Environmental Science and Pollution Research (2021) 28:11509–11517
https://doi.org/10.1007/s11356-020-11393-9

RESEARCH ARTICLE

Appraisal of chromium in chicken reared on maize irrigated with sewage water

Zill-e-Huma [1] · Zafar Iqbal Khan [1] · Ijaz Rasool Noorka [2] · Kafeel Ahmad [1] · Kinza Wajid [1] · Muhammad Nadeem [3] · Mudasra Munir [1] · Ifra Saleem Malik [1] · Madiha Kiran [4] · Tahir Hussain [3] · Muhammad F. Qamar [4] · Tasneem Ahmad [5] · Saif Ur Rehman [6] · Muhammad Fahad Ullah [7]

Received: 27 April 2020 / Accepted: 22 October 2020 / Published online: 30 October 2020

Abstract

In the present study, the outcome of sewage, canal, and ground water on the chromium (Cr) concentration in corn and ultimately in chicken body parts was reported. To evaluate Cr level, atomic absorption spectrophotometer (Flame Atomic Absorption Spectrophotometer AA 6300, Shimadzu Japan) was used. The highest level of Cr in grains (0.50 ± 0.05 mg/kg), shoots (0.90 ± 0.01 mg/kg), and roots (1.01 ± 0.02 mg/kg) were noticed in the Sadaf variety watered with canal water. The least concentration of Cr was recorded in grains (0.07 ± 0.01 mg/kg), shoots (0.59 ± 0.01 mg/kg), and roots (0.71 ± 0.01 mg/kg) of Pearl variety irrigated with ground water. The maximum concentration of chromium in the blood (1.68 ± 0.02 mg/kg) and bones (1.26 ± 0.24 mg/kg) was observed in chicks fed on Millet Research Institute (MMRI) grains reared with the sewage water. The lowest concentration was observed in the blood (1.60 ± 0.04 mg/kg) and in bone (0.80 ± 0.01 mg/kg) of the chicks fed Pearl variety grains reared with canal water. In the second experiment, the maximum content of Cr was determined in the blood (0.74 ± 0.04 mg/kg) and bones (1.76 ± 0.02 ppm) of chicks consuming Sadaf variety grains reared with canal water and the least concentration in the blood (0.26 ± 0.03 mg/kg) and bones (1.64 ± 0.01 mg/kg) was determined on the consumption of the Pearl variety grains reared with ground water. A similar trend was observed in other body organs. It was concluded that polluted water causes higher accumulation levels of Cr in plant parts and even in animals' body parts after the utilization of such plants.

Keywords Chromium · Sewage water · Corn · Chickens · Target hazard quotient

Introduction

Sewage water is chiefly consumed as a possible source of vegetation for growing vegetables as well as forages around the sewage treatment sites that are directly or indirectly consumed by human beings. Raw sewage has two main constituents, i.e., inorganic and organic nutrients that are chiefly important for plant growth (Khan et al. 2011). Sewage agriculture is fairly practiced in all metropolitan areas of Pakistan. Sewage water of some cities, where industrial effluent is discharged, may have toxic metals in excessive amounts. So, the domestic sewage contents may vary with the type of industrial discharge and their waste (Antil 2012).

The contamination of crops with toxic metals is a global quandary (Khan et al. 2020; Wajid et al. 2020). The metals get an entry into the soil and accumulate in different parts of the plant through various sources. Food is a major pathway of exposure to several metals, predominantly in populations consuming impure foods. Risk assessment aims to guesstimate the likelihood of damage to human health from exposure to

Responsible editor: Mohamed M. Abdel-Daim

✉ Zafar Iqbal Khan
zafar.khan@uos.edu.pk

1 Department of Botany, University of Sargodha, Sargodha, Pakistan

2 Department of Plant Breeding and Genetics, University College of Agriculture, University of Sargodha, Sargodha, Pakistan

3 Institute of Food Science and Nutrition, University of Sargodha, Sargodha, Pakistan

4 Department of Pathobiology, University of Veterinary and Animal Sciences, sub-campus Jhang, Lahore, Pakistan

5 Pakki Thatti R & D Farm, Toba Tek Singh, Pakistan

6 Institute of Geology, University of Punjab, Quaid-i-Azam Campus, Lahore, Pakistan

7 Department of Earth Sciences, University of Sargodha, Sargodha, Pakistan

a substance. Due to their bioaccumulation and toxicity, contamination occurs in the food chain that results in a great risk for living beings (Ahmad et al. 2018a, b). Chromium (Cr) as a poisonous element is significantly known by its carcinogenic property that acts as highly reactive/oxidative metal. So, it can be easily stored into earth, plants, and animals. Therefore, the increased concentration of Cr accumulation might cause a decline in production, growth, and nutrients of vegetation.

Cr is a grey, glistening metal that is extremely resilient to common eroding elements (Kumar and Chopra 2015). Its different characteristics make it the sixth most abundant transition metal and twenty-first most abundantly metal found in the earth, discovered by French chemist Louis Nicolas Vauquelin in 1797, named as chromium (Greek chroma; color) as its compounds have different color characteristics.

