Removal of Zinc from Waste Water Using Low Cost Adsorbents

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Abstract - *Water is one of the most essential renewable natural resource required for the sustenance of life on earth. The increasing concentrations of heavy metals like zinc cause adverse effects to biotic life. Majority of the remedial measures used to remove the pollutants from water have complex procedures and are uneconomical. Adsorption is widely used for the toxic metal removal due to its higher removal percentage, simplicity and effectiveness. In this paper, we compared the removal efficiency of rubber seed shells and tamarind pod shells for zinc metal removal from water using spectrophotometer. We have studied the effect of various parameters like pH, adsorbent dosage, initial concentration and contact time. The maximum removal efficiency of zinc metal by using rubber seed shells and tamarind pod shells as adsorbent are 86% and 84%. Freundlich and Langmuir isotherms were plotted and Langmuir isotherm was found to be the best model with correlation coefficient (R^2) value of 0.9808.*

Key Words: Adsorption, Zinc, Tamarind pod shells, Rubber seed shells, UV Visible Spectrophotometer

1. INTRODUCTION

A day without using water is unimaginable. According to the World Water Council, about 1.2 billion people worldwide do not get safe drinking water. The availability and distribution of drinking water are decreasing globally because of increased population, industrialization and over exploitation of natural resources. This will lead to serious water stress situations in the upcoming years around the world with predicted intense impact between 2020 and 2050. Besides, increased contamination of natural water resources is further making them unsafe for consumption. Water contamination is generally caused by the accumulation of foreign pollutants in water bodies due to geogenic and anthropogenic activities. The pollutants of major concern are categorised as organic, inorganic and biological contaminants.

Inorganic pollutants are non-biodegradable chemical elements which persist for a long time in the environment. They accumulate in a living system through water as well as food chain and when consumed above a permissible limit may lead to several acute and chronic diseases. It mainly includes heavy metals such as zinc, lead, copper, cadmium etc. Main sources of these pollutants are ground, surface or river water which is mainly associated with unregulated release of chemicals from industries directly into water resources without any treatment. It may be also due to imbalanced geogenic leaching due to environmental and human interventions. Thus it becomes necessary to control the presence of heavy metals in water resources and to develop sustainable remedial measures for the same.

2. OBJECTIVES

- To study about the metal removal efficiency of natural adsorbents in water.
- To study the effect of pH, concentration, adsorbent dosage and contact time on adsorption.
- To study the sorption behaviour of zinc on different natural adsorbents.

3. ZINC

Zinc is a heavy metal which have high production demand in the industrial sector. It is an unavoidable raw material for electroplating, automobile, fertilizer, paint and many other industries. The malleable property that zinc shows helps in easily converting them into different shapes and sizes. Even though the presence of zinc in air, water, soil, plants and in human body is inevitable, their excess concentration can be dangerous. Considering all the sources by which zinc enters human body, the Bureau of Indian Standards has set the permissible amount of zinc in drinking water as 5 mg/l. Too much of zinc can cause nausea, stomach pain, vomiting in human. While in plants, it results in stunting of shoot, curling and rolling of leaves etc. Thus there is a necessity for the removal of excess amount of zinc metal from water.

4. ADSORPTION

Many methods are being used for the metal removal processes like ion exchange, membrane filtration, chemical filtration, adsorption etc. Among these methods adsorption is widely used for the toxic metal removal due to its higher removal percentage, simplicity and effectiveness. Adsorption can be defined as a process by which the molecule or ion in gas or liquid is attracted to the surface of a substance. The materials which is adsorbed is known as adsorbate and the surface to which it is adsorbed is known as adsorbent. Depending upon the forces acting between adsorbent and adsorbate, the adsorption process can be categorized into physisorption and chemisorption. In physisorption, the main forces acting are physical forces such as weak Van der Waals forces while in chemisorption it is strong chemical forces. The process of adsorption is mainly influenced by several factors such as initial metal ion concentration, pH of the solution, contact time, adsorbent dosage etc. Since the conventionally available activated carbon is expensive, there is an urge for a low cost alternative to be used as adsorbent for heavy metal removal.

