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Accumulation and Translocation of Micro-Nutrients in Soil and Plants of Orchard and Non-Orchard Fields

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Abstract. The present study was conducted in the Plum orchard zone of district Peshawar. The study was aimed to investigate the levels of different micronutrients in the orchard soil and crop in corresponding to non-orchards. For this purpose, samples of soil and seasonal crop (wheat crop) were collected from both orchard and non-orchard fields. The collected samples were analyzed for various metals such as Mn, Fe, Cu, Zn, Cd, Cr, Ni and Co through Atomic Absorption Spectrophotometer. The results showed that in orchard soils, mean concentrations of Mn (486.9 mg/Kg), Cu (81.66 mg/Kg), Cd (2.21 mg/Kg), Cr (54.2 mg/Kg) and Ni (27.9 mg/Kg) were observed above their allowable limits. Similarly, in orchard wheat crops, a higher accumulation of Fe (416.1 mg/Kg), Cu (18.6 mg/Kg), Cr (1.5 mg/Kg) and Cd (0.63 mg/Kg) was calculated in the wheat grain/seed part. In non-orchards, all metals were found at safe levels. Analysis of the irrigation water revealed higher limits of Mn (0.06 mg/L), Fe (1.94 mg/L), Cd (1.29 mg/L), Cr (3.14 mg/L) and Ni (1.23 mg/L). Geo-accumulation Index showed a moderate and heavy level of contamination in orchard soils ($I_{geo.}$ <1, 2). Higher uptakes of Mn (0.81) and Cu (0.87) were calculated in wheat crops of orchards through Transfer Factor (TF). Based on the observations, it is concluded that metals enrichment in orchard fields can be attributed due to excessive applications of fungicide sprays, fertilizers and contaminated water sources that introduce trace-elements into the soil and are subsequently absorbed by plants. Therefore, it is considered important to take appropriate measures to monitor the soils, crops and water for different micronutrients.

Keywords: contamination, fungicides, micronutrients, transfer factor, wheat crop

Introduction

Contamination of soil, water and the food system with trace elements can pose risks to plants, animals and humans (Bolan *et al*., 2014). Trace elements are also known as micronutrients because they are needed in small amounts for the growth of plants and animals (Shirisha *et al*., 2014). Micronutrients are more prevalent in surface soils, but plants absorb micronutrients from the lower parts of the soil (Nazir *et al*., 2015). Micronutrients in the soil can affect crop quality and production. Although their lack or low availability can seriously disrupt plant production and the health of animals and humans (Naser *et al*., 2012). Metals such as Mn, Fe, Zn, Cu and Ni act as micronutrients at lower concentrations and toxic at higher concentrations (Singh *et al*., 2010). At higher concentrations, micronutrients congregate for a long time in the soil and have adverse effects on soil and crop quality. Whereas, Cr and Cd are considered toxic even at their low level (Behera *et al*., 2011).

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Plants need nutrients for their growth, which come from the soil. Therefore, plants are considered to accumulate different nutrients from their surroundings. The accumulation of metals in plants is associated with plant species, growth stages, climatic conditions and particularly soil type (Bangash *et al*., 2011). Plants grown on a metals rich soil, often show metals uptake by the root system (Ivezic *et al*., 2013).

Soil contamination with toxic metals arises from anthropogenic sources that are the origin of potential risks (Eded, 2012). Soil amendments, including minerals and organic fertilizers are the major sources involved in introducing micronutrients into soil (Kumar and Chopra, 2013). The intensive use of fungicides/pesticides in horticulture practices is a serious threat to the soil environment (Cheng *et al*., 2015). Long-term irrigation of agricultural fields with wastewater causes accumulation of metals in soil and plants. It also leads to food safety issues and possible health risks (Khan *et al*., 2013). In these situations, the soil acts as a sink for accumu-lating micronutrients and provides a source for these metals when their quantity exceeds the soil's holding capacity (Selim, 2013).

Stone fruits such as Plum and Peach are treated with continuous sprays of copper-based fungicides. Fungicides called Bordeaux mixture ($CuSO_4 + Ca(OH)_2$), are used to protect fruits from fungal attack and to improve production (Khan and Nafees, 2017; Brunetto *et al*., 2016). Due to repeated applications of fungicides, an excessive amount of Cu is introduced into the soil. As a result, Cu uptake in crops and fruits is due to its potential soil accumulation resulting from the regular spraying of Cu-based fungicides (Bolan *et al*., 2014). The literature has shown that applications of phosphate fertilizers and tannery industries impart Cr, Cd and Ni accumulation. These metals are highly toxic and carcinogenic when present in excess (Khalid *et al*., 2017; Sabir *et al*., 2015). Higher accumulation of these metals in soils disturbs the soil ecosystems (Minnikova *et al*., 2017).

