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COMPARATIVE STUDY ON REMOVAL OF CADMIUM FROM WASTEWATER USING LOW COST ADSORBENTS AND MODIFIED LOW COST ADSORBENTS

Fathimath Rajula KT[1], M.A Chinnamma[2]

[1]*P G Student, Dept. of Civil Engineering, Malabar College of Engineering and Technology, Thrissur, India.*
[2]*Professor, Dept. of Civil Engineering, Malabar College of Engineering and Technology, Thrissur, India.*

Abstract – *Heavy metals are highly toxic and non biodegradable substances. Their presence in waters or soil may lead to long-term risk to ecology and human. Rapid industrialization and intensive agricultural activities have caused severe heavy metals contamination. Among the heavy metals, Cadmium (Cd) is one of the nonessential elements for living organisms and is carcinogenic at low concentrations. Cadmium interacts with the calcium metabolism of animals. That is why they need to be removed from waste water before treatment. There are many agricultural waste products that are effective in removing these kinds of toxic substances. Bamboo stem, dried banana peel, Rice husk, orange peel, Neem leaves, are some low cost adsorbents studied. Modified low cost adsorbents include cashew nut shell modified with H_2SO_4, peanut shell modified with ethylenediamine, Cucumber peel modified with Hcl, Orange peel modified with Kcl. Adsorbents are compared by analyzing the removal efficiency at varying pH, adsorbent dosage and contact time. Among these orange shows high removal efficiency around100% in both cases.*

Key Words: **Heavy metals, Adsorbents, Metabolism, Removal efficiency**, **Adsorbent Dosage**.

1. INTRODUCTION

Heavy metals are frequently detected in wastewaters, especially in industrial discharges or mixed domestic-industrial drainage. Water pollution by heavy metals is one of the most important environmental problems because they do not degrade into harmless products, tend to accumulate and are toxic to human beings [3]. An excessive level of cadmium ions in water can seriously endanger the bio-systems and may cause adverse health effects such as bone lesions, cancer. It is therefore of a high interest to develop effective methods to remove these heavy metal ions from wastewater. The US Environmental Protection Agency (USAEPA) and WHO has established a maximum contaminant level of 0.005 mg/L and 0.003 mg/L respectively for cadmium in drinking water [3]. The widely used activated carbon and ion-exchange resins remain relatively expensive materials, thus, the need for the elimination of toxic cadmium from contaminated waters has directed research interest towards the use of low-cost alternatives [3]. Adsorbents used are naturally available agricultural waste products and modified with chemical reagents.

2. LOW COST ADSORBENTS

Increased concentration of heavy metals in waste water and high cost for removing them enhances the usage of low cost adsorbents. Bamboo stem, dried banana peel, Rice husk, orange peel, Neem leaves are studied.

2.1 Effect of pH

Adsorption capacity of majority of agro wastes increases with increasing pH of the solution until an optimum value is reached. After that optimum value the adsorption capacity remains constant or decreases. Bamboo stem shows optimum pH of 5. Binding decreased after pH 5 due to the formation of soluble hydroxides [2]. In case of dried banana peel high increase in rate of metal removal was observed at pH range of 4-7. In acidic pH adsorption is less due to the presence of H^+ resulting in competition between Cd and H^+ for surface area. Adsorption is less in case of alkaline pH also due to the precipitation of hydroxide [4]. Optimum pH of rice husk is 6-9. After pH of 8.3, Precipitation of Rice husk solution starts [9]. In case of orange peel it is found that the pH 9 is the best condition for the adsorption process. 98.8% of Cd is removed at this pH [1]. In case of neem leaves it was seen that there was no adsorption between pH 2.0 and 3.5, and the adsorption was only 8.8% at pH 4.0, but the adsorption increased to 70.0% at pH 7.0 and 93.6% at pH 9.5 [10].

2.2 Effect of Contact Time

Metal ions removal was increased with an increase in contact time before equilibrium was reached. After this equilibrium period, the amount of metal adsorbed did not change significantly with time. The fast adsorption at the initial stage was probably due to availability of sufficient number of vacant sites on the surface of the adsorbent. Contact time needed for bamboo stem was 90 minutes and the sorption decreases after 300 minutes [2]. Adsorption rate gradually increased up to of 50 min of contact time for dried banana leaves. After 50 min less increase in adsorption rate was observed and remained almost constant after 120 minutes, therefore the optimum contact time was chosen as 120 minutes [4]. In case of rice husk the increasing contact time increased the cadmium adsorption and it remained constant after equilibrium was reached in 60 min for

different initial concentrations [9]. Orange peel shows optimum contact time of 30 minute at 90^0C [1]. In case of neem leaves, contact time reaches to equilibrium in 120-300 minute [10].

