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Assessment of Heavy Metal Concentration in Soil and Plant and Evaluation of Bioconcentration Factor at Loumbila Market Gardening Perimeters, Burkina Faso

Bambara Telado Luc [a*], Kabore Karim [b], Derra Moumouni [c], Tougma Kiswendsida Alain [d], Ousmane Ibrahim Cisse [e] and Francois Zougmore [e]

[a] Institute of Sciences and Technology, Ouagadougou, Burkina Faso.
[b] Physics Department, Virtual University, Ouagadougou, Burkina Faso.
[c] Physics Department, University Norbert Zongo, Koudougou, Burkina Faso.
[d] Laboratory of Materials and Environment, University Joseph Ki-Zerbo, Ouagadougou, Burkina Faso.
[e] Physics Department, University Joseph KI-ZERBO, Ouagadougou, Burkina Faso.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Agricultural soil quality deterioration resulting from an increase in the level of heavy metals is becoming more and more pronounced, thus raising the question on the safety status of human health and the environment. Determination of heavy metal concentration in soils and plants from Loumbila market gardening (Burkina Faso), and calculation of bioconcentration factor were undertaken. The heavy metals such as copper (Cu), nickel (Ni), lead (Pb), chromium (Cr), cadmium (Cd) and zinc (Zn) were measured using an atomic absorption spectrometer, model PERKIN ELMER AANALYST 200.
In the soil where the pepper was grown, the concentration of chromium was 175 mg/kg, which is higher than the concentration limit which is 150 mg/kg. Also the concentrations of lead in the soils of onion (118 mg/kg), green bean (118 mg/kg), carrot (178 mg/kg) and pepper (135 mg/kg) were

**Corresponding author: E-mail: telado.luc.bambara@gmail.com;*

above the limit which is 100 mg/kg. The concentrations of chromium in Onion leaves (3.72 mg/kg), onions (4.65 mg/kg), lettuce (4.89 mg/kg), green beans (5.89 mg/kg) and bell peppers (3.56 mg/kg) were concentrations above the limit established by the FAO/WHO, which is 2.3 mg/Kg. The concentrations of lead in carrot, onion leaf, onion, lettuce, green bean and bell pepper were above the limit proposed by FAO/WHO.

The bioconcentration factors show that the onion leaf (0.731), onion (0.929), lettuce (0.876), green bean (0.987) and bell pepper (0.858) are the plants that accumulate zinc and the carrot (0.524) accumulates nickel. The bioaccumulation of the metals in the vegetable from Loumbila market gardening decreased in the order of onion > lettuce > green bean > bell pepper > onion leaves > carrot.

Keywords: Heavy metals; concentration; bioconcentration factor; soil; plant.

1. INTRODUCTION

In countries witnessing rapid industrialization, one of the most pressing environmental issues challenging the global sustainable development agenda is environmental pollution due to toxic metals. Metal pollutants gain entry into the air, soil, and water bodies via natural and anthropogenic routes, including domestic and agricultural use, metals mining and smelting activities, and other industrial productions [1]. Rapid industrialization, inappropriate utilization and disposal of toxic trace metal containing wastes, excessive use of fertilizers and pesticides are the main causes of toxic trace metals in agricultural soils, which become hazardous to human and environmental health. The main heavy that contribute to environmental pollution, particularly in areas with high anthropogenic activities are lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), iron (Fe), zinc (Zn), chromium (Cr). The capacities of heavy metal uptake and accumulation, mechanisms of metal concentration, exclusion and compartmentation vary among different plant species and also between various parts of plants [2, 3].

The problem of contaminated soil on the perimeters of market gardening is very worrying today in urban cities in emerging countries. Heavy metals such as lead, cadmium, copper, zinc and mercury cannot be biodegraded and therefore persist in the environment for long periods. The accumulation of heavy metals in the environment can affect human and animal health [4]. Understanding the origin of heavy metal pollution, the phenomenon of accumulation in soils, and their possible interactions with soil constituents is a priority in many environmental studies. The accumulation of heavy metals in agricultural soils presents an increased risk of food pollution and a potential risk to human health [5].

The use of waste water can increase crop productivity, but also increases the contamination of heavy metals (Pb, Ni, Cd, Cu, Zn, Mn, Cr…) in the plants. The plants (*Amaranthus, Fenugreek and Spinach*) heavy metals concentrations depend on the soil concentration [6] [7]. The vegetable from the contaminated soil can accumulate high concentrations of heavy metal and cause some serious risks to human health [8]. As an example, John *et al.*, show that the vegetable and the soil from Kaduna city are polluted by Pb, Cd and Cr [9]. The concentration of Pb in cabbage, (10.51), lettuce (10.19), green pepper (9.44), hot pepper (7.61) and ayoyo (9.05) from some parts of Accra were higher than the FAO/WHO maximum recommended limit of 0.30 mg/kg for Pb [10].

