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Investigational Study On Removal Of Chromium Using The Mixture Of Bagasse And Coal Ashes

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ABSTRACT
Heavy metal pollution has become one of the most important problems today and the use of low cost methods for the removal of heavy metals from industrial effluent has been widely investigated. Cr (VI) is one of the highly toxic metals entire into the environment from mining, leather tanning, electroplating, textile industry, production of steel and other metal alloys etc. The efficiency of the mixture of bagasse and coal ash for the removal of Cr (VI) ions from the aqueous solution has been studied. The batch adsorption experiments have been carried out to optimize the dependent parameters like pH, initial Cr (VI) ion concentration, adsorbent dosage and equilibrium contact time on the adsorption process. Adsorption process and the extent of adsorption are dependent on the physical and chemical characteristics of adsorbent, adsorbate and the experimental conditions. The maximum metal adsorption was found to occur at initial pH 2. The adsorption process was well fitted with Langmuir and Freundlich isotherm models and the results found that adsorption process is irreversible in nature.
Keywords: *Chromium (VI), Bagasse, Coal ash, Langumuir isotherm, Heavy metal*

1. INTRODUCTION

Due to its toxicity and hazard to both human life and the ecosystem, the presence of heavy metals in the environment is a serious issue.Heavy metals that have been designated as priority pollutants include lead, cadmium, mercury, arsenic, copper, chromium, and others (Panda. H 2017, et al).

These pollutants often build up in bottom sediments where they can be released by a variety of remobilization processes, eventually making their way to people where they can cause both chronic and acute illnesses. A popular form of trivalent chromium [Cr (III)] and hexavalent chromium [Cr (VI)], both of which are employed in a variety of industrial operations, is Cr. Ammonium dichromate, calcium chromate, chromium trioxide, chromic acid, lead chromate, potassium chromate, potassium dichromate, sodium chromate, strontium chromate, and zinc chromate are only a few of the numerous compounds that contain Cr (VI), which has a wide range of commercial uses. According to Andal, N. M. et al. (2013), Cr (VI) is also utilised in a number of other sectors, including electroplating, tanneries, glass ceramics, fungicides, rubber, fertilisers, mining, and metallurgy.

Hexavalent chromium is a health risk due to its propensity to react with other substances. Hexavalent chromium is more dangerous than any other metal since it is extremely mobile and is thought to be acutely poisonous, carcinogenic, and mutagenic to living things. Additionally, it has an impact on the respiratory, renal, and skin systems of people. It results in conditions including dermatitis, bronchitis, nasal septal perforation, bronchogenic cancer, liver damage, and the development of ulcers.

In industrial waste water, Cr (VI) concentrations range from 0.5 to 270 mg/L. According to Esmaeili, H. et al. (2018), the tolerance limit for Cr (VI) discharge into inland surface water is 0.1 mg/Land and 0.05 mg/L for potable water. Industries must treat their effluents to lower the Cr (VI) ion content in water and waste water to acceptable levels before transporting and cycling it into the natural habitats in order to adhere to this requirement.

There are many techniques used to extract Cr (VI) from aqueous solutions and industrial waste water. These processes include chemical precipitation after a reaction, ion exchange, reduction, adsorption,

electrochemical precipitation, cementation, evaporation, reverse osmosis, foam separation, freeze separation, and biosorption. The majority of these systems struggle with high material regeneration and capital costs (Alinnor I.J, 2007). Adsorption is by far the most adaptable and efficient way for such removal, especially when coupled with proper regeneration processes, therefore there is a need for a method that is cost-effective. Recent research has demonstrated that heavy metals may be eliminated utilising waste products such sawdust, coconut husk, shell, and coir (Tan W.T et al., 1993), and duck weed (Upatham.E.S et al., 2002).
For the treatment of industrial waste water, adsorption of heavy metals from aqueous solutions is a considerably less expensive technique. The use of affordable adsorbent materials and the efficiency of adsorption technology in lowering the concentration of heavy metal ions are its main benefits (Taghi Ganji, M et al. 2005).
The mixture of bagasse ash and coal ash was chosen as the study's adsorbent material ash sample since it is an industrial waste that isn't often used for anything else. It was gathered from the sugar business, where boiler plant byproduct ash was used. It was decided to attempt using this substance to create a low-cost adsorbent. Reusing the ash as an adsorbent helps the sugar sector to save money on disposal costs and preserves important landfill space.

