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RESEARCH ARTICLE

LEAD, NICKEL AND COPPER CONCENTRATION IN WASTEWATER USED FOR IRRIGATION IN ERBIL CITY KURDISTAN REGION, IRAQ

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ABSTRACT

At Tooraq area (6 km southwest Erbil / the Capital of Kurdistan Region of Iraq) farmers irrigate about 600-700 Donums by untreated wastewater for growing and production of variety of uncooked vegetables which consume by more than one million people. Thus, it is possible that these activities will create harmful effects on environment and cause health risks for the community here. Hence, it is necessity to assess the quality of Erbil's wastewater and determine the levels of some heavy metals bio-accumulated in both soil and some uncooked vegetables irrigated by the wastewater, becomes an urgent need and even a commendable effort. During this investigation samples including; wastewater, collected from five sites, according to a regular schedule at fortnightly (two samples per month) interval periods; water quality assessment and levels of some heavy metals. Lead values of wastewater were ranging from 0.118-0.599 mg.l⁻¹; nickel value from 0.073-0.295 mg.l⁻¹, and copper were ranging from 0.201-0.583 mg.l⁻¹. Wastewater that used for irrigation of vegetables.

KEYWORDS

Wastewater, lead, Nickel, Copper, Bioaccumulation.

1. INTRODUCTION

Water is essential to all aspects of life and cannot be replaced. Humans can survive for extended periods of time without food, but only a few days without water. Clear, colorless, and free of any odd tastes or odors are characteristics of good water. A diluted mixture of different wastes from commercial, industrial, residential, and other human activities is known as wastewater or sewage. Heavy metals are among the toxicants, pathogenic organisms, and organic and inorganic matter found in sewage in general. One of the biggest disposal issues related to irrigation for agricultural activities is wastewater. (Yates, 2000). Using an average of 70% of all surface water supplies worldwide, agriculture is the single largest user of fresh water resources. Reclaimed agricultural water is returned to the surface or groundwater. But agriculture is a source of water pollution as well as a victim of it. (Cook et al., 2000). Not all kinds of waters are appropriate for agriculture, just as not all waters are suitable for human consumption. Irrigation with water that contains contaminants harmful to plant growth is insufficient. Human activity and the composition of the soil that will be irrigated have a significant impact on the quality of suitable irrigation water. For many years, the toxicity of heavy metals ingestion has been a significant concern for human health. The health effects of long-term, chronic low-level exposures have become a greater concern due to the prevalence of contamination from both natural and man-made sources. Numerous studies have demonstrated that some common garden vegetables can draw large amounts of metals from the soil. (LeCoultré, 2001). It is obvious that Erbil's wastewater is much polluted and creates harmful effects on environment and health risks for community. At Tooraq area farmers irrigate about 600-700 donums by wastewater without any pretreatment for production of uncooked vegetables which consumed by more than one million people in Erbil City as an important part of the human diet, which contain proteins, vitamins, minerals.

2. MATERIALS AND METHODS

2.1 Water Sampling

At the field Plate (1), Figure (1), Figure (2). For the purpose of the present investigation four sites were selected along the main sewage canal of Erbil city. Site five (unpolluted water) College of science was supplied by unpolluted water from Manticawa-92 well (ground water) as reference site in November.29.2021 and ended in June. 1.2022. wastewater samples from selected sites were taken using clean pre-washed 5litter polyethylene containers. Sampling containers were rinsed several times with the water sample placing them beneath the water surface, and then they were filled, labeled and stoppered. All water samples were returned back to the laboratory as soon as possible in a cool and dark condition for limitation of nutrient consumption by available algae and/or microorganisms in the water samples. For heavy metal analysis water samples were collected in pre-washed polyethylene bottles acidified with few drops of nitric acid. This for minimization of precipitation and adsorption of available heavy metals on the container walls as recommended by Abbawy and Hassan, 1990. The concentrations of heavy metals were determined using atomic absorption spectrophotometer (APHA 1998).

