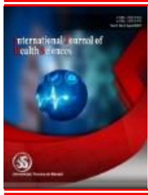

International Journal of Health Sciences
Available online at www.sciencescholar.us
Vol. 8 No. 1, April 2024, pages: 1-9
e-ISSN: 2550-696X, p-ISSN: 2550-6978
https://doi.org/10.53730/ijhs.v8n1.14642

Reducing Heavy Metal (Zn, Cu) Toxicity in a Semi-Arid Area by Halophytes

Rezkallah Chafika [a], **Djilani Ghemam Amara** [b]

Manuscript submitted: 09 October 2023, Manuscript revised: 18 November 2023, Accepted for publication: 27 December 2023

Corresponding Author [a]

Keywords

halophytes;
heavy metal (Zn, Cu);
reducing;
semi-arid area;

Abstract

This work is the subject of a study of the effect of Atriplexhalimus on the variability of the percentage of certain heavy metals in the region of Boukhadra-Ouanza north of Tébessa, which is characterized by the proximity of an ancient mining area and with different levels of salinity. Where we made field trips, the first to know the area and determine the sampling locations, and the second to take samples. The latter (soil surrounding the roots of the cut plant and soil without vegetation at a distance of one meter), then we measured the salinity standards (electrical conductivity and the percentages of certain heavy metals. The samples were analyzed at the Geology Laboratory, Faculty of Nature and Life Sciences, University of Tébéssa, where soil CE was calculated and compared to the percentage of heavy metals (zinc and copper)in the soil. The results showed the presence of a significant proportion of heavy metals such as zinc and copper, especially in the third study area, which is considered high by World Health Organization standards and to acceptable standards, because the latter is located near an abandoned mining area, unlike the high salinity factor in the first and second areas. Showed the response of this type of plant to heavy metals, where we compared.

Contents

[a] Department of Biology Faculty of Science Exacte and Natural Science and Life, University of Tebessa, Algeria & Laboratory of Applied Chemistry and Environment, Faculty of Exacte Science University of Eloued, Algeria
[b] Laboratory Biology, Environment and Health (LBEH), Department of biology, Faculty of Nature and Life Sciences, University of El Oued 39000, Algeria

1 Introduction

In Algeria, no reliable and precise cartographic study has been identified making it possible to delimit the areas affected by the salinity of the land and the quantification of the content of salts and heavy metals in the soil, however, there are some fragmentary data which give an overview. general idea about this phenomenon of land degradation.

According to Szablocs (1989), three million two hundred thousand hectares are subject to varying degrees of severity of salinization phenomena, a good part of which is located in the steppe regions, where the salinization process is more marked due to the temperatures. high throughout most of the year, as well as the lack of efficient drainage. The accumulation of heavy metals in soils is a concern in agricultural production due to their adverse effects on crop growth, food quality, and environmental health (Costa & Duta, 2001).

Also, contaminated soil is of great concern today for emerging countries. Heavy metals such as lead, cadmium, copper, zinc, and mercury cannot be biodegraded and therefore persist in the environment for long periods of time. In addition, they are continually added to the soil by various activities: in agriculture by the application of sewage sludge or in the metallurgical industry. The accumulation of heavy metals in the environment can affect the health of humans and animals (Wang et al., 1997).

In this topic, there is a presentation of soil salinity confirmed in past studies of the northern region of the Elouinet-Boukhadra Ouinza collapse basin. The region will be a center of development for the two abandoned mining communes for the coming decades, classified as a steppe zone extending over the semi-arid climatic stage (300 to 400 mm), it is dominated by particular vegetation such as l mugwort (Artemisia herba alba), esparto (Stipatenacissima), esparto (Lygeumspartum) and orach (A triplex halimus) (FAO, 2010).

The introduction of plant species tolerant to abiotic stress and of high socio-economic value constitutes one of the approaches for the reclamation of saline soils. The ideal choice of vegetation appropriate to these conditions constitutes the first step in solving the salinity problem. This is how the introduction of halophilic species whiché complete their life cycles at high salinity levels and which have the ability to accumulate high concentrations of micronutrients, higher than normal levels (Wang et al., 1997; Saikachout et al., 2015), are promising for soil desalination in arid and semi-arid areas (Messedi et al., 2004). The approach adopted is based on the synchronic study by comparing soils planted with A triplex halimus species and a control soil, all the perimeters studied are included. The aim is to determine the effects of plantations on some salinity parameters and heavy metals in the soil.