2. MATERIALS AND METHODS

2.1 Experimental site and material collection

The study was done from January to March 2023 at the Annapoorana Engineering College in Salem (11.57975° N, 78.04941° E), Bagasse ash is a byproduct, or in other words a landfill waste from the boiler plants of sugar mills which was collected from Sakthi sugars, Erode and Thermal power stations produce enormous quantities of coal ash as a by-product of combustion. This coal ash is dumped in large amounts in landfills. Which was collected from NLC INDIA Limited, Neyveli.

2.2 Sample preparation

2.2.1 Mixture of Ash

In this study we take 80% of Bagasse ash and 20% of Coal ash to form an adsorbent medium. This ash mixture is used as an effective adsorbent in this study for the removal of Chromium. To eliminate the adhering organic debris, the sample was treated with hydrogen peroxide (100 volumes) at 60° C for 24 hours. Before usage, the material was cleaned with deionized water, dried at 100 degrees Celsius, powdered, pulverised, and sieved to the necessary particle size. The material was placed in a vacuum desiccator to be used later.

2.2.2 Synthetic Chromium Solution

Synthetic chromium solution was prepared by adding 0.1414 g of Potassium di chromate salt to the 1 liter of distilled water so that Chromium concentration in that solution was 50 mg/l and that solution was used for all experiments. (Kumar P et al, 2019)

2.3 Mode of operation

2.4 Batch Experiments

The experiments were conducted in 250 ml Erlenmeyer flasks containing in 100 ml Cr (VI) aqueous solution at desired level of each component at the beginning of the adsorption .The flasks were agitated on a shaker at a 120 rpm constant rate for 60 min to ensure equilibrium was reached. In batch experiments, pH, contact time and adsorption capacity studies of ash sample were conducted. In batch experiments, pH, contact time and adsorption capacity studies of ash sample were conducted. About 0.2 g of ash sample was allowed to contact with heavy metal solution in the pH range of 1-8 under the shaking condition and room temperature. In batch experiments, ash sample was allowed to contact with heavy metal solution for a certain period of time 10,20,30,40,50,60,70 and 80 minutes. The favourable pH condition and saturated time of ash sample to adsorb the heavy metal were then applied to the adsorption capacity study by varying the concentration of heavy metal up to 50 mg/L.

The amount of Cr (VI) adsorbed by the ash sample and the % removal of Cr (VI) are calculated using the following Eq. (1) & (2) respectively.

1. $q = (C_i - C_o)/w$ Eq. (1)
2. % removal of Cr (VI) = $(C_i - C_o/C_i) \times 100$ - Eq. (2)

Where,
q is the adsorption capacity in mg/gl,
C_i, C_o are the initial and outlet concentration of Cr (VI) in mg/L,
w is the total amount of ash sample in g.

2.4.1 Measurement of Cr (VI) Concentration in Aqueous Solutions

In the present study, di – phenyl carbazide method is used for the analysis of Cr (VI) in the solution which only measures the amount of chromium (VI).This method has reportedly used in many studies for analysis of Cr (VI) at low pH (Sanchez-Hachair, A., et al, 2018). The concentration of Cr (VI) ions in the effluent is determined spectrophotometrically by developing a purple – violet color with 1, 5-di phenyl carbazide in acidic solution as a complexing agent. The absorbance of the purple- violet colored solution is read at 540 nm after 20 min.