2.2 Digestion of Sample

2.2.1 Digestion of Water Samples for Determination of Heavy Metals

Water samples were digested as presented in following steps (APHA (1998):

About 100 ml of water brought to a 125 ml beaker, 5 ml conc. HNO₃ was added to the samples and boiled on a hot plate to the lowest possible

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volume. The heating continued and adding of concentrated. HNO_3 until digestion was complete as shown by a light- colored, clear solution. The

digested samples were completed with deionized water to the mark in 25- ml volumetric flask.



Plate (1), (St.1): Shows the main sewage channel of Erbil city, wastewater exploitation for Agriculture and irrigation.



Figure (1): Satellite imagery of Erbil, shows vast farmlands around the main sewage Channel of Erbil City.

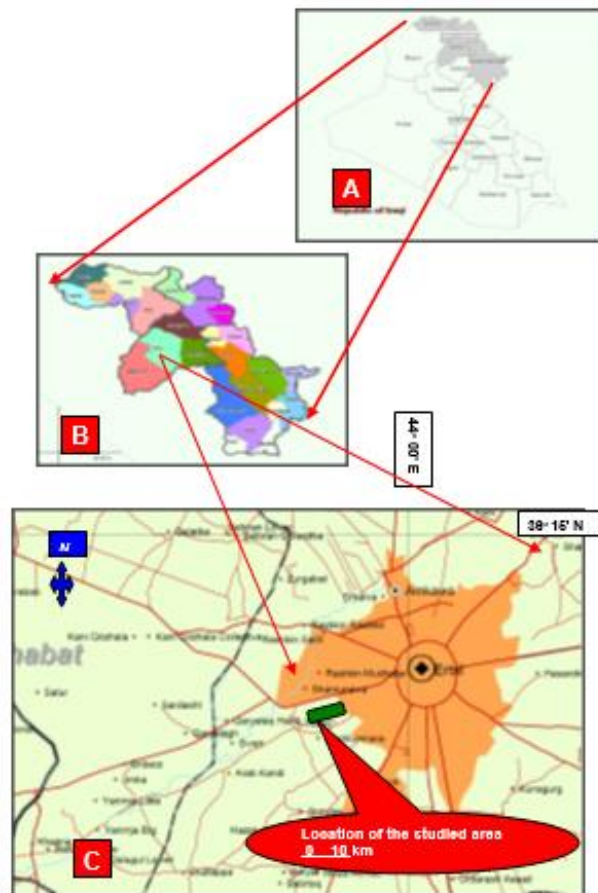


Figure (2): Map Shows

- A. Iraq, location of (Erbil) Province is indicated.
- B. Kurdistan Region of Iraq.
- C. Erbil City, location of the studied area is indicated (Green Rectangular).

spectrophotometer equipped with hollow- cathode lamp (electrodes discharge source lamp) for heavy metal analysis standard instrumental conditions as shown in (Table 1).

2.4 Statistical Analysis

Complete randomized Block Design (CRBD) was used for the analysis of the data by using the Micro soft program (STATGRAF Ver.4) obtained from the entire of the study using LSD test (Least Significant Differences) to determine the presence or absence of the statistical differences.

2.3 Determination of Heavy Metals in Water Samples

After digestion processes the concentration of lead, nickel and copper were determined by (PHILIPS Model SP9) atomic absorption

Table 1: Wave length and standard conditions of (PY UNICAM-PHILIPS Model SP9 AAS) for measurement of different heavy metals. (Milner and Whiteside, 1984)

elements	Wave length	Slit width	Lamp current	Flame gas
Pb	283	0.7	15	A-Ac
Ni	232	0.2	30	A-Ac
Cu	324	0.7	10	A-Ac

3. RESULT

Heavy metals concentration in the studied water (Table 2-4)

Among the mean content of dates and sites of sampling, the following are recognized:

