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COMPARATIVE STUDIES OF ADSORPTION OF CHROMIUM (VI) IONS ONTO DIFFERENT INDUSTRIAL WASTES

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ABSTRACT

This is especially true for the hexavalent form of chromium, which is harmful to humans." Chrome plating, textile manufacturing, and electroplating are examples of industries that dump Cr(VI) into their effluents. In addition to being poisonous and environmentally persistent, wastes that contain chromium cannot be decomposed or detoxified through biological processes. Chemical precipitation, ion exchange, and adsorption are some of the methods that have been applied in the process of removing heavy metals from the environment. Even though they are frequently utilized, activated carbon adsorption systems are quite costly, and the cost of regeneration is also extremely high to begin with. Because of this, it is possible that their application in wastewater treatment would not be economically viable. As a result, it is necessary to find and investigate the adsorptive properties of alternatives that are inexpensive. In order to select suitable adsorbents that are available locally and commercially, such as activated alumina and ion exchange resin, with a particular focus on low-cost adsorbents such as saw dust, treated saw dust, and sand, the current investigation was carried out. Additionally, a comparative study of the applicability of these adsorbents to the removal of heavy metals was carried out. A presentation of the findings from these research can be found in this paper.

Keywords:- *chromium, adsorption.*

INTRODUCTION

When foreign substances or any type of energy that is harmful to the environment or living beings are introduced into the environment, this is referred to as environmental pollution. Environmental pollution can be broken down into two primary categories: natural pollution and pollution caused by human activity. Natural pollutants include sulfur that is produced by volcanic eruptions, radioactive elements that are found in nature, and atmospheric hydrocarbons; however, the impacts of these natural pollutants are not as long-lasting as those of man-made pollutants. The term "man-made pollution" refers to a type of pollution in which the agent that causes pollution is produced by human beings themselves under certain conditions that are under their control. According to Ukaogo et al. 2020, in 2015, diseases caused by pollution were responsible for 9 million premature deaths. This figure significantly exceeds the number of deaths caused by other variables associated to mortality. In today's world, the rise in population has led to a growth in the demand for products such as textiles, leather, food processing, mining operations, deforestation, dyeing, automobiles driven by petroleum, mechanized agriculture, cosmetics, and other items that contribute to pollution of the air, land, and water. Each and every type of pollution has an impact on a significant section of the world's living population. Pollutants have an impact on the ecosystem because of their high stability, carcinogenic effect, and mutagenic effect on humans. Additionally, pollutants inhibit the penetrating power of light in water, which results in a decrease in the ability of aquatic plants to produce oxygen through the process of photosynthesis (Auta & Hameed 2013, Kabra et al. 2013, Moussavi & Khosravi 2011). The presence of pollutants is also responsible for a wide range of non-communicable diseases, such as cardiovascular disease, cancer, neurological disorders, respiratory difficulties, and birth defects in children.

OBJECTIVES

1. To study adsorption of chromium (vi)
2. To study industrial wastes

Chromium

Chromium contamination is one of the most common types of heavy metal pollution, and it is created by a variety of activities, including metal coating, metal cutting, leather tanning, the manufacturing of dye and pigment, mining, the preservation of wood, tanning, pulp, and paper production (Engwa et al. 2019). In aqueous solutions, chromium can be found in two different oxidation states: trivalent chromium (III) and hexavalent chromium (VI). (Tchounwou et al. 2012, Engwa et al. 2019, Nur-E-Alam et al. 2020) Research has shown that compounds containing Cr (VI) are more harmful than those containing Cr (III) due to the fact that they are more soluble. In the event that more than 0.1 parts per million (EPA limit) (Engwa et al. 2019) of Cr (VI) is ingested into the body through the digestive system, it has the potential to induce a variety of health issues, including nausea, vomiting, and bleeding in the brain. In addition, exposure to chromium can result in a number of health problems, including irritation of the skin and lung cancer. As a result, wastewater that contains chromium ought to be treated prior to disposal in order to forestall the occurrence of such adverse consequences.

Industrial Wastewater Treatment

Through the process of wastewater treatment, hazardous substances in the water are removed, resulting in a quality that is desirable. A simple definition of decolorization is the process of removing color from a substance, which may or may not involve the actual disintegration of the intricate dye molecules. The garbage that is colorless may still contain organic materials and may be more hazardous than the waste that was colored in the beginning. In light of this, the removal of the color in the wastewater does not always indicate the breakdown of the molecules of the organic dye. In the process of decolorization, the chromophore link is broken, but the primary pieces of the original molecule are not affected in any way. For this reason, the reduction in total organic carbon and carbon dioxide may be minimal even if the wastewaters are completely decolored. In terms of organic loadings and toxicity, these intermediates can provide substantial challenges for treatment activities carried out farther downstream as well as for aquatic bodies that are receiving the water. The organic amines that are formed under reducing conditions, whether chemically or biologically, have far greater harmful impacts on the environment than the component that they are derived from by themselves. Both physical and chemical processes, as well as biological processes, are included in the treatment process. According to Englande et al. (2015), some of the treatment options that are accessible can be categorized as the source therapy, pre treatment, primary treatment, secondary treatment, tertiary treatment, or advanced treatment.

