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Heavy Metals Concentrations in Groundwater Used for Irrigation

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ABSTRACT

Background: The main objective of this study was characterization of selected heavy metals concentrations (Lead, cadmium, copper, zinc, nickel and chromium) in groundwater used for irrigation in Tabriz City's countryside.
Methods: After consulting with the experts of agriculture department and site survey, 38 irrigation water samples were taken from different farms (34 wells) without primary coordination with farm owners. All of samples were acidified to achieve pH≈2 and then were concentrated from 10 to 1 volume. The concentrations of Cd, Pb, Cu, Cr, Ni, and Zn in the samples (totally 228) were determined with a flame atomic absorption spectrophotometer.
Results: In none of 38 farms, irrigation with surface runoff and industrial wastewater was observed. The average concentrations of Cd, Pb, Cu, Cr, Ni, and Zn in the irrigated water were determined 6.55, 0.79, 16.23, 3.41, 4.49, and 49.33µg/L, respectively. The average and even maximum concentrations of heavy metals in the irrigation water at the studied area were less than toxicity threshold limits of agricultural water.
Conclusion: Currently, not using of surface runoff and industrial wastewater as irrigation water by farmers indicates that the controlling efforts by authorities have been effective in the area. Water used for irrigation of the farms and groundwater of the studied area are not polluted with heavy metals and there is no risk from this viewpoint in the region.
Keywords: Heavy metals, Water, Irrigation, Farms, Countryside

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Introduction

The question of whether vegetables, fruits and food crops consumed are safe for human is of great interest and concern, consequently, surveys of food contamination with pesticides, heavy metals and fertilizers have been increasing [1]. Heavy metals are important environmental pollutants, particularly in areas with high anthropogenic sources [2]. These pollutants are extremely persistent in the environment, nonbiodegradable nonthermodegradable, therefore could readily accumulate to toxic levels [1, 3].

Heavy metals contribute to environmental pollution because of their unique properties; heavy metals do not leach from the topsoil and have the potential to accu-

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mulate in the different organs (such as the kidneys, bones and liver) leading to unwanted side effects [4,5]. Each heavy metal shows specific signs of its toxicity. For instance, Pb, As, Hg, Zn, Cu and Al poisoning have been implicated with gastrointestinal (GI) disorders, diarrhea, stomatitis, tremor, hemoglobinuria causing a rust-red color to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia. Some effects of heavy metals could be toxic (acute, chronic or sub-chronic), neurotoxic, or even carcinogenic, mutagenic or teratogenic [5]. Heavy metals can accumulate in the soil at toxic levels due to long-term application of wastewater. Metals can be transferred from soil to the other ecosystem components, such as underground water or crops, and can affect human health through the water supply and food [1, 6]. Soils, as filters of toxic chemicals, may adsorb and retain heavy metals from wastewater. However, when the capacity of soils is reduced to retain toxic metals due to continuous loading of pollutants or changes in pH, soils can release heavy metals into groundwater or soil solution available for plant uptake. The amount of heavy metals mobilized in the soil is a function of pH, clay content, organic matter content, cation exchange capacity and other soil properties making each soil unique in terms of pollution management [7].

Access to adequate water for irrigation is a matter of increasing concern in the world and to face the growing demand for irrigation water, non conventional resources are often used. In the countryside of some of large cities in developing countries, application of industrial or municipal wastewater effluent for irrigation is a common practice. Important sources of heavy metals in runoffs and sewages are urban and industrial effluents, deterioration of sewerage pipe and treatment works, and the corrosion of household plumbing fixtures [1, 7]. Heavy metals such as lead, copper, zinc and cadmium can enter to water from car components, tyre abrasion, lubricants and industrial and incinerator´s emissions [8].

In Tabriz as center of East Azerbaijan Province, surface runoffs and sewages are collected and transmitted through specific canals to west and south west part of the city that are industrial. In addition there are a lot of farms in west and south west of the city and because of the prevailing conditions on the region, pollution of the underground water with heavy metals is possible. Due to the shortage of water resources for irrigation, collected surface runoff and sewage are considered as a potential source of water for irrigation. In addition, disposal of the industrial and municipal wastewater and urban runoff to the lands, are the cause of concerns about possible contamination of underground water resources and agricultural water wells to heavy metals and other pollutants.

There is no comprehensive research concerning the status of water used in irrigation of agricultural crops considering heavy metal pollution in Iran. On the base of our search on databases, there are a few studies mainly in relation to soil conditions and crops about contamination by heavy metals in southern part of Tehran and some other limited studies such as in Isfahan and Hamadan [9-11]. Therefore, assessment of water used for irrigation of farms in Tabriz countryside for the presence of heavy metals is of great importance.

The objective of this study was to determine the concentration of cadmium (Cd), lead (Pb), copper (Cu), chromium (Cr), nickel (Ni) and zinc (Zn) in water used for irrigation of farms in Tabriz west and southwest countryside.

