Adsorption Studies on Red Mud: Removal and Recovery of Cr (VI) from Wastewater

Maruwada Srinivasan[1], Ramprasad Naik Desavathu[2], Rakesh Roshan Dash[3]

[1]Ph.D Scholar, GIET UNIVERSITY
[2]Professor, GIET UNIVERSITY
[3]Professor, VSS University of Technology Burla

Abstract
The addition of any organic, inorganic, biological, or radiological substance to water that changes its physical and chemical properties is known as water pollution. These pollutants come in contact with water by rapid and unplanned industrial progress, overpopulation, discharge of sewage into water bodies, etc and such water is unfit and very harmful to public health, animals, plants, and aquatic life. Water pollution due to heavy metals and organic pollutants has been a major Concern for a long. Heavy metals are nonbiodegradable and are the cause of many dreadful disorders in the long run; on the other hand, many organic pollutants are carcinogenic. Sources, toxicity, and hazardous effects of some important heavy metals are also summarized. Heavy metals are also summarized. Include preliminary treatment, primary treatment, secondary treatment, and tertiary treatment. The main objective of preliminary treatment and primary treatment is the removal of gross solids such as large floating and suspended solid matter, grit, oil, and grease if present in considerable quantities. Secondary treatment is a biological process involving bacteria and other microorganisms removing the dissolved and colloidal organic matter present in the wastewater. Tertiary treatment is the final treatment, meant for "polishing" the effluent from the secondary treatment processes to improve the quality further.

Keywords: aquatic life, heavy metals, pollutants

1. Introduction

The unthoughtful race for industrial development and unlimited exploitation of natural resources have adversely affected all forms of life in the biosphere. This has threatened the survival of all living organisms. Air has become dangerous to breathe, water is unfit to drink, soil is unsuitable for crops and aquatic ecosystems antagonized marine creatures. Industrialization has given us radioactivity, dangerous effluents, poisonous gases, and heavy metals etching our environment. Thanks to pollution, all these are the gifts of industrialization to modern civilization. The term pollution is defined as an undesirable change in chemical, physical, and biological characteristics of air, water and soil which creates a potential health hazard to living organisms and harmfully affects life.

Classification of pollution

Environmental pollution can be classified as Air pollution, Water pollution, Soil pollution, radioactive pollution, noise pollution, and thermal pollution.

Water pollution: The addition of any organic, inorganic, biological, or radiological substance to water that changes its physical and chemical properties is known as water pollution. industrial progress, overpopulation, discharge of sewage into water bodies, etc and such water is unfit and very harmful to public health, animals, plants, and aquatic life. Water pollutants can be classified into four major categories. Organic pollutants, inorganic pollutants, suspended solids sediments, and radioactive materials.

Heavy metals pollution:

Heavy metals can be defined in many ways, based on their physical, chemical, and biological properties. Metals with a specific gravity of about 5g/cm3 or greater are generally defined as heavy metals and these include metals from IIA, IIIB, IVB, VB, and VIB of the periodic table.

Environmental effects of heavy metals:

From the environmental point of view, the metals that are of greatest concern are those which, either by their presence or their accumulation, can have a toxic or inhibitory effect on living things. Metals like cadmium, chromium, copper, zinc, nickel, lead, and mercury, enter the environment through industrial waste,

2. Prepare Your Paper before Styling

2.2 TECHNOLOGIES FOR TREATMENT OF WASTEWATER CONTAINING HEAVY METALS:

Different techniques have been used for the removal of heavy metals from wastewater. Chemical, physical, biological, and electrochemical techniques are the most common for the removal of toxic metals from wastewater.

Chemical techniques for wastewater treatment include chemical precipitation, ion exchange, and adsorption. In biological treatment, microorganisms are used for the removal of heavy metals in the wastewater. Examples of physical processes are membrane filtration, flotation, coagulation, and flocculation. Conventional methods include reverse osmosis, electrochemical treatment, evaporative recovery, ion exchange, chemical precipitation, membrane filtration, chemical oxidation-reduction, electrodialysis, ultrafiltration, and solvent extraction. The applicability and use of all these common techniques are limited by their low efficiency, critical operating parameters, and production of secondary sludge.

