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Assessment of heavy metals in irrigation water collected from various vegetables growing areas of swat valley

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The water of poor quality used for irrigation purpose has the potential to be a direct source of contamination and a vehicle for spreading contamination in the field. Several wide ranging review articles have been published which highlight irrigation water as a source of heavy metals toxicity which leads to chronic diseases in the human body such as respiratory problem, kidney, reproductive issue, skeletal problem, diarrhea, obesity, vomiting etc. Here a study was plan to determine the microbial and heavy metals status of irrigation water collected from various locations of district Swat in various months. The analyses were carried out at Environmental Horticulture Laboratory, Department of Horticulture, The University of Agriculture Peshawar during the year 2018 – 19.The experiment was laid out in Randomized Complete Block Design (RCBD) with two factors and three replicates. Factor A consist of different locations and factor B represents various months. Result of heavy metals concentration in different region maximum Lead, Cadmium, Chromium, Nickel and Copper (4.27, 0.56, 0.81, 1.33 and 1.51 mg L^{-1} respectively) were noted for the irrigation water samples collected from Mingora while minimum Lead, Cadmium, Chromium, Nickel and Copper concentration (2.59, 0.30, 0.27, 0.40 and 0.54 mg L^{-1} respectively) were noted for the samples of Matta. Whereas results of heavy metals content in irrigation water samples for various months maximum content of Lead, Cadmium, Chromium, Nickel and Copper (4.56, 0.63, 1.15, 1.31 and 1.48 mg L^{-1} respectively) were noted for the samples collected in Jan/Feb while lowest values for Lead, Cadmium, Chromium, Nickel and Copper (2.38, 0.24, 0.21, 0.41 and 0.52 mg L^{-1} respectively) were noted in the samples of July/August. A significant interaction was found for all the studied parameters it was concluded that the concentration of heavy metal was maximum in irrigation water samples collected from Mingora location during Jan/Feb because Mingora is the most polluted area as compared to other studied regions where as the water content in winter goes to freeze and mostly contaminated water is used for irrigation purposes.

Keywords: Irrigation water, Various months, Different regions and Heavy metals Contamination.

INTRODUCTION

Any metallic chemical element that has relatively high density and toxic or poisonous at certain concentrations is term as heavy metals. They are a natural component of earth crust's that cannot be degrading nor destroyed. They enter our body to a small extent through various ways such as food, drinking water and air. Besides trace elements, some heavy metals e.g. copper, selenium, zinc etc are essential to health maintain various metabolic processes in the body but at high content they lead to poisoning. The poisoning of heavy metals could results from drinking contaminated water, high emission sources in the environment air or through the food chain. Heavy metals contamination implication mostly associated with agricultural production. In elevated concentration these heavy metals possess a significant risk to the human body (Gupta 1998). Heavy metals like cadmium (Cd), lead (Pb), zinc (Zn) and copper (Cu) have been considered as risk factors to the human body they enter our body through vegetable consumption (Kachenko and Sing, 2006). Consumption of contaminated food causing various diseases, diminish important nutrients in the body. Cause to minimize immunological defense, growth retardation, disabilities and gastrointestinal cancer (Arora et al. 2008). Mostly in urban areas sewage water used for irrigation of various vegetables productions. Special attention is needed because it makes an unsuitable environment for human health as well as animals and plant growth also affected by heavy metals toxicity. Contaminated and waste water irrigation led to the accumulation of these heavy metals in soil and plants body (Sharma *et al*., 2007). Irrigation from contaminated sources plays a vital role in the incensement of heavy metals in the soil and crops (Mapanda *et al*., 2005). Waste water irrigation increases the metals in the soil from 2% to 89% and in the crops body from 14% to 90% (Sarabjeet and Dinesh, 2007). Growth media such as soil, air, nutrient solution and water which plants take through roots and foliage is considered as the main source of heavy metals. Contaminated water irrigation makes the soil polluted with various heavy metals and plants absorb and settle them in their edible tissues (Lokeshwari and Chandrappa, 2006). Heavy metals contamination potential to health risks is one of the serious environmental issues concerned by various food safety organizations (Cue et al. 2005). Precipitation replaces or supplement used for the production of various crops is term as irrigation water. Metals present in irrigation water transmitted to plants body and the use of these fruits and vegetables can cause various diseases in human health (Ebrahimi et al. 2011).Toxic heavy metals environmental contamination has become one of the major causes of concern for humans and vegetables which are used as fresh are particularly prone to cause such illnesses. Heavy metals in ground water, surface water bodies, soil can occur in the food commodities and from natural and anthropogenic sources also (Duke and Williams, 2008). Chemical substances such as heavy metals are the major factor that contributes to polluting the environment and also believed that they can disturb the living ecosystem (Kabata et al. 2001).Generally, metals are non-biodegradable they originate from two main sources natural and anthropogenic. Natural sources include parent material weathering, bed rock erosion, volcanic activities, forest fire and other deposits. Anthropogenic sources might be wastewater irrigation or sewage sludge, fertilizer application, electroplating, industrial discharge, atmospheric deposition and smelting (Wuana and Okieimen, 2011; Fulekar et al. 2009; Frost and Ketchum, 2000). Abakpa et al. (2013) examined various waste water quality in Nigeria, Kano State which was used for the production of different vegetables. They concluded that industrial discharge, domestic sewage is major sources of water pollutions their physiochemical parameter is higher than acceptable limits. Malan et al. (2015) concluded horticultural area including soil, water and vegetables both in winter and summer seasons in Western Cape Province, South Africa for various heavy metals content. They found a significant concentration of heavy metals (Cd, Cr, Mn, Ni, Pb and Zn) in water, soil as well as in vegetables. Another factor responsible for these deteriorations includes inappropriate manure use, bio solids, pesticide, fungicides etc. Besides these postharvest practices from harvesting till consumption followed by packing, storage, transportation all these factors throughout the food supply chain plays an important role in physical, chemical and biological contaminations of the products. Keeping in view the deleterious effect due to consumption of contaminated ready to eat vegetables, we designed a study aimed to investigate the current status of irrigation water in various months used for raising vegetables in different area of district Swat, Pakistan.