3.1 Lead Concentrations in Irrigation Water

The results of pb concentration in wastewater Table 2, figure 3 indicated that there was significant differences ($P < 0.01$) between the studied sites and sampling dates with LSD($\alpha 0.01$) value of 0.06 and 0.11 respectively with total mean of 0.345 mg. l⁻¹ with a mean standard deviation of ± 0.025 was recorded from entire sampling period. Among the location of Tooraq wastewater, highest location mean of Pb concentration 0.417mg.l⁻¹ was observed in water samples collected from site three which differed significantly from all other sites. The lowest sewage sites mean pb content 0.301 mg.l⁻¹ was obtained from site one which was different significantly from the site three but insignificantly from the site two. Among the dates, the highest 0.358 mg.l⁻¹ date's mean of pb content was observed during mid of April, which was different significantly from mid of May and beginning of June but insignificantly from the other studied dates. The lowest date's mean of pb content 0.215 mg.l⁻¹ was obtained during the beginning of June was different significantly from March, April but insignificantly from the other.

3.2 Nickel Content in Irrigation Water

Table 3, figure 3 summarizes Nickel content in irrigation water in different sites in Tooraq village .We can observe the following results that were obtained throughout the period of the study:

Among the locations of Tooraq village, the following can be observed the Statistical analysis of data showed significant differences ($P < 0.01$) between the studied sites as a spatial variation with LSD ($\alpha 0.01$) value of 0.04, generally the sampling dates differed insignificantly as a temporal variation with LSD ($\alpha 0.01$) value of 0.05,, have been observed with total mean 0.161 mg. l⁻¹, the recorded fluctuation of Ni values around the general mean was ± 0.012 overall the investigation period. Highest Ni content 0.214 mg .l⁻¹ was observed in water sampled from site two that differed significantly from all other sites. The lowest Ni content 0.131mg.l⁻¹ was obtained from site one that differed significantly from site two. Among the dates, the following are recognized: The highest Ni content 0.239mg.l⁻¹ was observed in end of April that was different significantly from end of Nov., mid of Dec., Jan., and end of Feb. The lowest Ni content 0.127mg.l⁻¹ was obtained during the end of Nov.

3.3 Copper Concentrations in Irrigation Water

Table (4), figure (3) summarizes copper content in irrigation water in different sites in Tooraq village. The results of copper concentration in wastewater indicated that there was significant differences ($P < 0.01$) between the studied sites and sampling dates with LSD($\alpha 0.01$) value of 0.07 and 0.11 respectively with total mean of 0.367 mg. l⁻¹ with a mean standard deviation of ± 0.022 was recorded from entire sampling period. The highest Cu content 0.422 mg.l⁻¹ was observed in water sampled from site two. The lowest Cu content 0.336 mg.l⁻¹ was obtained from site three that differed significantly from site two, but insignificantly from site one. Among the dates of sampling, the following are recognized, the highest Cu content 0.540mg.l⁻¹ was observed in mid of May that was different significantly from other dates. The exception, for end of Nov.and mid of April. The lowest Cu content 0.246mg.l⁻¹ was obtained during end of Jan.

Table 2: Lead concentration (mg.L⁻¹) in water with mean \pm SD of different sampling sites of the studied area during the period of the study.

Site No.	29.Nov	14.Dec	30.Dec	15.Jan	29.Jan	13.Feb	28.Feb	15.Mar.	29.Mar.	15.Apr	30.Apr.	16.May	1.June	
Sewage water	S.1	0.326	0.351	0.275	0.383	0.313	0.321	0.267	0.395	0.371	0.256	0.242	0.212	0.207
	S.2	0.322	0.301	0.321	0.211	0.314	0.301	0.305	0.402	0.368	0.567	0.378	0.221	0.118
	S.3	0.406	0.421	0.414	0.310	0.282	0.320	0.402	0.501	0.512	0.589	0.599	0.345	0.321
Mean		0.351	0.358	0.337	0.301	0.303	0.314	0.325	0.433	0.417	0.471	0.406	0.259	0.215
Ground water	S.4	0.020	0.021	0.012	Nd.	0.019	0.021	0.028	0.020	0.022	0.020	0.022	0.015	0.016
Reference site	S.5	0.041	0.015	0.015	Nd.	0.018	Nd.	Nd.	0.017	0.017	0.018	0.015	0.022	0.012

Nd. Means non detected (0.00)

LSD (0.01) for studied sites = 0.068

LSD (0.01) for sampling dates = 0.110

Table 3: Nickel concentration (mg.L⁻¹) in water with mean \pm SD of different sampling sites of the studied area during the period of the study.

