

Lead, Nickel and Copper Concentration in Soil Farm Irrigated by Wastewater of Hawler City Kurdistan Region, Iraq

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Abstract

More than two million people are thought to live in Erbil City, Northern Iraq, where this work was conducted. During low-level periods, the city's sewage discharge can reach 77760 m³/day, and during high-level periods, it can reach 108000 m³/day. Local farmers use about 225 hectares of dispersed farmland, all irrigated by raw sewage water, to produce raw vegetables for the local market. Some toxic heavy metals, namely Pb, Ni and Cu bioaccumulation rates in sewage, soil and some uncooked vegetables in five different locations/ farms were followed up (only bioaccumulation rates of Lead values were ranging from 45.09 to 67.21mg.kg⁻¹ in the soil of the studied locations. Nickel concentration values were from 15.03-29.79mg.kg⁻¹, and copper was ranging from 34.06 to 49.94 mg.kg⁻¹ which are within the range of (MPL).

Keywords: Wastewater, Pb, Ni, Cu, Bioaccumulation, Polluted soil.

Introduction:

Wastewater is a dilute mixture of various wastes from residential, commercial, industrial and other human activities. Sewage in general contains toxicants, pathogenic organisms, organic and inorganic matter among which are heavy metals. Wastewater is one of the largest disposal problem associated with irrigation for agricultural activities (Yates, 2000). Agriculture is the single largest user of fresh water resources, using a global average of 70% of all surface water supplies. Agricultural water is recycled back to surface water and or ground water. However, agriculture both cause and victim of water pollution (Cook et al., 2000). Just as not all waters are suitable for human consumption in the same way, not all types of waters are suitable for agriculture. Water containing impurities injurious to plant growth is not satisfactory for irrigation. The quality of suitable irrigation water is very much influenced by human activities and the constituents of the soil, which is to be, irrigated (Amin and Aziz, 2005).

Toxicity of ingested heavy metals has been an important human health issue for decades. The prevalence of contamination from both natural and anthropogenic sources has increased concern about the health effects of chronic low-level permanently exposures. Many researchers have shown that some common garden vegetables are capable of accumulating high levels of metals from the soil (LeCoultré, 2001). Heavy metals occur as natural constituents of the earth crust, and are persistent environmental contaminants since they cannot be degraded or destroyed. To a small extent, they enter the body system through food, air, and water and bio-accumulate over a period of time. The poisoning effects of heavy metals are due to their interference with the normal body biochemistry in the normal metabolic processes. The natural effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic (Duruibe et al., 2007). It is

obvious that Erbil's (Northern Iraq) sewage water is much polluted, assessed as causing irrigation problems and health risks for the community. Farmers here irrigate about 225 hectares by sewage water without any pre-treatment for the production of uncooked vegetables which consumed by about two million people as an important part of the human diet, which contain proteins, vitamins, minerals.

Materials and Methods

Soil sampling:

Composite surface 30 cm (assumed to be the root depth of the concerned vegetables) soil samples from 3 different nearer farmlands **Plate (1, 2), Figure (1)** were collected separately and properly labeled during the study period from (Nov.2021 until June. 2022).. The soil samples were then air- dried and crushed to pass through a 2 mm mesh sieve (Ryan 2001).



Plate (1), (St. 2): Showing farms that located in site two

Plate (2), (St. 3): Shows motor generator used for wastewater pumping.

Laboratory methods:

Digestion of soil samples for determination of heavy metals:

Soil samples were digested according to Rump, (1999) as shown in the following steps: About 3gm of dried sample were placed in a cylindrical 200 ml glass vessel fitted with an air or water condenser and 21ml hydrochloric acid, 35% HCl, and 7ml nitric acid 65 % HNO₃ were added .The mixture is kept at room temperature for several hours or over night. It is then heated to boiling point for 2 hours on a metal heating plate. The contents of the vessel are made up to 100 ml with deionized water. After sedimentation or filtration of the solution the elements can be determined.