MATERIALS AND METHODS

To examine the status of irrigation water used for vegetable production the experiment entitled "Assessment of heavy metals in irrigation water from vegetables growing areas of swat valley" was undertaken at the Environmental Horticulture laboratory Department of Horticulture,The University of Agriculture Peshawar (UAP) during the year 2019. The experiment was carried by using Randomized Complete Block Design (RCBD) replicated three times.

Laboratory Procedure:

Materials and Equipment Sterilization

To prevent contamination all glassware's used for microbial and heavy metals analyses was sterilized under laboratory conditions through the standard procedure with tap water washing properly followed by distilled water and autoclaving them where needed at 121 ºC for 20 minutes at 15 pound-force per square inch (psi).

Samples Collection

Irrigation water used for vegetable production was collected from various locations namely Matta, khwazakhela Mingora and Kabal. One liter water samples were collected in sterile graduated bottles and brought to Environmental Horticulture Laboratory for heavy metals analysis.

Heavy Metals Analyses in Water

During water samples collection 2 to 3 drops of acids (HCL or HNO_3) were added to the bottles then processed with filtration stage in the laboratory. Quantification of heavy metals such as Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni) and Copper (Cu) were carried out using Atomic Absorption Spectrophotometer (AAS) with the help of the wet digestion method (Richard, 1954).

Atomic Absorption Spectrophotometer (AAS) Procedure

The prepared irrigation water samples were analyzed by Atomic Absorption Spectrophotometer (AAS). Before samples analyses, cathode lamp for each metals was fitted in AAS then set apparatus with a precise wavelength which is different for singular metals. AAS was then standardized with various stock solutions of well-known concentrations for every heavy metal available at the laboratory after standardization of samples. Data were analyzed and recorded cautiously.

RESULTS

Lead (Pb) concentration in irrigation water:

Data regarding the concentration of Pb in irrigation water show a considerable variation for the irrigation water sample collected from different location in various months and their interaction (Table 1). The mean table of the data for different locations indicated that maximum (4.27 mg L^{-1}) Pb concentration was observed in the irrigation water sample collected from Mingora followed by Kabal (3.47 mg L^{-1}) whereas minimum (2.59 mg L^{-1}) Pb concentration was recorded for the samples collected from Matta. In the case of various months, the highest (4.56 mg L^{-1}) Pb concentration was recorded for the samples collected in Jan/ Feb followed by Nov/Dec (4.38 mg L^{-1}) while the lowest (2.38 mg L^{-1}) Pb was recorded in May/June. Regarding their interaction the maximum Pb (6.08 mg L^{-1}) in Jan/Feb was noted for Mingora and the minimum Pb (1.8 mg L^{-1}) was noted in May/June from Matta as shown in Fig. 1.