2 Materials and Methods

Equipment
Region of study

Soils in the arid lands of grasslands as a result of management change that affect the abundance and movement of water and salts and Heavy metals in the rhizosphere, several other factors contribute to the regulation of processes: topography, the content of rock salt clean, underlying geology and layer hydrology.

The study area is located in the extreme east of Algeria at the edge of the desert, about 230 km south of Annaba on the Mediterranean coast, the region is limited to the south by the Wilaya of Eloued and to the west by that of constant and to the East by Tunisia.

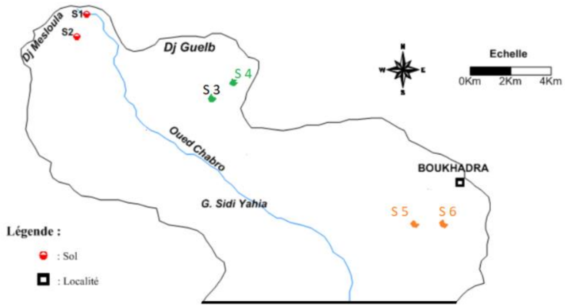

Figure 1. Map of plantation zones (black triangle) in the study area

The hydrographic network is well-developed and represented by small temporary streams with broad and well-developed valleys, flowing into large wadis, the most important of which are Oued Mellegue and Oued Chabro. The distribution of soils is generally very heterogeneous, moreover, if we consider salinity as a regionalized variable (Rezkallah et al., 2014), Measuring points located above are characterized by a successive accumulation of salts in depth, those which are located an accumulation of salts on the surface (job, 1981).

Figure 2. Satellite photo showing the different wadis in the study region (Source: Google Earth 2023).

A semi-arid climate, for example, characterized by a very cold winter and a very hot and dry summer, results in phenomena of shrinkage and sliding of clay soils. Periods of drought spread over several hydrological months of the year will contribute to the considerable loss of water from the interstices of the clays, and therefore their withdrawal, which will subsequently produce landslides. The vegetation cover of the area is almost non-existent, due to the dry climate, high temperature, and lack of humidity. We find this area degraded and containing some plant species that are tolerant to the conditions of the area, such as Atriplex halimus plants, on which this research was conducted (Benhammou et al., 2009; Thyagaraju, 2016; Hernández et al., 2017).

Figure 3. Photos of the Atriplex species in the study area

Table 1
Characteristics of other designs Atriplex halimus

Description	Arbuste; The densely packed touffs are blanc argenté. Many new and large sizes. Single flowers, yellow ones, put them in the bathroom
Conditions écologiques	Climat : *Précipitations de 150 à 1000 mm* M : 30.3 à 30.8^{0}C ;* m : 6.8 à 7.7^{0}C. Sol marneux et limoneux compacts profonds. Semi-aride, présaharien ; Altitude de 0 à 1 500 m.
Mise in culture	The October transplantation took place in March, 5 x 2 m cartons, and a density of 1000 pieds/ha. Floor height: 50 to 60 cm La production 1000 to 2000 UF/ha/an.
Valeur fourragère	à 0.56 UF/Kg MS. The protein content varies between 12 and 18% per kilogram of breast milk. Origins South of Europe

Location and conditions of the experiment: The soil analyses were carried out at the Faculty of Science, Department of Geology (University of Tébessa), the experiment was carried out during the academic year 2022/2023. Sampling: A series of random soil samples collected some samples of Atriplex Halimus planted soil and unplanted soil in the study area; during the month of March 2023.

