EVALUATION OF THE EFFECTS OF REACTION TIME AND ADSORBENT DOSAGE IN HEAVY METALS REMOVAL EFFICIENCY IN WASTEWATER TREATMENT WITH THE USAGE OF AQUATIC FERNS

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In this work, a new low-cost phytoremediation metal removal method is introduced and its comparison with active sludge usage is studied to treat a wastewater containing heavy metals. The effects of adsorbent dosage and reaction time on efficiency were studied by experimental tests and it was performed in a semi-industrial scale.

In this study, the use of aquatic ferns in removal of the existing heavy metals in a domestic wastewater was experimented and the results proved their remarkable efficiency in treating such a wastewater as there were more than 99% and 98% removals of the two studied heavy metals respectively.

Keywords: Adsorbent dosage, aquatic ferns, heavy metals, reaction time, wastewater treatment

1. Introduction

Today, one of the most important issues for researchers and industrialists is environmental protection from the pollution of the industries and modern technologies, and heavy metals are considered as those important pollutants. Due to the fact that the physical and chemical separation methods of heavy metals have some limitations, phytoremediation treatment which has several advantages such as low operating costs, reduced biological and chemical sludge levels, high efficiency, resilience biological mass and recovery of heavy metals can be considered for heavy metals removal in aqueous solutions [1],[2].

It should be mentioned that the removal of heavy metals from sewage is a major issue in public health, since these metals are very different from other toxic pollutants due to their sustainability and the tendency to accumulate in living

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organisms. Several studies have been conducted on the removal of heavy metals from wastewater, but unfortunately, these techniques have still remained in laboratories and at pilot levels [3].

One of the purposes of this study was to make these studies in to practice. Heavy metals are kinds of biodegradable and non-biodegradable pollutants that enter the environment through household wastewater or wastewater from various industries and through the water and soil, they enter to the food chain [4]. So their removals in a wastewater treatment system should be seriously considered.

2. Materials and methods

In this research, absorbents of aquatic ferns were prepared and then removal of heavy metals and some other contaminants were investigated by them and compared with active sludge. It should be noted that the two effective parameters on removal; time and adsorption dosage were investigated and then tested with optimal amounts of actual wastewater. For the initial experiments, the jarring test device was used as a discontinuous mixer reactor for the mixing of effluent and absorbent in the laboratory. The reason for this choice is to create conditions that are almost identical to those of a continuously stirred reactor. In the second stage, the reactor was designed and constructed on a semi-industrial scale and the removal rate of contaminated metals was achieved in optimal conditions from the first stage.

- *Preparation of Non-live ferns*

The new ferns were collected from a wetland. It was milled before being used at a dry environment. To remove all particles with a size of about 2 mm before use, it was sieved. In order to improve the quality of removing contaminations and isolating the soil, fern mass was washed with distilled water and 0.2% normal sulfuric acid followed by 0.1% normal reflux. It was then dried again in an oven at 60 ° C until it reached to constant weight.

- *Sampling and preparation of Active Dry Sludge*

The activated sludge was taken from the returned aeration ponds of the wastewater treatment plant and first dried at ambient temperature and in the open area. The active sludge dried before milling to the degree of pouring. This adsorbent was sieved to remove all particles larger than 2 mm before use. In order to improve the quality and eliminate the relative contamination, the active sludge powder was washed with distilled water and with 0.2% normal sulfuric acid and then was washed with a normal pH of 0.1%. In an oven at 60 ° C, it reached to its constant weight again.

In order to understand the process of the tests better, a general overview of the laboratory stage is presented as a flow chart in Fig. 1.

