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Natural Adsorbent (Adsorption) for Removal of Heavy Metals from Waste Water

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Abstract
Removal of heavy metals from wastewater is a major ecological problem. Adsorption process for the removal of heavy metal from synthetic wastewater by using low cost adsorbent (Sulphuric acid treated Sugar cane bagasse). It is cost effective method and also it do not cause the any type of environment pollution. Concentrations vary between 5 – 20 ppm. As concentration increases % removal decrease at particular stage after that rate of adsorption constant. The percentage of adsorption of each metal ion, the mass of Bagasse varied from 2 to 20 g/L, the pH of the solution being maintained to 5 with a contact time of two hours. Contact time on the adsorption of copper and nickel ions on the Sugarcane Bagasse was carried out at pH 5 with a Bagasse mass of 20 g/L while varying this parameter from 0.5 to 5 hours. The percentage of each metal adsorbed as function of the pH for a mass of untreated Bagasse of 10 g/L and a time of contact of two hours. The percentage of each metal adsorbed increases with the pH. The maximum adsorption of each and every metal ion found at pH range from 5 to 6.

Keywords – Natural Adsorbent, Sugarcane Bagasse, Heavy Metal Removal, Wastewater Treatment, Adsorption Process.

INTRODUCTION

The toxic metals from the earth's crust to the environment are increases due to rapid developments and increase in mining and industrial activities. The presence of these toxic metals in environment cause the changes of human exposure to these metals in excess of their natural levels through ingestion, inhalation or skin contact. Many diseases from these environmental factors are injurious to bio-systems.
Due to human activity concerning heavy metals constitutes a major health hazard. In various industrial and agricultural activities many heavy metals used that can be found in waste waters in soluble or insoluble form. Heavy metals are toxic for human health and all watery species depending on their concentrations and bioaccumulation conditions.
Specific gravity greater than about 5 or relatively high density or high relative atomic weights are called as heavy metals, (especially one i.e. poisonous) one mercury or lead. Heavy metals have density criteria range from above 3.5 g/cm^3 to above 7 g/cm^3.

Important sources of heavy metals are

1. Urban industrial aerosols created by combustion of fuels
2. Metal ore refining
3. Industrial processes
4. Liquid and solid wastes from animals and man
5. Mining wastes
6. Industrial and agricultural chemicals.
7. Leaching processes
8. Chemical conversions
9. Automobile exhausts

Properties of Heavy Metals

1. Heavy metals occur near the bottom of the periodic table.
2. Heavy metals have high densities.
3. They are toxic in nature.
4. Heavy metals are non-degradable.
5. Density > 5 gm/cc.
6. They have harmful effect on biological systems.
7. Specific gravity of heavy metal are more than 5.
8. They have tendency to accumulate in organisms.
9. They have high relative atomic weight.
10. They are poisonous in nature.
11. Heavy metals are the stable bio toxic compounds.
12. Heavy metals can be found in waste waters in soluble or insoluble form.

I. LITERATURE REVIEWS

By previous studied there are a number natural of materials are available such as leaf mould , rice husk , groundnut husk, coconut husk and palm pressed fibers , coconut shell , coconut jute , coconut tree sawdust, cactus, olive stone cake and wool and pine needles have been used as an adsorbent for the removal of the heavy metal ions.
Experimental study by Wantanaphong et al. carried out the biosorption of copper, lead, zinc and cadmium by using a range of waste products and natural materials including chitin, fly ash, clay soil, cocoa shell, calcified seaweed and the natural zeolite clinoptilolite. Under batch experiments it's clear that all had ability to remove more than 70 % of metals from solution.[1]

As per study Mise and Rajamanya reported the activated carbon derived from Sorghum vulgare can be used as an efficient adsorbent for the removal of Cr (VI) and removal of copper ion from electrochemical wastewater using Sand as an adsorbent.
Adsorption is highly effective for heavy metal removal. This method have removal efficiency of copper achieved more than 97 percent in the proved by experiment.[1].

Dr. P. Akhila Swathanthra, Dr. B. Sarath Babu, M. Srinivasa Rao, Dr. V. V. Rao has studied that Adsorption behaviour of copper from waste water has been investigated in this paper using Bagasse. The maximum removal of Copper is above 93% was observed at pH of 5 for Bagasse in 100 ppm Copper solution. [2].

