International Conference Sustainable Agriculture and the Environment

Mostaganem , May 27 and 28, 2024

REMEDIATION OF AGRICULTURAL SOILS CONTAMINATED WITH HEAVY METALS THROUGH THE INTERACTION BETWEEN *Aporrectodea caliginosa* AND *Hordeum vulgare* L.

LAICHE Fahima[1], KLECHE Meriem[2].

1 et 2 Research Laboratory: Applied Neuroendocrinology, Department of Biology, Faculty of Science, Badji Mokhtar University. Annaba, Algeria.

E-mail : f.laiche@ensti-annaba.dz

Abstract

The soil organisms undergo frequent variations in abiotic parameters, while the chemical contamination of the environment, resulting from metallurgical activities, has led to significant soil pollution by heavy metals. The introducing of earthworms into soils contaminated with metals has been suggested as an aid to phytoremediation processes. The research aims to explore the impact of a bio-accumulator and bio-indicator model in ecotoxicology: the earthworm *Aporrectodea caliginosa* (Savigny, 1826); or the study investigates the accumulation of potentially toxic metals, including Fe, Zn, and Cu, which can reach harmful concentrations., by a hyperaccumulator plant: barley *Hordeum vulgare* L. The results indicate that metals accumulate in barley depending on the type of metal, site, and the presence of earthworms. However, their presence alters the metal concentrations in *Hordeum vulgare* L plants, with notable variations between roots and leaves. The findings underscore the capacity of earthworms to influence the accessibility of heavy metals absorbable by plants in polluted soils. Furthermore, the study emphasizes the significance of expanding the ecological perspective of phytoremediation by examining the interplay among earthworms, plants, and soil. This interaction not only shapes the concentrations of heavy metals in the soil but also influences their uptake by these hyperaccumulator plants.

Keywords: *Earthworm, Heavy metals, Hyperaccumulator plant.*

Introduction

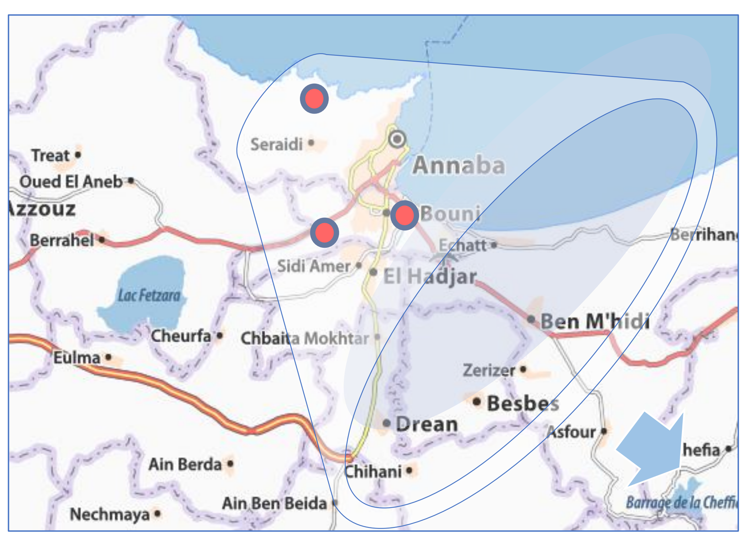
Trace metals are among the most dangerous pollutants because of their high toxicity and persistence in the environment. These elements invade the various compartments of the ecosystem and have the capacity to accumulate in soils, thus directly or indirectly affecting living organisms **(Hodson, 2013)**. It has been reported that the bioavailability of metals in soil depends on soil type, metal species, metal kinetics and the age of metal contamination in the soil.

While it is true that many plants cannot tolerate large quantities of heavy metals, a minority are able to accumulate them without suffering any apparent damage. These plants, commonly known as hyper-accumulators of heavy metals **(Jost, 2018)**. These plants have a capacity to store up to 100 times more ETM than non-accumulating plants **(Evlard, 2013)** and accumulate concentrations in their aerial parts that are 10 times higher than those usually found in plants growing in uncontaminated soil.

Because of their ability to resist and accumulate metals, earthworms are considered to be a good bio-indicator of effect and exposure to many metal pollutants(**Beeby, 1993 ; van Gestel *et al.*, 1995**).