The anthropogenic activities of this metal lead to the significant contamination of the environment (Khan et al. 2019a, b, c, d). A high concentration of Cr in plants is responsible for chlorosis, necrosis, reduction of protein contents, and inhibition of enzymes activity (Damera et al. 2015). Some scientists carried out researches and revealed that the presence and geographical allocation of different diseases could be linked with the existence of toxic elements in the geologic environment (Dampare et al. 2006). For this reason, it is critical to frequently evaluate and keep an eye on the concentrations of metal species in soils for the appraisal of human exposure as well as for a sustainable environment. Keeping in view the toxic effects of Cr metal, this study was planned to check the effects of concentration of polluted and ground water on the maize grains and its effects on the body parts of chicks.

Materials and methods

Study area

Investigation of soil culture was performed that had been planted in the plastic bags at the wire house of University College of Agriculture, University of Sargodha, Pakistan. The area of Sargodha city has a great amount of nutrients producing different kinds of crops especially corn. Corn is a great source of human and animals feed as roasting cobs, fodder for livestock, and grains for feed and nutrition supply.

Seed source

Seeds received from Corn and Millet Research Institute (MMRI) Yousafwala, Sahiwal, Pakistan, were Pearl (white), Sahiwal-2002 (yellow), MMRI (yellow), Sadaf (white).

The experimental project was carried out using CRD (completely randomized design) that had three replications and three water regimes (ground water (35 ft depth), sewage water, and canal water). The sources of water remained viable variables.

In the experiment, 20-kg sandy loam soil was kept in the soil bags, and field capacity was measured through volumetric means. Two liters of water from each treatment was consumed for the irrigation of soil bags since growing to harvest. The soil analysis was performed before the storage of bags. Water analysis was also done before the beginning of the study of each source and found buffer for any metal in it. Two experiments were directed in two different seasons; the first experiment in the spring season (E-1) and the second experiment in the autumn season (E-2).

The four seeds were sown in each bag and at the three-leaf stage, two weak seedlings were uprooted for ample space of remaining seedlings. All standard agronomic techniques were practiced to keep the crop good standing and green for the significant production of corn. Corn was harvested at the time of maturity and grains were detached from each cob. The metal analysis was performed for each sample of 10 g, i.e., grains, roots, stem, and leaves of the plant, and the lasting sample fed to the chickens under trial.

The next step was to identify the metal translocation from feed to animal. For this experiment, 2-day old domestic chicken breeds (Missouri golden) were bought from the hatchery in Sargodha, and a small pen was prepared in accordance to the requirement of chicken. Two chickens were kept in separate places and fed through prepared (by three treatments with respect to water was given) corn grains. The chickens were fed on ground corn grains (variable factors) mixed with standard chicken feed (constant factor) till 45 days of age/maturity. Following that, chickens were slaughtered to evaluate the metal transfer to their body parts. The blood, bone, breast meat, liver, heart, kidney, and gizzard were evaluated to identify the translocation of Cr from corn to chickens through the wet digestion method.

Digestion of samples for metal detection

Samples of water, used for irrigation, were digested by using the method of Gupta et al. (2013). The soil samples were taken out from the oven after 5 days, and digestion was formed through the wet digestion method delineated by Kovačević et al. (1988). Ten-gram samples from each part of the corn plant, i.e., root, stem, leaf, and seed were analyzed to evaluate the chromium concentration as described by Scancar et al. (2000). Chick samples were also analyzed individually as reported by Mohammed et al. (2013) except the blood which was processed by the procedure as given by the Kazi et al. (2008). Following digestion, all the samples were processed to evaluate the chromium value by atomic absorption spectrophotometer (Flame Atomic Absorption Spectrophotometer AA 6300, Shimadzu Japan).

Statistical analysis

SPSS version 13 was used for statistical analysis. 3-factor analysis of variance was used to analyze the Cr concentration data, where the 3 factors are season (spring, autumn), variety of corn (4 types), and water source (ground, sewage, and canal). Separate analyses were conducted for each plant part and animal part. The differences between the mean concentration values were found at $p > 0.05$ (not significant); $p < 0.05$ (significant); $p < 0.01$ (highly significant) probability levels.

The target hazard quotient (THQ) is the ratio of the potential exposure to a substance and the level at which no adverse effects are expected. If the hazard quotient is < 1, then no adverse health effects are expected as a result of exposure. If the hazard quotient is > 1, then adverse health effects are possible. The target hazard quotient (THQ) was also measured using the following equation (Naughton and Petróczi 2008).

$$\mathrm{THQ} = (\mathrm{EF} \times \mathrm{ED} \times \mathrm{FIR} \times \mathrm{C}/\mathrm{RFD} \times \mathrm{BW} \times \mathrm{AT}) \times 10^{-3}$$

where EF is the exposure frequency, ED is the exposure duration, and FIR is the food ingestion rate. In this study, the rate of ingestion of the tissues of chicken was supposed to be 32.7 g/person/day. C is the metal concentration in tissues of chicken (mg/kg dry weight), RFD is the oral reference dose for metal, BW is the average consumer body weight (70 kg), and TA is the average exposure time for non-carcinogens (365 days/year × ED).

Results

Water

Figure 1 shows that sewage water and canal water have almost the same Cr concentration, with the canal being very, very slightly higher, and the least concentration was found in ground water. So the trend for Cr in water was sewage water ≥ canal water > ground water.

Soil

The trend for Cr concentration in soil was the same as in water that was sewage water-watered soil > canal water-watered soil > ground water-watered soil. So the highest amount of Cr was present in the soil sample watered with sewage water because it contained the highest amount of it as compared to other samples (Fig. 2).