The concentration of cadmium (Cd), lead (Pb) and chromium (Cr) in vegetable species (*Telferia occidentalis, Talinum triangulare, Ocimum gratissimum, Celosia argentea, and Amaranthus Viridis*) cultivated in Lagos farmlands and floodplains, were above standard limit [11]. Heavy metals in plants can accumulate in the human body and cause diseases such as Colon, stomach, liver, lung, bladder and kidney cancers [12] [13] [14].

Trace metal elements contained in wastewater are toxic and non-biodegradable substances that accumulate in the soil and, depending on biogeochemical conditions, can lead to soil degradation [15]. Studies show that even treated wastewater also contains heavy metals that can contaminate crops when used for irrigation [16].

Metal elements such as Fe, Zn, Mo, Cu, Co and Cr are known to be essential elements in the living organism. However, a high concentration can be potentially toxic [17].

Pollution can be due on the one hand to the use of wastewater for irrigation and on the other hand to the proximity of the production sites of major urban traffic axes and industries that emit heavy metals [18]. The accumulation of heavy metals in soil can be due to the irrigation water and thereafter contaminate the vegetable and fruit. Heavy metal concentrations in vegetable are different from those of the fruits revealing the difference between their capacities for accumulation [19].

The contamination of soils, plants and water by heavy metals constitutes an important public health issue that requires more information on the various sources of pollution and the rate of contamination. Preliminary studies on heavy metal pollution in the market gardening areas of Ouagadougou and Loumbila have revealed a deterioration in soil quality [20]. Concentration values of certain metals (Cr, Mn, Ni and Hg) in irrigation water were found to be above standards. A high concentration of chromium was observed in tomatoes [21]. The alert resulting from this study on the potential risk of pollution of agricultural soils and transfer of pollutants into the food chain justifies the need to continue studies on the market gardening areas of Ouagadougou and Loumbila on other plants.

The bioconcentration factor (BCF) for the heavy metals in the leafy vegetables decreased in the order of Cd (5.85) > Hg (3.83) > Fe (0.31) > Zn (0.11) > Cr (0) = Ni (0). The capacity of leafy vegetables to accumulate Fe, Cd, Zn, Cr, Ni, and Hg decreased in the order of *Amaranthus Spinosa* > *Corchorus Olitorious* > *Brassica Oleracea* > *Brassica Rapa*. In the non-leafy vegetables, the BCF decreased in the order of Hg (2.46) > Zn (0.12) > Fe (0.1) > Cd (0) = Cr (0) = Ni (0). The capacity of non-leafy vegetables to accumulate Fe, Cd, Zn, Cr, Ni, and Hg decreased in the order of *Daucus carota* > *Raphanus sativus* > *Allium cepa* ~ *capsicum annuum*. The low BCF for Cr and Ni in all vegetable species may be due to the toxicity of the crops [22].

Based on the work carried out on heavy metals in plants in West Africa (Ghana, Nigeria, etc.) in general and in Burkina Faso in particular, this study focused on copper (Cu), chromium (Cr), zinc (Zn), lead (Pb), nickel (Ni), and cadmium (Cd) in the most consumed plants [10] [11] [20].

The objective of this study is to estimate the concentration of heavy metals (Cu, Cr, Zn, Pb, Ni, and Cd) in soil and vegetables at the Loumbila market gardening sites and evaluate the bioconcentration factor.

2. MATERIALS AND METHODS

2.1 Study Area

In this study, the vegetable samples were collected in different agricultural areas at the Loumbila market garden. Distance of 18 kilometers from Ouagadougou capital city of Burkina, Loumbila market garden is expanding around the dam. The dam is located at a longitude of 01˚24'07.4 West and a latitude of 12˚29'35.8 North with a water capacity of 42.2 million cubic meters. It is used by market gardeners to irrigate plants [23].

Loumbila’s market gardening areas have a much diversified production of vegetables, namely onion, tomato, okra, zucchini, African eggplant, eggplant, pepper, bell pepper, lettuce, cabbage, carrot, green bean, and potato. Market garden products from Loumbila can be found in most markets in the city of Ouagadougou or exported to neighboring countries. These reasons led to the choice of the Loumbila market gardening areas to carry out this study, by choosing the most consumed vegetables in the city of Ouagadougou.

2.2 Samples and Sampling Techniques

The samples of soils and vegetables were collected from the market garden of Loumbila.