Sampling: With the aim of carrying out various soil analyses, the samples were taken randomly, fairly representative of the three planting zones, 6 soil samples were taken from the rhizosphere of the Atriplex halimus compared with the control soil (soil sounds planting with a depth between 10-20 cm), due to two sampling trips, the first in March 2023. All soil samples were taken and placed in identified airtight bags; 1000g of A horizon soil to a depth of 18 to 25 cm. In the laboratory of the geology department, the soil samples collected were spread out on paper and allowed to dry in the open air, in conditions where microorganisms do not have the possibility of modifying their properties (Van Oosten & Maggio, 2015; Long et al., 2011; Belkheiri & Mulas, 2013).

This step is followed by separating the fine and coarse parts of the soil with a round mesh sieve of 2 mm in diameter. The analyses were carried out only on the fine fraction (diameter < 2 mm). At the laboratory level, we placed the soil in distilled water at a rate of 1/5, for a 24 h, then we filtered it and calculated the electrical conductivity by condictemetr and the percentage of Zn and Cu phtometre d'absorption atomique.

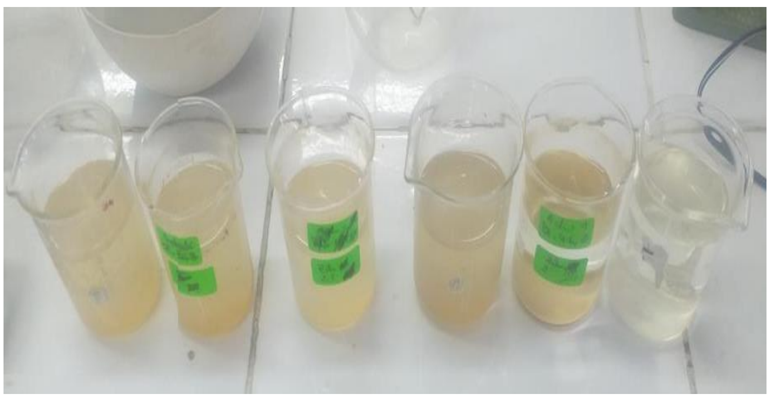

Figure 4. Soil solutions are taken from planted and unplanted soils.

Statistical study of the data

The statistical study was carried out on the basis of two factors:

- Single genotype of (Atriplex halimus) plus a control.
- Three planting zones.
- a sampling campaign.

The means of the variables measured on the different distributions were subjected to an analysis of variance with three classification criteria, using the SSPSS V 26 software

3 Results and Discussions

Table 2
Analysis of the parameters of the soil samples

Zone	Soil	EC (µS/cm)	Cu (mg/l)	Zn (mg/l)
1	Planted soil	762	0,004	0,010
	Unplanted soil	1007	0,024	0,031
2	Planted soil	328	0,016	0,019
	Unplanted soil	150,1	0,010	0,041
3	Planted soil	132,5	0,037	0,244
	Unplanted soil	130,6	0,347	0,347

The planting effect of Atriplex: On the electrical conductivity (EC) of the soil solution: The analysis of the variance of the results obtained on the electrical conductivity (EC) of the soil solution shows that the effect of the species and salinity and the non-significant interaction (Table 3).

Table 3
Analysis of variance of the effect of Atriplex halimus on the electrical conductivity (EC) of the soil solution

Sources	dl Effect	MC Effect	F Obs.	P value
Species	1	0	0	0
Salinity	0	0	0	0
Interaction	1	1165,633	0,005	0,947

The analysis curve shows that the increase in electrical conductivity in the soil of zone 1 compared to the others is regular in the soils of zones 2 and 3. The effect of Atriplex. Halimus is positive except at zone 1 with a value of 1007 (µS/cm) in soil without planting eliminated at 762 (µS/cm) of planted soil. The electrical conductivity of a soil solution is an important index of the soluble salt contents in this soil (Rezkallah, 2016).

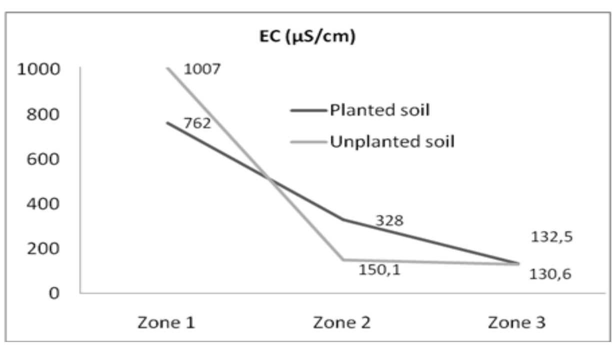

Figure 5. Average electrical conductivity of atriplex halimus soil solution

On the electrical conductivity (EC) of the soil solution: The analysis of the variance of the values obtained for Zn and Cu in the soil indicates that the results are highly significant (Table 3).