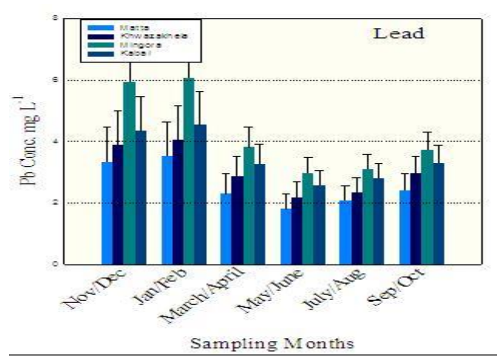

Figure1: Lead concentration (mg L^{-1}) in irrigation water collected in different months from various locations of District Swat.

Cadmium (Cd) concentration in irrigation water:

Data regarding Cd concentration in irrigation water a significant difference was found for the samples collected from various regions in different months and their interaction as well (Table 1). Data about various locations showed that the highest (0.56 mg L^{-1}) Cd concentration was observed for the samples collected from Mingora followed by the Kabal region (0.41 mg L^{-1}), while the lowest (0.30 mg L^{-1}) Cd content was recorded for Matta locality. Data for different months highest Cd was noted in Jan/Feb (0.63 mg L^{-1}) and lowest Cd was noted for the sample collected in July/August (0.24 mg L^{-1}).

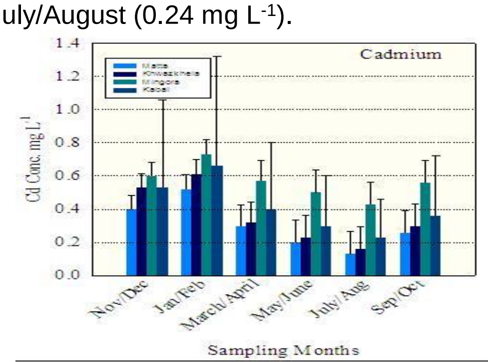

Figure 2: Cadmium concentration (mg L^{-1}) in irrigation water collected in different months from various locations of District Swat.

Regarding their interaction as shown in Fig. 2 maximum Cd was observed in water samples collected from Mingora in Jan/Feb (0.73 mg L^{-1}) and minimum Cd concentration was observed for Matta location in July/Aug (0.13 mg L^{-1}).

hromium (Cr) concentration in irrigation water:

Statistical results for Cr concentration in irrigation water showed a significant variation for a different location in various months and their interaction was also found significant (Table 1). Data regarding different location maximum (0.81 mg L^{-1}) Cr concentration were noted for irrigation water sample collected from Mingora followed by Kabal (0.59 mg L^{-1}) whereas minimum Cr (0.27 mg L^{-1}) was obtained in a water sample from Matta. In the case of various months highest Cr content was recorded for the irrigation water samples collected in Jan/Feb (1.15 mg L^{-1}) and the lowest Cr content was recorded in July/Aug (0.21 mg L^{-1}).Data regarding interaction as shown in Fig. 3. showed the maximum Cr was noted for water samples collected from Mingora in Jan/Feb (1.89 mg L^{-1}) and minimum Cr was noted for Matta in July/Aug (0.15 mg L^{-1}).

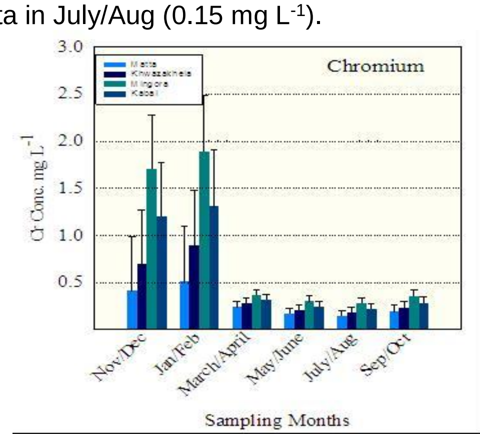

Figure 3: Chromium concentration (mg L^{-1}) in irrigation water collected in different months from various locations of District Swat.

Nickel (Ni) concentration in irrigation water:

Analysis of variance showed a significant difference for Ni concentration from various location, different months and their interaction (Table 1). The mean table for different locations indicates that the highest Ni concentration (1.33 mg L^{-1}) was observed for the irrigation water samples from the Mingora region and the lowest content (0.40 mg L^{-1}) was recorded for Matta region samples. Data for various months indicated that maximum Ni content was noted for the samples collected in Jan/Feb (1.31 mg L^{-1}), while minimum Ni content was noted for the sample collected in July/Aug (0.41 mg L^{-1}). Likewise their interaction showed that maximum Ni concentration (2.07 mg L^{-1}) was observed for the samples collected from Mingora in Jan/Feb while minimum concentration (0.24 mg L^{-1}) was observed for the samples from Matta in July/Aug as shown in Fig. 4.