The agricultural soil sample was collected at three or four different points on the diagonal profile of each site. The soils from the different points were mixed and kept in sterile plastic bags.

Sampling was carried out at regular intervals and over the entire plot for each type of sample. The different plants were sampled by separating the different plant tissues (roots, leaves, stems and fruits) of each plant using a ceramic knife to avoid contamination. To measure an average concentration, at the plot level, the samples were mixed by family and constitute an aliquot. Plant samples for analysis of heavy metals were placed in plastic bags.

The vegetables were washed up with tap water thoroughly to remove the attached dust particles, soil, unicellular algae, etc. Then they were washed with distilled water and finally with deionized water. The washed vegetables were dried at room temperature to remove surface water.

Carrot, onion leaves, onion, lettuce, green beam and bell pepper were collected during the vegetable sampling.

2.3 Laboratory Analysis

The soils and vegetables samples were analysed for heavy metals such as chromium (Cr), zinc (Zn), lead (Pb), nickel (Ni), cadmium (Cd), and Mercury (Hg) using Atomic Absorption Spectrometer, model PERKIN ELMER AANALYST 200.

Mechanical preparation consisted of sieving the soil samples through a certified 200 mesh (75 microns) sieve. The test portion used is one gram. The soil samples were weighed using a PA214C balance from OHAUS PIONEER, with a precision of 10^{-4} g and a capacity of 200 g. The mineralization consisted in mineralizing the samples weighed by aqua regia (2.5 mL of HNO_3 + 7.5 mL of HCl) at a controlled temperature (water bath at 90 ± 50°C) for one hour. The acids used are of the analytical type. The solution obtained is consequently brought to 100 mL by way of demineralized water with a conductivity of less than 2 µS / cm.

The vegetable sample (1 g) was weighed into a 100 ml volumetric flask and concentrated acids of 10.0 mL of concentrated sulphuric acid were added to each sample. The samples obtained after adding concentrated acid were gently on a hot plate, stirring occasionally until the powder completely dissolved in the solution (about 10 to 15 minutes). Then 10ml of distilled water was added and the whole was heated gently for a few minutes (5 to 10 minutes). Finally, the solution was left to stand for it to settle well and the filtrate was taken for analysis.

The analysis results are valid based on the performance of the analysis methods used (limit of detection and quantification, data of duplicates and reference materials inserted in the chemical preparation of the samples, selectivity of the method, the robustness of the method, data for control solutions, data for chemical blanks, etc.).

2.4 Bioconcentration Factor

Bioconcentration factor (BCF) is defined as the ratio of the metal concentration in the plant to the metal concentration in the soil. BCF measures the heavy metal accumulation efficiency in plants. When the BCF values are greater than 1, indicates that the species is a hyperaccumulator of Heavy Metals [1-3 ; 22; 24-25].

$$BCF = \frac{heavy\ metal\ concentration\ in\ plant}{heavy\ metal\ concentration\ in\ soil}$$

3. RESULTS AND DISCUSSION

3.1 Concentration of Heavy Metals in Agricultural Soils

Table 1 presents the concentrations of Cu, Ni, Cr, Cd, Pb and Zn in some market gardening soils at Loumbila. The soils were taken according to the plant produced. The soils for the production of onions, green beans, lettuce, carrots and bell peppers are the subject of this study.

The copper concentrations in the studied soils vary from 33 mg/kg to 51 mg/kg with an average of 37.4 mg/kg. The copper concentrations obtained in this study were all below the limit value for copper in agricultural soils.

The studied soils present nickel concentrations which were between 19 mg/kg and 29 mg/kg with an average of 23 mg/kg. The limit value for nickel in soils is 50 mg/kg, which is higher than the values obtained in this study.

Table 1. Concentration of some heavy metals in the market gardening soils of LOUMBILA

	Concentration in ppm (mg/kg)					
	Cu	**Ni**	**Cr**	**Cd**	**Pb**	**Zn**
Soil of onion and green beans	34	29	83	ND	118	79
Soil of Lettuce	35	24	69	ND	46	80
Soil of bell pepper	33	22	66	ND	82	82
Soil of carrot	34	21	62	ND	178	90
Soil of pepper	51	19	175	ND	135	107
Average	37.4	23	91	ND	111.8	87.6
Limits values	100	50	150	3	100	300

On the soil where the pepper was grown, the concentration of chromium was 175 mg/kg, which is higher than the concentration limit which is 150 mg/kg. The other soils had chromium concentrations below the limit. This high concentration of chromium in soil can lead to a high concentration of chromium in the pepper.

In all soil samples analyzed in this study, the cadmium concentration was below the detection limit.

