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Phytoremediation using *Phragmites australis* roots of polluted water with metallic trace elements (MTE).

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ABSTRACT

This work aims the study of the ability of Phragmites australis roots to accumulate and transfer metals such as iron and zinc present in water filled with discharges from industrial sources. We are interested in the movement and distribution of these metals in the roots through a lagoon system designed for vertical flow in the laboratory through two trays where treatment plants Phragmites australis were planted. The results showed the presence of high concentrations of metals such as iron and zinc concentrates in the roots. After purification, the concentrations of these metals are highly decreased, confirming the effectiveness of the system.

Keywords: *Phragmites australis*, pollution, metals, SEM-EDS, MTE.

INTRODUCTION

Management of wastes in general and liquid wastes in particular manner constitutes today, a very alarming environmental question in developing countries.The majority of the African countries, shortly after their independence chose the traditional systems of purification of wastewater (activated sludge in particular) [1, 2] natural methods of wastewater treatment. This is macrophytes lagoon, technique in which the plants develop complex mechanisms to absorb the organic or mineral substances of water through their roots and their sheets, which are then transported in other parts of the plant to be used, transformed, degraded or stored [3].

The purpose of the present study is to estimate the purification performance of an installation of lagoon with macrophytes, (*Phragmites australis)* with vertical flow and this through the study of the capacities of roots to absorb/adsorb the metal particles present in wastewater. We were interested particularly in the industrial wastes of an iron and steel complex located in the area of Annaba (Northeastern Algerian) because of the presence of water strongly charged with metals.

Two techniques are used in the identification and the localization of metals: Scanning Electronic Microscopy observation (SEM) and analysis by X-rays (ICP: Inductively Coupled Plasma, OES: Optical Emission Spectrometry) of the fragments of isolated roots.

MATERIALS AND METHODS

Description of purification system
Our tests are performed with batch cultivation in identical containers of 40 liters. The experiment was performed with two tanks; the first tank is filled with a mixture of raw sewage not settled collected directly from the Oued carting industrial waste water. In which were planted reeds (*Phragmites australis*); the flow is vertical.

Biological Material
In our work, we used a macrophyte known for its strong purifier: common reed (*Phragmites australis*) an invasive plant species [4]. The reed is probably one of the most common vascular plants in the world [5]. Once implanted in the tray, the plant root system develops in very important manner.

Analysis of metals in the roots
Root samples were collected, weighed, and mineralized method of CIRAD (2004) [6]. This method of solution of minerals contained in plant material is intended for appropriate matrices poor in silica and the residue that, after passing the oven is very small. From roots, solutions dissolved heavy metals were determined ICP/OES [6].

Analysis with the SEM (scanning electronic microscopy)
Roots were observed by scanning electronic microscopy to visualize the state of the roots and the distribution of different metals [7].

Identification of metals by X-rays
The SEM observation is coupled to an Energy Dispersive Spectrophotometer (EDX system) which allows the analysis of X-rays emitted by the sample for the qualitative determination of metals [7].

RESULTS

Variations of the Iron rate and Zinc on the level of the roots
Tables (1) and (2) represent changes in the rate of iron and zinc in roots of *Phragmites australis*, before and after treatment E1 and E2. These results indicate that our water samples are heavily laden with heavy metals and especially iron, probably due to the release of the steel, it is the same for Zinc. We found an increase in the Iron and Zinc level through seasons. On the other hand we confirmed the decrease of about 50% of the content in both metals after the first and second treatment E1, E2 suggesting a high capacity for accumulation in the roots.

Table 01: Changes in levels of iron in the roots before and after treatment 1 and 2.

Seasons	Iron (mg/l)		
	Control	E1 (Roots)	E2 (Roots)
Spring	1,73	4,32	2,37
Summer	1,523	5,12	2,25
Autumn	0,979	8,55	4,45
Winter	1,231	7,228	3,112