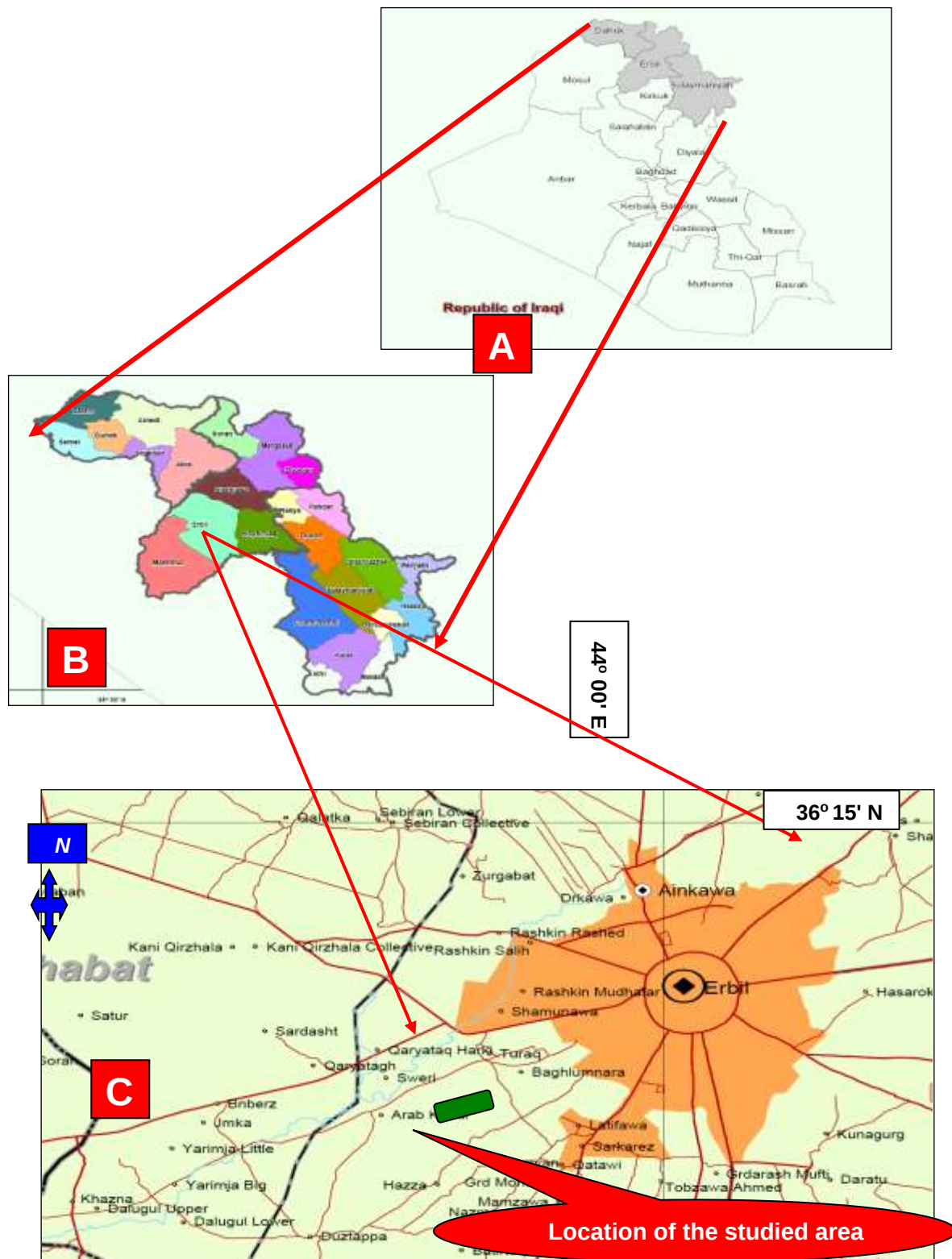


Figure (1): Map Shows;
 A. Iraq, location of Hewler (Erbil) Province is indicated.
 B. Kurdistan Region of Iraq.
 C. Erbil City, location of the studied area is indicated (Green Rectangular).

Determination of Heavy metals in soil samples

After digestion processes the concentration of lead, nickel and copper were determined by (PHILIPS Model SP9) atomic absorption spectrophotometer equipped with hollow- cathode lamp

(electrodes discharge source lamp) for heavy metal analysis standard instrumental conditions as shown in (Table 1).

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

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.