The concentration of zinc in soils varies between 79 mg/kg and 107 mg/kg with an average of 87.6 mg/kg. The zinc concentrations in the studied soils were below the limit of 300 mg/kg.

The results of this study show that the concentrations of lead in the soils of onion, green bean, carrot and pepper were above the limit which is 100 mg/kg. These high lead concentrations in soils can lead to high concentrations of lead in onions, green beans, carrots and peppers. Lead concentrations in lettuce and pepper soils were below the limit.

The mean concentration of heavy metals in the agricultural soils samples from Loumbila market gardening decreased in the order Pb > Cr> Zn > Cu > Ni > Cd.

3.2 Concentration of Heavy Metals in Some Plants

Table 2 presents the concentrations of Cu, Ni, Cr, Cd, Pb and Zn in carrot, onion leaf, onion, lettuce, green bean and bell pepper sampled from some soils of Loumbila.

The concentrations of copper in the studied plants vary from 16.06 mg/Kg to 19.81 mg/Kg. All measured concentrations in the studied plants were below the limit established by the FAO/WHO.

The concentrations of chromium in the studied plants vary from 1.3 mg/Kg to 5.89 mg/Kg. Onion leaves, onions, lettuce, green beans and bell peppers have chromium concentrations above the limit established by the FAO/WHO, which is 2.3 mg/Kg. Carrots have a chromium concentration lower than the limit established by the FAO/WHO. Consumption in large quantities of onion leaf, onion, lettuce, green bean and pepper from the study area can be the cause of diseases such as stomach cancer, and intestine, … [14].

Concentrations of lead in carrot, onion leaf, onion, lettuce, green bean and bell pepper were above the limit proposed by FAO/WHO. The high concentrations may be due to the high concentrations of lead observed in crop soils. The lettuce growing soil had a lead concentration below the limit whereas the lettuce leaves have a lead concentration above the FAO/WHO limit. This high concentration of lead in lettuce leaves may be because lettuce is accumulating lead. Consumption in large quantities of these products from the study area can be the cause of cardiovascular disease (hypertension), kidney damage [12], and liver disease [14].

The concentrations of zinc in carrot, onion leaf, onion, lettuce, green bean and pepper were higher than the limit proposed by the FAO/WHO although the concentrations in the soils were lower. These high concentrations of zinc in carrots, onion leaves, onions, lettuce, green beans and bell peppers show that the studied plants were hyper-accumulators of zinc.

The mean concentration of heavy metals in the edible portions of the vegetables decreased in the order Zn > Cu > Pb > Ni > Cr > Cd.

Table 2. Concentrations of heavy metals in the studied plants

	Concentration in ppm (mg/kg)					
	Cu	**Ni**	**Cr**	**Cd**	**Pb**	**Zn**
Carrot	17.6	11	1.3	ND	27.02	42.95
Onion leaves	16.4	11.16	3.72	ND	10.48	57.72
Onion	19.81	10.05	4.65	ND	11.52	73.37
Lettuce	16.9	5.09	4.89	ND	15.44	70.1
Green bean	16.06	8.58	5.89	ND	4.09	78
Bell pepper	19.65	7.01	3.56	ND	1.73	70.39
Average	17.74	8.82	4.00	ND	11.71	65.42
FAO/WHO safe limit	40	-	2.3	0.2	0.3	20

3.3 Soil-Plant Concentration

Fig. 1 presents a histogram comparing the concentrations of copper, nickel, chromium, cadmium, lead and zinc in the carrot and its cultivation soil.

The concentration of lead was the highest in carrot cultivation soil, while zinc is the metal with the highest concentration in carrot. Carrots accumulate less chromium than the other heavy metals studied.

Fig. 2 presents a histogram comparing the concentrations of copper, nickel, chromium, cadmium, lead and zinc in lettuce and its growing soil.

Zinc has a high concentration in lettuce and in its growing soil. Chromium has a fairly high concentration in soil, while its concentration in lettuce is the lowest. This reflects a high absorption of zinc and a low absorption of chromium by lettuce.

Fig. 3 presents a histogram of the concentrations of heavy metals in green beans and their cultivation soil.

Lead has a high concentration in green bean soil but a low concentration in the green bean. Zinc has a high concentration in green beans and very close to the soil concentration. This reflects a high absorption of zinc and a low absorption of lead by the green bean.

Fig. 4 presents a histogram of the concentrations of heavy metals in the pepper and its cultivation soil.

Zinc has a high concentration in the pepper and in its cultivation soil. Lead has a fairly high concentration in soil, while its concentration in pepper is the lowest. This reflects a high absorption of zinc and low absorption of lead by the bell pepper.