Materials and Methods

After site visiting, investigation and also gathering required field data form responsible organization and authorities it was found out that currently water sources being used for irrigation was well water. It should be notified that other sources of water maybe use illegally by farmers currently or were used in the past. However after consulting with experts of Agriculture Department and site survey, sampling farms and their related wells used in irrigation were determined in the west and south west of Tabriz City (locating of most farm lands in the west and south west countryside of city was reason of selecting of mentioned sampling area). Then without prior notification of farm owners and with coordination of Agriculture Department and their experts, sampling was conducted in the end of spring and all of summer of 2010.

Samples were collected from 34 wells (38 farms, 4 farms water was coming from same wells) and their locations were recorded accurately with GPS device (Fig.1). The sites were selected in such a way to cover all of agricultural area of suburb of west and south west of the city. For collecting of samples polyethylene bottles were used which were washed out in advance and were soaked in acid (2+1HCl) for 24 hours and then, were rinsed with distilled water for three times. All of the samples were acidified to achieve pH≈2, and then in laboratory the samples concentrated 10 to 1 volume in 80 °C and were kept in refrigerator for final analysis, according to standard methods manuals [12]. After preparation of samples, Cd, Pb, Cu, Cr, Ni and Zn concentrations (a total of 234 heavy metal concentrations) were measured using flame atomic absorption spectroscopy device calibrated with standard solutions (Buck Scientific Model).

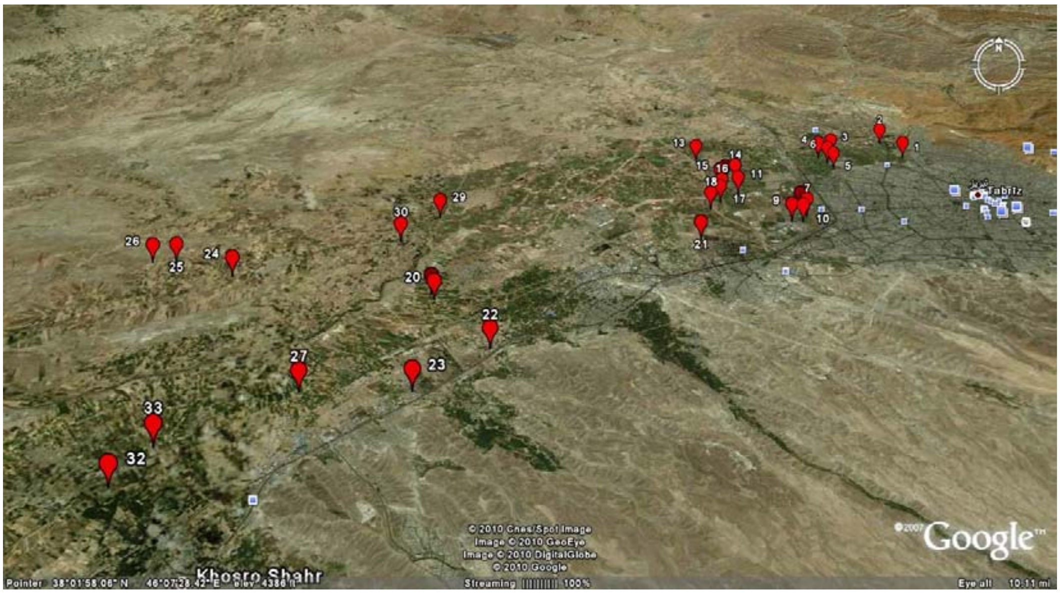

Fig.1: Distribution of sampling points in the west and southwest of Tabriz farms

Quality control measures in analyzing procedure were taken to confirm accuracy and precision of analyses. Samples were carefully handled to avoid contamination. Glasswares were cleaned properly. Deionized water was used throughout the study. Reagent blank determinations were used to correct the instrument readings during in the analyses. About 25% samples of all were analyzed repeatedly to ensure the precision and accuracy of analysis.

Average, standard deviation, maximum and minimum values of each heavy metal concentration were calculated using Microsoft office Excel software.

Results

The results of well-water analysis for cadmium Cd, Pb, Cu, Cr, Ni and Zn are presented in Table 1. Also the comparison of results with toxicity threshold limits of those heavy metals in irrigation water and maximum allowable levels of heavy metals in drinking water have been presented in the same table [11- 13].