Contamination of soil with micronutrients influences their retention and transport in the soil-water-plants system (Parveen *et al*., 2012). Regrettably, soil has been depleted of important minerals in which the food/crop is grown. Soil has been considered as a base and is the only hope for a healthy life. Therefore, life is dependent on soil fertility (Bangash *et al*., 2011). Metals accumulation in the soil is based on several factors such as pH, soil texture, organic content, moisture content etc. (Leblebici *et al*., 2018).

The literature has revealed that high accumulation of micronutrients in agricultural soils can pose threats to human health (Ping *et al*., 2011). High accumulation of micronutrients in soil and water resources draws a lot of attention due to their toxicity to humans through the food chain. To verify the level of different micronutrients, the present study also aims to know the nutrient contents in the soil and their uptake by plants to reduce or improve their serving size.

Materials and Methods

The current work was conducted in the orchard area of district Peshawar. Plum orchards and their adjacent non-orchard fields were selected as study area, located near the highway. The study area is renowned for its horticulture which includes a variety of orchards such as plums, pears, peaches and straw-berries. Because of the growing trend of horticulture, farmers want to get a good yield and therefore use excessive agrochemicals (fertilizers and fungicides). Beside, the availability of irrigation water is also a big problem and that is why farmers use sewage sources for irrigation purposes. By adopting such methods (agro-chemicals and wastewater), soil toxicity is caused by the accumulation of metals in excess. To handle these problems, it is important to regularly monitor soil, water and crop.

Field survey, sample collection and preparation. During the reconnaissance survey, 30 sampling points were selected for both orchard and non-orchard fields. The composite soil samples were collected from selected sites with 0-25 cm depth with the help of a spade. 6 points were selected randomly (3 for each, orchard and non-orchard) after dividing the selected fields into a grid of 1 m^2. Each composite sample consisted of 10 randomly selected points, covering 10% of each site. Each sample was taken in a labeled clean polythene bag and stored in the laboratory for analysis. The collected soil samples were thoroughly mixed, air passed, crushed to pass through a 2 mm sieve and stored in labeled plastic pots for laboratory experiments. The irrigation water channels were sampled by collecting five water samples in 2 L cleaned plastic bottles. Each sample was acidified with 1 mL of HNO_3 to prevent the bacteriological activity and then stored in the laboratory for analysis. The crop and fruit samples were collected randomly at the time of maturity. Both the crop and fruit were oven-dried. Wheat crop was divided into root, shoot, leaf and stem parts and each part was ground, crushed into powder form and stored for analysis.

Chemical analysis. The electrical conductivity and pH of soil samples were measured with a suspension of 1:5, soil/water, using conductivity meter and pH meter respectively (Richard, 1960). Soil moisture content was determined by oven drying (Polubesova *et al*., 2009). In this method, an air-dried soil sample of 30 g was taken in a pre-weighed porcelain dish and weighed. Put the porcelain dish in the oven at 180 °C for 24 h. After 24 h, the porcelain dish was removed and weighed. Finally, the moisture content of the soil samples was calculated by taking the soil values dried in air and oven in the formula:

$$\text{Moisture content} = \frac{(\text{Wet weight - dry weight})}{\text{Dry weight}} \times 100\%$$

Soil texture was measured by the pipette method (Gee and Bauder, 1986). In the pipette method, 20 g of each soil sample was dissolved in a small amount of distilled water in a shaker cup and 5 mL of sodium hexametaphosphate was added and stirred for a few minutes.

The solution was dropped into a 500 mL cylinder and filled with water, covered with parafilm, inverted and allowed to stand for 48 sec. After 48 sec, the first aliquot of the top 10 cm of suspension was taken and labeled it as a 10 cm pipette. Put the aliquot in a pre-weighted china dish and placed it in oven at 105 °C. After 40 min, another 25 mL aliquot was taken from the top 5 cm in a separate pre-weighted china dish and baked at 105 °C. After overnight, the china dish was removed from oven and took its weight for 2nd reading. The differences between initial and final readings were noted. The percentages of sand, silt and clay were calculated using the given formulas:

$$\text{Clay (\%)} = \frac{20 \times \text{mass of clay}}{\text{Total mass of soil (20 g)}} \times 100\%$$