Site No.	29.Nov.	14.Dec.	30.Dec.	15.Jan	29.Jan	13.Feb.	28.Feb	15.Mar.	29.Mar.	15.Apr.	30.Apr.	16.May	1.June	
Sewage water	S.1	0.098	0.103	0.194	0.144	0.132	0.124	0.103	0.092	0.172	0.184	0.207	0.078	0.073
	S.2	0.173	0.152	0.127	0.097	0.214	0.295	0.197	0.287	0.259	0.205	0.294	0.293	0.190
	S.3	0.109	0.181	0.176	0.162	0.089	0.091	0.086	0.105	0.112	0.177	0.216	0.112	0.195
Mean		0.127	0.145	0.166	0.134	0.145	0.170	0.129	0.161	0.181	0.189	0.239	0.161	0.153
Ground water	S.4	0.015	0.016	0.015	0.013	0.015	0.022	0.025	0.015	0.015	0.016	0.020	0.018	0.016
Reference site	S.5	0.011	0.013	0.014	0.012	0.012	0.011	0.012	0.015	0.014	0.015	0.011	0.014	0.012

LSD (0.01) for studied sites = 0.044

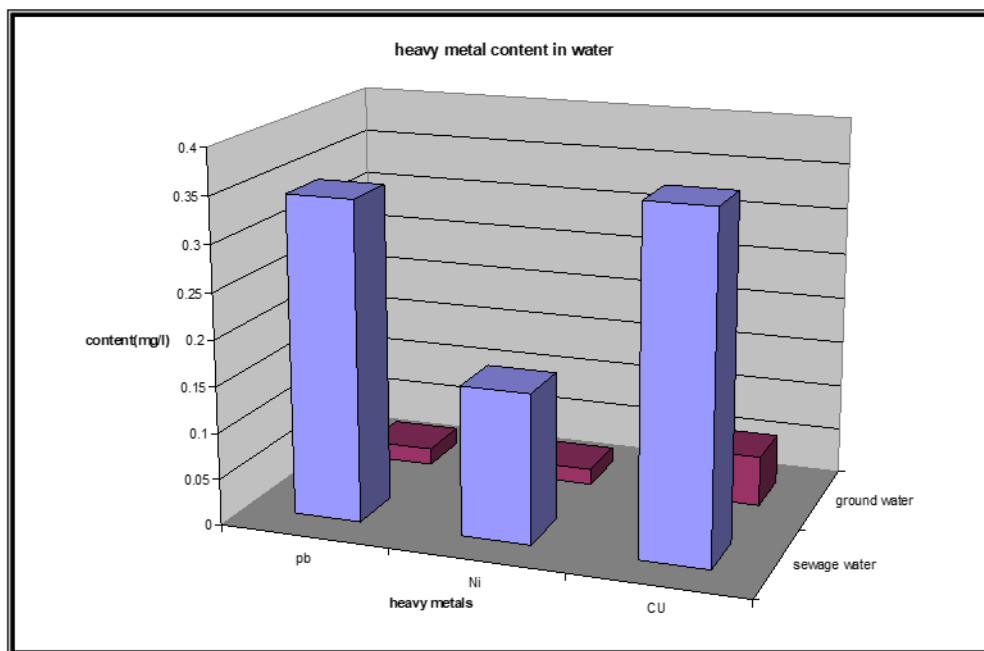
LSD (0.01) for sampling dates = 0.053

Table 4: Copper concentration (mg.L⁻¹) in water with mean ± SD of different sampling sites of the studied area during the period of the study.