Fig. 5 presents a histogram comparing the concentrations of copper, nickel, chromium, cadmium, lead and zinc in the onion, these leaves and its cultivation soil.

Onion growing soil has a high lead concentration and a low nickel concentration. Onion leaves have a high zinc concentration and a low chromium concentration. Onion has a high zinc concentration and a low chromium concentration. This reflects a high absorption of zinc and a low absorption of chromium by the onion and these leaves. The onion accumulates more copper, chromium, lead and zinc than these leaves. As for onion leaves, they accumulate more nickel.

The results of soil and plant concentrations show that zinc is the heavy metal that accumulates the most in onion leaf, onion, lettuce, green bean and pepper. Lead and chromium accumulate less in most studied plants.

3.4 Bioconcentration Factor

Table 3 presents the bioconcentration factors of copper, nickel, chromium, lead and zinc in carrot, onion leaf, onion, lettuce, green bean and bell pepper.

The carrot has a bioconcentration factor that varies from 0.021 to 0.524. The most accumulative metal in the carrot was a nickel.

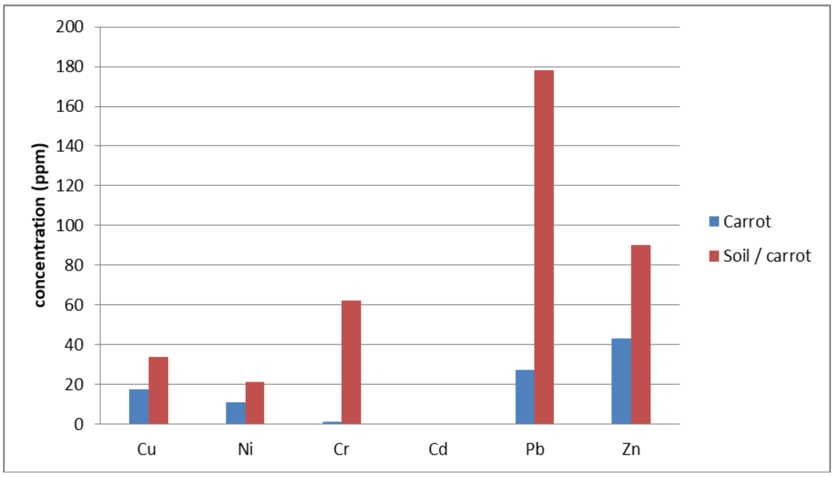

Fig. 1. Concentration of heavy metals in the carrot and its cultivation soil

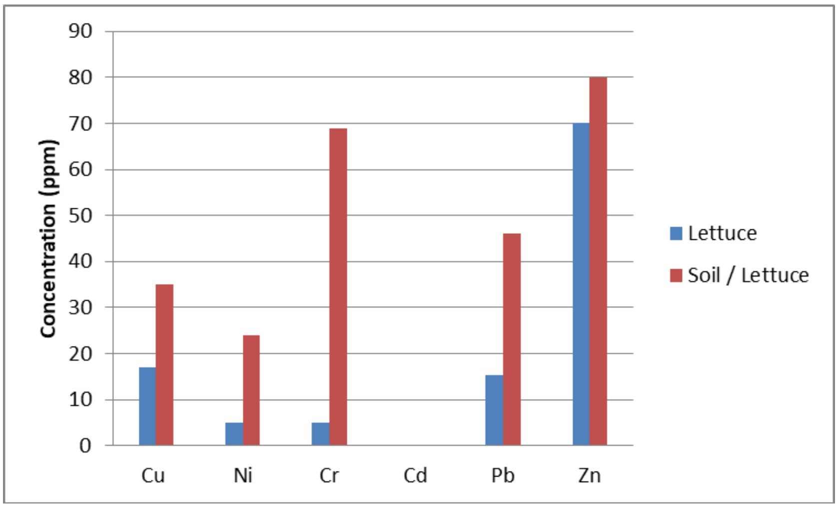

Fig. 2. Concentration of heavy metals in lettuce and its growing soil