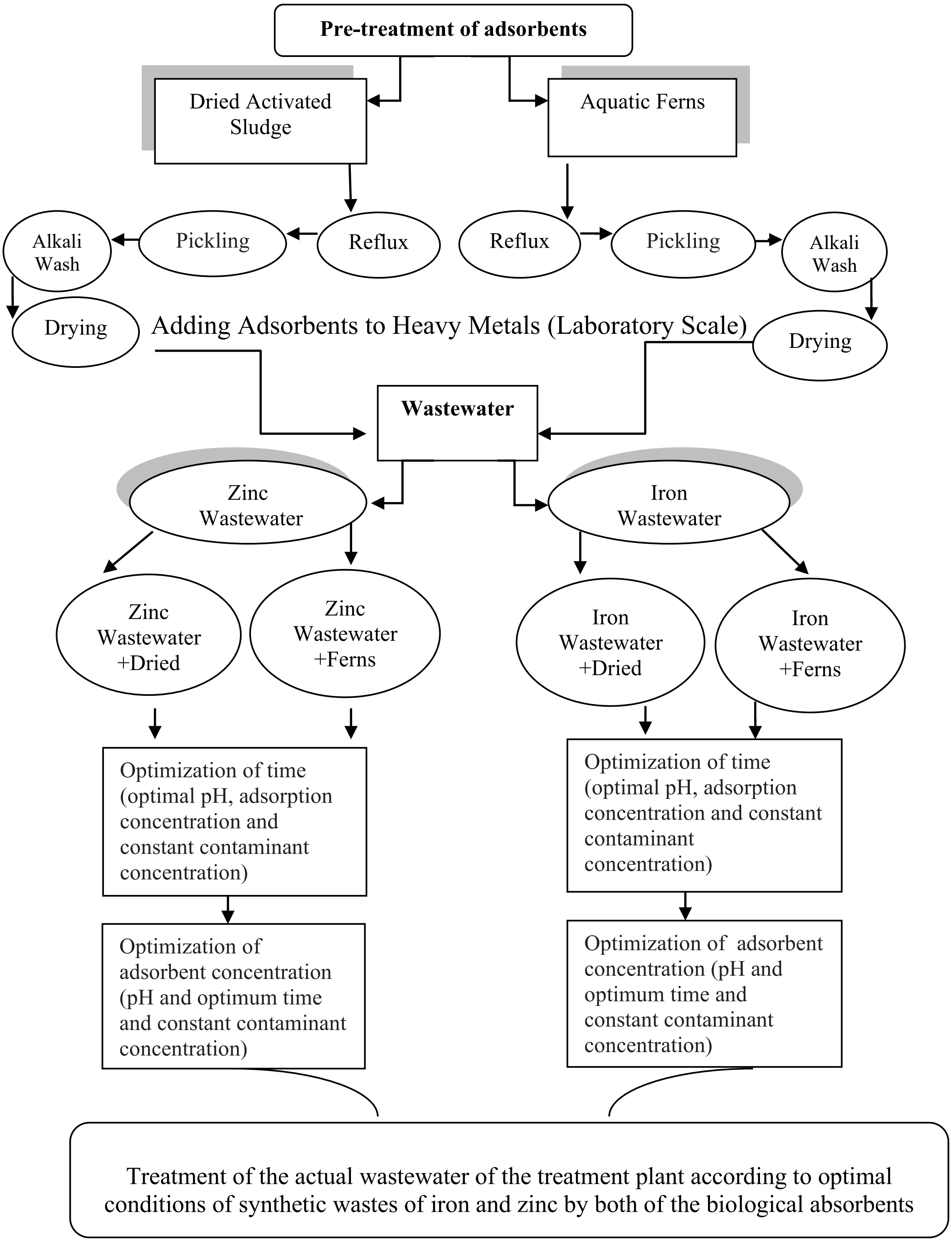

Fig.1.The treatment process flowchart with the two methods

3. Results and Discussion

The Effective Factors on Iron Removal by Aquatic Ferns and Active Sludge

A. Time variations

In the first hours of contact, due to the absorption of a large number of adsorbent spaces, it may be empty and after a certain time depending on the type of absorbent there is no available space for the pollutant and the removal will be stopped [5].

According to the results, the best removal of iron by ferns in 120 minutes was equivalent to 99.4% and the best removal for dry sludge in 90 minutes was 90.4%, and after these times, the fixed removal has decreased to some extent.

B. Variation of the amount of adsorbent

In general, the rate of removal of contaminants is effective by the parametric absorber, specifically in the larger scale (industrial), the increase in wastewater is directly related to the amount of biological mass [6]. The best removal rates of iron were recorded in the presence of 6 grams per liter of ferns adsorbent (99.4%) and 5 grams per liter of dry sludge (90.4%). In the case of adsorbent, ferns were removed from 4 grams to a high percentage, and in lower amounts, removal was slowly carried out, but in dry sludge, the adsorbent was not significantly affected in its rising trend. It should be noted that due to saving the amount of adsorbents, before the other stages of testing, tests with lower absorbent values were performed and then optimization was accomplished.

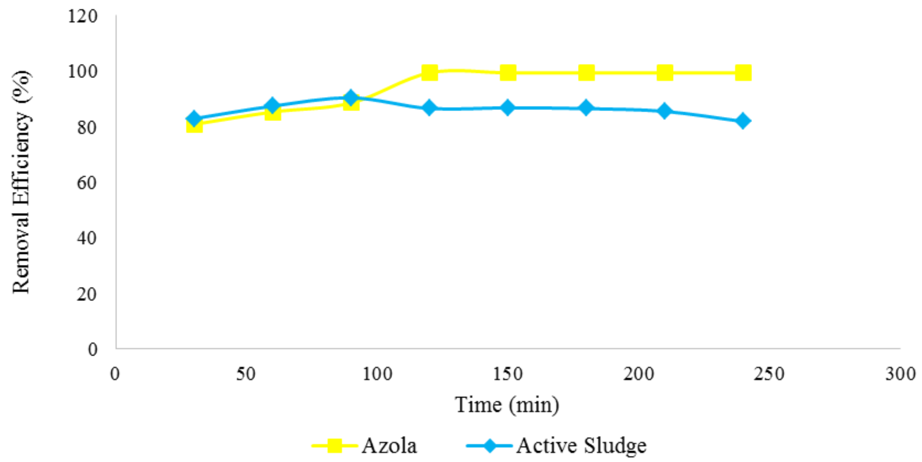

Fig.2. Effect of reaction time at Fe:50 ppm, with aquatic ferns 6 g/l and active sludge 5 g/l

