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Suggestions and Recommendations for Future Research in Phytoremediation on Aquatic Environment

Analia Iriel[1,2]*, Gabriela Lagorio M[3,4] and Alicia Fernández Cirelli[1,2]

[1]INPA, Universidad De Buenos Aires, Conicet, Facultad De Ciencias Veterinarias, Buenos Aires, Argentina

[2]CETA, Universidad De Buenos Aires, Facultad De Ciencias Veterinarias, Buenos Aires, Argentina

[3]INQUIMAE, Universidad De Buenos Aires, Conicet, Facultad De Ciencias Exactas Y Naturales, Buenos Aires, Argentina

[4]Dpto. De Química Inorgánica, Analítica Y Química Física, Facultad De Ciencias Exactas Y Naturales, Universidad De Buenos Aires, Buenos Aires, Argentina

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***For Correspondence**

Analia Iriel, INPA, Universidad de Buenos Aires, Conicet, Facultad de Ciencias Veterinarias, Buenos Aires, Argentina,
Tel : +5411 4524 8484

E-mail: iriel.analia@gmail.com

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ABSTRACT

Phytoremediation is an attractive and ecofriendly solution for remediation of polluted soils and water. Despite the large number of papers published on this topic, discussion of the results in literature is valuable but insufficient in order to take concrete and practical decisions in remediation processes by using living plants. In this sense, there is a remarkable difference between approaches used for living and nonliving biomass.

In this brief commentary we suggest a series of recommendations for planning experiments and for the processing of results when using plants in pollutants´ removal. The objective is obtaining useful and clear parameters such as the optimum contact time for maximum uptake of the pollutant, the removal rate and the maximum sorption capacity, to decide which species and conditions should be chosen for the uptake process.

The presence of contaminants in soils and water bodies involves great risks to the health of plants, animals and humans [1]. In particular, drinking water containing pollutants encloses a great threat to human health due to the daily intake.

In this context, phytoremediation using macrophytes offers an attractive solution for water treatment due to its simplicity, low cost of implementation, great sustainability and ecofriendly character [2]. Moreover, the plants can act themselves as indicators of pollution in the environment by varying its optical properties, which in turn may be non-destructively and remotely sensed [3].

There are many works in literature that have studied the uptake of different aquatic pollutants by living plants [4]. The results presented in this kind of articles are strongly determined by the boundary conditions in which the experiments are conducted, by the physicochemical properties of the aquatic environment and especially by the pollutant´s concentration in the water. Even when these works are highly valuable, in general, they do not offer enough information to take practical decisions on the phytoremediation process. Some reflex ions on this point are presented in this short commentary.

Whenever a phytoremediation process is addressed, previous relevant questions arise to make the right choice of the plant:

What species of plants have higher contaminant removal capacity? How efficiencies of different plant species are compared? What species should be chosen? What is the minimum time required for the removal process?

Most of the published works on environmental remediation by living plants have reported the removal percentage of pollutants. Nevertheless, this data does not suffice because it is highly dependent on the starting concentration of the contaminant in the aquatic environment [5]. Indeed, these questions can only be answered after a detailed analysis of kinetics and equilibrium aspects.

In fact, even when there are a lot of works that have studied the behavior of plant species in contact with solutions of toxic substances, analysis of the process´s kinetics and the maximum uptake capacity by living plants are scarce in literature [6,7]. Conversely, this type of analysis is common when using nonliving biomass for sorption experiments [8]. The reason for these differences in both approaches is due in part to the fact that when using living organisms removal is a complex process involving both biosorption and bioaccumulation and from a strict point of view the basic assumptions involved in the models for equilibrium isotherms (usually applied to inert surfaces) are questionable [9,10]. Nevertheless further information should be obtained from experiments with living plants [6].

Making a brief summary of our suggestions to address a study in phytoremediation we can list the following recommendations

Temporal Evolution of Pollutant Uptake

It is important to register the time evolution of the contaminant uptake process in order to obtain the value of time required for the system to reach an equilibrium or quasi-equilibrium state. This value represents the time beyond which the sorbed contaminant concentration remains constant.

As a Matter of Fact, in This Analysis, Two Scenarios are Possible

One reaching a quasi-equilibrium state and another where the system fails to reach it. In the first case it is possible to determine the time needed to obtain the highest percentage of removal at a given concentration of pollutant. In the second one, the amount of contaminant removed, continuously increases without a steady state and an optimal time may not be predicted.