There are many studies going on regarding the usage of bio adsorbents for heavy metal removal. Bio adsorbents are cheap and easily available which in turn can reduce the treatment cost of waste water along with decrease in the quantity of waste water sludge formation. The experiment aims at removing zinc from waste water using locally available rubber seed shells and tamarind pod shells as adsorbent.

5. EQUIPMENT USED

Table -1: List of Equipment Used for the Study

Name Of Equipment	Company	Specification
Hot Air Oven	KEMI KOS -3	Working temperature: 50^0C to 250^0C
UV Visible Spectrophotometer	SYSTRONICS. MODEL 108	200-900(+_0.5)nm :0.5nm B/W
Magnetic Stirrer	KEMI.KMS 350	Stirring speed - 1200RPM[approx.], 1 litre
Digital pH Meter	SYSTRONICS,MK VI	pH Range: 0-14 pH Millivolt range: 0 to 1999 mV Resolution :0.01pH; 1 mV

Fig -1: UV Visible Spectrophotometer

Fig -2: Hot Air Oven

6. METHODOLOGY

6.1 Preparation of Adsorbents

Rubber seed shells were collected from rubber plantation located at Pezhakkappilly, Muvattupuzha. They were cleaned using wet cloth to remove impurities and dust particles from the shell surface. Later the shells were cut into small pieces and the seeds were taken out. Tamarind pods were collected from Kottapady, Perumbavoor. The fruit part including the seeds was separated from pod shells. Both the shells were washed using distilled water. Then the shell samples were dried in oven at a temperature of 200^0C for 6 hours. The dried samples were taken out, crushed and sieved through Indian Standard sieves. The particles that passed through 300 µm and retained in 150 µm were collected into separate containers.

Fig -3: Rubber Seed Shells

Fig -4: Tamarind Pod Shells

6.2 Preparation of Stock Solution

To prepare stock solution of zinc metal, 110 gm of Zinc Sulphate Heptahydrate was weighed and diluted with distilled water in a 250ml volumetric flask to give a concentrated solution of 1000mg/L. The above prepared solutions were further diluted for getting solutions with required concentrations.

6.3 Experimental Procedure

Sample Testing: From stock solution, diluted solutions with different metal ion concentrations were prepared. Adsorbents were weighed and added to the each sample prepared. Each samples were stirred using magnetic stirrer and kept for a specific time. The filtered solution is then inserted to the spectrophotometer and absorbance value is noted for each sample. Corresponding final concentration for each absorbance value was obtained from the calibration curve. The percentage removal efficiency of zinc can be determined by using the following formula:

$$\text{Adsorption efficiency } (\%) = \frac{IC - FC}{IC} \text{ X } 100$$

IC and FC are initial and final concentration of metal ion concentrations (mg/L) respectively.

7. RESULTS & DISCUSSIONS

7.1 Effect of Initial Concentration

The experimental study was carried out by varying initial metal ion concentration from 10-50mg/L and keeping pH, adsorbent dosage and contact time as constant. It was observed that adsorption efficiency increased with increase in concentration. The maximum value of adsorption efficiency was observed at 50mg/L and they are 84% for rubber seed shells and 80% for tamarind pod shells.

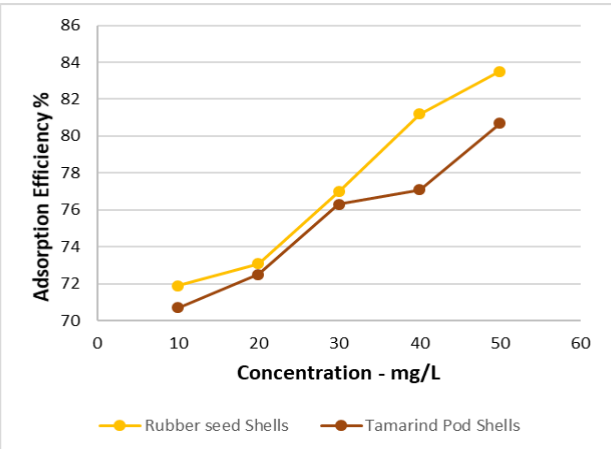

Chart -1: Concentration vs Adsorption Efficiency

7.2 Effect of pH

pH influences adsorption efficiency. pH of prepared sample solution was varied by adding HNO_3. From the chart it was observed that there is a steep increase in adsorption efficiency up to pH 6 followed by a gradual decrease. Maximum adsorption efficiency was found while testing the solution having pH 6 and they are 80% for rubber seed shells and 78% for tamarind pod shells.