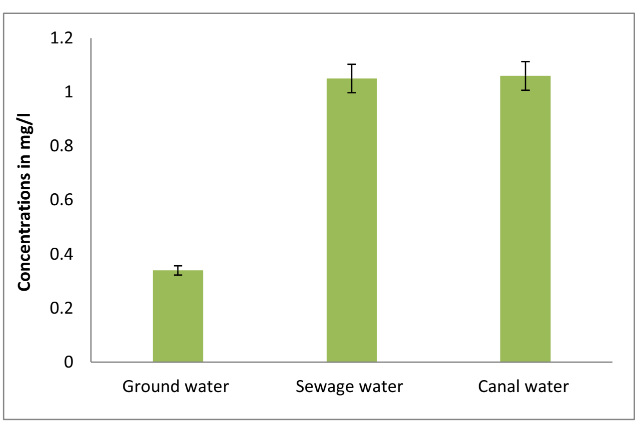

Fig. 1 Concentration of Cr in ground, sewage and canal water. Bar, mean concentration of Cr; Error bar, standard error

Concentration of Cr in plant parts

Grains

ANOVA concluded that seasons, varieties, and treatments resulted in significant value of Cr outcomes in all plant parts (Table 1). In the first experiment, the highest value (0.50 ± 0.05 ppm) of Cr for grains was determined in Sadaf variety at canal water treatment and the least (0.07 ± 0.01 ppm) value of Cr was evaluated in Pearl variety grains at ground water treatment. In the second experiment, the highest level of Cr (0.58 ± 0.06 mg/kg) was assessed in Sadaf variety grains at canal water treatment and the lowest (0.04 ± 0.01 mg/Kg) value of Cr was assessed in Pearl variety at ground water treatment (Fig. 3).

Shoot

In the first experiment, the highest (0.90 ± 0.01 mg/kg) concentration of Cr for the shoot was assessed in Sadaf variety at canal water treatment and the lowermost value (0.59 ± 0.01 mg/kg) of Cr was assessed in the shoot of Pearl variety at ground water treatment. In the second experiment, the maximum value of Cr (1.30 ± 0.01 ppm) was assessed in the shoot of the Sadaf variety at canal water treatment and the minimum value of Cr (0.70 ± 0.02 ppm) was assessed in Pearl variety at ground water treatment (Fig. 3).

Root

In the first experiment, the highest (1.01 ± 0.02 ppm) concentration of Cr for root was assessed in the Sadaf variety at canal

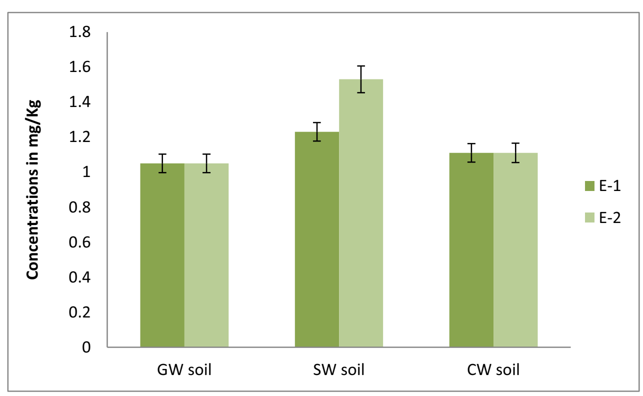

Fig. 2 Concentration of Cr (mg/kg) in soil irrigated with ground water (GW), sewage water (SW), and canal water (CW). Bar, mean concentration of Cr; Error bar, standard error. E-1, first experiment; E-2, second experiment

Table 1 Analysis of variance of data for Cr (mg/kg) in four varieties of maize treated with canal, ground, or sewage water conducted in two experiments conducted in two seasons

Mean squares				
SOV	DF	Grains	Shoots	Roots
Season	1	0.0630**	1.1615**	6.6612**
Variety	3	0.5451**	0.4345**	0.1700**
Treatment	2	0.0406**	0.0455**	0.0340**
SxV	3	0.0188**	0.0441**	0.0074**
SxT	2	0.0063ns	0.0041**	0.0027ns
VxT	6	0.0009ns	0.0013ns	0.0023ns
SxVxT	6	0.0043ns	0.0002ns	0.0016ns
Error	48	0.0020	0.0008	0.0015

ns, non-significant ($p > 0.05$); **highly significant ($p < 0.01$)

water treatment and the least (0.71 ± 0.01 ppm) value of Cr was assessed in the root of Pearl variety at ground water treatment. In S-2, the maximal level of Cr (1.64 ± 0.02 mg/kg) was assessed in the root of Sadaf variety at ground water treatment and the lowest (1.32 ± 0.02 ppm) value of Cr was assessed in Pearl variety at ground water treatment (Fig. 3).

Concentration of Cr in body parts of chickens

The results concluded through ANOVA were significant of seasons, varieties, and treatments on Cr concentration in body parts of chicks (Table 2).

In the first experiment, the highest value of Cr for blood (1.68 ± 0.02 mg/kg) was in those chicks who consumed MMRI grains reared with sewage water and the least showed in the blood (1.60 ± 0.04 ppm) of the chicks who consumed Pearl variety grains reared with canal water as food. In the second experiment, the maximum value of Cr resulted in the blood (0.74 ± 0.04 ppm) of chicks who consumed Sadaf variety grains reared with canal water and the least value (0.26 ± 0.03 ppm) resulted on the usage of the Pearl variety grains reared with ground water (Fig. 4).