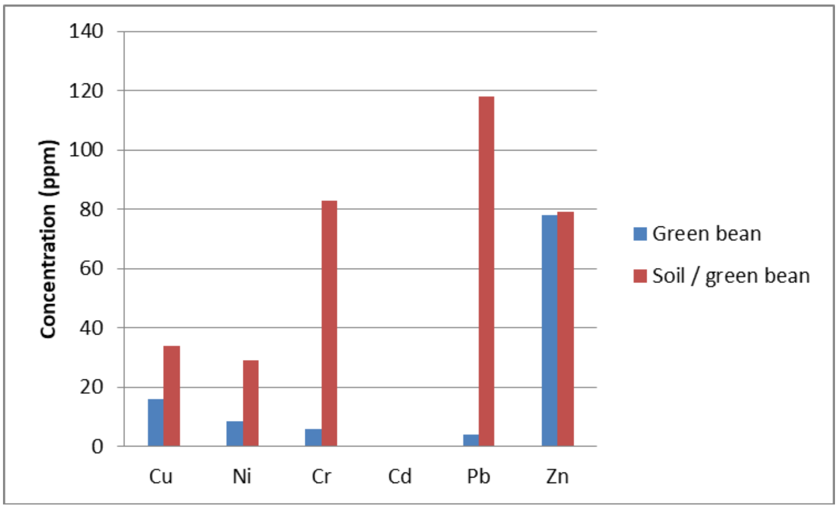

Fig. 3. Concentration of heavy metals in green beans and their growing soil

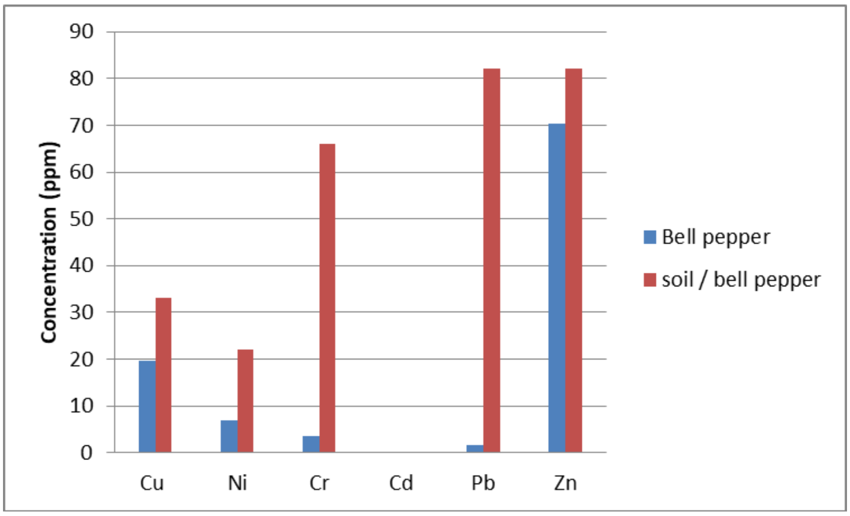

Fig. 4. Concentration of heavy metals in bell pepper and its growing soil

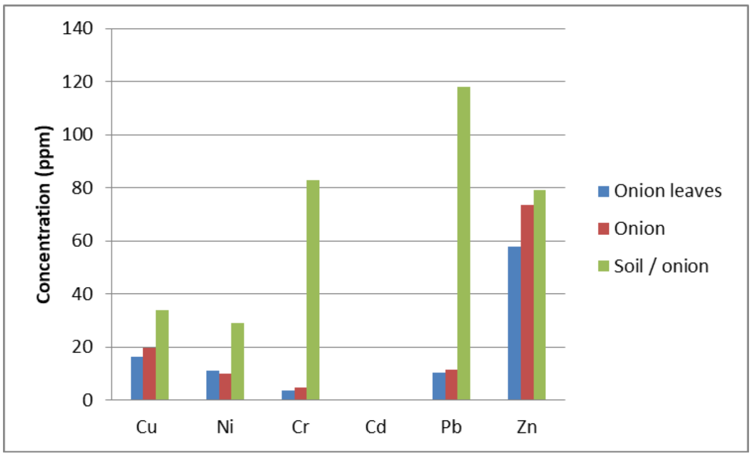

Fig. 5. Concentration of heavy metals in onion, onion leaves and growing soil

Table 3. Heavy metal Bioconcentration factor

	Cu	Ni	Cr	Pb	Zn
Carrot	0.518	0.524	0.021	0.152	0.477
Onion	0.583	0.347	0.056	0.098	0.929
Onion leaves	0.482	0.385	0.045	0.089	0.731
Lettuce	0.483	0.212	0.071	0.336	0.876
Green Bean	0.472	0.296	0.071	0.035	0.987
Bell pepper	0.595	0.319	0.054	0.021	0.858

The bioconcentration factor ranges from 0.056 to 0.929 in onions and ranges from 0.045 to 0.731 in onion leaves. The most accumulative metal in the onion and the leaves is zinc, which has a bioconcentration factor close to one in the fruit. This reflects a strong transfer of zinc from the soil to the plant.

In lettuce, the bioconcentration factor ranges from 0.071 to 0.876. The most accumulating metal in lettuce was zinc.

Green beans have a bioconcentration factor that varies from 0.035 to 0.987. The most accumulative metal in the green bean is zinc, which has a bioconcentration factor roughly equal to one. This reflects a strong transfer of zinc from the soil to the green bean.