Materials & Methods

Study area and sampling sites



El Hadjar steel complex

Hadjer Al Adiss (site I)

Bouchegouf (control site)

Pont Bouchet (site II)

Biological material

Barley, *Hordeum vulgare* L (Feillet, 2000)

Kingdom	Plantae
Sub-kingdom	Tracheobiont
Class	Angiospermae
Subclass	Monocotyledonae
Order	Poales ; cyperales
Sub -Order	Commelimidae
Family	Poaceae
Subfamily	Pooideae
Genus	Barley
Species	***Hordeum vulgare* L**

- ✓ Adaptability to different environments.
- ✓ Resistant plant .
- ✓ Important cereal.
- ✓ Hyperaccumulative plant.
- ✓ Very active root system.

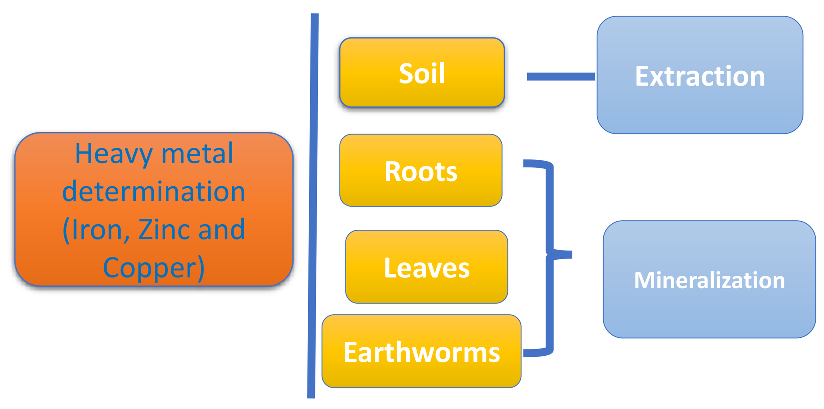
Endogeic species, *Aporrectodea caliginosa* (Savigny, 1826)

Kingdom	Animalia
Phylum	Annélide
Class	Clitellata
SubClass	Oligochaeta
Order	Crassiclitellata
Sub-Order	Lumbricina
Family	Lumbricoidea
Sub-Family	Lumbricidae
Genus	Aporrectodea
Species	***Aporrectodea caliginosa***

- ✓ Improving fertility and preserving soil structure.
- ✓ Modification of the biotope of microbial communities.
- ✓ Resistance and accumulation capacity of metals.
- ✓ Affecting the physical and chemical properties of the soil.

Méthods

	Site 1					Site 2					Site Témoin (St)				
S I	SV_1	SV_2	SV_3	SV_4	SV_5	SV_1	SV_2	SV_3	SV_4	SV_5	StV_1	StV_2	StV_3	StV_4	StV_5
S II	SP_1	SP_2	SP_3	SP_4	SP_5	SP_1	SP_2	SP_3	SP_4	SP_5	StP_1	StP_2	StP_3	StP_4	StP_5
S III	SVP_1	SVP_2	SVP_3	SVP_4	SVP_5	SVP_1	SVP_2	SVP_3	SVP_4	SVP_5	$StVP_1$	$StVP_2$	$StVP_3$	$StVP_4$	$StVP_5$



Physico-chemical parameters

Results & Discussion

Relative contaminant in soil (F) = (V0 – VF)/(V0) × 100 %

System		Iron %	Zinc %	Copper %
S I	StV	1.58	3.92	8.50
	S1V	0.38	0.73	3.42
	S2V	0.75	3.02	1.00
S II	StP	43.37	44.13	37.55
	S1P	38.66	38.38	40.86
	S2P	38.71	58.26	54.06
S III	StVP	46.40	54.47	48.15
	S1VP	39.29	41.59	44.58
	S2VP	40.21	61.22	54.69

where V0 is the initial fraction of metal in the soil before the experiment, and VF is the fraction of metal at the end of the experiment. This could help to investigate the mechanisms by which earthworms, plants and their combination could affect the availability of heavy metals in soils.