2.4.2 Analysis of Chromium Using Ultra Violet Absorption Spectrophotometer

UV Absorption Spectrometer was used to analyze the initial and residual Chromium concentration after each and every experiment. This instrument is more accurate in analyzing the heavy metals. The baseline was set using distilled water and following that instrument was calibrated with 10 mg/l, 20mg/l, 30mg/l, 40mg/l, and 50mg/l concentration of chromium solution. After calibration the instrument was put in the sample mode. Then, the Chromium solution will directly be evaluated in form of graph of 530 nm by the instrument and shall be shown in note pad in digital format (Onchoke, K. K., & Sasu, S. A. 2016).

3. RESULTS AND DISCUSSION

3.1 Particle size analysis

Particle size analysis of mixture ash revealed that major fraction, 90.20% (approx.), of fly ash particles are in the size range of 1–250 μ. Based on the particle size, the specific surface area of fly ash is found to be 0.502 m^2/g.

3.2 Optimum dosage

In adsorption studies, the optimal dose plays a key role in regulating the startup and running costs. In 8 distinct conical flasks, 100 ml of a synthetic solution containing 50 mg/l was treated for one hour with ash at doses of 0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4, and 1.6 g. Then, a UV absorption spectrophotometer was used to quantify the chromium content. Figure 1. depicts a dosage adsorption study for evaluating the kinetics of chromium adsorption on ash.

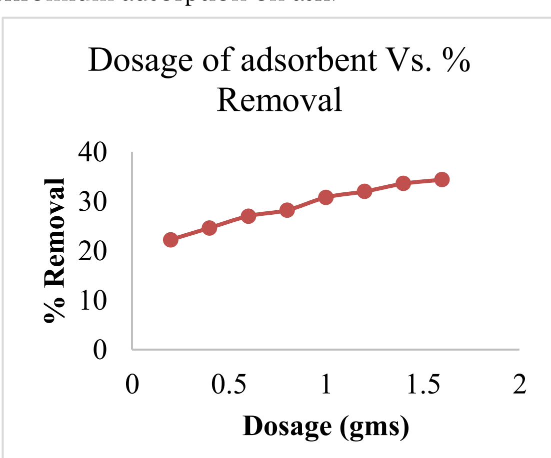

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Figure 1. Dosage adsorption study for evaluation of the kinetics of chromium adsorption on ash

From the graph 0.2 grams were taken as dosage in case of Ash, as the amount of ash increases the percentage removal also increases. The percentage removal of Chromium at a dosage of 1.6 grams was 34.4% at a contact time of 1hour.

3.2 Optimum time

To determine the ideal moment For a given dosage of 0.2 g of Ash, 100 ml of a synthetic solution containing 50 mg/l was treated with the ash for several periods of time—10, 20, 30, 40, 50, 60, 70, and 80 minutes—in 8 separate conical flasks. Then, a UV absorption spectrophotometer was used to quantify the chromium content. The graph was then drawn between the percentage removal and various times.

Figure 2. shows the impact of time on the chromium removal for

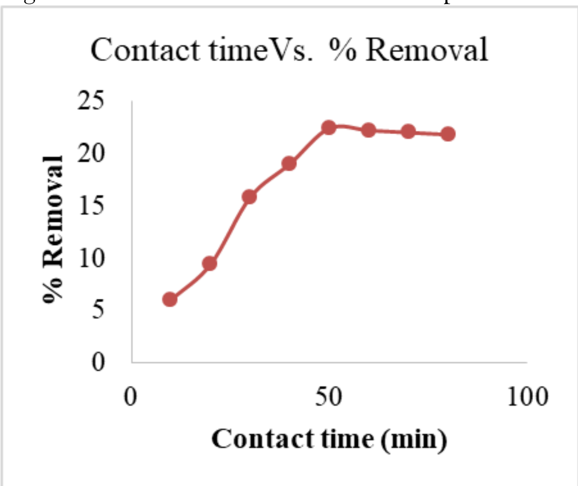

Figure 2. Effect of time on chromium removal for ash

The graph shows that the largest amount of adsorption occurred at 50 minutes. Therefore, for Ash, 50 minutes was determined to be the ideal contact time. Chromium was removed at a percentage of 22.4% at 0.2 g after 50 minutes of contact.