In the first experiment, the highest value of Cr for the bone (1.76 ± 0.02 ppm) was in chicks who consumed Sadaf variety grains reared with canal water and the least concentration was obtained in the bone (1.64 ± 0.01 ppm) of the chicks that consumed Pearl variety grains reared with ground water infeed. In the second experiment, the supreme level of Cr was established in the bone (1.26 ± 0.24 mg/kg) of chicks who consumed MMRI variety grains reared with canal water and the least value (0.80 ± 0.01) has occurred in the consumption of the Pearl variety grains reared with ground water (Fig. 4).

In the first experiment, the supreme value of Cr for meat (1.85 ± 0.00 ppm) was in chicks who consumed Sadaf variety grains reared with canal water and the lowermost value has occurred in meat (1.72 ± 0.02 ppm) of the chicks who consumed Pearl variety grains reared with ground water as feed. In the second experiment, the supreme value of Cr was obtained in the meat (1.35 ± 0.15 ppm) of chicks who consumed Pearl and Sahiwal-2002 variety grains raised with canal water and the least value (1.18 ± 0.04 ppm) was obtained on the consumption of the Pearl variety grains reared with ground water (Fig. 4).

In the first experiment, the uppermost value of Cr for the liver (1.86 ± 0.06 ppm) was in chicks who consumed Pearl variety grains reared with canal water and the lowermost level was obtained in the liver (0.02 ± 0.01 ppm) of the chicks who consumed Sadaf variety grains reared with ground water fed to them. In the second experiment, the uppermost value of Cr was obtained in the liver (1.44 ± 0.07 mg/kg) of chicks who consumed MMRI variety grains reared with sewage water,

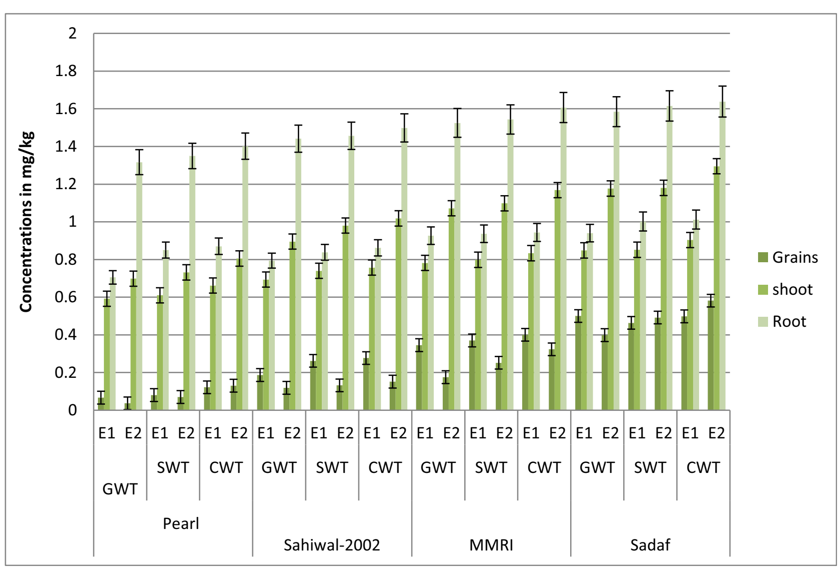

Fig. 3 Concentration of Cr (mg/kg) in four varieties of maize treated with canal, ground, or sewage water conducted in two experiments in two seasons. E-1, first experiment; E-2, second experiment. Bar, mean concentration of Cr; Error bar, standard error

Table 2 Analysis of variance of data for Cr (mg/kg) in body parts of chicken feed on maize grains treated with canal, ground, or sewage water in two experiments conducted in two seasons

Mean squares								
SOV	Df	Blood	Bone	Meat	Liver	Heart	Kidney	Gizzard
S	1	15.6123**	5.8786**	3.2500**	0.0428ns	21.7258**	15.1830**	17.8767**
V	3	0.0968**	0.0955**	0.0117ns	0.6871**	0.0475**	0.0064**	0.1214**
T	2	0.0092**	0.0191*	0.0167*	0.2559**	0.0091**	0.0047**	0.0465**
SxV	3	0.0732**	0.0417**	0.0025ns	0.8687**	0.0070**	0.0059**	0.0665**
SxT	2	0.0091**	0.0028ns	0.0074ns	0.1671**	0.0003ns	0.0000ns	0.0031ns
VxT	6	0.0008ns	0.0061ns	0.0009ns	0.1358**	0.0008ns	0.0005ns	0.0020ns
SxVxT	6	0.0003ns	0.0038ns	0.0007ns	0.1438**	0.0003ns	0.0004ns	0.0045ns
Error	24	0.0011	0.0052	0.0047	0.0276	0.0005	0.0007	0.0040

ns, non-significant ($p > 0.05$); **highly significant ($p < 0.01$)

and lowermost (1.29 ± 0.09 ppm) was obtained on the consumption of the Pearl variety grains reared with ground water (Fig. 4).

In the first experiment, the supreme value of Cr for the heart (0.23 ± 0.02 ppm) was in chicks who consumed Sadaf variety grains reared with canal water and the lowermost level was occurred in the heart (0.02 ± 0.00 ppm) of the chicks who consumed Pearl variety grains reared with ground water. In the second experiment, the supreme value of Cr was obtained in the heart (1.59 ± 0.03 mg/kg) of chicks who consumed Sadaf variety grains reared with canal water and the lowermost value (1.40 ± 0.00 mg/kg) was obtained on the consumption of the MMRI variety grains reared with ground water (Fig. 4).