The most efficient methods for heavy metal removal are ion exchange and adsorption. In these methods, various types of adsorbents are used with simple, easy convenient procedures for having high removal efficiency. However, ion exchange is expensive and the use of this technique is limited because of its selectivity for specified metal ions in comparison with other metal ions.

In adsorption, a certain adsorbent is used for the removal of heavy metal from wastewater and it is considered to be the most effective process because of its high efficiency. Adsorption also produces high-quality effluent. Adsorbents can also be regenerated by using suitable adsorption processes. Adsorption is one of the most effective processes of advanced wastewater treatment, which industries employ to reduce hazardous metals present in the effluents.

3. Abbreviations and Acronyms

AMD: acid mine drainage

CAC: commercial activated carbon

CKD: cement kiln dust
CSC: coconut shell charcoal
FA: fly ash
FSH: sunflower head waste
LR: laboratory reagent
MINAS: minimal national standards
MOEF: Ministry of Environment and Forest
PPM: Part per million
RM: red mud
RPM: revolution per minute
SEM: Scanning electrons microscope
TFW: tea factory waste

4. Units

%R: Removal of chromium in percentage
b: Langmuir constant
C: Degree centigrade
Ce: Concentration of adsorbate in solution at equilibrium
Co: Initial concentration of adsorbate
Cs: Saturation concentration of the adsorbate
g : Gram
h: Initial Sorption rate
k: Thomas rate constant
k1: First-order reaction rate constant (min-1)
K2: Pseudo second-order rate constant (g/mg .min)
Kf: Freundlich characteristics constants
l : Litre
L: Length of the adsorbent bed
m: Mass of adsorbent
mg : Milligram
min: Minute
ml : Millilitre
n: Adsorption equilibrium constant amount
q: Amount of adsorbate adsorbed per unit weight of adsorbent
Q : Volumetric flow rate

5. Equations

ADSORPTION ISOTHERMS:

The amount of adsorbate that is adsorbed per amount of adsorbent is determined as a function of concentration at a constant temperature. The resulting function is called the adsorption isotherm. Adsorption experiments are carried out to develop adsorption isotherms in which the amount of the adsorbent is changed while the initial concentration and volume of the adsorbate are kept constant.

The adsorbent phase concentration after equilibrium is computed using the equation given:

$$qe = \frac{(Co - Ce)\,V}{m}$$

where, qe = adsorbent (i.e., solid) phase concentration after equilibrium, mg adsorbate/g adsorbent.

Co = initial concentration of adsorb ate, mg/L.

Ce = final equilibrium concentration of adsorb ate after adsorption has Occurred mg/l

V = volume of liquid in the reactor, L

m = mass f absorbent, g.

Commonly used adsorption isotherms are Langmuir adsorption isotherm and Freundlich adsorption isotherm.

Langmuir Adsorption Isotherm:

The Langmuir adsorption isotherm is given as:

$$\frac{x}{m} = \frac{able}{1 + bCe}$$

where, x/m = mass of adsorbate adsorbed per unit mass of adsorbent, mg adsorbate /g adsorbent.

a , b = empirical constants

Ce=equilibrium concentration of adsorbate in solution after adsorption, mg/l

The assumptions in the Langmuir isotherm are: (1) Maximum adsorption of the adsorbate occurs at homogeneous saturated monolayer sites on the adsorbent surface.

(2) The energy of the adsorption is constant. Equilibrium in the adsorption process occurs when all the adsorption sites of the adsorbent get saturated with adsorbate (atoms, molecules, ions) or when the rate of the adsorption of the adsorbate molecules becomes equal to the rate of desorption of the adsorbate molecules from the surface of the adsorbent.

Freundlich Adsorption Isotherm:

The Freundlich adsorption isotherm is an empirical relation and is given as:

$$x/m = Kf\ Ce^{1/n}$$

Red mud is relatively toxic and always poses a serious pollution hazard; it also has significant alkaline properties. Depending upon the number of mud-washing stages, the water associated with the mud may contain 3-10 g dm-3 alkalinity (expressed as Na_2CO_3). In addition, the amount produced is significant. Around 1-2 tons of residues are generated per ton of alumina produced. It is estimated that in Greece around 10000 metric tonnes of red mud are produced annually. The fineness of solid particles and the large quantity of residue make further disposal or utilization very difficult.