Experimental Study influence of contact time on the adsorption of copper and nickel ions on the Sugarcane Bagasse was carried out at pH 5 with a Bagasse mass of 20 g/L while varying this parameter from 1 to 5 hours .[13].

By the reported N Prapurna and M Viswanathan has studied that the Adsorption Kinetics for the simultaneous and selective removal of Cr (VI) and Cu (II) ions from aqueous mixture was investigated using sugarcane bagasse. [8]

II. MATERIAL AND METHODS

Conventional Methods for Heavy Metal Removal
Several methods have been used for the removal of heavy metals from water and waste water. For removal of heavy metals from contaminated waste water as follows

1. Chemical precipitation
2. Ultra-filtration
3. Ion exchange,
4. Reverse osmosis
5. Electro winning
6. Carbon adsorption
7. Phytoremediation

Adsorption Process
Process which leads to the equilibrium distribution between the adsorbent and the solution is nothing but adsorption. Based on the interpretation of the adsorption isotherms which translate the relation between the concentration of pollutant in solution and its adsorbed quantity, followings are the number of materials

1. leaf mould
2. Rice husk
3. Groundnut husk
4. Coconut husk and palm pressed fibers
5. Coconut shell
6. Coconut jute
7. Coconut tree sawdust
8. Cactus
9. Olive stone cake
10. Wool and pine needles
11. Bagasse.

Theory of adsorption
In this process molecules of a gas or liquid contact and adhere to a solid surface. It occurs at an interface between any two phases. The liquid-solid interface is carried out in water and wastewater treatment process.

1. Liquid-liquid
2. Gas-liquid
3. Gas-solid

4. Liquid-solid interfaces.

Types of Adsorption

Physisorption-Physisorption or physical adsorption occurs as result of energy differences and/or electrical attractive weak forces such as the (Van der Waals forces), the adsorbate molecules (liquid contamination) are physically attached to the adsorbent molecules (solid surface).

Chemisorption- Chemisorption or chemical adsorption occurs when a chemical compound is produced by the reaction between the adsorbent and the adsorbed molecule.

Adsorption isotherms models-Adsorption models are frequently used to describe the equilibrium between metal ions in solution and metal ions adsorbed on the surface.

The two most commonly used equilibrium isotherms

1. Langmuir isotherm model
2. Freundlich isotherm model

Factors affecting the adsorption process

1. Effects of initial concentration and contact time on adsorption
2. Effect of solution pH on adsorption
3. Effect of temperature on adsorption

III. EXPERIMENTAL ANALYSIS

Preparation of Synthetic wastewater:

1. Take 5 mg metal powder in crucible then add 5 ml of concentrated nitric acid in to it.
2. Heat it till all brown fumes removed.
3. The remaining blue solution in crucible will dilute in 1000 ml of distilled water.
4. If we take 5 mg solution in 1000 ml water is 5 ppm solution.
5. Similarly we can make 10 L synthetic water of various concentrations solution.
6. For make various ppm solution follows the process steps from 1 – 4 as above mentioned.

Preparation of Adsorbents-Adsorbent (Sugarcane bagasse) collected from Sugar industry.

1. Crush the sugar cane bagasse and make powder.
2. Firstly the adsorbent was washed with distilled water.
3. Dried it at room temperature to avoid the release of color by adsorbent into the aqueous solution.
4. The activation of adsorbent is carried out by treating it with concentrated Sulphuric acid (0.1N) and is kept in an oven maintained at a temperature range of 150ºC for 24hr.
5. Again is washed with distilled water to remove the free acid and put in to oven for removal of moisture and then adsorbent is passed from 500 micron mesh size and collected for experimental use.

Experimental procedure

1. Take the 10 L known concentration solution in the vessel.
2. Weighed amount of the adsorbent with waste water aqueous metal solutions of known concentration and pH value.
3. The metal solutions were agitated by agitator for a desired time.
4. The samples were withdrawn from the stirrer at the pre-determined time intervals and adsorbent was separated by filtration.
5. Analysis the concentration by help of the spectrophotometer.
6. Take the readings at various time of interval 30 , 60 ,90 up to 120 min.
7. Analysis the optimum time of adsorption time. Take the reading for various pH and also for various concentrations.