In the first experiment, the supreme value of Cr for the kidney (0.40 ± 0.00 mg/kg) was in chicks who consumed Sadaf variety grains reared with canal water, and the least value was obtained in the kidney (0.27 ± 0.04 mg/kg) of the chicks who consumed Sahiwal-2002 variety grains reared with ground water. In the second experiment, the supreme value of Cr occurred in the kidney (1.51 ± 0.06 ppm) of chicks who consumed Sadaf variety grains reared with canal water and least value (1.44 ± 0.00 mg/kg) was obtained on the consumption of the Sahiwal-2002 and MMRI variety grains reared with ground water (Fig. 4).

In the first experiment, the supreme value of Cr for the gizzard (0.44 ± 0.02 mg/kg) was obtained in chicks who consumed Pearl variety grains reared with sewage and canal water and the least value occurred in the gizzard (0.00 ± 0.00 ppm) of the chicks who consumed Sahiwal-2002 variety grains reared with ground water. In the second experiment, the supreme value of Cr was obtained in the gizzard (1.53 ± 0.02 ppm) of chicks who consumed Pearl variety grains reared with canal water and least value (1.34 ± 0.01 ppm) was formed on the consumption of the MMRI variety grains reared with ground water (Fig. 4).

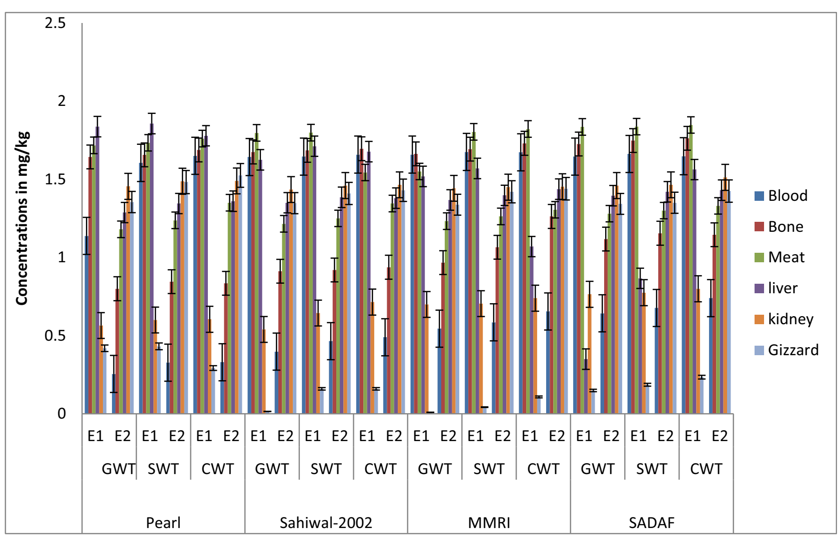

Fig. 4 Concentration of Cr (mg/kg) in body parts of chicken feed on maize grains treated with canal, ground, or sewage water conducted in two experiments conducted in two seasons. E-1, first experiment; E-2, second experiment

Discussion

The maximum permitted value for Cr set by WHO (2004) is 0.05 mg/l and FAO is 0.10 mg/l (Ayers and Westcot 1985). In all water samples, the concentration of Cr was high than its maximum permissible limit. Even the ground water and canal were not safe for human consumption. Among all the samples, the highest value of chromium was observed in sewage and canal water. In the current research, the values for Cr in all water resources used for irrigation were lower compared to those found by Nazir et al. (2015) who found the chromium concentrations in all water samples ranged between 1.313 and 2.886 mg/l and higher than those found by Nazif et al. (2006) and Soomro et al. (2014) who studied various trace and heavy metals concentration in Phuleli canal water including Cr in various seasons. Samples in the present research were taken from the canal situated in the mid of the Sargodha city. This canal carries industrial dump including other sources of pollution like animal feces and domestic garbage. Some congested housing colonies are also disposing of their wastes into canal water (Wattoo et al. 2006; Khan et al. 2017; Khan et al. 2019a, b, c).

In the current research, though all the water samples used for irrigation showed the values of Cr above its safe limit but all maize grown soil samples irrigated with these water showed the level of Cr within the safe limit [400 mg/kg] (WHO 1996). The trend for Cr in soil was SW irrigated soil>CW irrigated soil>GW irrigated soil. The present research values of Cr in soil samples were higher than those found by Khan et al. (2015), Perveen et al. (2012), Khan et al. (2011), and lower than those found by Nazir et al. (2015). The permitted value of Cr in agronomic crops is 2.30 ppm (Pendias and Pendias 1984). Cr concentration in the entire sample was found less than the maximum permitted value of Cr in crops (2.30 ppm). In both experiments, Sadaf variety showed a higher concentration of Cr in all parts under CWT. And Pearl variety showed a lower concentration in all parts of the plant in both seasons. Compared to the soot and grains root showed the higher values of Cr. The trend for Cr was Root>Shoot>Grains. The same trend for Cr in the wheat plants was found by Al-othman et al. (2012). They conducted a research to compare the various metals (e.g., Cd, Pb, As, Ni, Cu, Zn, Mn, and Cr) concentration in different body parts of wheat plants (e.g., roots, stem, leaves, and seeds) found at numerous locations in Pakistan that were watered with altered water sources, i.e., canal, tube well, river, and rain. The concentration of chromium in grains indicated that grains were safe for animal consumption and the highest values of Cr in grains were near to those found by Tegegne (2015) in cereals and also found the level of Cr in grains within safe limits. Shoot and root values of Cr were more or less similar to those found by Nazir et al. (2015) in leaves, shoot, and root of Acacia *modesta*, *Dodonaea viscose*, and *Tamarix aphyda.* Naz et al. (2016) directed a research study to identify the metal's toxicity in spinach watered with sewage, canal, and tube well water resources, and contrary to present research results for Cr, they found the high level of Cr in leaves and root of spinach watered with sewage water-related to canal and tube well water as in their research the sewage water contained the higher value of Cr compared to other water resources divergent to present research.

