Pb; 0.1 mg/kg Cu; 0.1 mg/kg Zn; 0.1mg/kg Ni; 0.02 mg/kg Cd and 0.3 mg/kg Mn. The result of this study agreed with the data reported by ,(Koack et al 2005). Akan et al (2013) mentioned that the high levels of these heavy metals place the consumers of these vegetable crops grown within the study area at health risks with time unless urgent steps are taken by the relevant agencies to address this issue.

According toMandapa et al(2005) heavy metals are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops . And this is supported by the present report also.Spinach is a leafy vegetable and it accumulated high amount of metals when irrigated with waste water than the other grain and fruit crops. Al Jassir et al., (2005) and Farooq et al (2008) also observed that vegetables, especially those of leafy vegetables grown in heavy metals contaminated soils, accumulate higher amounts of metals than those grown in uncontaminated soils because of the fact that they absorb these metals through their leaves.

Conclusion

Spinach grown by irrigation with the industrial waste water and ground water of Bhiwadi area accumulate high amount of heavy metals in their leaves and the levels of heavy metals are more than the permissible limits given by WHO/FAO and it (plant) not suitable for eating and it may be harmful for people's health.

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Figure 1. showingmap of study area

Figure 2.

A,B,C : collection sites of untreated water, treated water and ground water respectively.

D,E, F : plants grown in untreated water ,treated water and ground water respectively

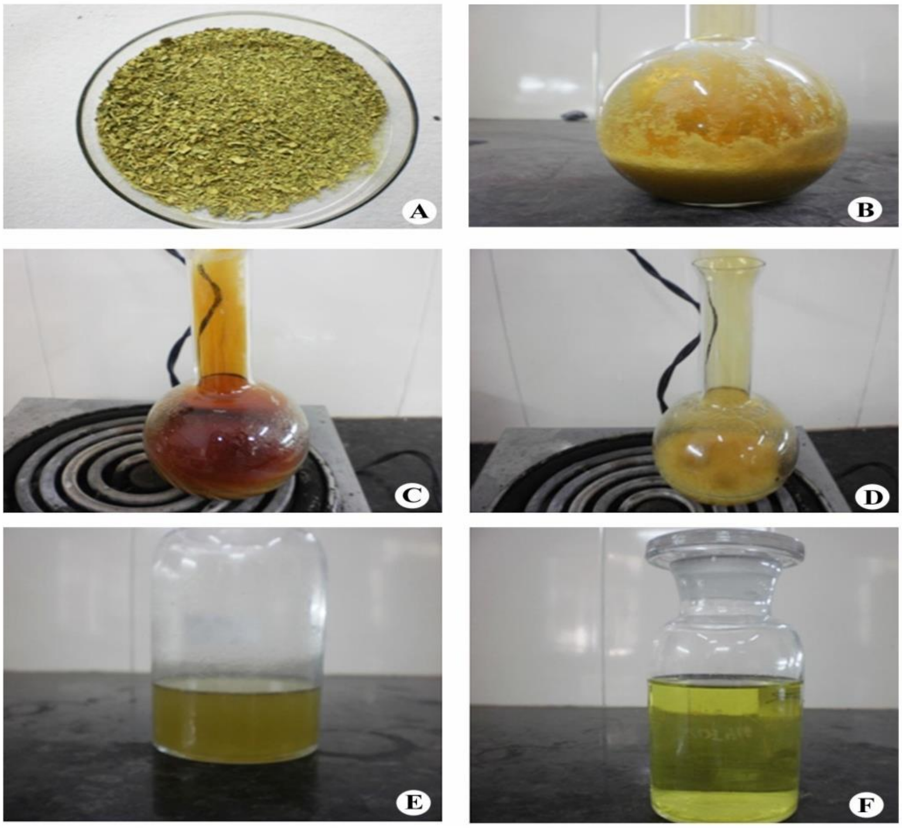

Figure 3.

A : Dry leaf material
B : Acid mixture with material
C : Released brown fumes during digestion
D : white fumes released after brown fumes
E : Solution after digestion for metal digestion
F : Solution after digestion and filteration

