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Predicting the Adsorptive Capacities of Biosolid as a Barrier in Soil to Remove Industrial Contaminants

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***Abstract*—**The major environmental risk of soil pollution is the contamination of groundwater by infiltration of organic and inorganic pollutants which can cause a serious menace. To prevent this risk and to protect the groundwater, we proceeded in this study to test the reliability of a biosolid as barrier to prevent the migration of very dangerous pollutants as 'Cadmium' through the different soil layers.

In this study, we tried to highlight the effect of several parameters such as: turbidity (different cycle of *Hydration/Dehydration*), rainfall, effect of initial Cd(II) concentration and the type of soil. These parameters allow us to find the most effective manner to integrate this barrier in the soil. From the results obtained, we found a significant effect of the barrier. Indeed, the recorded passing quantities are lowest for the highest rainfall; we noted also that the barrier has a better affinity towards higher concentrations; the most retained amounts of cadmium has been in the top layer of the two types of soil tested, while the lowest amounts of cadmium are recorded in the bottom layers of soils.

***Keywords*—**Adsorption of Cadmium, Barrier, Groundwater Pollution, Protection.

I. Introduction

GROUNDWATER coming from the infiltration of rainwater into the ground are, in the most cases, better quality than surface water because they are less directly exposed to various forms of pollution. However, if the pollution is more discreet, they can persist a long time into the soil and it became very difficult in this case to remedy this contamination. The soil is also considered as receptor of all different types of pollution whatever their origin urban or industrial. The pollution caused by heavy metals is the most redoubtable form of pollution especially for its multiple sources: atmosphere waters and currently can be found in urban landfills [1], [2]. In Algeria, the situation is aggravated by both the growth democratic of population in the coastal strip, where the most of urban centers and industrial areas are located, and the inadequacies of existing infrastructure, which are not able to cope with environmental management of pollution. Consequence among others: contamination of surface water and groundwater by illegal dumping, causing a damage to public health. Pollution by heavy metals, being the most feared pollution, because it is considered as micropollution very difficult to detect, and which can lead to apparent malfunction in aquatic ecosystems particularly groundwater [3].

The major sources of anthropogenic emissions of heavy metals such as Cadmium, Lead and mercury are thermal power plants, the units of the industry including the steel industry, combustion of waste, traffic, and mineral fertilizers. As can be expected for anthropogenic pollutants, heavy metals in soils in rural areas are well below that found in urban and industrial areas [4], [5].

The persistence of metals is especially pronounced in the environment. Unlike organic pollutants, metals cannot be degraded biologically or chemically. Metals and their compounds are often transported over long distances by air or water without undergoing transformation. In the environment, a metal compound may only be converted into other compounds in which the metal remains, and in some cases, lead to transformation reactions producing toxic compounds (e.g. methylation of mercury) or immobilisation (e.g. precipitation of Pb SO4) [6].

To solve this problem, it is essential to develop a strategy to safeguard our heritage aquifer. We tried in this study to find a solution to unwanted infiltration (heavy metals) by the establishment of a Permeable Reactive Barrier (PRB) in soil [7]-[9]. The follow-up the influence of several parameters such as rainfall, the initial concentration of cadmium and type of soil, will allow us to find the most appropriate way to integrate this barrier in the soil [10], [11].

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II. Materials and Methods

We have introduced, into a series of transparent containers, one first layer of soil, and then we placed our barrier at a height of 20mm (about 200g). This latter is covered by another layer of the same soil. For each experiment, several witnesses have been prepared (Fig. 1).

In this study, we have chosen to highlight the influence of the following parameters:

- Rainfall: the volumes paid correspond to rainfall of: 27, 32 and 43mm.
- Nature of soil: we have chosen two types of soil: clayey soil and sandy soil.
- The initial concentration of Cd^{2+}: 50 and 200mg/L.

Past volumes, trough different layers are filtered and analyzed by:

- Spectrophotometry UV visible (scanning 200-400 nm),
- Atomic Absorption Spectrophotometry.

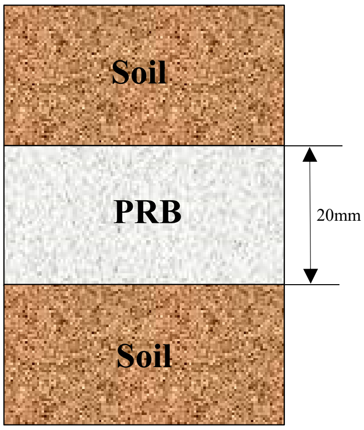

Fig. 1 Schematic illustration of the designed PBR

III. Results and Discussion

A. Effect of Turbidity

After the fifth passage of water cycle (*Hydration/ Dehydration*) (Figs. 2 and 3), we noted that the turbidity decreased significantly and the allure of the all curves tends to resemble like the witness. This behavior may be due to the important turbidity generated by the barrier [12].