2.3 Effect of Adsorbent Dosage

Increasing adsorbent dosage indicate increase in number of site available for adsorption. As dosage increases adsorption capability also increases. When bamboo stem was used as adsorbent, Cadmium showed the percentage metal bound at 0.25 g biomass dose was 73.4% and increased to about 95.4% at 2.0 g biomass dose. Generally, sorption did not increase. Maximum removal was observed at adsorbent dose of 0.5 g/100ml [2]. Adsorption dosage of dried banana peel significantly reduces with increase in biomass dose beyond 1.5 g which makes the use of biomass dose beyond the amount unnecessary for that concentration [4]. Rice husk shows a significant increase in uptake when the dose was increased from 0.5 to 2.5 g/L. Any further addition of the adsorbent beyond this did not cause any significant change in the adsorption [9]. Orange peel reaches optimum dosage at 1 ppm [1]. This shows its high potential for removing heavy metals.

3. MODIFIED LOW COST ADSORBENT

The literature reveals that chemically modified biosorbent showed better adsorption capacities than unmodified forms. It can be attributed to the higher number of binding sites, better ion-exchange ability and formation of new functional groups that favor Cd uptake [3]. These modifications improve the adsorption capacity to various extents.

3.1 Effect of pH

When sulfuric acid treated cashew nut shell (STCNS) adsorbent was used, the maximum percentage removal of metal ions from aqueous solution was observed at solution pH 5.0. To avoid the formation of these complexes, all the experiments were conducted at optimum solution pH 5.0 [6]. In case of modified peanut shell (MPS) with ethylenediamine, adsorption rate increases up to pH 3.5. After3.5 equilibrium is attained [8]. Almost all metal ions can be absorbed to the extent of almost 90-100% at weakly acidic conditions when orange peel treated with Kcl (KOP) is used. The pH range of 5.0-5.5 was chosen as optimum [7]. For cucumber peel modified with Hcl maximum percentage removal was achieved at pH 5 and after that up to pH 6 removal capacity remains constant [5].

3.2 Effect of Contact Time

Adsorption increases with increase in contact time. With the further increase in time, the availability of the uncovered surface area and the remaining active sites decrease, and therefore, the driving force decreases. For STCNS percentage removal of metal ions was increased with the increase in contact time and the equilibrium was reached at 30 min of contact time [6]. MPS showed an increasing trend up to a reaction time of 30 min beyond which adsorption appeared to have approached equilibrium. After 1 h, the adsorption capacity of Cd by MPS was still increasing. After 2 h, equilibrium is obtained [8]. In case of KOP, It is seen that the adsorption process proceeds rapidly and adsorption equilibrium can be attained within 20 min. After 20 minute is reached and attains equilibrium no further increase in adsorption is obtained [1]. Optimum contact time for cucumber peel is 30 minutes and maximize near the equilibrium (150 minutes) [5].

3.3 Effect of Adsorbent Dosage

The maximum percentage removal of metal ions for STCNS was observed at 1 g/L of adsorbent dose and then it remains almost constant. Therefore, the optimum STCNS dose was taken as 1g/L [6]. For MPS the adsorption dosage of 10ppm is needs to achieve equilibrium. At this dosage amount adsorbed is 12.5 mg/g [8]. in case of KOP only 0.5g of adsorbent is required for complete adsorption. Also, complete regeneration of adsorbent is possible. This regenerated adsorbent can be used with same initial adsorbent quality [7].

4. CONCLUSION

From low cost adsorbents like bamboo stem, dried banana peel, rice husk, orange peel, Neem leaves, removal of Cadmium with orange peel shows good result. Orange peel removed around 98.9% contaminants from waste water with pH of 9.5 and with contact time of 30 minutes [1]. Among modified low cost adsorbents orange peel modified with Kcl shows good adsorbent with removal efficiency of 99-100% with optimum pH of 5 and contact time of 20 minute [7]. From these results, it is also found that orange peel has greater adsorption capability. These orange peels not only remove Cd but also all most all heavy metals like lead, mercury, Zinc, etc [7]. Thus orange peel has an excellent adsorption power with or without modification. This may due to the presence of some functional groups which the orange peels contain such as hydroxyl and carboxyl; these functional groups make them a potential adsorbent for removing heavy metal ions. By using this modified orange peel with Kcl, we can regenerate the adsorbent completely and it can be used for 10 repeated cycles with same efficiency [7].

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