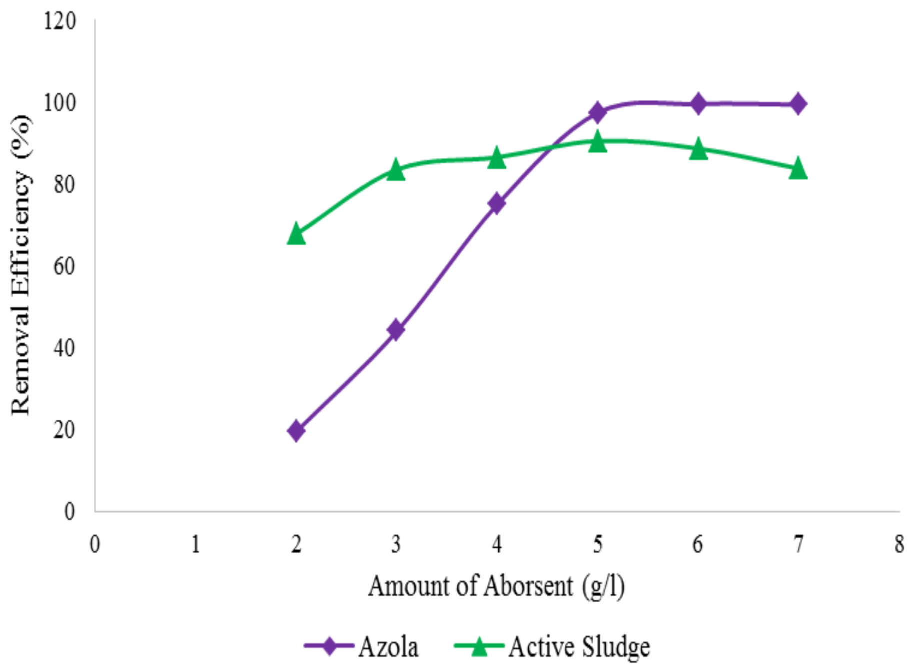

Fig.3. Effect of adsorbent dosage at Fe:50 ppm, with aquatic ferns and active sludge

The Effective Factors on Zinc Ions Removal by Aquatic Ferns and Active Sludge

A. Time variations

According to the results, the best removal of zinc were recorded by ferns in 120 minutes (98.8%) and by active sludge in 90 minutes (93.3%) and after the above mentioned periods in active sludge, the removal rate has been fixed linearly and dropped to some extent in ferns.

The rate of absorption and removal time depend on the type and size of metal ions and the structure of active groups on the absorbent surface, and the number of collisions between the metal and the adsorbent can be effective at the rate of removal [7].

The presence of active carboxylate groups in the activated sludge cell wall and ferns increase the rate of removal of metal cations by the adsorbent during the first hours of contact, and when many of these spaces are occupied, the reaction speed is reduced to a level that there is no other free space on the adsorbent and the removal will be stopped [8].

As it is depicted, optimum reaction time was 120 minutes and 90 minutes for aquatic ferns and active sludge, respectively. But it can be seen that for aquatic ferns, reduction phenomenon reached to equilibrium values faster and in the case of active sludge it was reduced at latter times. Influence of type and size of heavy metal ions, active group structures on the absorbent surface and number of collisions between heavy metal and absorbent on removal time and efficiency could not be negligible.

A. Variation of the amount of adsorbent

The ability to exchange ions from active ions is located on the ferns cell wall with heavy metal ions. Therefore, the removal rate is definitely and directly related to the amount of adsorbent. Increasing the concentration of dried biomass in the solution causes the biomass to stick together and prevent the metal from reaching the active surface of the biomass, so the increase in the amount of warm biomass will not have much effect [9],[10].

The best ferns absorbent effect is 6 grams per liter with the removal efficiency of 98.8% and for active sludge is at 5 grams per liter with the removal efficiency of 93.2%.