$$\text{Silt (\%)} = \frac{20 \times \text{mass of silt+clay-mass of clay}}{\text{Total mass of soil (20 g)}} \times 100\%$$

$$\text{Sand (\%)} = 100\% - (\%\text{ silt} + \%\text{ clay})$$

Soil organic content was measured by the Walkley black method (Nelson and Sommers, 1982). In this method, 1 g of soil was taken in a 500 mL flask followed by the addition of 10 mL of $K_2Cr_2O_7$ solution and 20 mL. H_2SO_4 and stirred this solution for one min. The solution was heated on a hot plate for 5 min and then allowed to stand for 30 min. After 30 min, the solution was diluted to 200 mL with distilled water and added 10 mL H_3PO_4, 0.2 g NaF and 3-4 drops of ferrous indicator and titrated it against $FeNH_4SO_4$ solution. The final reading was noted when the color changed from greenish blue to reddish-brown. The percentage value of carbon content was calculated with the help of given formula:

$$\text{Organic content (\%)} = \frac{\text{mL blank-mL sample } (MF_e + 2)\ (0.3)}{\text{Wt of dry soil}}$$

The metals present in soil, crop and fruit were measured using an aqua-regia (HNO_3: HCl: $HClO_4$, 5:1:1) extraction method. In this method, a soil sample of about 1 g was digested in 15 mL of aqua-regia at a temperature of 80-180 °C to obtain a clear solution. This solution was filtered and diluted with distilled water to 50 mL and was subjected to a spectrophotometer for analysis. Representative water samples were also subjected to atomic absorption spectrophotometer for micro-nutrients analysis (Chen and Ma, 1998).

Statistical analysis. Mathematical calculations such as mean and standard deviation of analyzed metals were calculated using MS Excel 2007. For the comparative study, t-test was employed in two different domains (orchard and non-orchard) using the SPSS software. Statistically, significant differences were investigated in the average metal concentrations among soil and crop groups. A probability level $p < 0.05$ was considered significant. The correlation coefficient was established among soil, water and crop samples using MS Excel, 2007.

Geo-accumulation index. This is used to find the accumulation of metals in soils, represented by I_{geo} (Muller, 1969). The accumulation index was calculated using the formula:

$$\text{Igeo} = \frac{\log_2 \text{Cn}}{1.5 \times \text{Bn}} \quad \text{............................. (eq. 1)}$$

where:

C_n = is the total metal concentration in soils (mg/Kg); B_n = is the natural background value and 1.5 is the variation in metals quantity due to logarithmic effects.

Muller, (1969) grouped I_{geo} into seven classes for each metal.

Class 0—uncontaminated ($I_{geo} \leq 0$),
Class 1—uncontaminated to moderately contaminated ($0 < Igeo \leq 1$),
Class 2—moderately contaminated ($1 < I_{geo} \leq 2$),
Class 3—moderately to heavily contaminated ($2 < I_{geo} \leq 3$),
Class 4—heavily contaminated ($3 < I_{geo} \leq 4$),
Class 5—heavily to extremely contaminated ($4 < Igeo \leq 5$),
Class 6—extremely contaminated ($I_{geo} \leq 5$).

Transfer factor. The transfer factor is used to check the transfer efficiency of metals from soil to crop. The plant uptakes from soil was measured as the ratio of metal concentration in crop to the metal concentration in corresponding soil. The TF was calculated for each part of the crop (edible and non-edible) using equation-2. Its maximum limit is 1.

$$\text{TF} = \frac{C_{crop}}{C_{soil}} \quad \text{....................................... (eq. 2)}$$

where:

C_{crop} and C_{soil}, show the metal concentrations in crop and soil samples respectively (Cheng *et al*., 2015).

Results and Discussion

Physico-chemical properties of soil. The analyzed soil samples of orchards showed an average pH value of 6.07. In their adjacent non-orchard fields, soil pH ranged as 7.6 (Table 1). Orchard fields were observed with low pH as compared to agricultural non-orchard fields. pH of soil is the measure of soil alkalinity or acidity. For soil, the optimal pH range is 7.5-8 (Pietri *et al*. 2008). The EC was observed in the average range of 630 µS/cm and 610 µS/cm in soils of orchard and non-orchards respectively (Table 1). Soil samples showed low EC values which may be because of low clay contents when compared with national guidelines standards of 2000 µS/cm (Rayan *et al*. 2001).