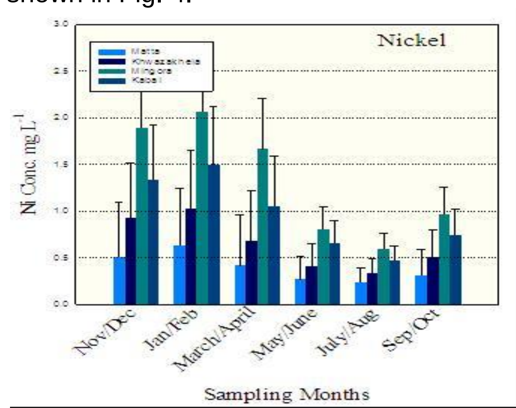

Figure4: Nickel concentration (mg L^{-1}) in irrigation water collected in different months from various locations of District Swat.

Copper (Cu) concentration in irrigation water:

Data regarding copper concentration in irrigation water show a significant variation for the sample collected from a different location in various months and their interaction was also found significant (Table 1). Mean table figures for different locations showed that the highest Cu concentration (1.51mg L^{-1}) was observed for Mingora while the lowest Cu (0.54 mg L^{-1}) was observed for the sample of Matta region. Whereas data for various months maximum Cu (1.48 mg L^{-1}) content in irrigation water samples was recorded for Jan/Feb and minimum (0.37 mg L^{-1}) was recorded in July/Aug.

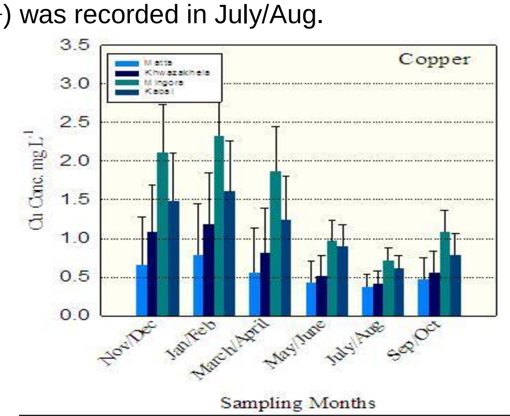

Figure 5. Copper concentration (mg L^{-1}) in irrigation water collected in different months from various locations of District Swat.

Table 1: Lead Conc. (mg L^{-1}), Cadmium Conc. (mg L^{-1}), Chromium Conc. (mg L^{-1}), Nickel Conc. (mg L^{-1}) and Copper Conc. (mg L^{-1}) concentration in irrigation water sample collected from different locations and in various months.

Locations (L)			**Parameters**		
	Lead Conc. (mg L^{-1})	Cadmium Conc. (mg L^{-1})	Chromium Conc. (mg L^{1})	Nickel Conc. (mg L^{-1})	Copper Conc. (mg L^{-1})
Matta	2.59d	0.30c	0.27d	0.40d	0.54d
Khwazakhela	3.05c	35bc	0.41c	0.65c	0.76c
Mingora	4.27a	0.56a	0.81a	1.33a	1.51a
Kabal	3.47b	0.41b	0.59b	0.96b	1.10b
LSD (P≥ 0.05)	0.18	0.121	0.013	0.146	0.014
Various Months (VM)					
Nov/Dec	4.38b	0.51b	1.00b	1.17b	1.33b
Jan/Feb	4.56a	0.63a	1.15a	1.31a	1.48a
March/April	3.06d	0.39bc	0.30c	0.95c	1.12c
May/June	2.59e	0.30cd	0.23e	0.54e	0.70e
July/August	2.38f	0.24d	0.21f	0.41f	0.52f
Sep/Oct	3.10c	0.37cd	0.26d	0.63d	0.73d
LSD (P≥ 0.05)	0.022	0.148	0.016	0.017	0.017
Interaction(L×M)	0.044	0.29	0.032	0.035	0.034
Significance(P≥ 0.05)	Sig	Sig	Sig	Sig	Sig

In case of their interaction the maximum Cu concentration (2.33 mg L^{-1}) was noted for the samples collected from Mingora region in Jan/Feb and minimum concentration (0.37 mg L^{-1}) was noted for Matta region in Jan/Feb as shown in Fig. 5.