In the current research, all parts of the plant showed the highest values of Cr under CWT as the canal water had the highest concentration of Cr in it compared to sewage and ground water. Prolonged exposure to water pollution may cause cancer and a baby's birth defects (Perveen et al. 2006).

The maximum allowable concentration of Cr in meat is 50 ug/g recommended by WHO (1996). The current research values of Cr in all studied parts of the chicken were within safe limits. In the current research, values of Cr in the blood of chickens were lower than those found by Tsipoura et al. (2008) in the blood samples of three bird species. The values of Cr in bone and meat samples were higher than those found by Mahmud et al. (2011) who appraised the Cr level in bones and meat parts of the poultry, and Kekkonen et al. (2012) found the level of different metals including Cr in the livers of sparrows. But present research values of Cr in the bone, liver, heart, and kidney were lesser than found by Tenai et al. (2016) who carried out an experiment to identify the heavy metals concentration in different body parts of the lesser flamingos in four eastern rift valley lakes.

Deng et al. (2007) observed the value of eleven trace metals from ten body parts of Great Tits and Greenfinches collected at China to evaluate the accumulation of metals, their allocation among tissues, species, and gender-related differences. The level of chromium in the kidney of Great Tits and Greenfinches was higher than those found in the present research. Great Tits and Greenfinches samples of the hearts showed the Cr level 4.66 ± 0.95 mg/kg, 0.69 ± 0.06 mg/kg, respectively which was higher than the present research values of Cr in the heart. However, the values of Cr in the liver of Great Tits and Greenfinches were 1.86 ± 0.33, 0.96 ± 0.34 respectively which were in line with those found in current research values of Cr in the liver of chickens.

Mcbride (2007) reported that contaminated soil used for the farming of human or livestock feeds is the main cause of trace metals accumulation in the eatable body parts of plants, producing a great risk to humans and animals. Accumulation of heavy metals within the body may take place by contaminated food and water (Gabol et al. 2014). However, in the present research, the amount of Cr in the grains was below the maximum permissible limit so all chicken samples were also contained Cr within the safe limit.

The more the THQ value, the greater will be the possibility of the threat to the human body. THQ value suggested by USEPA is an integrated risk index being greatly used to

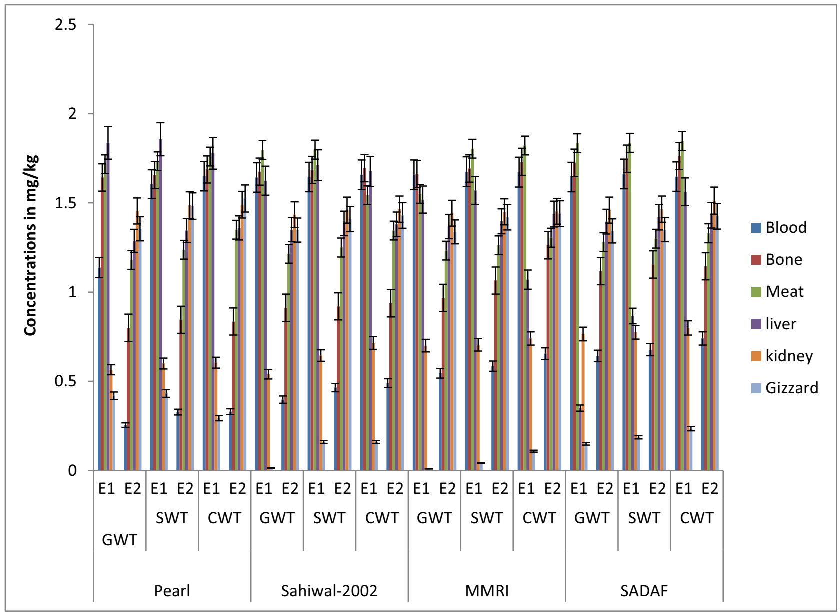

Fig. 5 Health risk estimate for Cr ingestion from chicken breast muscle and viscera (liver and gizzard) of E-1 and E-2. E-1, first experiment; E-2, second experiment

determine the risk of metals in contaminated foods. So, it is calculated by comparing the intake of pollutant amount with a reference standard dose (Storelli 2008). In the current research, the target hazard quotient values for the individual metals in meat, the liver, and gizzard were less than 1 and were within safe levels which showed that the ingestions of Cr metal by these chickens will not cause the significant danger for the human body. Giri and Singh (2015) also found THQ < 1 for Cr in fish species, Puntiusconchonius, Mystusgulio, Labeorohita, Labeocalbasu, and Labeobata, and also in the shrimp species Penaeusindicus (Fig. 5).