The level of moisture content was 1.7 and 1% in soils of orchard and non-orchards, respectively. Moisture content is closely linked with soil texture to maintain it at certain level. Sharma *et al*. (2010) reported that moisture content promotes leaching of nutrients from upper to lower soil layers and thus affects crop production.

Organic matter in soil samples was measured with 2.8% in orchards and 1.6% in non-orchards. Results showed high organic contents in orchard fields (Table 1). According to literature, the higher organic contents in orchards can be possible because of the high usage of agrochemicals and tree residues (Gregoricha *et al*. 2003). The plant residues after decomposition, contributes to soil organic matter and help to improve the soil fertility. Abraham (2013), reported that organic content is responsible for the availability of micronutrients from soil to crop.

The mechanical soil tests showed the enrichment of silt and sand, showing sandy loam and loamy sand nature of soil. These soils possess low water holding capacity when compared to heavy clay textured soils (Table 1).

Soil micronutrients. Among analyzed metals, Mn, Cu, Cd, Cr and Ni were observed above the permissible limits in orchard soils. In non-orchards, their concentrations were within the allowable limits (Table 2). Literature revealed that in orchard fields, copper availability can be associated to prolong use of Cu-based fungicides to get a good yield (Khan *et al*., 2017; Fana *et al*., 2012). Excessive concentrations of Cu lead to liver cancer and other intestinal diseases in humans (Sun *et al*., 2010). Therefore, the nutrients found above their permissible limits are regarded as toxic metals.

Literature has shown that Cr, Cd and Ni enrichment in soils is due to anthropogenic activities like excessive uses of agrochemicals (Chen *et al*., 2015; Khanlari *et al*., 2008). Iyaka (2011) investigated high dispersion of nickel in the soil structure which caused toxicity to humans *via* food chain contami-nation. Lu *et al*. (2014) reported that toxic metals such as Cd and Cr accumulate

Table 1. Physico-chemical properties of soil

Sample	pH			EC uS/cm			Organic carbon (%)			Moisture content			Sand	Silt	Clay	Texture
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	(%)	(%)	(%)	
Plum Orchard	6.03	6.11	6.07	613	652	630	2.4	3.8	2.8	0.7	1.9	1.7	62	28	10	Sandy loam
Non-Orchard	7.41	7.8	7.60	588	628	610	1.5	1.8	1.6	0.5	1.2	1	51	31	16	Sandy loam

Table 2. Concentrations of micro-nutrients in soils of orchard and non-orchards

Element	Orchards				Non-Orchards				P(2-tail)	PL in soil
	Min	Max	Avg	S.D	Min	Max	Avg	S.D		mg/Kg
Fe (mg/Kg)	5148	5578	5302.2	16.42	3076	3920	3366	13.21	0.607	21,000b
Mn (mg/Kg)	391.4	567.03	486.9	4.06	395.1	513.04	460	4.01	0.467	320a
Zn (mg/Kg)	70.41	76.04	73.21	1.10	63.95	69.02	65.8	1.01	0.001	84.7a
Cu (mg/Kg)	68.91	87.52	81.66	1.31	17.52	21.13	19.03	0.03	0.000	40b
Co (mg/Kg)	20.44	25.01	22.13	0.04	9.44	13.16	10.05	0.01	0.019	--
Cd (mg/Kg)	1.68	3.12	2.21	0.002	0.27	0.35	0.29	0.003	0.000	0.58a
Cr (mg/Kg)	48.3	57.03	54.2	0.88	28.54	33.18	30.42	0.08	0.001	50c
Ni (mg/Kg)	22.8	30.15	27.9	0.06	11.36	17.01	15.04	0.02	0.002	19a

Source: (a) Khanlari *et al*., 2008, (b) Nergus, 2002, (c) Shanker *et al*., 2005.

in soil for longer times and pose their toxic effects on the soil and crop grown over there.

Fe and Zn were observed within their permissible limits in both orchard and non-orchard fields. Literature revealed that zinc deficiency is associated with excessive applications of phosphate fertilizers (Li *et al*., 2006). Phosphate fertilizers reduce zinc availability in soil and its availability to plants due to precipitation of $Zn_3(PO_4)_2$. Like other trace-elements, Co was observed high in orchard soils as 22.13 mg/Kg. In non-orchards, the concentrations were observed as 10.05 mg/Kg. In soil, cobalt contamination found rare when compared with other metals (Table 2). Cobalt is non-biodegradable and possesses carcinogenic effects at higher concentrations (Garoui *et al*., 2011). Results of statistical analysis showed significant differences for Zn, Cu, Co, Cd, Cr and Ni, while the results were found insignificant for Fe and Mn.