Site No.	29.Nov.	14.Dec.	30.Dec.	15.Jan	29.Jan	13.Feb.	28.Feb	15.Mar.	29.Mar.	15.Apr.	30.Apr.	16.May	1.June	16.May	1.June	
Sewage water	S.1	0.316	0.321	0.309	0.212	0.217	0.214	0.206	0.323	0.315	0.499	0.424	0.544	0.564	0.343	0.127
	S.2	0.412	0.374	0.316	0.320	0.312	0.387	0.404	0.473	0.427	0.522	0.583	0.501	0.452	0.422	0.083
	S.3	0.413	0.309	0.305	0.352	0.208	0.201	0.209	0.212	0.305	0.424	0.403	0.576	0.447	0.336	0.114
Mean		0.380	0.335	0.310	0.295	0.246	0.267	0.273	0.336	0.349	0.482	0.470	0.540	0.488	0.367	0.022
Ground water	S.4	0.054	0.055	0.046	0.047	0.056	0.055	0.056	0.057	0.056	0.055	0.057	0.055	0.054	0.054	0.003
Reference site	S.5	0.051	0.048	0.042	0.051	0.042	0.043	0.043	0.054	0.050	0.048	0.048	0.043	0.045	0.047	0.004

LSD (0.01) for studied sites = 0.0742

LSD (0.01) for sampling dates = 0.119

**Figure 3:** mean concentration of heavy metal in different stations of main sewage canal and ground water of Hawler city.**Table 5:** Irrigation water quality guide lines, maximum permissible levels mg/kg of heavy metals in soil and vegetables.

parameter	Recommended maximum concentration (MPL)
Pb in waste water mg.l ⁻¹	2
Ni in waste water mg.l ⁻¹	0.20
Cu in waste water mg.l ⁻¹	0.20
Pb in soil mg.kg ⁻¹	100
Ni in soil mg.kg ⁻¹	50
Cu in soil mg.kg ⁻¹	100
Pb in vegetables mg.kg ⁻¹ .d.wt	0.3
Ni in vegetables mg.kg ⁻¹ .d.wt	67.9
Cu in vegetables mg.kg ⁻¹ .d.wt	73.3

Source: Botswana and FAO irrigation water quality (Emongor et al., 2005)

4. DISCUSSION

4.1 Lead Concentration in Irrigation Water

From Table (Table 5), it seems that value of lead in the studied sewage water ranged between 0.118-0.599 mg.l⁻¹. Lead concentration in irrigation water sampled from main sewage canal of Hewler city is, beyond maximum permissible level (Table 5) of pb in irrigation water which is 65 µg.l⁻¹ but lower than the 5.00 mg.l⁻¹, Jordan guidelines, (EPA, 2001; Al-Radaida, 2002). When we make a comparison between these results and the results of the other we can find that the concentration of pb come in agreement with results of a researcher in 2008 with the range 0.213-0.557 ppm (Othman, 2008). And near to the range 0.055-0.497 ppm for pb recorded by (Lak, 2007). This value was higher than that obtained 376.8 µg.l⁻¹ by researcher in 2005 on Dohuk wastewater (Sulaivaney, 2005). The present findings were come in contrast to researchers in 2001 who recorded low level of lead in ground and surface water on arable land (Karlik and Szpakowska, 2001). Also the values of Lead in the studied well water ranged between (nondetectable to 0.041 mg.l⁻¹), comparing the

present Lead values to the guideline values, it was less than the maximum acceptable level of pb in irrigation water proposed in 1985 (FAO Ayres, 1985). The results of pb in ground water in the present study were near to the outcomes (0.01 to 0.039 mg.l⁻¹) of pb recorded by (Toma, 2008). Lead values of two studied wells during studied period lies on save side. The results of this investigation indicated significant variability in both spatial and temporal points of view. This variation may be due to pH, alkalinity, ionic strength, weathering of mineral and soils, atmospheric decomposition, domestic effluents and dilution factor (WHO, 2004). Large amount of pb released from, civiler diesel engine, vehicle, automobile emission during march and April with sequence of rainfall the precipitated pb was percolated in to the waste water with formation of froth due to chemicals (soaps, detergents) and biosurfactants. (Lokeshwari and Chndrappa, 2006). The pb concentration generally increased at St.3 this may be due to the considerable amounts of pb released from automobiles, vehicle emission and diesel fuels washing up and the fact that the bottoms of streaming waters always contain high pollutants because they receive wastewater and other pollutants from all parts of the residential places, in addition to the presence of yard graves near this site (Othman, 2008).