Table 4
Analysis of variance of the effect of Atriplex halimus on heavy metals in the soil solution

heavy metals	Number of soil	Mc effect	M deviation	Mc error
Cu	6	0,07300	0,134723	0,055001
Zn	6	0,11533	0,143692	0,058662

Table 5
Analysis of variance of the effect of Atriplex halimus on heavy metals in the soil solution

	T	df effect	P value	M deferential
Cu	-71,399	5	0,000	-3,927000
Zn	-66,221	5	0,000	-3,884667

The results obtained show that almost all soils exceeded the recommended agricultural standard. According to the table of standards (30-100) of Cu and (100-300) of Zn. Is generally high.oscillating between 0.004 and 0.024 of Cu from zone 1 and 0.16 and 0.10 in zone 2 and 0.037 with 0.347 from zone 3 Figure 3.

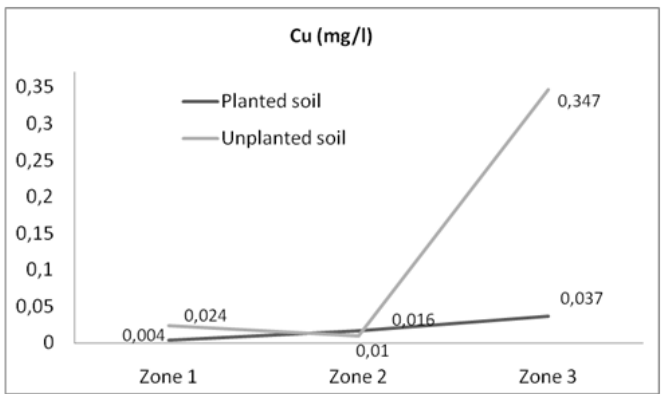

Figure 6. Average Cu contents of Atriplex halimus soil solution

Also for Zn 0.010 and 0.031 from Zones 1. 0.019 and 0.041 from zone 2. 0.244 and 0.347 from zone 3.

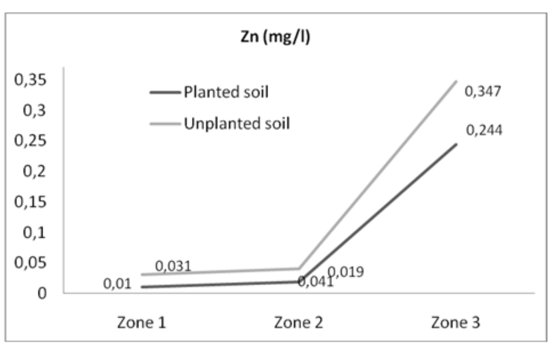

Figure 7. Average Zn contents of the Atriplex halimus soil solution

Zones of strong mineralization are located almost in all parts of the study region, especially zone 3 for the two heavy metals Cu and Zn. We also noticed the presence of the same percentage of the same metal in several samples, especially zones 1 and 2 for the two heavy metals Cu and Zn. According to (Ghalmi, 2019), the study area can be subdivided into five classes: insignificant pollution (IP<1.0), low (IP: 1.0 to 1.5), moderate (IP: 1.5 to 2 .0), high (IP: 2.0 to 2.5) and very high (IP > 2.5).

For example, the percentage of copper in the soil without planting in Zone 3 is very high compared to the others and very low in the soil planted or not in Zone 2 and 3 of Zone 1. We conclude from the graphs that there is no relationship between the percentage of heavy metals and salts in the soil (Katsou et al., 2011; Basta & McGowen, 2004; Navarro et al., 2008).