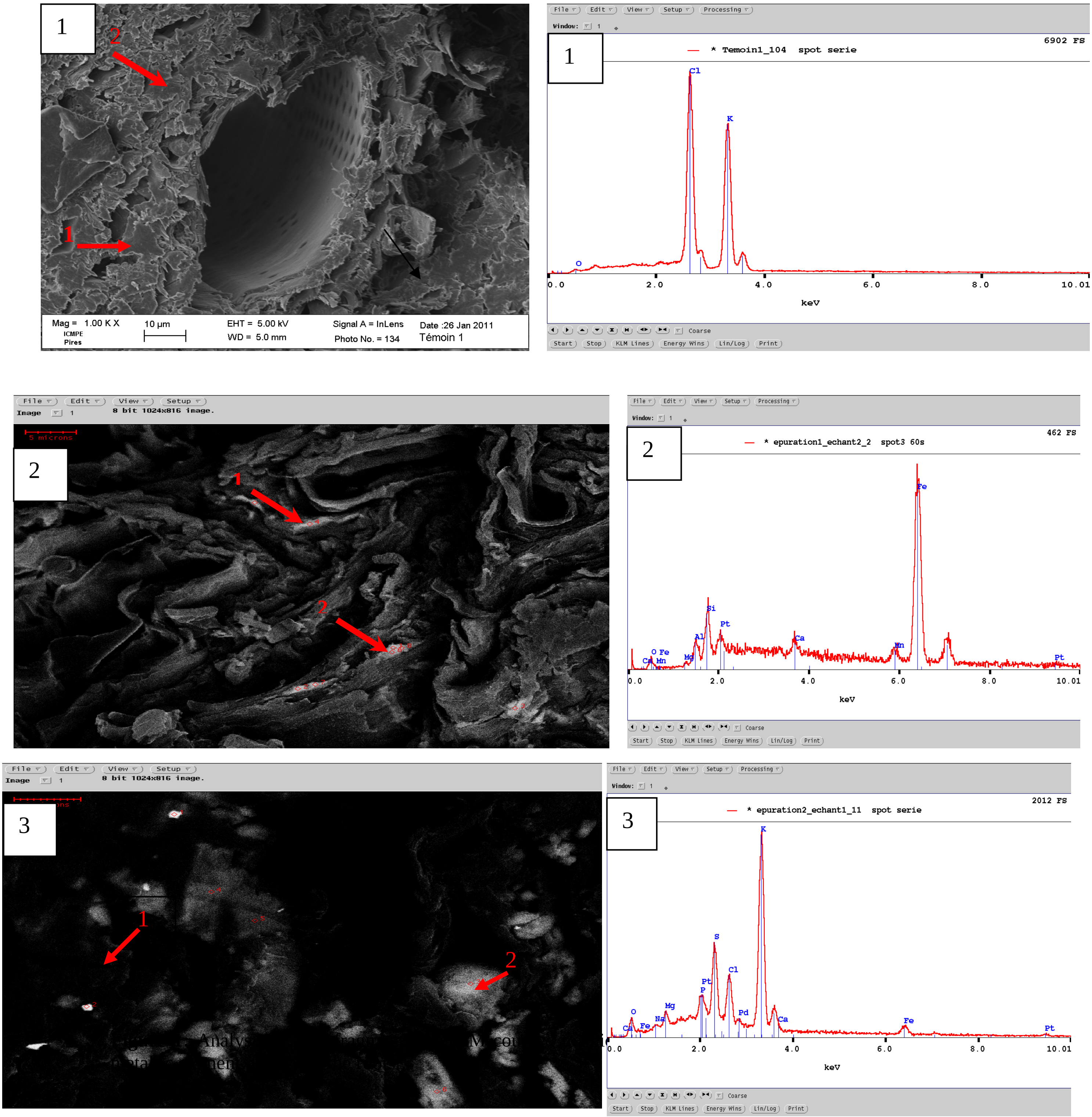
Table 02: Changes in levels of zinc in the roots before and after treatment 1 and 2.

Seasons	Zinc (mg/l)		
	Control	E 1 (Roots)	E 2 (Roots)
Spring	0,039	0,989	0,733
Summer	0,032	0,591	0,37
Autumn	0,051	2,25	0,989
Winter	0,049	1,612	0,531

E1: purification 1; E2: purification 2.

Scanning Electronic microscopy
Distribution of metals in the control roots (1) and treated (2), after E1 showed a high accumulation of metals in the epidermis of roots. Same observation after treatment (E2) (3) visible as a whitish deposits.

Identification of the deposits by SEM-EDX
Spectra (2) and (3) confirm that the most abundant element is iron with high concentrations. However, even after the second treatment, the metal deposits persist. This result suggests the design of a third cleansing tank. On the other hand, the X-ray analysis reveals the presence of other metals from industrial sources such as aluminum or cadmium. In contrast, the peak corresponding to iron decreased significantly after the second treatment without disappearing completely.



DISCUSSION

In this work, we have demonstrated a strong presence of metals in the roots of plants P*hragmites australis* planted in hydroponic wastewater loaded with metals correlated with a significant decrease in water growth medium. According to Ye et *al*. (1997b) *Phragmites australis* has a high tolerance to zinc and iron, but also to Lead and Cadmium, which probably explains the strong presence of these elements in the roots. Indeed Piechalak et *al.* (2002) [8] showed that macrophytes were able to accumulate significant levels of heavy metals. After the second treatment (E2) metal concentration decreased, probably as explained [9] because of the exclusionary strategy adopted by tolerant species, it is to reduce the absorption of Iron and Zinc by roots and their transfer to the aerial parts [10].

On the other hand, [11] showed that Zn (being in the roots form complex Zn-histidine) is transported to the aerial parts mainly in cationic form free Zn^{2+} with a small proportion associated organic acids (mainly citrate) to be finally stored in the vacuoles of the leaf cells as a complex with citrate.

The observation by SEM showed the presence of iron-rich particles around the roots and a layer of aluminum silicate. Our results are in agreement with those of Bordeleau (1998) [12], which states that Phragmites australis with its roots assimilate metals and reduces their concentration in the medium, while Sevrin et *al*. (1995) explains the decrease in the rate of iron accumulation by microorganisms contained in sewage. However, according to Ortega-Villasante et *al*. (2007) [13, 14], the roots of reeds seem therefore increase their capacity for tolerance to both metals by complexing with glutathione in supporting ROS induced indirectly by their presence. Moreover, [15]Carranza-Alvarez et *al.* (2008) state that in the species *Phragmites australis*, There is a power metal accumulator higher in roots compared to stems. In addition, *P. australis* is generally known to accumulate some advantage MTE (Zn, Cu, Pb, and Cd) (Fediuc and Erdei, 2002) [16].

CONCLUSION

Phragmites australis are known for their accumulator power, can response to the pollution in a sensitive and effective manner, hence the importance of their use in phytoremediation. Our results showed that the use of a vertical flow constructed wetland where phytopurification by macrophytes would reduce the pollution of wastewater particularly those charged in metals.

Our results also revealed strong purifying/accumulator power of *Phragmites australis* roots, particularly for trace elements. This hyper accumulation is probably the cause of their high tolerance to high levels of pollution.

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