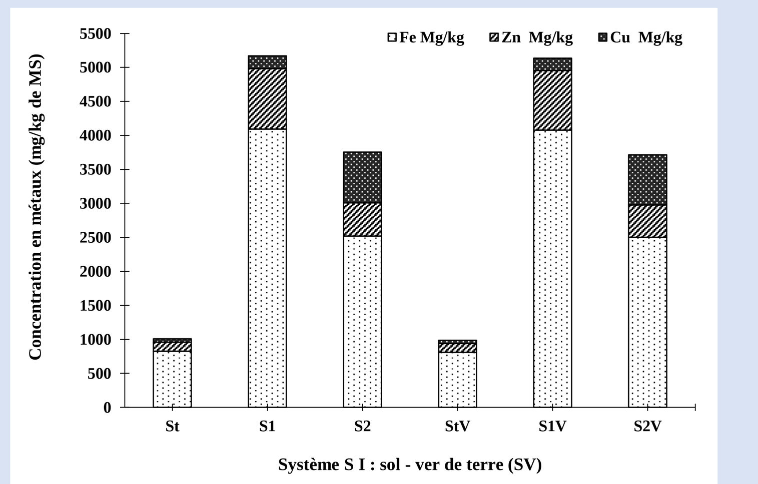


Fig. 1 : Concentration of metals in the system I

(St : Control Site, S1: Site I, SII : Site II, V : Aporrectodea caliginosa , P : Hordeum vulgare L)

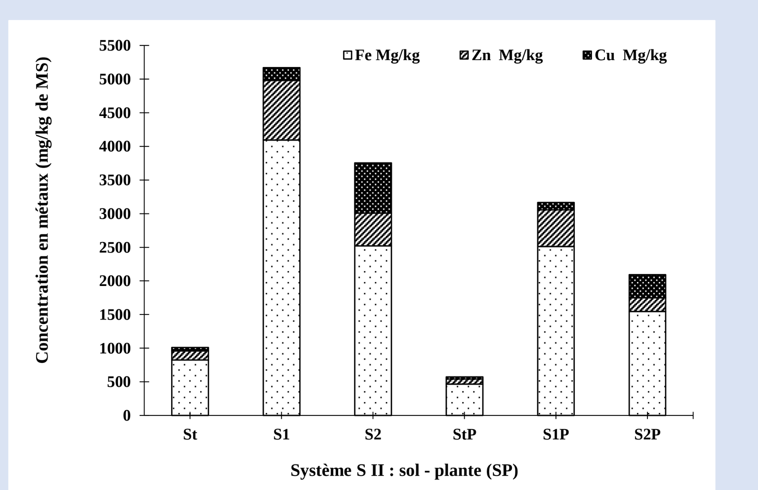


Fig. 2 : Concentration of metals in the system II

(St: Control site, S1: Site I, SII: Site II, *V : Aporrectodea caliginosa , P : Hordeum vulgare* L)

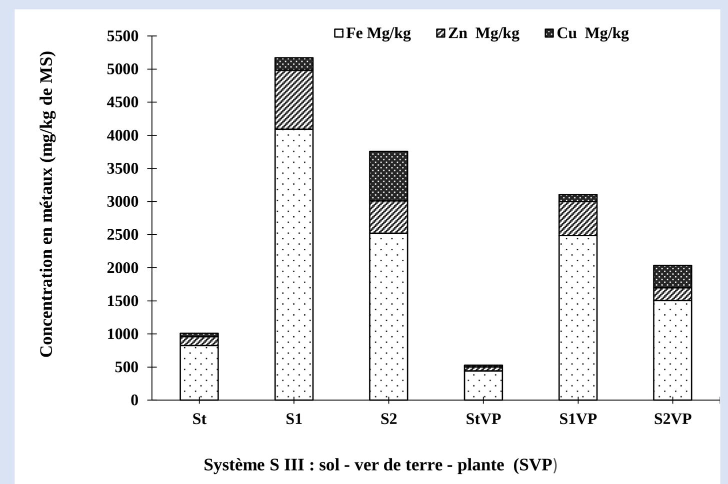


Fig.3 : Concentration of metals in the system III

(St : Control Site, S1: Site I, SII : Site II, V : Aporrectodea caliginosa , P : Hordeum vulgare L)