Results:

Heavy metals content in the studied soil (Figure 2-4)

Lead concentration in the soils of the studied locations in Tooraq village is represented in Figure 2 and 5. The results of lead concentration in soil indicated that there was significant differences ($P < 0.01$) between the studied sites and sampling dates with $LSD(\alpha 0.01)$ value of 1.9 and 3.1 respectively with total mean of 55.81 mg.kg⁻¹ with a mean standard deviation of ± 0.90 was recorded for studied farm from entire sampling period. The highest concentration general mean of pb 63.26 mg.kg⁻¹ in soil is observed in third location which differed significantly from all other location, except that of second location. The lowest pb content 47.12 mg.kg⁻¹ was found in the soil of fourth location which was differed significantly from all other location. The highest pb content (57.52 mg.kg⁻¹) was obtained during the mid of April significantly differed from the end of Feb.

Nickel concentration in the soils of the studied locations in Tooraq village is represented in (Figure 3 and 5) . The results of Nickel concentration in soil indicated that there was significant differences ($P < 0.01$) between the studied sites and between sampling dates. The highest concentration of Ni 27.80 mg .kg⁻¹ in soil is observed in third location which was differed significantly from second location. The lowest Ni content 19.15 mg .kg⁻¹ obtained in soil of fifth location, which was differed significantly from all other location except with four which differed insignificantly. The general mean of Ni concentration in the soils of studied farms regarded from 23.44 mg .kg⁻¹ with a mean standard deviation of ± 1.04 . The highest dates mean of Ni content 25.27 mg .kg⁻¹ was obtained during the beginning of June which was differed from the end of Feb. and the beginning of March but insignificantly differ from all other dates, the lowest dates mean of Ni content 21.77 mg.kg⁻¹ was observed during the end of Feb. Which differed significantly from the beginning of June but insignificantly from all other dates.

Copper concentration in the soils of the studied locations in Tooraq village is represented in (Figure 4 and 5). The results of copper concentration in soil indicated that there was significant differences ($P < 0.01$) between the studied sites and sampling dates with $LSD(\alpha 0.01)$ value of 1.9 and 3.2 respectively, The general mean of Cu concentration in the soils of studied farms regarded from 41.64 mg .kg⁻¹. With a mean standard deviation of ± 1.62 was recorded from entire sampling period. The highest concentration of Cu 46.65 mg .kg⁻¹ in soil is observed in first location which differed significantly from all other location. The lowest Cu concentration 36.76 mg .kg⁻¹ obtained in soil of fourth location, which was differed significantly from all other location, except that of fifth location which was different insignificantly. The highest concentration of cu 45.16 mg .kg⁻¹ in

soil observed during mid of May which was different significantly from all other sampling dates, the lowest concentration of Cu 39.67 mg .kg⁻¹ in soil observed during the mid of Jan.

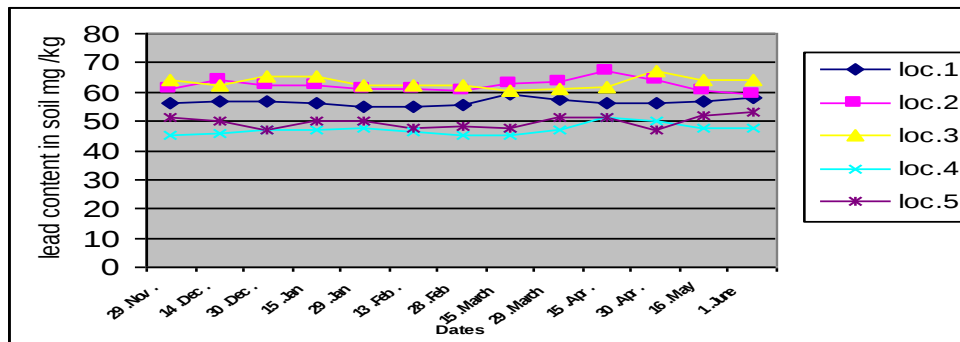


Figure (2) : Lead concentration (mg.kg⁻¹) in soil of different locations of the studied area during the period of the study.