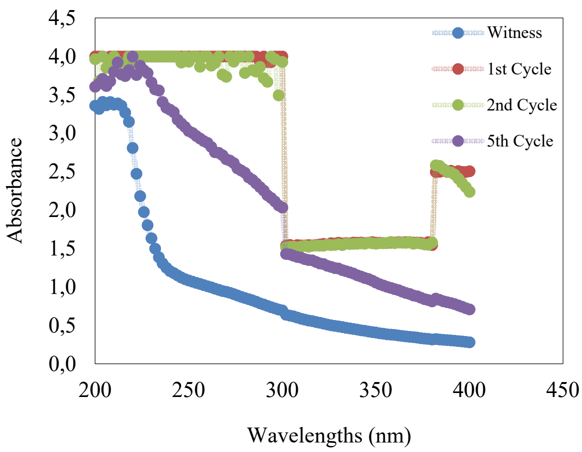

Fig. 2 Effect of turbidity on the PRB

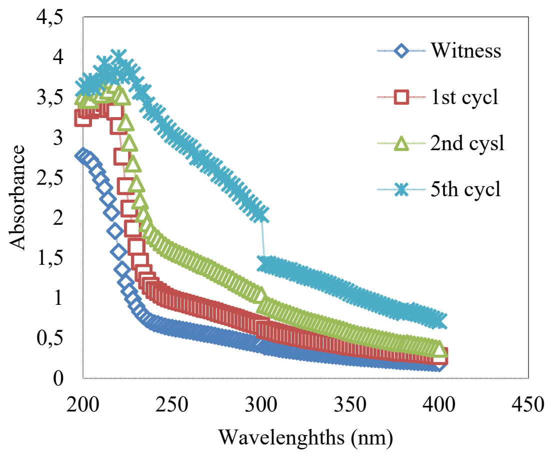

Fig. 3 Effect of the number of hydration / dehydration on the mixture PRB/Soil

B. Effect of Rainfall

Generally, the results shown in Fig. 4, show that the amount passed through the layer soil-barrier are small than those passed through the witness. We note also that there is no very apparent variation between rainfall of 27mm and 32mm; but we find that the recorded past quantities are lowest for rainfall of 43mm, this difference can be explained by the increasing in solubilization of basic salts, thereby contributing probably to the precipitation of cadmium ions in soil [13].

Fig. 5 shows clearly that the amount of Cadmium retained depends on rainfall. Indeed, when the rainfall increase the retained amount increases. The most important amount is retained on the top layer of soil.

In the bottom layer of soil, the amounts of cadmium recorded are lowest compared to those retained by the PRB, this explains that the rainfall increase the diffusion through different layers of soil but the pollutant remains trapped in the PRB [14].

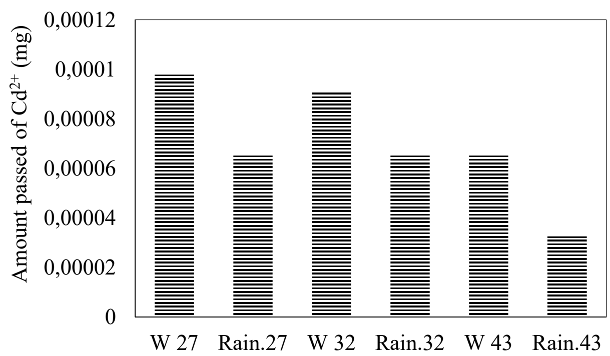

Fig. 4 Effect of rainfall 27, 32 and 43mm

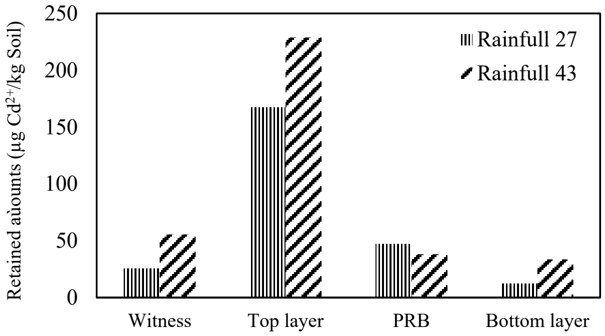

Fig. 5 Variation the retained amount of cadmium in soil layers (27 and 43 mm rainfall)

C. Effect of initial Cd(II) Concentration

Histograms show in Fig. 6, indicate three important points:

- Firstly, the amount dropped by the witness is more important when the initial concentration increase, indeed, the amounts dropped are in the order of 0,0008 and 0,001mg for the two witnesses W 50 and W 200, respectively,
- Secondly, the efficient intervention of barrier placed between the two layers of soil. Indeed, the quantity dropped in this case decrease in both cases of the initial concentrations tested,
- Thirdly, from the result obtained in the latter case (Conc.200), we find that the barrier has a better affinity towards the higher concentrations.