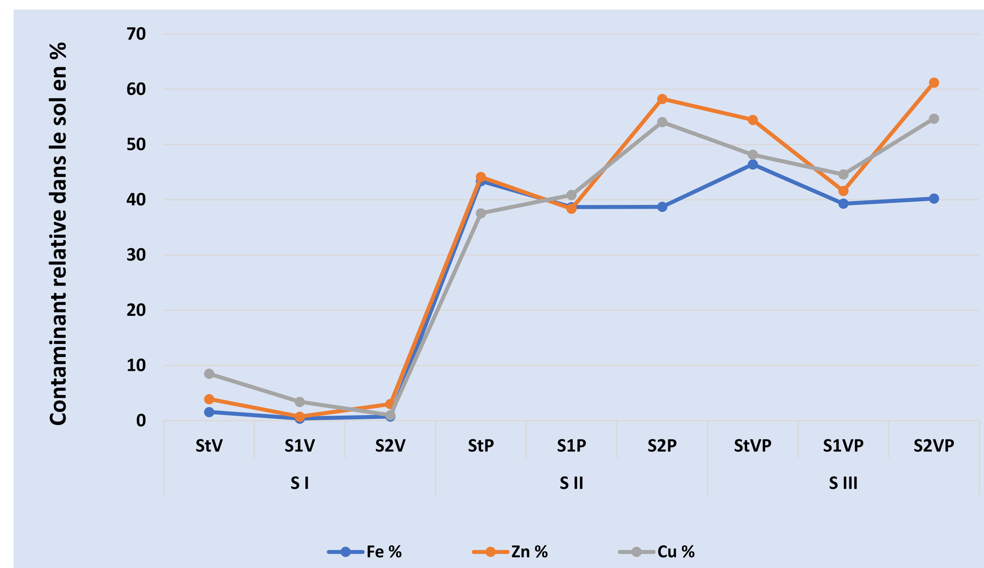


Fig. 4 : Bioavailable fractions of metals in the soil of the three systems

Conclusion

Our experiment was conducted *on Hordeum vulgare* L with a view to assessing its capacity to tolerate and accumulate heavy metals (Zinc, Iron and Copper). Analyses of metals after phytoextraction of soils contaminated by these heavy metals revealed a considerable reduction in metals in all soils. As a result, phytoextraction of soil polluted by heavy metals appears to be an alternative, less costly, more extensive and more respectful of the soil and the environment, and more acceptable for soil remediation than physical-chemical techniques, which are cumbersome and often destructive. The results suggest that the earthworms *Aporrectodea caliginosa* and the *Hordeum vulgare* L plants altered the availability of metals in contaminated soils after 42 days of exposure.

These results revealed that earthworm activities can alter the availability of heavy metals that can be absorbed by plants in contaminated soils. In addition, the results of the study show that the ecological context of phytoremediation should be broadened by considering soil-plant-soil worm interactions, which influence both plant health and heavy metal uptak

References

Beeby, A., 1993. Toxic metal uptake and essential metal regulation in terrestrial invertebrates. In: Dallinger, R., Rainbow, P.S. (Eds.), Ecotoxicology of Metals in Invertebrates. Lewis Publishers, Chelsea, MI.

Evlard A., 2013. Le potentiel du saule pour la phytostabilisation des sols pollués par les éléments traces métalliques. Université de Liège.

Feillet P.,2000. Le Grain de blé: composition et utilisation, Editions Quae, P.124-128.

Hodson M. E., 2013. Effects of Heavy Metals and Metalloids on Soil Organisms, in Alloway B.J. Heavy Metals, Soils, Environmental Pollution, EPOL, vol. 22, pp. 11-50.

Jost J.B., 2018.Les plantes hyperaccumulatrices de métaux lourds. Une solution à la pollution des sols et de l'eau Éditions Connaissances et Savoirs, Paris, 163 p.

Savigny , J.C., 1826. Analyse d'un Mémoire sur les Lombrics par Cuvier. *Mémoires de l'Académie des sciences de l'Institut de France*, 5 : 176-184

van Gestel, M., van Dis, W.A., Dirven van Breemen, E.M., Sparenburg, P.M., Baerselman, R., 1991. Influencen of cadmium copper and pentachlorophenol on growth and sexual development of *Eisenia Andrei* (Oligochaeta, Annelida). Biology and Fertility of Soils 12, 117–121.