This type of experiment allows estimation of the necessary minimum contact time between plant and polluting solution to achieve the required removal efficiency [3,6].

Removal Rate

The study of the pollutant removal rate as a function of the initial concentration provides information on the kinetics order of the process and consequently on the variation of this rate with changes of the initial pollutant concentration in the water body [6].

Quantity of Removed Pollutant as a Function of its Initial Concentration in Solution

Another important analysis is the evaluation of the amount of pollutant retained in the plant as a function of its initial concentration in the aquatic media, for a given contact time (evaluated in previous kinetic assays) and constant temperature (isothermal). In this study, when a plateau is found for high pollutant concentration, the maximum sorption capacity may be obtained [6]. This parameter is a useful and practical tool to compare the efficiency among different plant species. This type of comparison is very common in remediation where the sorbent is a non-living biomass, but curiously it was not universally implemented for sorption by living plants.

When the plateau is not reached because of plant death, due to the toxic effect of the pollutant, a maximum operational capacity may be estimated as the highest value that allows an acceptable functioning of the plant photosynthetic apparatus. Monitoring of the photosynthetic efficiency of the plant can be performed during the water treatment, non-destructively, by using variable chlorophyll fluorescence measurements [3].

Models

The fit of the experimental data to different sorption models such as Langmuir, Freundlich and Dubinin Raduskevich, can give additional information about the nature of interaction established between the contaminant and the plant [11,12]. However, a good fit to these models does not necessarily imply that the basic hypotheses of them are valid in these systems [5,6].

Despite the large number of papers published in phytoremediation work, there are very few which paid attention to all the aspects discussed here. In our opinion, it is important to consider them in future studies of phytoremediation to provide the necessary tools that allow a direct comparison among the applicability and efficiency of different plant species. Finally, it should be noted that for an integral help to improve decision-making in phytoremediation design, these selected suggestions must be complemented with other aspects. In particular, issues such as metabolism of contaminant in plants; contaminant release to the atmosphere; accumulation of contaminant or metabolites in tissues; plant management; monitoring plan; public acceptance; regulatory acceptance and cost, which have been extensively described in literature, should be considered [13].

REFERENCES

1. Shrestha S, et al. Assessment of groundwater vulnerability and risk to pollution in Kathmandu Valley, Nepal. Sci Total Environ. 2016;556:23-35.
2. Prasad MN, et al. Knowledge explosion in phytotechnologies for environmental solutions. Environ Pollut. 2010;158:18-23.
3. Iriel A, et al. Effect of arsenic on reflectance spectra and chlorophyll fluorescence of aquatic plants. Chemosphere. 2015;119:697-703.
4. Rahman MA and Hasegawa H. Aquatic arsenic: phytoremediation using floating macrophytes. Chemosphere. 2011;83:633-646.

5. Miretzky P, Saralegui A, Fernández Cirelli A. Aquatic macrophytes potential for the simultaneous removal of heavy metals (Buenos Aires, Argentina). Chemosphere. 2004;57:997-1005.

6. Iriel A, et al. Biosorption of arsenic from groundwater using Vallisneria gigantea plants. Kinetics, equilibrium and photophysical considerations. Chemosphere. 2015;138:383-389.

7. Keskinkan O, et al. Heavy metal adsorption properties of a submerged aquatic plant (Ceratophyllum demersum). Bioresource Technol. 2004;92:197-200.

8. Miretzky P, et al. Simultaneous heavy metal removal mechanism by dead macrophytes. Chemosphere. 2006;62:247-254.

9. Chojnacka K. Biosorption and bioaccumulation: the prospects for practical applications. Environ Int. 2010;36:299-307.

10. Velásquez L and Dussan J. Biosorption and bioaccumulation of heavy metals on dead and living biomass of Bacillus sphaericus. J Haz Mat. 2009;167:713-716.

11. Elangovan R, et al. Biosorption of chromium species by aquatic weeds: kinetics and mechanism studies. J Hazard Mater. 2008;152:100-112.

12. Baig JA, et al. Biosorption studies on powder of stem of Acacia nilotica: Removal of arsenic from surface water. J Hazard Mater. 2010;178:941-948.

13. Mc Cutcheon SC and Schnoor JL. Phytoremediation: transformation and control of contaminants. John Wiley & Sons. 2003.

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