The Use of Low-Cost Materials for the Removal of Toxic Pollutants from Aqueous Environment

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Introduction

Various low-cost materials such as wood, fly-ash, chitin, peanut shell, rice straw and husk have been reported to be suitable for the removal or reduction of toxic pollutants in the aqueous environment[1-3]. These materials provide a cheap alternative for removing pollutants as compared to the conventional methods, which required the use of more expensive synthetic ion-exchanger or activated carbon. In our laboratory we have studied extensively various agricultural by-products and industrial wastes for the removal of heavy metals and coloured wastes from synthetic solutions and industrial effluent. The objective of the project was to investigate and exploit further the potential of low-cost biological materials/industrial wastes in the removal of toxic metals and organic pollutants (dyes) in aqueous environment. Various chemical and physical modifications would be experimented in order to increase sorption capacities of these materials. This would provide a value-added product to an otherwise waste materials.

Materials and Methods

Various low-cost materials and industrial wastes were collected and processed. Materials studied include spent bleaching earth from palm oil mill, chrome waste from electroplating plant, rice husk, moss, non-living biomass of water hyacinth roots, *hydrilla verticillata*, coconut husk and peanut hull. The materials were sieved into suitable particle size and where relevant they were physically or chemically modified. Chemical modification involved the use of N-(3-chloro-2-hydroxypropyl)trimethyl ammonium chloride. Parameters that would affect the uptake of metals/dyes by these materials were investigated in order to ascertain their maximum sorption capacities.

Results and Discussion

Results and discussion are divided into two categories – removal of anions like Cr(VI) and AS(V) and organic pollutants like acid dyes.

Cr(VI) and As(V) – Although various biological materials could remove both types of anions, discussion will be focused on rice husk as the material contained a high per cent of silica which provides mechanical strength without cross-linking. Quaternization process on rice husk was carried out according to standard procedure. The quaternized rice husk provided a larger working pH range than that of untreated husk which sorbed Cr(VI) typically at about pH 2. However, after quaternization the range was extended from 2 – 10. The maximum uptakes were 32.2 and 4.82 mg/g for treated and untreated husks, respectively. A column containing treated and untreated husks could successfully remove both Cu(II) and Cr(VI) from a sample of electroplating waste. The column could be regenerated and used repeatedly without apparent loss in efficiency after 5 cycles. The presence of other anions especially sulphate has to be taken into consideration as it competes for binding sites with Cr(VI) especially if its concentration is high. In the case of As(V) it was found that under batch conditions, the uptake was pH and temperature dependent. Equilibrium was attained within 20 minutes and sorption appeared to be essentially an ion exchange process. Experimental data could be fitted into the Langmuir isotherm with a maximum sorption capacity of 18.98 mg/g at pH 7 and 28°C. Anions such as chromate and sulphate interfere with the uptake of As(V) by quaternized rice husk. In the column studies, results show that breakthrough depends on bed depth but not on flow rate as sorption was very rapid.

Reactive dyes- Various chemically modified biological materials could be used to remove acid dyes from textile effluent. However, discussion will be confined to the use of quaternized rice husk. Sorption of hydrolyzed Reactive Blue 2 by quaternized rice husk showed that the binding capacity of the sorbent was not suppressed by dye bath conditions of high concentration of electrolytes. The physical stability of the husk was examined by treating it with various concentrations of NaOH solution. No dissolution of sorbent occurred even in 1 M solution. Results also show that 97% of the dyes was removed using a sample of textile effluent.

Conclusions

Low-cost biological materials, which generally could not sorb negatively, charged species efficiently could be made to do so upon quaternization. Rice husk is most promising as it contains a high percent of silica and this provides mechanical strength without having to undergo a cross-linking reaction. Hence the cost of production is reduced. Further study should focus on less expensive quaternization process.

Benefits from the study

The results show that low-cost materials or industrial wastes could be converted into value-added products. In the case of Cr(VI) and As(V) their removal could be brought about by materials which have undergone a quaternization process. The same material could also be used to remove acid dyes from textile effluent. The findings are useful in wastewater treat-

ments where the more expensive activated carbon could be replaced by these materials. These findings can act a platform for further study on the possibility of using low-cost materials as sorbents for toxic metals and dyes in aqueous environment.

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None.

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None.

Graduate Research

None.

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