Conclusion

Most of the diseases were occurred due to protracted contact with environmental pollution. Food crops grown in contaminated soil may lead to the uptake and buildup of heavy metals in grains, with a resulting risk to human and animal health as well. In the present study, it was found that the use of sewage and canal water affected the Cr content in the grains which were then used as feed for chicken and resulted in the increase of Cr concentration in chicken tissues. In the present research, the THQ values for Cr metal in poultry edibles (breast meat, liver, gizzard) were less than 1 suggested that it is not any risk to human health from exposure to excessive consumption of these chicken meat as THQ values for all metals indicated that they were safe for human consumption. Sewage water was responsible for the transfer of a considerable amount of heavy metals to the soil, to plant, and to chicken, so this study may also help to establish baseline data regarding environmental and food chain safety and suitability of sewage irrigation in future crop production.

Authors' contribution ZIK, IRN, and KA supervised the study. ZH, KW, and MN performed the experiment. MM, ISM, and MS done statistical analysis. TH, MFQ, and TA wrote the manuscript. SUR and MFU reviewed the manuscript.

Availability of data and materials Not applicable

Compliance with ethical standards

Competing interests The authors declare that they have no conflict of interest.

Ethical approval Not applicable

Consent to participate Not applicable

Consent for publication Not applicable

References

Ahmad K, Ashfaq A, Khan ZI, Bashir H, Sohail M, Mehmood N, Dogan Y (2018a) Metal accumulation in *Raphanus sativus* and *Brassica rapa*: an assessment of potential health risk for inhabitants in Punjab, Pakistan. Environ Sci Pollut Res 25(8):16676–16685. https://doi.org/10.1007/s11356-018-1868-7

Ahmad K, Nawaz K, Khan ZI, Nadeem M, Wajid K et al (2018b) Effect of diverse regimes of irrigation on metals accumulation in wheat crop: an assessment-dire need of the day. Fresenius Environ Bull 27(2):846–855

Al-othman ZA, Ali R, Naushad MU (2012) Hexavalent chromium removal from aqueous medium by activated carbon prepared from peanut shell: adsorption kinetics, equilibrium and thermodynamic studies. Chem Eng J 184:238–247

Antil RS (2012) Impact of sewage and industrial effluents on soil-plant health, industrial waste. Prof.Kuan-Yeow Show (Ed.), ISBN: 978-953-51-0253-3, InTech. [online] http://www.intechopen.com/books/industrial-waste/impact-ofsewer-water-and-industrial-wastewaters-on-soilplant-health

Ayers RS, Westcot DW (1985) Water quality for Agriculture. Food and Agriculture Organization (FAO) of the United States, Rome

Damera V, Chinna V, Azeem US (2015) Heavy metals effect in food crop of (*Vigna radiate*) and its remediation. J Chem Biol Phys Sci 5:917–924

Dampare SB, Ameyaw Y, Adotey DK, Osae S, Serfor-Armah Y, Nyarko BJB, Adomako D (2006) Seasonal trend of potentially toxic trace elements in soils supporting medicinal plants in the eastern region of Ghana. Water Air Soil Pollut 169(1–4):185–206

Deng H, Zhang Z, Chang C, Wang Y (2007) Trace metal concentration in great tit (parus major) and greenfinch (carduelissinica) at the western mountains of Beijing, China. Environ Pollut 148:620–626

Gabol K, Khan MZ, Khan MA, Khan P, Fatima F et al (2014) Induced effects of lead, chromium and cadmium on Gallus Domesticus. Can J Pure Appl Sci 8:3035–3042

Giri S, Singh AK (2015) Human health risk and ecological risk assessment of metals in fishes, shrimps andsediment from a tropical river. Int J Environ Sci Technol 12:2349–2362

Gupta S, Jena V, Jena S, Davic N, Matic N et al (2013) Assessment of heavy metal contents of green leafy vegetables. Croat J Food Sci Technol 5:53–60

Kazi TG, Memon AR, Afridi HI, Jamali HK, Arain MB et al (2008) Determination of cadmium in whole blood and scalp hair samples of Pakistani male lung cancer patients by electrothermal atomic absorption spectrometer. Sci Total Environ 389:270–276

Kekkonen J, Hanski IK, Vaisanen RA, Brommer JE (2012) Levels of heavy metals in house sparrows (*Passer domesticus*) from urban and rural habitats of southern Finland. Ornis Fennica 89:91–98

Khan MJ, Jan MT, Mohammad D (2011) Heavy metal content of alfalfa irrigated with waste and tubewell water. Soil Environ 30:104–109

Khan ZI, Ahmad K, Ashraf M, Parveen R, Mustafa I et al (2015) Bioaccumulation of heavy metals and metalloids in Luffa (*Luffa Cylindrica* L.) irrigated with domestic wastewater in Jhang, Pakistan: a prospect for human nutrition. Pak J Bot 47:217–224

Khan ZI, Iqbal S, Batool F, Ahmad K, Elshikh MS, Al Sahli A et al (2017) Evaluation of heavy metals uptake by wheat growing in sewage irrigated soil: relationship with heavy metal in soil and wheat grains. Fresenius Environ Bull 26(12A):7838–7848

Khan ZI, Iqbal S, Ahmad K, Ashfaq A, Bashir H, Dogan Y (2019a) Assessment of heavy metal content of wheat irrigated with wastewater in Sargodha, Pakistan: Implications for human health. Trace Elem Electrolytes 36(2):82–92. https://doi.org/10.5414/TEX01530