The bioconcentration factor varies from 0.021 to 0.858 in bell pepper. The most accumulative metal in bell pepper was zinc.

The bioconcentration factors show that the onion leaf, onion, lettuce, green bean and pepper are the plants which that accumulate zinc and the carrot accumulates nickel.

The bioaccumulation of the metals in the vegetable from Loumbila market gardening decreased in the order of Onion > lettuce > green bean > bell pepper > onion leaves > carrot.

4. CONCLUSION

This study has revealed that the concentrations of lead (Pb) in the soils of onion, green bean, carrot and pepper are above the limit which is 100 mg/kg. These high lead concentrations in soils can lead to high lead concentrations in onions, green beans, carrots and peppers. Lead concentrations in lettuce and pepper soils are below the limit.

The values of the bioaccumulation show that the onion leaf, onion, lettuce, green bean and bell pepper were the plants that accumulate zinc (Zn) and the carrot accumulates nickel (Ni).

The mean concentration of heavy metals in the agricultural soils samples from Loumbila market gardening decreased in the order Pb > Cr> Zn > Cu > Ni > Cd. The mean concentration of heavy metals in the edible portions of the vegetables decreased in the order Zn > Cu > Pb > Ni > Cr > Cd. For the individual vegetables, the bioaccumulation of the heavy metals in the edible parts decreased in the order of onion > lettuce > green bean > bell pepper > onion leaves > carrot.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kamal Usman, Hareb Al Jabri, Mohammed H. Abu-Dieyeh, Mohammed HSA. Alsafran. Comparative Assessment of Toxic Metals Bioaccumulation and the Mechanisms of Chromium (Cr) Tolerance and Uptake in *Calotropis procera.* Frontier Plant Science; 2020.
   Available:https://doi.org/10.3389/fpls.2020.00883
2. Hira Amin, Basir Ahmed Arain, Taj Muhammad Jahangir, Muhammad Sadiq Abbasi & Farah Amin. Accumulation and distribution of lead (Pb) in plant tissues of guar (*Cyamopsis tetragonoloba* L.) and sesame (*Sesamum indicum* L.): profitable phytoremediation with biofuel crops, Geology, Ecology, and Landscapes. 2018;2(1):51-60.
   DOI: 10.1080/24749508.2018.1452464
   Available:https://doi.org/10.1080/24749508.2018.1452464.
3. Anna Chrzan. Monitoring bioconcentration of potentially toxic trace elements in soils trophic chains. Environ Earth Sci. 2016;75:786.
   DOI 10.1007/s12665-016-5595-4.
4. Dung HTM. Impacts des metaux lourds sur l'interaction plante/ver de terre/microflore tellurique. These, Presentee et soutenue publiquement le 22/12/2012 pour l'obtention du grade de Docteur de L'UNIVERSITE PARIS EST. 2012 ;169.
5. Salano EM. Assessment of Heavy Metal Pollution in Soils and Water of Samburu County, Kenya. Thesis, Kenyatta University, Nairobi; 2013.
6. Puttaih JET. Assessment of Heavy Metals Uptake in Leafy Vegetables Grown on Long Term Wastewater Irrigated Soil across Vrishabhavathi River, Bangalore, Karnataka. IOSR Journal of Environmental Science, Toxicology and Food Technology. 2013;7:52-55.
   Available: https://www.iosrjournals.org/iosr-jestft/papers/vol7-issue6/I0765255.pdf
7. Yadav A, Yadav PK, Shukla DN. Investigation of Heavy Metal Status in Soil and Vegetables Grown in Urban Area of Allahabad, Uttar Pradesh, India. International Journal of Scientific and Research Publications. 2013;3:1-7.
8. Naser HM, Sultana S, Mahmud NU, Gomes R, Noor S. Heavy Metal Levels in Vegetables with Growth Stage and Plant Species Variations. Bangladesh Journal of Agricultural Research. 2011;36:563-574.
   Available:https://doi.org/10.3329/bjar.v36i4.11743
9. Jacob JO, Kakulu SE. Assessment of Heavy Metal Bioaccumulation in Spinach, Jute Mallow and Tomato in Farms within Kaduna Metropolis, Nigeria. American Journal of Chemistry. 2012;2:13-16.
   Available:https://doi.org/10.5923/j.chemistry.20120201.04,
   http://journal.sapub.org/chemistry
10. Lente I, Ofosu-Anim J, Brimah AK, Atiemo S. Heavy Metal Pollution of Vegetable Crops Irrigated with Wastewater in Accra, Ghana. West African Journal of Applied Ecology. 2014;22:41-58.
11. Adedokun AH, Njoku KL, Akinola MO, Adesuyi AA, Jolaoso AO. Heavy Metal Content and the Potential Health Risk Assessment of Some Leafy Vegetables Cultivated in Some Flood Plains and Farmlands in Lagos, Nigeria. FUNAI Journal of Science & Technology. 2017; 3:30-47.
12. Huss J. Les risques sanitaires des metaux lourds et d'autres metaux. Rapport 1 de la Commission des questions sociales, de la sante et de la famille, de l'Assemblee parlementaire de l'union europeen, Doc. 2011;12613.
13. Said BM. Etude des impacts environnementaux des debris de demolition de la region de Boumerdes. These soutenue le pour l'obtention du grade de docteur de l'Universite M'Hamed Bougara-Boumerdes, Annee universitaire: 2010/2011, 2011 ;146.
14. Aloueimine SO. Methodologie de caracterisation des dechets menagers à Nouakchott (Mauritanie): Contribution à la gestion des Dechets et outils d'aide à la decision. These Presentee et soutenue publiquement le 13 Avril 2006 pour l'obtention du grade de Docteur de l'Universite de Limoges. 2006;195.
15. Matech F, Zaakour F, Moustarhfer K, Chemsi Z. Concentrations en elements traces metalliques dans les sols irrigues par les eaux usees versees dans L'OUED MERZEG (CASABLANCA-MAROC).