Red mud is composed mainly of non-toxic fine particles of silica, aluminum, iron, calcium, and titanium oxides along with some other minor components.

6. Headings

The objective of the present thesis is to evaluate the performance of red mud and fly ash as low-cost adsorbents for the removal of lead from wastewater and it includes the following aspects:

- A study of the use of fly ash and red mud to remove heavy metal contaminants from industrial wastes.
- Batch study analysis and isotherms model experiments to assess the adsorption potential of fly ash and red mud for lead.
- Elution of metal ions from the adsorbents after adsorption.

7. Figures and Tables

1.1 Chemical Composition of the Red Mud Samples

Major constituent	***Content*** (%)
Al_2O_3	16.94
Fe_2O_3	39.34
CaO	13.2
SiO_2	6.95
TiO_2	4.79

Table1.2 ***Permissible limits of toxic heavy metals:***

Metals	Permissible limits for industrial effluent discharge (mg/L)				Permissible limits for potable water (mg/L)			
	Indian Standard			WHO				
	Inland surface water	Public sewers	Marine coastal areas	Inland surface water	Indian standard IS 10,500	WHO	USEPA	EU Standard
Lead	0.10	1.0	2.0	0.1	0.05	0.01	0.015	0.01
Chromium	2.0	2.0	2.0		0.05	0.05	0.1	0.05
Zinc	5.0	15.0	15.0	5-15.0	5.0	3.0	5.0	---
Cadmium	2.0	1.0	2.0	0.1	0.01	0.003	0.005	0.005
Arsenic	0.2	0.2	0.2	--	0.01	0.01	0.01	0.01
Copper	3.0	3.0	3.0	0.05-1.5	1.5	2.0	1.3	2.0

Table-1.3 Langmuir adsorption isotherm

Langmuir model	Q_0(mg/g)	b(l/mg)	R^2	R_L
Fly ash	714.28	0.144	0.9922	0.409
Red mud	666.66	0.1304	0.9885	0.427

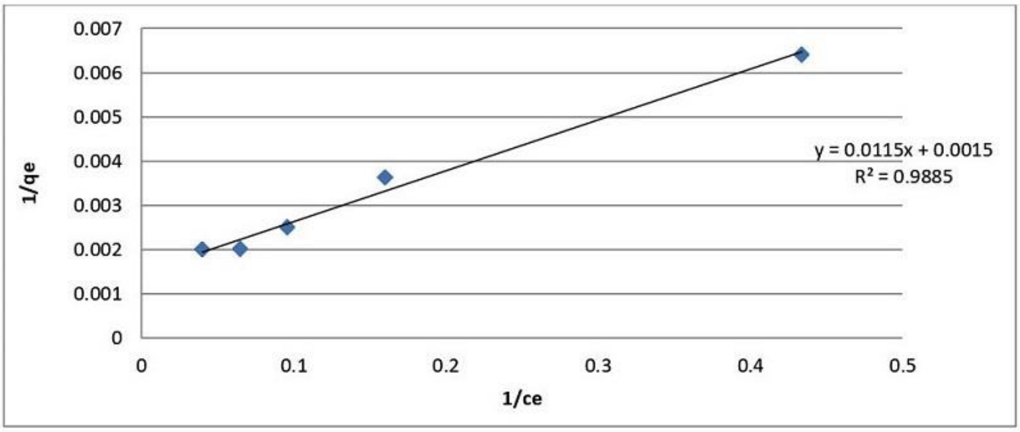

Fig. 2.1 Langmuir isotherm for red mud

8. Appendix

LIST OF TABLES

9. Conflict of Interest

I hereby declare that the project entitled "**Adsorption studies on Red Mud: removal and recovery of Cr (VI) from wastewater"** under the guidance of **Dr.Ramprasad Naik Desavathu** in the Department of Civil Engineering is a bonafide work carried out by us and the results embodied in this report have not been reproduced/copied from any other source and have not been submitted to any other university or institution for the award of any other degree.

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