IV. RESULT AND DISCUSSION

Effect of pH on rate of Adsorption

Table shows the effect of pH on % reduction of metals .As per observation it is clear that the % removal of metal increase with increase in pH. The optimum value of pH is 5-6 in which higher % of metal removed after this % reduction of metal decrease.

TABLE I EFFECT OF pH

Sr. No.	pH	% Removal of Metal
01	2	45
02	2.5	52
03	3	60
04	3.5	68
05	4	72
06	4.5	78
07	5	86
08	6	86
09	7	72

Effect of Contact Time on rate of Adsorption

Table shows the effect of contact time on % reduction of metals .As per observation it's clear that the % removal of metal increase with increase in contact time. The optimum value of contact time is 3.5-4.5 hrs in which higher % of metal removed after this % reduction of metal is constant.

TABLE II EFFECT OF CONTACT TIME

Sr.No.	Time in hrs.	% Reduction of Metal
01	0.5	45
02	1	52
03	1.5	60
04	2	68
05	2.5	72
06	3	82
07	3.5	88
08	4	88
09	4.5	88

Effect of Concentration on rate of Adsorption

Table shows the effect of concentration on % reduction of metals .As per observation it's clear that the % removal of metal increase with decrease in concentration. The optimum value of concentration is 5-10 ppm in which higher % of metal removed after this % reduction of metal is decrease.

TABLE III EFFECT OF CONCENTRATION

Sr. No.	Concentration in mg/l	% Reduction of Metal
01	5	90
02	10	88
03	15	84
04	20	82
05	25	80
06	30	78
07	35	76
08	40	74
09	45	72

Effect of Various Parameters on Rate of Adsorption

Effect of pH on the metal adsorption

The percentage of each metal adsorbed as function of the pH for a mass of untreated Bagasse of 10 g/L and a time of contact of two hours. The percentage of each metal adsorbed increases with the pH. The maximum adsorption of each and every metal ion found at pH ranges from 5 to 6.

Effect of contact time on the metal adsorption

Contact time on the adsorption of copper and nickel ions on the Sugarcane Bagasse was carried out at pH 5 with a Bagasse mass of 20 g/L while varying this parameter from 0.5 to 5 hours.

Effect of the mass of Bagasse on the adsorption

The percentage of adsorption of COD and decolorization of the mass of Bagasse varied from 2 to 20 g/L the pH of the solution being maintained to 5 with a contact time of two hours.

Effect of Concentration

In this experiment concentration vary between 5 – 20 ppm. As concentration increases % removal decrease at particular stage after that rate of adsorption constant.

V. CONCLUSIONS

Heavy metal can easily adsorbed from waste water by natural material with low cost and high efficiency. Adsorption is the efficient technique of removal of the heavy metal from the various types of waste water. Cost of this type of process is lowest than the convectional method.The percentage of each metal adsorbed as function of the pH for a mass of untreated Bagasse of 10 g/L and a time of contact of two hours. The percentage of each metal adsorbed increases with the pH. The maximum adsorption of each and every metal ion founds at pH range from 5 to 6.

Contact time on the adsorption of copper and nickel ions on the Sugarcane Bagasse was carried out at pH 5 with a Bagasse mass of 20 g/L while varying this parameter from 0.5 to 5 hours. In this experiment concentration varies between 5– 20 ppm. As concentration increases % removal decrease at particular stage after that rate of adsorption constant.

VI. FUTURE SCOPE AND BENEFITS

Future Scope

•Adsorption can be adopted to treat waste water.

• This process improves the efficiency of conventional method.

• This can be used as an additional treatment to treat waste water with Heavy metal removal.

• Adsorption process can make waste water for reusable as process water by removal of Heavy metal, color and impurities from waste water.

Benefits

- Capital cost significantly less than convectional technologies.
- Operating cost significantly less than convectional technologies.
- Low power requirements.
- Low maintenance.
- Minimal operator attention.
- Consistent and reliable results.

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