4.2 Nickel Concentration in Irrigation Water

Nickel is used in many industrial and consumer product, including metal processing, steel foundries, chemical industry, coinage and special alloys. (WHO, 2004). Nickel concentration in irrigation wastewater ranged between 0.073-0.295 mg.l⁻¹ (Table 5) according to Iraqi standard 100 µg.l⁻¹; 0.2 µg.l⁻¹ Jordan guidelines, (Abbawi and Hassan, 1990; Al-Radaida, 2002). These finding are in agreement with those researchers (Lak, 2007; Othman, 2008). The results of this investigation was higher than the results were recorded 43 µg.L⁻¹ of Ni in wastewater in Mosul (Nazif et.al., 2006). However nickel concentration in ground water (0.011-0.025 mg.l⁻¹) sampled during the studied period in a permissible range this may be attributed to the geological formation in the studied area, on the other hand the nickel ability to moving and transporting for along distance it is absorbed strongly by Fe, Mn, Co. Ni content of ground water. The results of this investigation come in accordance with outcomes in 2008 (Toma,

2008). Ni concentration increased during the end of April and there were significant differences between studied sites and sampling dates this variation may be due to the addition of Ni through human activities, industrial activity from the Cd-Ni batteries rather than multi-source of Ni comes from industrial region, fertilizer, pesticides used in farm land.

4.3 Copper Concentration in Irrigation Water

Copper concentration in irrigation water ranged between 0.201-0.583 mg.l⁻¹ (Table 5) exceed (MPL) the standard concentration 0.2 mg.l⁻¹ of Cu in irrigation water of FAO (1998), German and Swiss standard by (Neis, 1984). But didn't exceed (MPL) of Cu in irrigation water (1 mg.l⁻¹) (Table 5) (Ayres and westcot 1985). Copper content in wastewater of main sewage canal is in a good agreement with 0.0293-0.596 mg.l⁻¹ that of recorded by (Sofi, 2008). And 0.211-0.693 mg.l⁻¹ that reported by (Othman, 2008). This may be due to the fact that the main sewage canal at Tooraq village always contains high pollutants because it received wastewater from all parts of Hewler. The values of present investigation close to the results recorded by various researchers reported low concentration of Copper in various irrigation water (Lak, 2007; Nazif et al., 2006; Karlik and Szpakowska 2001). The trace metal (Cu) in the wastewater may have a variety of sources, including household detergents, corrosion of metal pipes in municipal and domestic plumbing systems (Cu), and handling of coins Cu (Nsing and Faur, 1998). Ground water samples of the studied wells showed concentration of Cu 0.042-0.057 mg.l⁻¹ in the permissible range (Table 5) was with in the range of 0.023-0.452 mg.l⁻¹ obtained (Toma, 2008). Copper concentration in the current research was higher than 1.2-7.6 µg.l⁻¹ the results recorded in 2002 (Ganjo and Aziz 2002). And 6.42 µg.l⁻¹ results observed in 2008 found low levels of copper that below the MPL ≥ 0.2 ppm in Shaqlawa ground water (Toma, 2008). Concentration of copper in irrigation water increased during April, May and June this may be due to the increasing of atmospheric deposition of heavy metals. Also, agricultural practice, application of fertilizer, pesticides percolation in to water course (Szoke 2005). In addition to the increasing of the effluent, detergents from house hold.

5. CONCLUSION

Wastewater of the main sewage canal of Erbil City contains high amounts of pollutants. Wastewater of the main sewage canal of Erbil City poses health risks in addition to unpleasant landscape. Analysis the wastewaters showed that values of pb and Ni crossed the maximum permissible levels for irrigation, while Cu content was always below the maximum allowable limits. Always lead and Nickel concentrations in the wastewater were increasing during March and April while copper content was increasing during mid of May. Lead, Nickel and Copper values in the two wells under study were lying on the safe side during the studied period.

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