From the above, concerning the variation of soil parameters as a function of salinity, and the effect of the plants studied, we can conclude that the accentuation of salinity affects all of the measured physicochemical components of the soil, but with more or less variable intensity. Thus, we noticed, in all cases, that salinity does not have a significant enough effect on soil pH. However, the type of species used clearly marked the characteristics of the soil. Indeed, the A.halimus species is characterized by a record neutral pH value. Unlike the EC and the TDS which presented a correlation, of a positive nature, with the effect of the species. As for soil minerals, it should be noted that the levels of sodium, calcium, and potassium showed a tendency to decrease compared to the species studied (Khadija et al., 2021; Riadh et al., 2010; Caparrós et al., 2022).

There is an inverse relationship between salinity and heavy metals, because the higher the percentage of salts, Due to the presence of a high percentage of cations according to Ross (1994), The presence of calcium in soils would also slow down copper from plants. We concluded through this research that the high percentage of salinity leads to a decrease in heavy metals, and also the contribution of Atriplex cuts to a decrease in the percentage of salinity against heavy metals.

4 Conclusion

Through the previous study, which is the absorption of salinity represented by electrical conductivity, as well as heavy metals represented by zinc and copper, a varying difference was observed in the rates of electrical conductivity for the study area. As for heavy metals, their values are somewhat high in all study areas, and this does not reflect the existence of a relationship between the presence of heavy metals and salts in the soil. As for the effect of harvest germination, It is positive on the salinity value in the first and third regions, and also on heavy metals for zinc in the three study regions, as for Copper in the first and third regions. Hence, we say that there is no competitive relationship between the absorption of zinc and copper by the harvest and the accumulation of salts in the soil.

Acknowledgments
We are grateful to two anonymous reviewers for their valuable comments on the earlier version of this paper.

References

Basta, N. T., & McGowen, S. L. (2004). Evaluation of chemical immobilization treatments for reducing heavy metal transport in a smelter-contaminated soil. *Environmental pollution*, *127*(1), 73-82. https://doi.org/10.1016/S0269-7491(03)00250-1

Belkheiri, O., & Mulas, M. (2013). The effects of salt stress on growth, water relations and ion accumulation in two halophyte Atriplex species. *Environmental and Experimental Botany*, *86*, 17-28. https://doi.org/10.1016/j.envexpbot.2011.07.001

Benhammou, N., Bekkara, F. A., & Panovska, T. K. (2009). Antioxidant activity of methanolic extracts and some bioactive compounds of Atriplex halimus. *Comptes Rendus Chimie*, *12*(12), 1259-1266. https://doi.org/10.1016/j.crci.2009.02.004

Caparrós, P. G., Ozturk, M., Gul, A., Batool, T. S., Pirasteh-Anosheh, H., Unal, B. T., ... & Toderich, K. N. (2022). Halophytes have potential as heavy metal phytoremediators: A comprehensive review. *Environmental and Experimental Botany*, *193*, 104666. https://doi.org/10.1016/j.envexpbot.2021.104666

Costa, A. C. A. D., & Duta, F. P. (2001). Bioaccumulation of copper, zinc, cadmium and lead by Bacillus sp., Bacillus cereus, Bacillus sphaericus and Bacillus subtilis. *Brazilian Journal of Microbiology*, *32*, 1-5.

FAO. (2010), Guidelines for soil description (4th Ed.). Food and Agriculture Organization of the United Nations, P- 97

Ghalmi, S. (2019). *Impact of abandoned mining sites on the environment. Case of the northern region of Tébessa. (Far East Algeria)* (Doctoral dissertation).

Hernández, E. H. O., Moncayo, E. H. O., Sánchez, L. K. M., & de Calderero, R. P. (2017). Behavior of clayey soil existing in the portoviejo canton and its neutralization characteristics. *International research journal of engineering, IT & scientific research*, *3*(6), 1-10.

Job, J. O. (1981). Some problems in analysis of soils in arid areas. *ACSAD, Damascus*, 219-237.