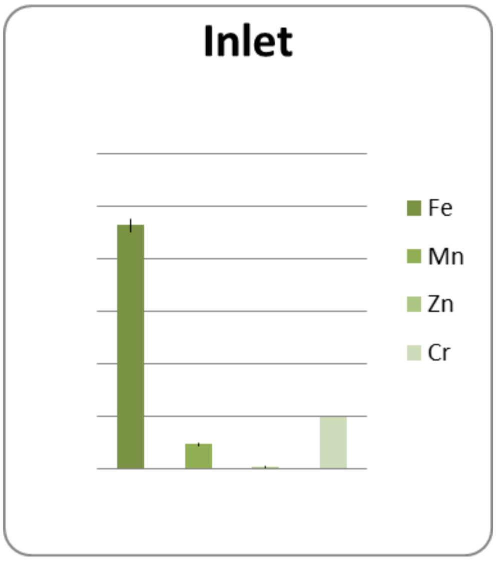

Figure .4 Showing levels of heavy metals in inlet water sample

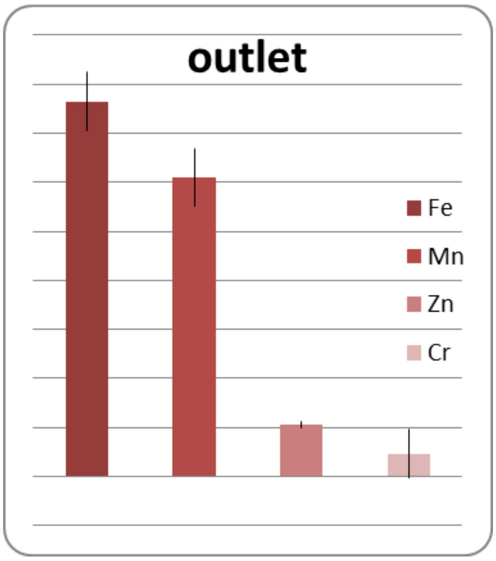

Figure .5 Showing levels of heavy metals in outlet water sample

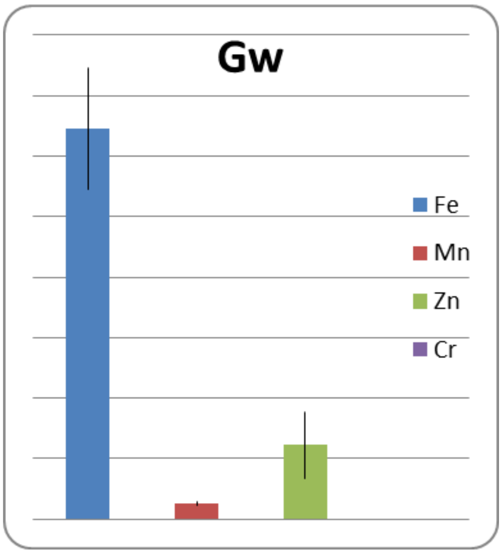

Figure .6 Showing levels of heavy metals in GW sample.

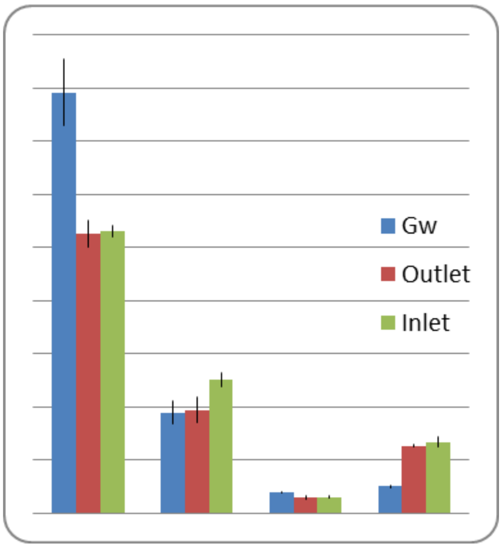

Figure .7 Showing levels of heavy metals in inlet, outlet and GW plant samples.

Table 1. Showing levels of Heavy metals in water samples

	Fe (mg/ml)	Cr(mg/ml)	Mn (mg/ml)	Zn (mg/ml)
Ground water	0.129±0.020	NT	0.0052±0.0008	0.024±0.011
Untreated water	92.75±2.54	19.81±0.327	9.153±0.250	0.595±0.014
Treated water	1.53±0.119	0.093±0.100	1.22±0.118	0.211±0.011
Indian Standards (IS) for drinking water ★	0 .3mg/l	0.05 mg/l	0.1mg/l	5mg/l
IS for irrigation water ✸	-	-	-	-

★IS :2296

✸ IS: 10500

Table 2. Showing levels of heavy metals in plant samples

	Fe(mg/ml)	Cr(mg/ml)	Mn(mg/ml)	Zn(mg/ml)
Ground water	7.92±0.627	0.393±0.0195	1.90±0.219	0.509±0.018
Untreated water	5.313±0.101	0.312±0.0131	2.513±0.129	1.346±0.0919
Treated water	5.27±0.257	0.295±0.0407	1.95±0.244	1.27±0.0176
WHO/FAO standards	0.3µg/gm	2.3µg/gm	0.3µg/gm	60µg/gm