European Scientific Journal. 2014 ;10:121-138.

16. Lokeshwari H, Chandrappa GT. Impact of Heavy Metal Contamination of Bellandur Lake on Soil and Cultivated Vegetation. Current Science. 2006;91:622-627.
17. Majolagbe AO, Yusuf KA, Duru AE. Trace Metals Characterisation in Environmental Media: A Case Study of Cement Production Area, Ewekoro, Southwest, Nigeria. European Scientific Journal. 2014;3:83-89.
Available:https://doi.org/10.11648/j.ajep.20140302.17
18. Tankari DBA, Guero Y, Dan Lamso N, Barage M, Balla A, Sterckeman T, Ech Evarria G, Feidt C. Evaluation des niveaux de contamination en elements traces metalliques de laitue et de chou cultives dans la vallee de Gounti Yena a Niamey, Niger. Journal of Applied Biosciences. 2013;67:5326-5335.
https://doi.org/10.4314/jab.v67i0.95056
19. Rapheal O, Adebayo KS. Assessment of Trace Heavy Metal Contaminations of Some Selected Vegetables Irrigated with Water from River Benue within Makurdi Metropolis, Benue State, Nigeria. Advances in Applied Science Research. 2011;2 :590-601.
Available :http://www.pelagiaresearchlibrary.com
20. Bambara LT. Etude de la Pollution en metaux lourds dans les zones de maraichage au Burkina Faso: Cas de Ouagadougou et de Loumbila. These unique de Doctorat, Universite Ouaga I Professeur Joseph KI-ZERBO. 2016;190.
21. Bambara LT, Kabore K, Derra M, Zoungrana M, Zougmore F, Cisse O. Assessment of Heavy Metals in Irrigation Water and Vegetables in Selected Farms at Loumbila and Paspanga, Burkina Faso. IOSR Journal of Environmental Science Toxicology and Food Technology. 2015; 9:99-103.
Available: http://www.iosrjournals.org
22. Andrews Obeng Affum, Shiloh Dede Osae, Edward Ebow Kwaansa-Ansah, Michael K. Miyittah. Quality assessment and potential health risk of heavy metals in leafy and non-leafy vegetables irrigated with groundwater and municipal-waste-dominated stream in the Western Region, Ghana. Heliyon 2020;6(2020) :e05829.
Available:https://doi.org/10.1016/j.heliyon.2020.e05829
23. Prosper D. Renforcement des capacites des exploitants maraichers: Cas du village de Noungou dans le departement de Loumbila, memoire presente a Institut International d'ingenierie en Eau et Environnement. 2007 ;124.
24. Hema Diwan, Altaf Ahmad, and Muhammad Iqbal. Uptake-related parameters as indices of phytoremediation potential. Biologia. 2010;65(6):1004—1011.Section Botany.
DOI: 10.2478/s11756-010-0106-7.
25. Leônidas Carrijo Azevedo Melo, Evandro Barbosa da Silva, Luís Reynaldo Ferracciú Alleoni. Transfer of cadmium and barium from soil to crops grown in tropical soils. Soil Use and Manegement • Rev. Bras. Ciênc. Solo. 2014;38(6).
Available: https://doi.org/10.1590/S0100-06832014000600028

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