Fig. 7 shows clearly the effect of the initial concentration of cadmium on its behavior in the different layers of soil.

We note that the surface layer is mainly responsible for the retention of cadmium with very important quantities (in order of 740µg/kg for the initial concentration of 200mg/L). This retention can only be explained by the precipitation phenomenon due to the basic pH of soil [15]. Moreover, there is always the efficient intervention of barrier by preventing cadmium to pass through the innermost layers of the soil [16].

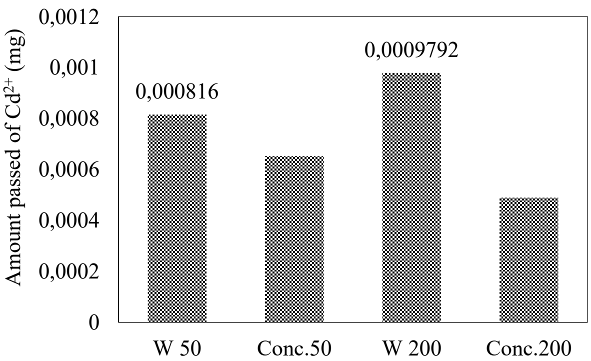

Fig. 6 Effect of the initial concentration of cadmium

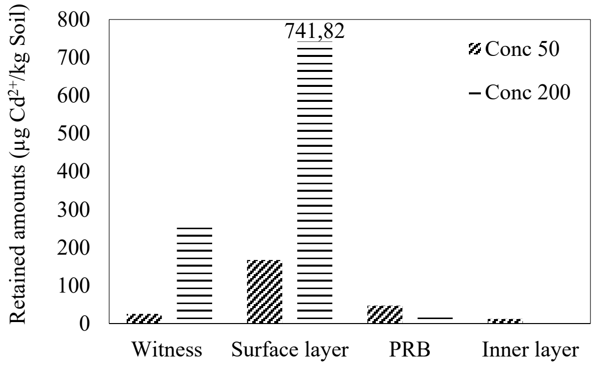

Fig. 7 Variation of the retained amounts of cadmium in soil layers (Initial concentrations 50 and 200mg/L)

D. Effect of the Type of Soil

Fig. 8 represents the amount of Cd^{2+} in the different layers of soil depending on the nature of the soil used. We observed that the same cadmium amount is retained by the both witnesses of the soils used. The amount of cadmium retaining in the top of layer of the two types of soil is important, while the lowest amounts of cadmium are recorded in the bottom layers of soils.

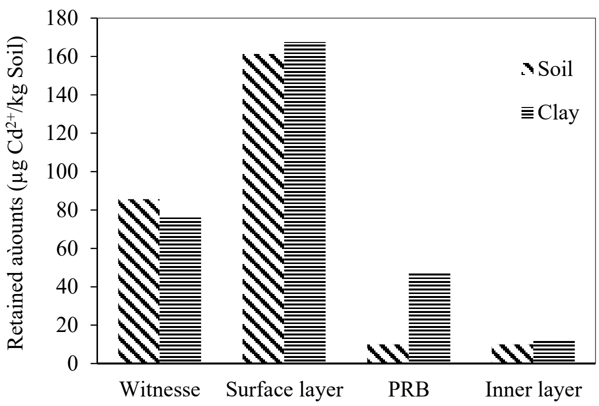

Fig. 8 Effect of the nature of soil on the Permeable Reactive Barrier

IV. Conclusion

Generally, and especially for this study, it was very interesting to see that the establishment of barrier to protect groundwater is important, and can have a repercussion on water quality of groundwater. Monitoring the influence of several parameters has been established, and we found that the rainfall plays a very important role; thus:

- The turbidity due to barrier is high for the lowest rainfall, it tends to diminish for the most abundant rainfall,
- The highest concentrations have less influence, and the precipitation phenomenon governs the presence of the cadmium ion in the filtrate,
- The soil nature affects the presence of the cadmium in the different layers of soil and the most important quantities are detected in the superficial parts of the soil.

DEDICATIONS

This work is dedicated to the Professor: Mohand Said Ouali.

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