

New Active Substrates (ASs) could be Used to Stop Heavy Metals from Migrating to the Soil and Water Environments

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Abstract

An alternative to the well-known reactive permeable barriers (PRBs) is the objective of this paper. Using a reactive barrier below the ground known as PRB is one method for cleaning up contaminated groundwater. New polymer active substrates (ASs) were used to prevent hazardous heavy metals from entering the soil. On the skeleton material (fiberglass or textile), Aliquat 336, bis(2-ethylhexyl)adipate, and polyvinyl chloride were utilized as the active substrates. Aliquat 336 bound the metal ions Cr(VI), Ni(II), Cu(II), Zn(II), Cd(II), and Pb(II). In contrast to the PRBs, the ASs were straightforward to obtain through pouring. The obtained ASs can be recycled and reused. The active substrates were bound to the study soil and a variety of metal ions from aqueous solutions. The active substrate was found to have reduced the concentrations of nickel, cadmium, lead, and chromium in the aqueous solution by more than 50% and more than 90%, respectively. Additionally, the use of revealed that the metals zinc and chromium had a high sorption efficiency of 81% and 66%, respectively, which restricted their movement from the soil to the water. In soil, the best combination of active substrate and plasticizer was the most efficient. This solution reduced copper, lead, and cadmium by more than 70% and by at least 50% for each tested metal ion.

Keywords: Active Substrate (As); Removal of heavy metal ions; Aliquat 336; Groundwater; Soil

Introduction

The natural formation of heavy metals in the environment is aided by mineral erosion, deposits of leached metal ore, and volcanic eruptions. On the other hand, poor waste and sewage management, in addition to the growth of agriculture and industry, including the automotive industry, has resulted in heavy metals entering environmental matrices in an anthropogenic manner. Contamination has an impact on the resources of groundwater and soil, and heavy metals in high concentrations may be harmful to both humans and animals. Therefore, the primary factor that influences the quality of groundwater and soil are heavy metal ions [1]. The quality of the groundwater is getting worse as a result of excessive leaching, which causes metal ions to interact with the layers of groundwater. The natural environment contains numerous toxic heavy metal ions, including Cr(VI), Ni(II), Cu(II), Zn(II), Cd(II), and Pb(II). These ions pose a threat to the surface and subsurface environments. The majority of heavy metals are toxic to organisms even in trace amounts, despite the fact that some of them are necessary for the body's proper growth and development. Because it is used as drinking water, reclaiming contaminated groundwater with heavy metals from natural or anthropogenic sources is a priority. Heavy metal ions have the potential to cause harm to humans and other species due to the ease with which they accumulate in living things. There are a number of methods for reclaiming heavy metal-contaminated soil and groundwater. The primary objectives of these processes are to either completely or substantially remove pollutants, extract pollutants for further purification, or stabilize pollutants by transforming them into less mobile or toxic forms. Matrixes that are uncontaminated should always be separated from matrixes that are contaminated in order to eliminate or limit heavy metal concentrations and reduce environmental contamination [2-5].

Toxic metals can be removed from soil and groundwater in a variety of ways, including reactive materials-based permeable reactive barriers (PRBs) and active treatment technology known as "pump and treat." In the conventional PRB method, reactive barriers are erected perpendicular to the potential course of contaminated groundwater.

Quantification of Aliquat in soil [6]

In order to ensure that Aliquat 336 is safe for the environment and does not leach from the active substrate, a study was carried out to examine it in the soil following the sorption process. The GC-FID method was developed for this purpose, and it has good linearity ($R^2 > 0.999$) across the tested concentration range. The most recent extraction technique had a recovery rate of 86 percent, a coefficient of variation of 3.8 percent, a quantification limit of 0.3 g•mL, and an analyte detection limit of 0.1 g•mL. The chromatographic analysis of the soil extract reveals that the characteristic peaks of the substances in Aliquat 336 were not observed following the sorption of heavy metals on the active substrate [7]. This is demonstrated by the chromatogram of the soil extract that Aliquat 336 was added to for method development. In the tested extracts, Aliquat 336 concentrations could not be measured or detected. The absence of peaks in the chromatograms suggested that the extracted samples did not contain any Aliquat 336 because the method allowed for the measurement of trace amounts. The analyses demonstrated that Aliquat 336 was unable to penetrate the soil [8,9].

Discussion

The data from the literature were compared to the findings. The percentages of sorption of individual metal ions (Cr(VI), Ni(II), Zn(II), Cd(II), Pb(II), and Cu(II)) are all influenced by the type of metal ion separated from the so-called feed phase solution, the pH of the medium, the specific surface type of the sorbent, and the contact time of metal ions with the sorbent [10].

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The authors compared the presented results to those obtained by adding Aliquat 336 to sorbents to remove heavy metals from solutions. A novel strategy for use in soil and soil-water environments is the incorporation of Aliquat 336 into the investigated active substrates. In the literature, Aliquat 336 has been used as an additive for polymer inclusion membranes (PIM) and emulsion liquid membranes (ELM) as well as an extractant in liquid-liquid extraction. Using the aforementioned techniques, heavy metals have been extracted from aqueous and electrolyte solutions like batteries. According to the findings, recovering the tested metal ions from multicomponent solutions was made simpler by the active substrates. Despite the fact that Kadiv was able to achieve a Pb(II) ion sorption level of 95%, 77% of the material was separated using. This made it possible to recover approximately 73% of Cd(II) ions, which were found to differ from the studied literature in the case of Pb(II) ions and made it possible to recover approximately 93% of Cr(VI) ions.

Conclusions

Under model conditions, the solutions presented in this paper effectively reduce the concentration of heavy metals in water, soil, and water-soil environments. Nickel, cadmium, and lead concentrations in the aqueous solution were found to have been reduced by more than half thanks to the active substrate; For chromium, this reduction was greater than 90%. Zinc and chromium migration from soil to water decreased significantly as well, with reductions exceeding 61 percent and 81 percent, respectively. The soil environment provided the active substrate with the most potent plasticizer. For each metal ion tested, this solution reduced levels by at least 50%, with reductions of more than 70% for cadmium, lead, and copper.

It has been shown that the active substrates can be made again and

used in subsequent sorption cycles, that they are cheap to make, and that they lower the concentration of metals in environmental matrices. Active substrates are a viable alternative to solutions that are currently available because of the aforementioned benefits.

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