3.3 Effect of pH

The adsorption is impacted by the solution's hydrogen ion concentration (pH). The synthetic chromium solution has a pH of 5.0 and a concentration of 50 mg/l. By changing the pH of the chromium solution from 1 to 8 using hydrochloric acid (HCL) and sodium hydroxide (NaOH), the ideal pH for extracting chromium using ash was discovered. The fixed volume of chromium solution (100 ml) was treated with 0.2 grammes of ash for 50 minutes at various pH levels (ranging from 1 to 8). The results were recorded. For each pH, the amount of chromium removed was measured, tabulated, and graphed. The greatest percentage of chromium elimination was used to calculate the ideal pH. Figure 3 provides the results for the adsorption using mixture ash.

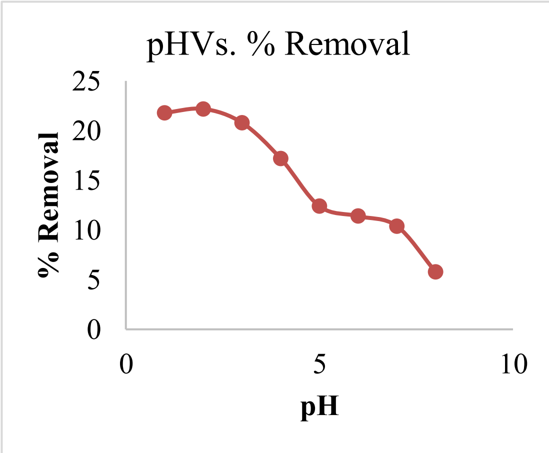

Figure 3. The table for the above data for adsorption using ash

The figure shows that at pH 2 for a dosage of 0.2 g and a contact time of 50 minutes, the maximum removal of 22.2% occurred.

3.4 Kinetics of Chromium Adsorption for Different Initial Concentration

For varying starting chromium concentrations—10 mg/l, 20 mg/l, 30 mg/l, 40 mg/l, and 50 mg/l—a constant volume (100 ml) of synthetic chromium solution was treated with 0.2 grammes of ash. At 50 minutes, the treated samples were checked for the presence of residual chromium. The resulting results are shown in Figure

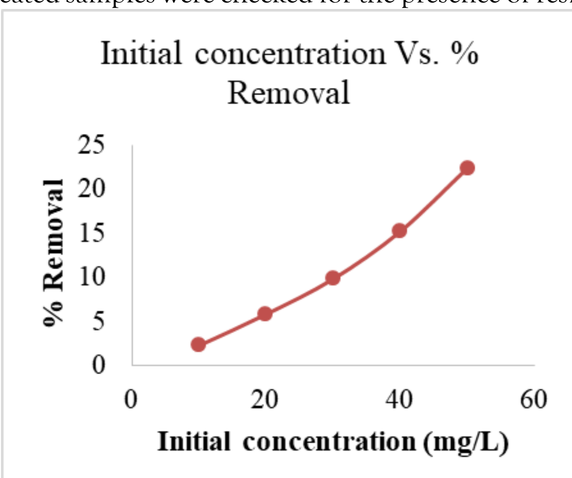

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Figure 4. Kinetics of Chromium Adsorption for Different Initial Concentration

The graph shows that as concentration increases, the percentage of elimination also rises.

3.4 Isotherm study

3.4.1 Langmuir isotherm

For 50 minutes, a constant volume (100 ml) of synthetic chromium solution was equilibrated with various ash doses (0.2 g, 0.4 g, 0.6 g, 0.8 g, 1.0 g, 1.2 g, 1.4 g, and 1.6 g). From each of the 8 reactors, the equilibrium state chromium concentrations were determined (Figure 5 and Table 1). Figure 5 and Table 1 include the information required for isotherm plots of ash