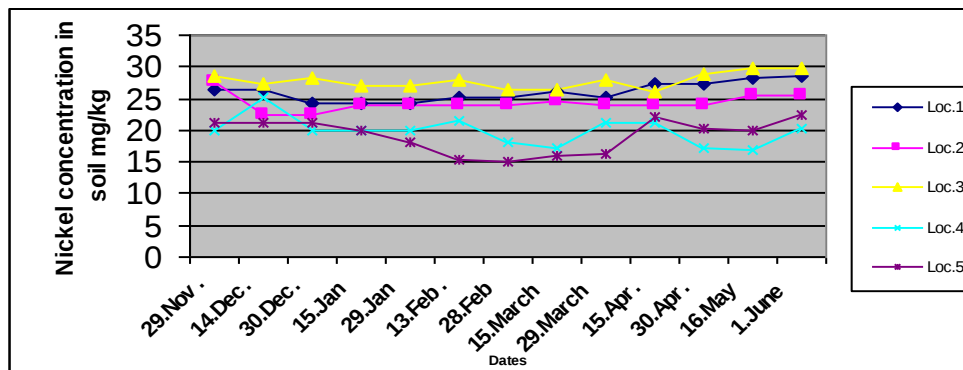


Figure (3) : Nickel concentration (mg.kg⁻¹) in soil of different locations of the studied area during the period of the study.

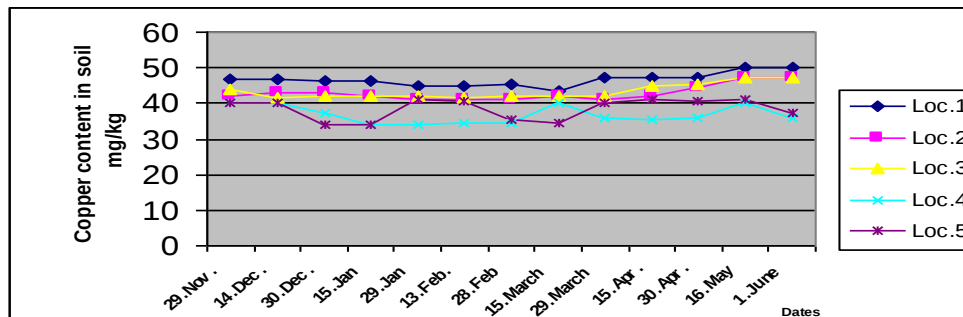


Figure (4) : Copper concentration (mg.kg⁻¹) in soil with of different locations of the studied area during the period of the study.

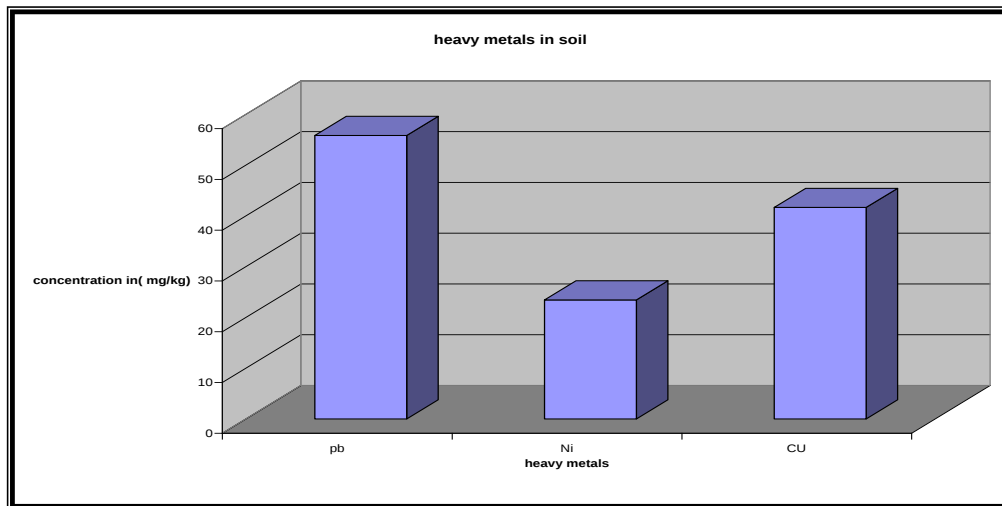


Figure (5): Mean concentration of heavy metals in soils of different location in Tooraq village and reference site in Hawler city.