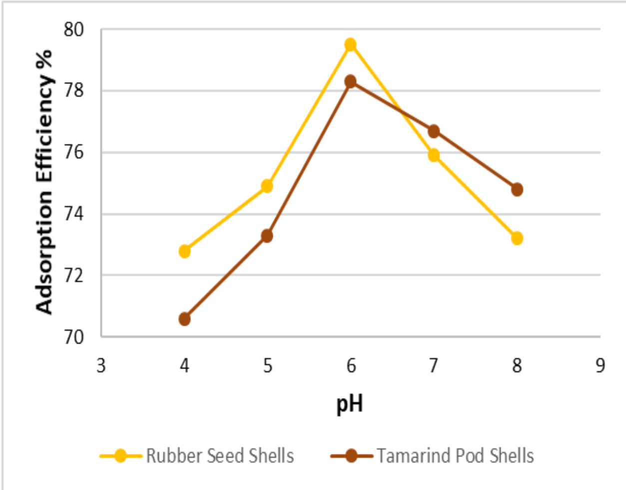

Chart -2: pH vs Adsorption Efficiency

7.3 Effect of Adsorbent Dosage

Adsorption efficiency varies with adsorbent dosage. The study was conducted by varying adsorbent dosage and by keeping all other parameters constant. From the chart, maximum percentage removal of zinc by using tamarind pod shells and rubber seed shells were noted at the adsorbent dose of 1gm and they are 85% and 84% for rubber seed shells and tamarind pod shells respectively.

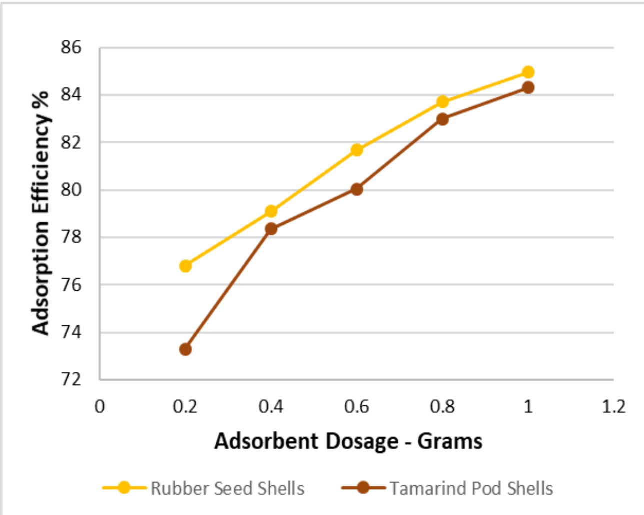

Chart -3: Adsorbent Dosage vs Adsorption Efficiency

7.4 Effect of Contact Time

The sample solutions were prepared and tested at specific time intervals. From the results obtained it was observed that there is an initial increase in adsorption efficiency with time and there after remains constant. Thus it can be concluded that the best contact time is 120 minutes, with adsorption efficiencies 85% and 80% for rubber seed shells and tamarind pod shells respectively.