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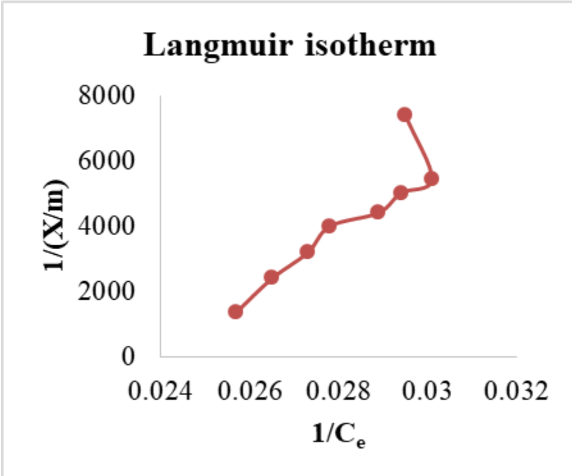

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Figure 5. ***Langmuir isotherm***

The Langmuir isotherm is given by,

$1/(X/m) = 1/q_m + 1/KA.q_m (1/C_e)$ Eq. (3)

Where

X/m = the amount of chromium adsorbed per unit weight of ash

KA and q_m are constant

KA = Rate of adsorption

qm = adsorption capacity of carbon.

A graph of 1/ C_e Vs. 1/(X/m) was plotted and it follows a linear path as shown in the figure 5.

From the figure,

Intercept 1/ q_m = 1400

Slope 1/KA. q_m = 933333.33

Therefore

q_m = 0.00071

KA = 0.0015

The Langmuir isotherm can be expressed in terms of a dimensionless value RL is defined as

RL = 1/ (1+KA.C_O) Eq. (4)

1/ (1+ 0.0015 *50) = 0.930

Where

C_O = Initial concentration

RL = Indicates the isotherm

Table 1. RL values for corresponding isotherm behavior

Value of RL	Isotherm behavior
RL>1	Unfavorable
RL=1	Linear
0<RL<1	Favorable
RL<1	Irreversible

As long as RL is between 0 and 1, irreversible adsorption for chromium absorption is indicated.

3.4.1 Freundlich isotherm

The adsorption data of chromium is also analyzed by a Freundlich model. Freundlich relationship in linear form is,

$\text{Log}(X/m) = \text{Log KF} + 1/n\ (\text{Log } C_e)$ Eq. (5)

To evaluate the constants, a Logarithmic plot of C_e Vs. X/m was made and a linear relationship was found to exist as shown in figure 6.

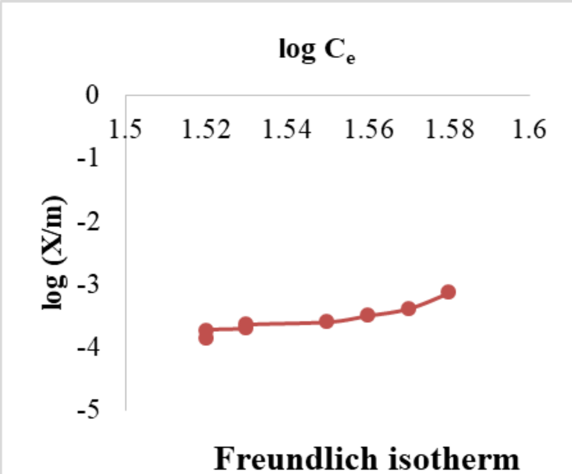

Figure 6. Logarithmic plot of C_e Vs. X/m

The value of Y intercept from the figure is Log KF = -3.14
Therefore, KF = 0.00724
The slope of the line will give the value of 1/n and given by, 1/n = 10.5
Therefore n = 0.095
The value of KF indicates the adsorption capacity and the 1/n the adsorption intensity.

4. CONCLUSION

The removal of chromium from wastewater was found to be successful using a mixture of coal fly ash and bagasse fly ash. By using mixed ash, chromium is removed through a particle diffusion method. Both the Langmuir and the Freundlich models apply to adsorption.
Given the facts discussed above, it is possible to draw the conclusion that the combination of Bagasse ash and coal ash system for the removal of chromium is extremely effective, affordable, quick, and repeatable. Therefore, wastewater and any other effluent may be successfully cleaned of chromium with this technology.

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