Khan ZI, Safdar H, Ahmad K, Wajid K, Bashir H, Ugulu I, Dogan Y (2019b) Health risk assessment through determining bioaccumulation of iron in forages grown in soil irrigated with city effluent. Environ Sci Pollut Res 26(14):14277–14286. https://doi.org/10.1007/s11356-019-04721-1

Khan ZI, Ahmad K, Rehman S, Ashfaq A, Mehmood N, Ugulu I, Dogan Y (2019c) Effect of sewage water on accumulation of metals in soil and wheat in Punjab, Pakistan. Pak J Anal Environ Chem 20(1):60–66. https://doi.org/10.21743/pjaec/2019.06.08

Khan ZI, Nisar A, Ugulu I, Ahmad K, Wajid K, Bashir H, Dogan Y (2019d) Determination of cadmium concentrations of vegetables grown in soil irrigated with wastewater: evaluation of health risk to the public. Egypt J Bot 59(3):753–762. https://doi.org/10.21608/EJBO.2019.9969.1296

Khan ZI, Safdar H, Ahmad K, Wajid K, Bashir H, Ugulu I, Dogan Y (2020) Copper bioaccumulation and translocation in forages grown in soil irrigated with sewage water. Pak J Bot 52(1):111–119. https://doi.org/10.30848/PJB2020-1(12)

Kovačević V, Vukadinović V, Bertić B (1988) Excessive iron and aluminum uptake and nutritional stress in corn (*Zea mays* L.) plants. J Plant Nutr 11:1263–1272

Kumar V, Chopra AK (2015) Toxicity of chromium in agricultural crops with respect to its chemical speciation-a review. World Appl Sci J 33:944–969

Mahmud M, Rehman R, Ali S, Anwar J, Abbas A (2011) Estimation of chromium (VI) in various body parts of local chicken. J Chem Soc Pak 33:339–342

Mcbride MB (2007) Trace metals and sulfur in soils and forage of a chronic wasting disease locus. Environ Chem 4:134–139

Mohammed AI, Kolo B, Geidam YA (2013) Heavy metals in selected tissues of adult chicken layers (gallusspp). ARPN J Sci Technol 3:518–522

Naughton DP, Petróczi A (2008) Heavy metal ions in wines: meta-analysis of target hazard quotients reveal health risks. Chem Cent J 2(1):1–7

Naz S, Anjum MA, Akhtar S (2016) Monitoring of growth, yield, biomass and heavy metals accumulation in spinach grown under different irrigation sources. Int J Agric Biol 18:689

Nazif W, Perveen S, Shah SA (2006) Evalution of irrigation water for heavy metals of Akbarpuraarea. J Agric Biol Sci 1:51

Nazir R, Khan M, Masab M, Rehman HU, Rauf NU et al (2015) Accumulation of heavy metals (Ni, Cu, Cd, Cr, Pb, Zn, Fe) in the soil, water and plants and analysis of physico-chemical parameters of soil and water collected from Tanda Dam kohat. Int J Pharm Sci Res 7:89–97

Pendias AK, Pendias H (1984) Trace elements in soil and plants. CRC Press, Boca Ratan

Perveen S, Nazif W, Rahimullah SH (2006) Evaluation of water quality of upper warsak gravity canal for irrigation with respect to heavy metals. J Agric Biol Sci 1:19

Perveen S, Samad A, Nazif W, Shah S (2012) Impact of sewage water on vegetables quality with respect to heavy metals in Peshawar Pakistan. Pak J Bot 44:1923

Scancar J, Milai R, Straar M, Burica O (2000) Total metal concentrations and partitioning of Cd, Cr, Cu, Fe, Ni and Zn in sewage sludge. Sci Total Environ 250:9–19

Soomro A, Siyall AA, Mirjat MS, Sial NB (2014) Seasonal variations of trace elements and heavy metal concentrations in phuleli canal water (Sindh), Pakistan. Sarhad J Agric 30:73–82

Storelli MM (2008) Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: estimation of target hazard quotients (THQs) and toxic equivalents (TEQs). Food Chem Toxicol 46:2782–2788

Tegegne WA (2015) Assessment of some heavy metals concentrations in selected cereals collected from localmarkets of Ambo city, Ethiopia. J Cereals Oilseeds 6:8–13

Tenai BC, Mbaria JM, Muchemi GM, Jansen R, Kotze A et al (2016) Assessment of heavy metals concentration in water, soil sediment and biological tissues of the lesser flamingos in four eastern rift valley lakes. Environ Sci Technol 10:162–166

Tsipoura N, Burgerb J, Feltesd R, Yacabuccia J, Mizrahie D et al (2008) Metal concentrations in three species of passerine birds breeding in the Hackensack Meadowlands of New Jersey. Environ Res 107:218–228

Wajid K, Ahmad K, Khan ZI, Nadeem M, Bashir H, Chen F, Ugulu I (2020) Effect of organic manure and mineral fertilizers on bioaccumulation and translocation of trace metals in maize. Bull Environ Contam Toxicol 104:649–657. https://doi.org/10.1007/s00128-020-02841-w

Wattoo MHS, Wattoo FH, Tirmizi SA, Kazi TG, Bhanger MI et al (2006) Pollution of Phulali canal water in the city premisesof Hyderabad: metal monitoring. J Chem Soc Pak 28:136–143

WHO (1996) World health organization: health criteria and other supporting information. In: Guideline for drinking water quality, pp 31–38

WHO (2004) Guidelines for drinking water quality. 3rd edn. [online] http://www.who.int /water_sanitation_health /dwq /guidelines/en/