Discussion

Lead concentration in studied soil:

Lead concentration **Figure (2)** ranged between 45.09-67.21mg.kg⁻¹ in soil sampled from farms of Tooraq village with grand mean of pb content 55.81 mg.kg⁻¹ that higher than maximum allowable level of 10mg.kg⁻¹ in soils stated by: (Bohn,2001) also was more than the average data (25-206 mg.kg⁻¹) that was reported by APHA (1998); and average data of 50-100 mg.kg⁻¹(Abdulbary 2000). The results of the present study higher than results obtained by Sulaivaney (2005) who confirmed undesirable concentrations of 24.5-35.36 mg.kg⁻¹ in farms that irrigated with wastewater of Duhok city but lower than results obtained by Amin, (1985) who reported high level of pb concentration of 59.5 and 175.4 mg.kg⁻¹ of soil along Hewler- Mosul highway. The highest concentration of 63.26 mg.kg⁻¹ in soil is observed in third location may attributed to that this element insoluble and is held tightly in soils (Darmody et.al., 2004). In the present study the accumulation of pb in third locations may be due to the always-crowded in large number of vehicles along Hewler-Mosul highway, The higher values are indicative of anthropogenic inputs, either due to excess application of fertilizers(Abreu et.al, 2005).

The lowest pb content (47.21 mg.kg⁻¹) was found in the soil of fourth location which was differed significantly from reference location this variation may be due to the always crowded in large numbers of motor vehicles and traffic density inside Hewler city along Hewler-kirkuk high way (Hääl et.al., 2008) (Lead) refining; lead is emitted during its mining and smelting activities, from automobile exhausts (by combustion of petroleum fuels treated with tetraethyl lead antiknock) and from old lead paints; Literature sources point to the fact that these metals are released into the environment by both natural and anthropogenic sources, especially mining and industrial activities, and automobile exhausts (for lead). They leach into underground waters, moving along water pathways and eventually depositing in the aquifer, or are washed away by run-off into surface waters thereby resulting in water and subsequently soil pollution. The availability of pb in soil is related to the soil characteristics, soil pH that affect the availability of most trace metals(Duruibe et.al, 2007).

Nickel concentration in studied soils:

Nickel concentration in soils of the studied locations was ranged between the minimum of 15.03 mg.kg⁻¹ and the maximum of 29.79 mg.kg⁻¹ (**Figure 3**).The general mean of Ni in soil of the studied farms was 23.44 mg.kg⁻¹ and revealing slight temporal variations between the sampling

dates and high spatial variation between the studied location, in this study Ni concentration was below the (MPL) of Ni concentration in the agricultural soil 40 mg.kg⁻¹ proposed by Bohn, (2001); values of 30-50 mg.kg⁻¹ mentioned by Abdulbary, (2000). Nickel contents in the present study were lower than 48.79-75.92 mg.kg⁻¹ of Ni in soil recorded by Alhamdani, (1987) in Mousle city. Nickel contents in the current study were much higher than 0.23 mg.kg⁻¹ in soil reported by Aganga et.al., (2005), also the same status for the results of El-Arby and Elbordiny, (2006) which recorded 0.97 mg.kg⁻¹ of Ni.

The results of Nickel concentration in soil indicated that there were significant differences between the studied sites; data revealed that the total content of these elements differed according to soil pH that for all metals studied the amount of extracted metal depends highly on the pH of the system the amount of extracted metal increases with decreasing values of PH. Buykx et.al,(2002), and water source used for irrigation, alkalinity, total suspended and dissolved solids (TDS), and chemical oxygen demand, organic matter in waste water. These conclusion coincide with those of Zerbe et.al., (1999) Agricultural areas are affected by atmospheric deposition of heavy metals. Also, agricultural practice, distances from road side, application of sewage sludge or phosphate fertilizers, pesticides, herbicide, insecticide, farmyard manure has lead to increased metal concentration in soils. Haugland et.al., 2002

Copper concentration in studied soils:

copper concentration in soils of the studied locations was ranged between the minimum of 34.06 mg.kg⁻¹ and the maximum value 49.94 mg.kg⁻¹ table (**Figure 4**).The mean of cu in soil of the studied farms 41.64 mg.kg⁻¹ was higher than the (MPL) of Cu concentration in the agricultural soil 20 mg.kg⁻¹ proposed by Bohn (2001); and 9-33 mg.kg⁻¹ of cu in the soil by APHA, (1998). But with in the range of 50mg.kg⁻¹ that mentioned by Abdulbary, (2000); 100 mg.kg⁻¹ proposed by Ewers, (1991). When we make a comparison between these results and the results of the others we can find that Cu contents 25 mg.kg⁻¹ in soil of Hewler city obtained by Amadi and Lazim, (1989) seem to confirm the present results. The total mean of Cu in soil of the studied farms 41.64 mg.kg⁻¹ was higher than the 19.4 mg.kg⁻¹ assessed by (Kucak and Blanusa, 1998). The accumulation of this element in soils is probably due to spraying with copper-based pesticides (Abrue et.al, 2005). Both the moisture and organic content of the soil play an important role in organic carbon and copper mobility. The mechanisms of soil and crop contamination may be due to repeated irrigation with waste water and evaporation during dry seasons. These observations coincide the records reported by (Adefemi et.al., 2007). Heavy metal-mediated toxicity in the environment is dependent on bioavailable metal concentrations both internal and external to microbial cells. Both internal and external metal bioavailabilities are influenced by multiple factors in the soil environment. External factors include pH, redox potential, ionic strength, organic matter and clay content (Rensing and Maier, 2003) cation exchange capacity (CEC), organic matter content, quantity and type of clay minerals, the content of the oxides of iron (Fe), aluminum (Al), and manganese (Mn), and the redox potential determine the soil's ability to retain and immobilize heavy metals (Aydinalp and Marinova, 2003).

Conclusion

The studied soils seem to reflect different metal contents, and subsequently the studied vegetables were bio-accumulating different concentrations of such metals. Extreme health risks are predicted concerning Pb levels in the studied vegetables, however, always its concentration was higher than the allowable limits, in contrast to Nickel and Copper contents. Generally Lead, Nickel, and Copper content in soils seem to increase during dry seasons.

References:

- A.P.H.A (1998). Standard Methods for the Examination of Water and Wastewater. 20th.Ed. America Public Health Association. 1015 Fifteenth Street.NW. Washington, DC. 20005-2605.
- Abdulbary, A. (2000). Environmental Pollution, Soil and Plant. College of Agriculture Univ. of Zakazik, Egypt. Universities publishing House.
- Abreu, C. A.; Rajj, B. V.; Abreu, M. F.; González, A. P., (2005). Routine soil testing to monitor heavy metals and boron. Sci. Agric. (Piracicaba, Braz.), 62, 6, p.564-571.
- Adefemi, O. S. Olaofe, O. and Asaolu, S. S., (2007). Seasonal variation in heavy metal distribution in the sediment of major dams in Ekiti-state. Pakistan Journal of Nutrition 6 (6): 705-707.
- Aganga, A. A ; Machacha, S.; Sebolai, B. and Thema, T. and Marotsi, B. B. (2005). Minerals in soils and forages irrigated with secondary treated sewage water in Sebele, Botswana. Journal of Applied Sciences. 5 (1): 155-161.
- Al-Hamdani, R. A. A., (1987). Industrial pollution by trace heavy metals on soil and plants. M. Sc. Thesis, Univ. of Mosul, Iraq.
- Amadi, T. H and Lazim, I. T., (1989). A study on micronutrients distribution in northeastern Iraq soil. Zanco Series, 2(4):19-38.
- Amin, K.N. and Aziz, S.Q. (2005). Feasibility of Erbil Wastewater Reuse for Irrigation, Zanco J. Vol.17, No.2: p 63-75.
- Amin, M.F., (1985). Pollution of soil with certain heavy metals and their impact on leaf litter decomposition and bacterial and fungal populations of soil Hawler city- Kurdistan region- Iraq. M. Sc. Thesis, Univ. of Salhddin.
- Aydinalp, C, Marinova. S, (2003). Distribution and forms of heavy metals in some agricultural soils. Journal of Environmental Studies, 12, 5, 629-633.
- Bohn, H.L.; Mcneal, B. L. and Oconnor, G. A. (2001). Soil Chemistry. Third edition. John Wiley & Sons, Inc. New York.
- Buykx, S. E.J. ; VandenHoop, M. A. and Loch, J.P.G. (2002). Dissolution kinetics of heavy metals in dutch carbonate and sulfide rich fresh water sediments. J. Environ. Qual. 31: 573-580.
- Cook, J. L.; Bunmann, P.; Jackman, J. A. and Stevenson, D. (2000): Pesticide characteristics that affect water quality. Texas Agriculture Extension Series. Texas A&M University system. USA.
- Darmody, R. G ; Marlin, J.C.; Talbott, J.; Green, R.A.; Brewer, E.F. and Stohr, C., (2004). Ecological risk assessment, Dredged Illinois river sediment: plant growth and metal uptake. J. Environ. Qual. 33: 458-464.
- Duruibe, J. O.; Ogwuegbu, M. O. C. and Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. International Journal of Physical Sciences 2 (5):112-118.
- Duruibe, J. O.; Ogwuegbu, M. O. C. and Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. International Journal of Physical Sciences 2 (5):112-118.
- El-Arby, A.M. and M.M. Elbordiny (2006). Impact of reused wastewater for irrigation on availability of heavy metals in sandy soils and their uptake by plants. J. Appl. Sci. Res.; 2(2): 106-111.
- Ewers, U., (1991). Standards, guideelines, and legislative regulations concerning metals and their compounds. In: Merian E, ed. Metals and their Compounds in the Environment Occurrence, Analysis and Biological Relevance. Weinheim: VCH, 458-468. by Ittana, (2002).
- Hääl, M. L.; Sürje, P. and Rõuk, H., (2008). Traffic as a source of pollution. Estonian Journal of Engineering, 14(1), 65–82.