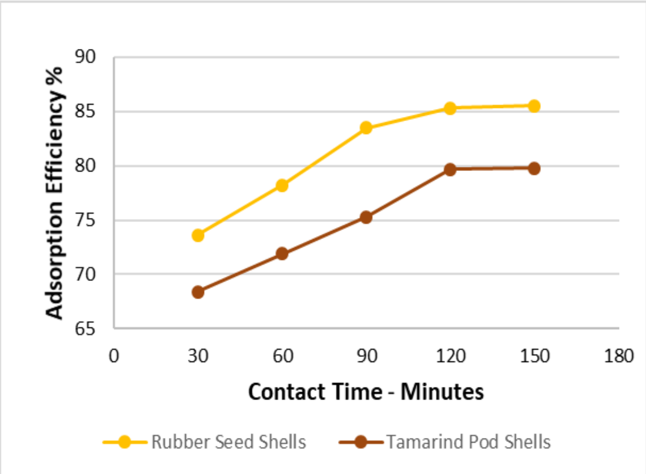

Chart -4: Contact Time vs Adsorption Efficiency

8. ISOTHERMS

Langmuir and Freundlich isotherms were plotted to validate the results. The best adsorption efficiency for zinc metal removal was shown by rubber seed shells. So isotherms with rubber seed shells as adsorbent was prepared and compared.

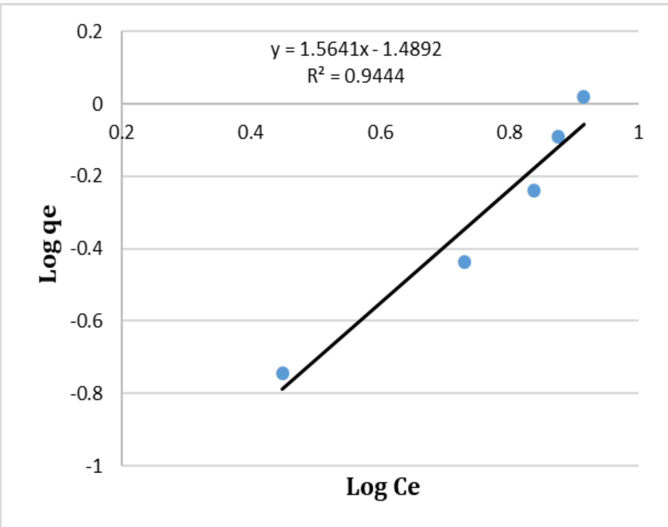

Chart -5: Freundlich Isotherm

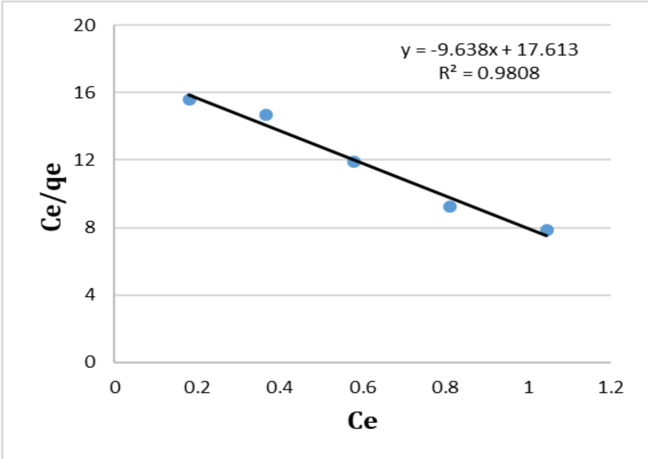

Chart -6: Langmuir Isotherm

The R^2 value obtained for Langmuir isotherm is higher than that of Freundlich isotherm and the values also fitted well with the Langmuir model.

9. CONCLUSION

There are many locally available materials in nature which are cost effective and can produce activated carbon. Rubber seed shells and tamarind pod shells are cheap and effective adsorbent which can be used for the removal of zinc ions from water. Experiment carried out showed that maximum removal efficiency of rubber seed shells and tamarind pod shells as adsorbents for zinc metal removal are 85% (150 min) and 84% (adsorbent dosage, 1m). From the above results, it can be interpreted that rubber seed shells show comparatively higher adsorption efficiency than tamarind pod shells. Freundlich and Langmuir isotherms were plotted and the data got well suited with Langmuir model with correlation coefficient (R^2) of 0.9808. Thus it can be concluded that rubber seed shells and tamarind pod shells can be used for heavy metal removal and by using these green adsorbents, we can also overcome the limitations of more expensive conventional adsorbents.

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