Katsou, E., Malamis, S., & Haralambous, K. J. (2011). Industrial wastewater pre-treatment for heavy metal reduction by employing a sorbent-assisted ultrafiltration system. *Chemosphere*, *82*(4), 557-564. https://doi.org/10.1016/j.chemosphere.2010.10.022

Khadija, D., Hicham, A., Rida, A., Hicham, E., Nordine, N., & Najlaa, F. (2021). Surface water quality assessment in the semi-arid area by a combination of heavy metal pollution indices and statistical approaches for sustainable management. *Environmental Challenges*, *5*, 100230. https://doi.org/10.1016/j.envc.2021.100230

Long, Y. Y., Shen, D. S., Wang, H. T., Lu, W. J., & Zhao, Y. (2011). Heavy metal source analysis in municipal solid waste (MSW): case study on Cu and Zn. *Journal of hazardous materials*, *186*(2-3), 1082-1087. https://doi.org/10.1016/j.jhazmat.2010.11.106

Messedi, D., Labidi, N., Grignon, C., & Abdelly, C. (2004). Limits imposed by salt to the growth of the halophyte Sesuvium portulacastrum. *Journal of Plant Nutrition and Soil Science*, *167*(6), 720-725.

Navarro, M. C., Pérez-Sirvent, C., Martínez-Sánchez, M. J., Vidal, J., Tovar, P. J., & Bech, J. (2008). Abandoned mine sites as a source of contamination by heavy metals: a case study in a semi-arid zone. *Journal of Geochemical exploration*, *96*(2-3), 183-193. https://doi.org/10.1016/j.gexplo.2007.04.011

Rezkallah, C., Djemai, R., Maalem, S., & Fehdi, C. (2014). The effects of salt water irrigation on the physicochemical properties of soil planted with Atriplex. halimus. *Africa Science: International Journal of Science and Technology* , *10* (1).

Rezkallah. Ch. (2016), Rehabilitation of salty soils in northern Tebessa (Morsott – El AouinetBoukhadra) by planting halophytic species of the atriplex genus (A. halimus, A. numularia) University of Badji – Mokhtar,

Riadh, K., Wided, M., Hans-Werner, K., & Chedly, A. (2010). Responses of halophytes to environmental stresses with special emphasis to salinity. In *Advances in botanical research* (Vol. 53, pp. 117-145). Academic Press. https://doi.org/10.1016/S0065-2296(10)53004-0

Ross, S. M. 1994. Toxic metals in soil-plant systems. John Wiley & Sons Ltd, Chichester, UK.

Saikachout, S., Benmansoura, A., Ennajah, A., Leclerc, J. C., Ouerghi, Z., & Karray Bouraoui, N. (2015). Effects of Metal Toxicity on Growth and Pigment Contents of Annual Halophyte (A. hortensis and A. rosea). *International Journal of Environmental Research*, *9*(2).

Szabolcs, I. (1989). *Salt-affected soils*. CRC Press, Inc..

Thyagaraju, N. (2016). Water pollution and its impact on environment of society. *International Research Journal of Management, IT and Social Sciences*, *3*(5), 1-7.

Van Oosten, M. J., & Maggio, A. (2015). Functional biology of halophytes in the phytoremediation of heavy metal contaminated soils. *Environmental and experimental botany*, *111*, 135-146. https://doi.org/10.1016/j.envexpbot.2014.11.010

Wang, L. W., Showalter, A. M., & Ungar, I. A. (1997). Effect of salinity on growth, ion content, and cell wall chemistry in Atriplex prostrata (Chenopodiaceae). *American Journal of Botany*, *84*(9), 1247-1255.

Biography of Authors

Rezkallah Chafika
MCA at Larbi Tebessi University, Tebessa, Algeria, specializing in plant biology and ecology, interested in studying the effect of plants to get rid of environmental problems such as salinity and pollution. 1 Department of Biology Faculty of Science Exacte and Natural Science and Life, University of Tebessa, Algeria & Laboratory Of Applied Chemistry And Environment, Faculty Of Exacte Science University Of Eloued, Algeria.
Email: chafika.rezkallah@univ-tebessa.dz

Djilani Ghemam Amarac
Prof at Eloued University, Algeria, specializing in plant biology and physiology, interested in studying the effect of plants to get rid of environmental and physiological. Laboratory Biology, Environment and Health (LBEH), Department of Biology, Faculty of Nature and Life Sciences, University of El Oued 39000, Algeria.
Email: ghemamamaradjilani@gmail.com