Micronutrients in wheat crop. In the wheat crop of orchard fields, the grain/seed part showed higher accumulation of Cu, Cr, Fe and Cd when compared with their permissible limits. In plants, the allowable limit of copper is 10 mg/Kg (Hassan *et al*., 2012). For humans, the recommended level of copper is 1.35 mg/day for adult male and 1.15 mg/day for an adult female by WHO (Sadhra *et al*., 2007). Cd, Cr, Fe and Cu contents in wheat grains of orchard fields were significantly higher over non-orchard fields. Furthermore, these metals showed significant results in other parts (stem, leaf, root) of wheat crops showing statistical differences between orchard and non-orchard fields (Table 3).

Pietrzak and McPhail (2004) stated that the prolonged use of Cu- based fungicides causes toxicity to plants. Teklic *et al*. (2008) reported that copper richness is harmful to human health. It is carcinogenic in which stores in the liver and brain and therefore, causes Wilson's disease. The research findings showed significantly higher concentrations of Cd in crop seeds, crossing the permissible limit (0.02 mg/Kg) recommended by Khan *et al*. (2008). WHO suggested the daily intake of cadmium in food as 1 µg/Kg per day (Limei *et al*., 2008).

Similarly, Cr uptakes were observed higher in the wheat plant of orchard fields. In plants, the allowable level for Cd is 1.30 mg/Kg (Iqbal *et al*., 2011). Chromium toxicity badly affects the growth of plants (Rai *et al*., 2004; Bratakos *et al*., 2002). Chromium intake for adults has been recommended as 25-35 µg/day by the Food and Nutrition Board and Institute of Medicines (Thor *et al*., 2011). The findings of the study are supported by Zhang *et al*. (2011) that accumulation of Cu and Cd in soil lead to contamination of agricultural products.

Results for Fe was observed above the permissible limit (20 mg/Kg) recommended by WHO (Shah *et al*., 2011). In plants, Fe exists with an average rate of 0.005% (Meng *et al*., 2005). The recommended nutritional intake of iron is 8-18 mg/day (Tokalioglu *et al*., 2010). Results of t-tests for iron showed significant differences in all parts of the wheat crop ($p>0.05$). In crop grain of orchards, copper, cadmium and chromium were investigated higher because of their higher accumulation in soils. This shows the metals availability to crop where they accumulate in seeds/grains and thus become a part of our food chain. Metals such as Mn, Co, Zn and Ni were observed below the permissible range (Table 3).

In non-orchards, all metals were found safe and below their allowable limits. Fe and Mn showed greater accumulations in root and stem parts of the wheat crops in both orchard and non-orchards. The USA Institute of Medicine (2002) suggested the level for manganese as 2.3-2.6 mg/day (Carmen *et al*., 2009). Results of t-test showed insignificant effects in all parts the of wheat plant ($p>0.05$).

Cobalt is an essential part of food that improves hemoglobin synthesis. The recommended daily intake for Co is 8 µg/day (Stoica *et al*., 2004). In crop root of wheat plant, Co was observed in high limit, which can harm the crop. The overall results for cobalt showed the uptakes of cobalt from soil into crop. It's higher concentrations in plant cause leaf drop and reduce shoot weight (Nair *et al*., 2012). Statistical analysis showed non-significant differences in all parts of the wheat crops ($p>0.05$), given in Table 3.

The results for Zn found within the allowable limit of WHO as 50 mg/Kg in plants (Shah *et al*., 2011). The availability of Zn has been considered essential for good health. In human diet, the permissible level of Zn is recommended as 15 mg/day (Tapiero *et al*., 2003). The t-test showed insignificant effects in analyzed parts of wheat crop for orchard and non-orchards ($p>0.05$), Table 3.

Nickel is an important element required for plants and animal's growth. In plants, its permissible limit is recommended as 10 mg/Kg by WHO (Hassan *et al*., 2012). The allowable limit of nickel in food is 100-300