DISCUSSION

One of the most important problems in the world is food security stated by (Mello, 2003; Mapanda et al. 2007; Gebrekidan et al. 2013). The exposure of soil to polluted water continuously for the long term will result in a high concentration of toxic metals which later become a part of plant tissues (Nayek et al. 2010). Qadir et al. (2008) stated that the continuous increase in population and urbanization generate the volume of waste water from domestic, industrial and commercial sources. Huiber et al. (2004) concluded that developing countries mostly depends on waste water irrigation. They have the water in the form of diluted raw sewage and the condition of water which is used is varying greatly which is strictly considered illegal. In recent times water concentration goes to limiting factors because of natural disturbance, the appropriate use of water and the available source is the important responsibilities of humankind. Agca and Ozdel (2014) stated that farmland contamination with heavy metals is a severe environmental issue in many countries because of toxicity. Contaminated water used for irrigation cause a significant accumulation of heavy metals in the farms as well as in crops. Irrigation with waste water increases the content of heavy metals significantly in the edible parts of the growing plants (Arora et al., 2008). Different industries like paint, pharmaceutical, dyeing, textile, garment, ceramic etc. discharge into nearby canals, streams and rivers cause considerable heavy metals contamination in irrigation water. Ahmad et al. (2012) and Zakir et al. (2015) stated the soil near industrial areas and their surface water is highly contaminated with various elements such as Pb, Zn, Cr, Cu and Cd due to waste discharge from industries. Farmer used this unhygienic water for irrigation purposes causing heavy metals contamination in vegetables. Municipal sewage and uses of other contaminated water for irrigations is an old practice in most of the developing countries including Pakistan (Ullah et al., 2011). There is no exception in densely populated and polluted cities, the problem is the disposal of municipal, industrial, and sewage effluent etc along with the scarcity of irrigation water is severe. Hassanzada et al. (2011); Mandour and Azab, (2011) stated that the rapid population growth, industrialization and agricultural activities may increase the risk index to the natural environment such as water, soil and air. The use of contaminated water for multi agriculture purposes bioaccumulation and high toxicity of heavy metals are considered as one of the most serious problems all over the world. Heavy metals are involved in various industrial processes, agricultural activities, domestic waste and vehicles emission (Hassanzada et al. 2011). According to our findings, the maximum concentration of heavy metals was seen in irrigation water collected from Mingora. In the case of various months high content was determined from the samples collected in Jan/Feb. It may be due to Mingora region is considered the most populated, with more industries and polluted area as compared to other while in winter seasons the water levels go to decline and the people used home waste water, sewage water, industrials waste water and other sources of water for irrigation purposes which may led to a high concentration of various toxic metals in irrigation water. Generally, two major sources are responsible for the occurrence of heavy metals such as natural and anthropogenic activities (Zhang 2006). Anthropogenic sources like waste water irrigation or sludge sewage, over fertilizer, different chemical sprays (Frost and Ketchum 2000), discharge of industries, mining processing (Khan et al. 2017), atmospheric, smelting deposition and electroplating (Wuana and Okieimen, 2011). The rapid acceleration in urbanization and industrialization may increase the concentration of heavy metals in the irrigation water, soil and vegetables (Islam et al., 2017). The vegetable from unhygienic farm can build up some high concentration of toxic metals which later on become a serious risk to human health. The use of waste water can increase crop productivity but also increased the contamination of heavy metals like (Pb, Ni, Cd, Cu, Zn, Mn, Cr etc.) in the plants (Jayadev and Puttaih 2013; Arti Yadav et al. 2013). Soil maintenance, productivity, crop quality and quantity etc. depends on the type of irrigation water. The physical, chemical and biological properties of soil structure and permeability are very sensitive to the type of exchangeable ions present in irrigation water.

CONCLUSION

It has been concluded that the irrigation water used in growing fields originates from a variety of water sources and more research needed to relate risk factors associated with the transfer coefficients for heavy metals by source, concentration and use. Among the main water sources used for irrigation, it can be identified from lower to higher contamination risk, the wells, rain water harvesting, rivers, and reservoirs. Irrigation water in the Swat district has enough heavy metals contamination that can cause serious health issues such as respiratory problem, kidney, reproductive issue, skeletal problem, diarrhea, obesity, vomiting etc.The concentration of heavy metals is high in the irrigation water samples collected from the Mingora location followed by Kabal as compare to another studied region. Comparing various months for the studied metals maximum range was noted in Jan/Feb followed by Nov/Dec. Guidelines governing irrigation water quality and strategies are required to reduce the risk of heavy metals transmission by food to the human body. Decontamination of irrigation water is highly recommended for hygienically safe agricultural production.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

My supervisors Dr. Mehboob Alam share the conception idea of research and I conduct the experiment, collect, analyze the water sample and wrote the paper.

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