Table1: Heavy metals concentrations ((μg/L) in the well water used for irrigation of farms in the west and south waste of Tabriz

Farm Number (well Number)	Cadmium	Lead	Copper	Chromium	Nickel	Zinc
1 (1)	8	4.08	23.00	1.96	0.00	31.97
2 (1)	8	4.08	23.00	1.96	0.00	31.97
3 (2)	0.75	0.00	28.00	1.15	8.75	55.97
4 (3)	5.5	0.00	11.83	2.91	0.00	24.97
5 (4)	4.25	0.00	8.50	0.42	0.00	18.97
6 (5)	3	0.00	16.83	0.83	8.75	5.97
7 (6)	4.25	0.00	21.83	3.19	8.75	18.97
8 (6)	4.25	0.00	21.83	3.19	8.75	18.97
9 (7)	5.50	0.00	10.17	2.28	0.00	88.97
10 (8)	9.25	0.00	11.83	2.47	8.75	131.97
11 (9)	9.25	0.00	15.17	1.95	0.00	179.97
12 (10)	4.25	0.00	13.50	4.53	8.75	44.97
13 (10)	4.25	0.00	13.50	4.53	8.75	44.97
14 (11)	11.75	0.00	13.50	6.47	0.00	45.97
15 (12)	10.50	0.00	10.17	3.22	0.00	30.97
16 (13)	0.75	0.00	13.50	0.46	0.00	29.97
17 (114)	6.75	0.00	11.83	5.83	8.75	17.97
18 (15)	0.75	0.00	8.50	4.22	0.00	28.97
19 (16)	8.00	0.00	25.17	3.58	8.75	39.97
20 (17)	5.50	0.00	15.17	4.89	8.75	57.97
21 (18)	11.75	0.00	16.83	3.55	8.75	20.97
22 (19)	11.75	0.00	13.50	2.63	8.75	24.97
23 (20)	0.88	0.00	13.50	2.54	0.00	26.97
24 (21)	4.25	0.00	6.83	2.65	0.00	26.97
25 (22)	10.50	0.00	5.17	2.36	8.75	47.97
26 (23)	4.25	0.00	13.50	3.06	8.75	35.97
27 (24)	1.75	0.00	0.17	2.74	8.75	52.97
28 (25)	6.75	0.00	10.17	2.09	0.00	21.97
29 (26)	14.25	4.08	25.17	2.47	0.00	31.97
30 (26)	14.25	4.08	25.17	2.47	0.00	31.97
31 (27)	6.75	0.00	10.17	2.09	0.00	21.97
32 (28)	14.25	4.08	36.83	2.47	0.00	97.97
33 (29)	4.25	0.00	21.83	3.19	8.75	18.97
34 (30)	5.50	2.30	25.17	6.29	8.75	59.97
35 (31)	4.25	0.00	15.17	9.57	8.75	203.97
36 (32)	3.00	5.85	3.50	5.89	0.00	25.97
37 (33)	6.75	0.00	18.50	5.14	0.00	70.97
38 (34)	8.00	0.00	26.83	5.19	8.75	96.97
Average (±SD)	6.55(±3.80)	0.79(±1.65)	16.23(±7.69)	3.41(±1.90)	4.49(±4.43)	49.33(±42.61)
Maximum	14.25	5.85	36.83	9.57	8.75	203.97
Toxicity Threshold limit in agricultural water (μg/L) (11,13)	5-10	5000	200	100	200	2000
Allowable Maximum level in potable water (μg/L) (12)	5	50	1000	50	20	3000

Discussion

The results indicated that the concentrations of studied heavy metals were less than toxicity threshold limit in irrigation water. Even maximum values of this study were below toxicity level. In addition, analyzed heavy metals concentrations, excluding cadmium, were below allowable maximum level in potable water. Despite of shortage of water resources for irrigation of the farms, irrigation with surface runoffs and wastewater was not observed during site visiting and sample collecting from different farms. In all 38 studied farms, irrigation waters were being supplied from wells, located in the farms or neighbor farms. This is attributed to enough investigations and monitoring by relevant organizations such as agriculture and health organizations. However it should be noted that sampling were conducted during the day, so there is the possibility of using of surface runoffs and industrial wastewater during night secretly.

There are a few available comprehensive researches concerning the quality of water used in irrigation of agricultural crops considering heavy metal pollution in the studied area and other reigns of Iran. This makes it difficult to compare the results of present study with other research findings. However, there is one available reported study about heavy metal concentrations in irrigation water in Dastgerd Desert in Isfahan. In that research concentrations of lead, zinc, copper, chromium and nickel was reported 0.097, 0.106, 0.022, zero and zero milligram per liter, respectively. Values of lead, zinc and copper in irrigation water of Tabriz west and southwest farms are less than that study. However, chromium and nickel concentrations were higher [10].

According to the results of our study and the local conditions, the following items were concluded:

- The average and even maximum concentrations of heavy metals in irrigation water in the studied area were less than toxicity threshold limit of agricultural water.
- Although the studied area is located in an industrial region, fortunately groundwater of that district is not polluted by heavy metals.
- The water used for irrigation is not polluted with heavy metals and there is not any risk from this viewpoint in the area.
- Currently, not using of surface runoff and industrial wastewater as irrigation water by farmers indicates that the controlling efforts by authorities were effective in the area.
- In spite of not finding of pollution in the studied area, in order to prevent of pollution of groundwater in the future, it is suggested that relevant authorities and industrial sector, should accelerate the construction or completion of surface water and wastewater collection systems and also wastewater treatment facilities.

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