Table 3. Concentrations of micro-nutrients in wheat crops

Element	Orchards				Non-orchards				
	Min	Max	Ave	S.D	Min	Max	Ave	S.D	P (2-tail)
Micro-nutrients in seeds of wheat crops									
Fe (mg/Kg)	318.7	479.5	416.1	4.07	230.4	320.6	260	3.06	0.012
Mn (mg/Kg)	289.8	462.7	392.8	4.06	267.5	435.5	381.6	4.01	0.958
Zn (mg/Kg)	39.41	48.8	43.5	1.04	36.5	45.01	41.33	1.02	0
Cu(mg/Kg)	15.73	21.02	18.6	0.06	5.97	8.49	7.61	0.01	0
Co (mg/Kg)	10.32	16.34	14.10	0.04	8.76	15.52	11.31	0.03	0.426
Cd (mg/Kg)	0.57	1.05	0.63	0.004	0.12	0.31	0.20	0.001	0
Cr(mg/Kg)	1.38	2.03	1.5	0.016	0.89	1.07	0.92	0.012	0
Ni(mg/Kg)	5.87	8.78	7.08	0.05	4.85	6.23	5.11	0.03	0.012
Micro-Nutrients in stem of wheat crops									
Fe (mg/Kg)	278.3	426.5	376.6	3.11	188.4	283.3	241.2	2.31	0.022
Mn(mg/Kg)	256.4	362.8	320.6	3.04	277.5	384.6	326.5	3.06	0.889
Zn(mg/Kg)	30.6	35.4	32.24	1.02	23.5	27.04	25.01	1.00	0.062
Cu (mg/Kg)	6.59	8.72	7.62	0.04	2.18	4.02	3.23	0.01	0
Co (mg/Kg)	8.45	14.74	11.83	0.03	9.3	13.01	10.04	0.03	0.262
Cd (mg/Kg)	0.16	0.25	0.18	0.002	0.06	0.15	0.09	0.001	0.004
Cr (mg/Kg)	0.98	1.03	1.01	0.011	0.41	0.69	0.49	0.001	0.002
Ni (mg/Kg)	1.96	3.01	2.12	0.021	0.78	1.67	1.01	0.011	0.026
Micro-nutrients in leaves of wheat crops									
Fe (mg/Kg)	421.8	634.6	581.4	5.34	200	411.3	344.2	3.04	0.013
Mn(mg/Kg)	366.8	464.2	472.8	3.58	352.3	438.7	410.2	3.16	0.726
Zn(mg/Kg)	32.8	37.2	34.5	1.05	21.3	24.2	22.5	1.01	0.795
Cu (mg/Kg)	3.9	6.7	5.7	0.011	2.8	4.3	3.1	0.011	0.055
Co(mg/Kg)	7.3	15.07	11.4	0.07	6.35	10.01	8.4	0.04	0.061
Cd (mg/Kg)	0.11	0.17	0.13	0.001	0.07	0.11	0.09	0.001	0.03
Cr (mg/Kg)	0.79	0.92	0.81	0.004	0.48	0.66	0.51	0.002	0.006
Ni (mg/Kg)	1.1	1.78	1.33	0.003	0.47	1.03	0.52	0.001	0.002
Micro-nutrients in roots of wheat crops									
Fe(mg/Kg)	646.4	880.3	678	5.06	265.8	437.5	304.7	2.41	0.002
Mn(mg/Kg)	377.1	527.4	431.6	3.88	324.8	512.2	430.2	3.85	0.817
Zn(mg/Kg)	34.5	44.1	40.3	1.07	35.5	41.9	38.4	1.03	0.062
Cu (mg/Kg)	1.42	3.01	2.2	0.005	0.87	2.6	1.8	0.003	0.043
Co (mg/Kg)	19.6	26.7	23.1	0.16	7.7	10.5	8.2	0.04	0.041
Cd(mg/Kg)	0.03	0.08	0.06	0.000	0.01	0.06	0.03	0.000	0.007
Cr (mg/Kg)	0.48	0.65	0.53	0.001	0.18	0.34	0.29	0.001	0.003
Ni (mg/Kg)	0.92	1.49	1.08	0.002	0.65	1.02	0.72	0.001	0.031

µg/day (Cempel *et al*., 2006). Ni showed insignificant results in all parts of wheat (Table 3). The comparative study showed high availability of micronutrients. The metals availability in orchards can be attributed due to low pH, high level of organic content and excessive use of agrochemicals.

Micronutrients in fruits. Plums are considered valuable and good sources of micronutrients. The average concentrations of metals in plum fruits were observed as Mn>Fe>Ni>Zn>Cu>Cr>Cd>Co (Table 4). The contribution of metals in fruits can be associated with fungicide sprays and their uptakes from soil.