- Haugland T.; Steinnes E. and Frontasyeva M.V.,(2002). Trace metals in soil and plants subjected to strong chemical pollution. [Water, Air, and Soil Pollution](#), 137(1): pp. 343-353.
- Kucak, A.and Blanusa, M.,(1998). Comparison of two extraction procedures for determination of trace metal in soil by atomic absorption spectrometer. *Arh hingrada toksikol*, 49(4): p327-334.
- LeCoultre, T.D. (2001). A meta- analysis and risk assessment of heavy metal uptake in common garden vegetables, M.Sc. Thesis, State University, East Tennessee.
- Milner, B. A and Whiteside, P. J., (1984). Introduction to Atomic Absorption Spectrophotometry. Third edition. Pye Unicame Ltd, England. 82 pp.
- Rensing, C.and Maier, R.M.,(2003). Issues underlying use of biosensors to measure metal bioavailability. [Ecotoxicol Environ Saf](#). 56(1):140-147.
- Rump, H.H. (1999). Laboratory Manual for the Examination of Water, Wastewater and Soil. Third edition. Wiley-VCH. New York. 225 pp.
- Ryan,J.;Estefan, G. and Rashid, A.(2001). Soil and Plant Analysis Laboratory Manual. Second edition. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. 172 pp.
- Sulaivaney, R.O.H. (2005). Heavy metal contamination in some vegetables irrigated wastewater of Duhok city-Kurdistan region-Iraq.M.Sc.Thesis,Univ.of Duhok.
- Yates, M.V.(2000). Pathogens in reclaimd water. University of California riverside.USA.
- Zerbe, J. ; Sobczynski, T. ; Elbanowska, H. Siepak, J.,(1999). Speciation of heavy metals in bottom sediments of lakes. *Jornal of. Environ.Studies*. 8(5): 331-339.

تركيز الرصاص والنيكل والنحاس في تربة المزرعة المروية بالمياه العادمة لمدينة هولير، إقليم كردستان، العراق

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الملخص

أكثر من مليوني شخص يعيشون في مدينة أربيل، شمال العراق، حيث تم إجراء هذا العمل. خلال فترات المستوى المنخفض يمكن أن يصل تصريف مياه الصرف الصحي في المدينة إلى 77760 م³/يوم، وخلال فترات المستوى المرتفع يمكن أن يصل إلى 108000 م³/يوم. ويستخدم المزارعون المحليون حوالي 225 هكتارًا من الأراضي الزراعية المنقرقة، المروية جميعها بمياه الصرف الصحي الخام، لإنتاج الخضروات النيئة للسوق المحلية. بعض المعادن الثقيلة السامة، وهي؛ تمت متابعة معدلات التراكم الحيوي للرصاص والنيكل والنحاس في مياه الصرف الصحي والتربة وبعض الخضروات غير المطبوخة في خمسة مواقع/ مزارع مختلفة (كانت معدلات التراكم الحيوي لقيم الرصاص فقط تتراوح بين 45.09 إلى 67.21 ملجم.كجم-1 في تربة المواقع المدروسة. وتراوح قيم تركيز النيكل من 15.03-29.79 ملجم. كجم-1، وتراوح تركيز النحاس من 34.06 إلى 49.94 ملجم.كجم-1 وهي ضمن نطاق الحد الأقصى المسموح به.

الكلمات المفتاحية: مياه الصرف الصحي، الرصاص، النيكل، النحاس، التراكم الحيوي، التربة

الملوثة