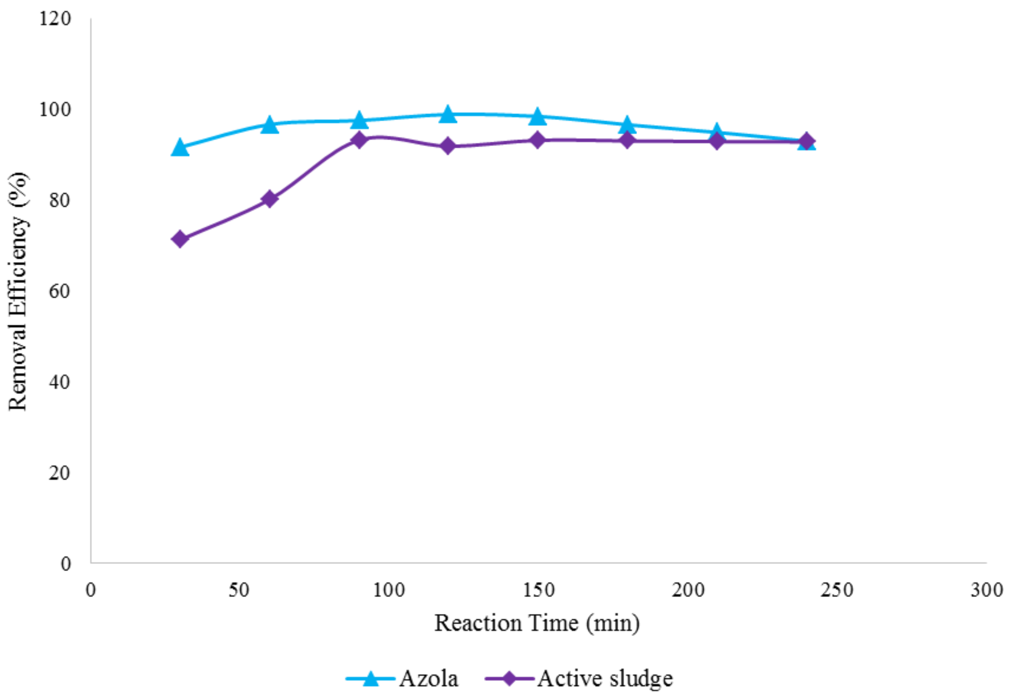

Fig.4. Effect of reaction time at Zn: 5 ppm, with aquatic ferns 6 g/l and active sludge 5 g/l

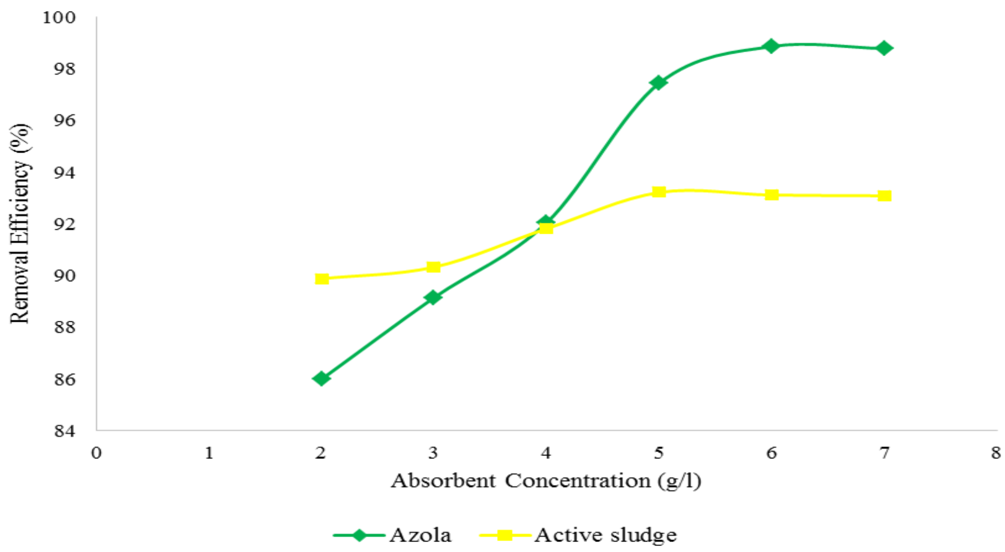

Fig.5. Effect of adsorbent dosage at Zn:5 ppm, with aquatic ferns and active sludge

4. Conclusions

The results of the present study showed that the prepared adsorbent could be appraised as a potential adsorbent in order to remove Fe and Zn ions from the aqueous solutions. Sharp slop of reduction in the first minutes could be explained via existence of active functional groups on the cellular surface of the absorbent. Also there is a direct relationship between removal efficiency and absorbent dosage.

There was a sharp ascending trend for aquatic ferns at concentrations above 4 g/l, but in the case of active sludge absorbent concentration did not have any particular effect on removal. Therefore, using aquatic ferns demonstrated a much more removal, which is the aim of the treatment and is a greater importance since the treated wastewater is used for watering agricultural purposes and containing the minimum amount of the studied metals is the priority.

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