Micronutrients in water. The average concentrations of micronutrients in water samples showed high limits of Mn, Fe and Ni when compared with WHO and USEPA standards for the surface water. Toxic metals (Cd, Cr) were also observed above their permissible limits (Table 5). A canal from the river Kabul is used as a water source for irrigation in the research area. Based on the results, the associated sources involed in water contamination are the release of industries from Hayatabad industrial estate (ICUN, 1994). Khan *et al*. (2011) investigated micronutrients in surface water of Shah Alam river (a tributary of Kabul river). Water from river Kabul is used as a major source of irrigation

Table 4. Concentrations of micro-nutrients in plum fruits

Element	Micro-nutrients in plum fruits			
	Min	Max	Avg	S.D
Fe (mg/Kg)	187.3	313.8	267.6	3.01
Mn (mg/Kg)	251.3	412.7	335.3	3.73
Zn (mg/Kg)	0.46	1.43	0.84	0.002
Cu (mg/Kg)	2.83	4.04	3.80	0.011
Co (mg/Kg)	0.27	0.32	0.29	0.001
Cd (mg/Kg)	0.20	0.41	0.30	0.001
Cr (mg/Kg)	0.66	0.85	0.72	0.002
Ni (mg/Kg)	1.43	2.01	1.73	0.002

Table 5. Micronutrients in water

Samples	Mn	Fe	Zn	Cu	Co	Cd	Cr	Ni
	(mg/L)							
S_1	0.08	0.6	0.02	0.13	0.02	1.02	1.12	1.05
S_2	0.06	1.7	0.01	0.02	0.001	0.19	1.01	0.03
S_3	0.04	0.6	0.21	0.51	0.03	0.14	0.05	0.10
S_4	0.06	0.9	0.01	0	0.002	1.01	3.36	1.20
S_5	0.04	1.5	0.03	0.31	0.001	2.01	1.03	0.30
S_6	0.08	1.7	0.22	0.02	0.03	0.90	0.34	1.05
Average	0.06	1.94	0.08	0.35	0.013	1.29	3.14	1.23
S.D	0.001	0.021	0.001	0.004	0.0001	0.072	0.141	0.031
WHO Stan-dards	0.05	1	3	2	0.04	0.01	0.05	0.2
USEPA 1986	0.05	0.3	5	1.3	-	0.005	0.1	0.1

Table 6. Geo-accumulation index of micronutrients in orchard and non-orchard soils

Metals (mg/Kg)	Fe	Mn	Zn	Cu	Co	Cd	Cr	Ni
Orchard	0.77	1.30	0.17	3.41	0.00	2.11	1.84	1.25
Non-Orchard	0.53	0.80	0.15	0.09	0.00	0.10	0.00	0.16

therefore the accumulation of metals in agricultural products takes place which contaminates the food chain. Iqbal *et al*. (2011) analyzed the higher concentration of micro-nutrients in soil and crop samples. This contamination was due to industrial wastewater, used for irrigation. Khan *et al*. (2013) stated that the use of wastewater for irrigation cause a high accumulation of micronutrients in agricultural soils, crops, vegetables and fruits. Shah *et al*. (2012) reported that the use of contaminated source of water for agricultural practices is closely associated with health risks. The results of the present study showed that irrigation water is involved in metals introduction into crop grown on contaminated soil.

Geo-accumulation index. High I_{geo} values were calculated for orchard soils. Cu and Cd were observed with moderate heavy contamination. Mn, Ni and Cr showed class-1 level of contamination while Fe and Zn ranged in class-0 (Table 6). This shows the contamination of orchard soils because of the higher accumulation of metals due to prolong use of agrochemicals. On other hand, non-orchards were observed uncontaminated with safe index values.

Transfer factor. Transfer factor for Mn and Cu showed maximum values. The overall trend of metals transfer in wheat crops of both orchard and non-orchard fields was as Cu>Mn>Co>Fe>Cd>Zn>Ni>Cr (Table 7). Higher uptakes were calculated for crop seeds only. The overall results showed the availability of nutrients in all parts of wheat plants. The differences in transfer factor among different parts of wheat crops may be attributed to variation in metal concentrations in soil and then their uptakes by different parts of wheat crop, while in plum fruit, the TF values were as Cu>Mn>Cd>Ni>Zn>Fe>Cr>Co (Table 7).

Table 7. Transfer factor from soil to wheat crop and fruits

Field	Sample	Mn	Fe	Zn	Cu	Co	Cd	Cr	Ni
Wheat crop in orchards	Seed	0.81	0.08	0.23	0.87	0.54	0.28	0.02	0.25
	Stem	0.65	0.07	0.09	0.42	0.54	0.07	0.02	0.07
	Leaf	0.88	0.17	0.07	0.47	0.52	0.05	0.01	0.04
	Root	0.97	0.15	0.02	0.69	0.84	0.02	0.01	0.04
Wheat crop in non-orchards	Seed	0.83	0.11	0.43	0.78	0.45	0.25	0.02	0.07
	Stem	0.34	0.10	0.17	0.71	0.91	0.08	0.01	0.05
	Leaf	0.36	0.17	0.17	0.88	0.70	0.06	0.01	0.02
	Root	0.54	0.11	0.10	0.92	0.88	0.04	0.01	0.03
Plum fruit		0.61	0.03	0.01	0.50	0.01	0.09	0.01	0.06

Table 8. Correlation (R^2) of metals

Field	Metals correlation (R^2) between crop and soils								
	Sample	Mn	Fe	Zn	Cu	Co	Cd	Cr	Ni
Wheat crop in orchards	Seed	0.681	0.661	0.387	0.788	0.284	0.633	0.691	0.863
	Stem	0.456	0.632	0.181	0.165	0.115	0.258	0.133	0.297
	Leaf	0.315	0.105	0.049	0.069	0.303	0.321	0.867	0.894
	Root	0.805	0.661	0.489	0.346	0.588	0.012	0.412	0.636
Wheat crop in non-orchards	Seed	0.452	0.557	0.590	0.751	0.139	0.139	0.185	0.106
	Stem	0.056	0.003	0.784	0.064	0.439	0.003	0.811	0.622
	Leaf	0.078	0.067	0.445	0.352	0.158	0.039	0	0.116
	Root	0.141	0.287	0.022	0.922	0.55	0.104	0.059	0.436
Plum Fruit	0.405	0.071	0.012	0.078	0.197	0.021	0.039	0.132	
	Metals correlation (R^2) between crop and water Samples								
Wheat crop in orchards	Seed	0.223	0.122	0.047	0.323	0.043	0.640	0.532	0.671
	Stem	0.050	0.154	0.002	0.12	0.267	0.086	0.013	0.084
	Leaf	0.062	0.231	0.034	0.001	0.514	0.061	0.012	0.054
	Root	0.455	0.642	0.001	0.031	0.137	0.012	0.02	0.041
Wheat crop in non-orchards	Seed	0.451	0.093	0.003	0.013	0.021	0.492	0.611	0.142
	Stem	0.302	0.464	0.002	0.051	0.324	0.072	0.011	0.062
	Leaf	0.051	0.032	0.015	0.067	0.263	0.074	0.011	0.013
	Root	0.664	0.315	0.001	0.015	0.028	0.327	0.665	0.542
Plum fruit	0.314	0.271	0.013	0.166	0.036	0.012	0.371	0.325	

Metals correlations. Among the micronutrients, Mn (R^2=0.681), Fe (R^2=0.661), Cu (R^2=0.788), Cd (R^2=0.633), Cr (R^2=0.691) and Ni (R^2=0.863) showed close associations between soil to crop seeds in orchard fields. Mn, Fe and Cu also showed strong correlations in orchard fields. In non-orchards, strong correlations were observed for Zn, Cu, Cr and Ni in seed and stem parts of the wheat crops (Table 8).

Water samples showed strong correlations with Fe, Cd and Ni in crop root and seed of orchard fields as (R^2=0.642), (0.640) and (0.671), respectively. In non-orchard adjacent fields, only Mn and Cr showed close associations in crop root and seeds respectively. The micronutrients in plum fruits were observed weak in correlations to both soil and water samples(Table 8). Results revealed that both soil and water are responsible for the availability of micronutrients in wheat crops.

Conclusion

Enrichment of micronutrients was higher in orchard fields. Among the trace elements, zinc has been found below the standards and its deficiency can affect plants growth by lowering soil output. On other hand, unnecessary levels of Cr, Cd, Ni, Fe and Cu were measured in the same soils. Another significant finding is the higher accumulation of Cr, Cu, Cd, and Ni in the wheat grains. The Transfer factor for the metals showed their uptake in seeds of orchard crop. Based upon investigations, it has been concluded that anthropogenic activities such as intensive use of fungicides spray and fertilizer application is one of the sources of soil contamination indirectly involved in the contamination of food/crops grown in these areas. Consumption of metal contaminated crops and fruits could be detrimental to the health of people who consistently consume such crops and fruits from their land. To reduce the metal load, it is therefore recommended to develop strategies to prevent long-term soil quality by reducing the metal inputs to agricultural lands.

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