Adsorption

Adsorption is the process of collecting molecules by the external surface or the interior surface (via pores) of solids or the surface of liquids for the purpose of analyzing them. In general, the term "adsorption" refers to the attractive propensity that solid substances have on their surfaces toward the molecules that come into touch with them. An adsorbent is a solid that is capable of absorbing, and the molecules that are capable of absorbing are referred to as the adsorbate. The removal of harmful pollutants from wastewater can be accomplished by the use of the adsorption process, which is one of the most efficient and economically viable methods. The removal of organic and inorganic contaminants from wastewater produced by industrial processes is a common application of adsorption. This was broken down into two distinct categories:

Physical adsorption

Physical adsorption is the term used to describe the process of adsorption that occurs when the attraction between the solid surface and the molecules that are adsorbed is of a physical nature. Weak attractive forces, such as Vander Waals and electrostatic forces, are responsible for the reversible adsorption that takes place between the molecules of the adsorbent and the molecules of the adsorbate throughout the physical process.

Chemical adsorption

Adsorption, on the other hand, is referred to as chemisorption in the scientific community. If the forces of attraction between molecules that have been adsorbed and the solid surface are caused by chemical bonding or by electrostatic attraction, then the phenomenon is said to have occurred. The adsorption of pollutants is influenced by the properties of the molecules. These properties include the surface area, size, and pore structure of the adsorbent, as well as the ionic or neutral nature, solubility, and molecular

structure of the adsorbate. In addition, the adsorption process is influenced by the pH of the solution, the temperature, and both organic and inorganic molecules.

Methods

Test solution

Dissolving the requisite quantity of analysis grade potassium dichromate in demineralized water that had been distilled was the method that was utilized to prepare the stock solution of chromium(VI). This was accomplished by merely diluting the stock chromium solution with demineralized water that had been distilled. The result was a solution with the required concentration.

Preparation *of treated sawdust*

It was decided to make a solution of ferrous sulphate that was saturated. Sawdust that had been cleaned and dried in the past was steeped in this solution for forty-eight hours, after which it was dried and utilized for the experiments.

Preparation of powdered activated alumina

In order to obtain powdered activated alumina with a particle size range of 25-150 mesh size, the activated alumina that was purchased from commerce was powdered and sieved.

Batch experiments

Using glass stoppered conical flacks that contained the requisite quantity of test fluid and adsorbent material, batch adsorption tests were carried out over the course of investigation. After the requisite amount of time had passed, the flasks that contained the test solution and the adsorbent were carefully shaken. A centrifuge was used to separate the contents, and then Whatman filter paper no. 41 was used to filter them. Spectrophotometric analysis was performed at 540 nm to determine the amount of unabsorbed chromium in the filtrate. This was done after complexing the filtrate with 1,5 diphenyl carbazide in following conventional procedures. For the purpose of background correction, blanks that included and did not contain adsorbent were also utilized in the same manner.

The % Cr (VI) removal is calculated as follows:

% Cr(VI) removal = (C.-C.)* 100/C,

where,

C= initial concentration of test solution, mg/L,

... (1)

C. final equilibrium concentration of test solution, mg/L.

GBC UV/VIS Spectrophotometer was used for spectrophotometeric analysis of Cr(VI).

Ion Exchange Method

In the process of water purification, dissolved particles can be removed from water through the use of two different processes: ion exchange and reverse osmosis. Exchangeable ions are contained within the functional groups that are located on the surface of the resin. In order to treat hard water, this technique involves exchanging the hard calcium and magnesium ions with the soft sodium ions. The ion exchange process is most frequently utilized for the purpose of water softening.

Results and Discussion

The following is a discussion of the outcomes of the tests that were conducted for the purpose of successfully removing hexavalent chromium from synthetic samples by utilizing adsorbents that were inexpensive.

Characterization of Adsorbent after the Adsorption of Cr(VI)

SEM

Through the use of a scanning electron microscope (SEM), the surface morphology of activated carbon can be observed. Scanning with a beam of electrons allows it to make images of the samples being scanned. Various signals are produced as a result of the interaction between the electrons and the atoms of the sample. These signals convey information about the surface of the sample. SEM pictures of PCAC, OBAC, and TSAC are shown in Figure 1. These images were taken both before and after the adsorption of Cr(VI). The results of this investigation demonstrated that PCAC, OBAC, and TSAC all have a porous structure, both before and after the adsorption of Cr+6. Immediately following the adsorption process, it verifies that the whole surface of the adsorbent is covered with Cr(VI) ions.

EDX

In this study, EDX analysis was utilized to investigate the chemical composition of PCAC, OBAC, and TSAC. The EDX peak in Figure 6.2 a, b, and c displayed the following peaks: Si (0.19 percent ± 0.05 percent), P (1.23 percent ± 0.12 percent (PCAC), P (7.66 percent ± 0.56 percent), Cl (1.52 percent ± 0.41 percent (OBAC), and P (1.05 percent ± 0.16 percent, S (2.44 percent ± 0.18 percent (TSAC). As seen in Figure 1, the peak for chromium was discovered on the surface of all of the carbon after the chromium ions had been absorbed by the carbon materials.

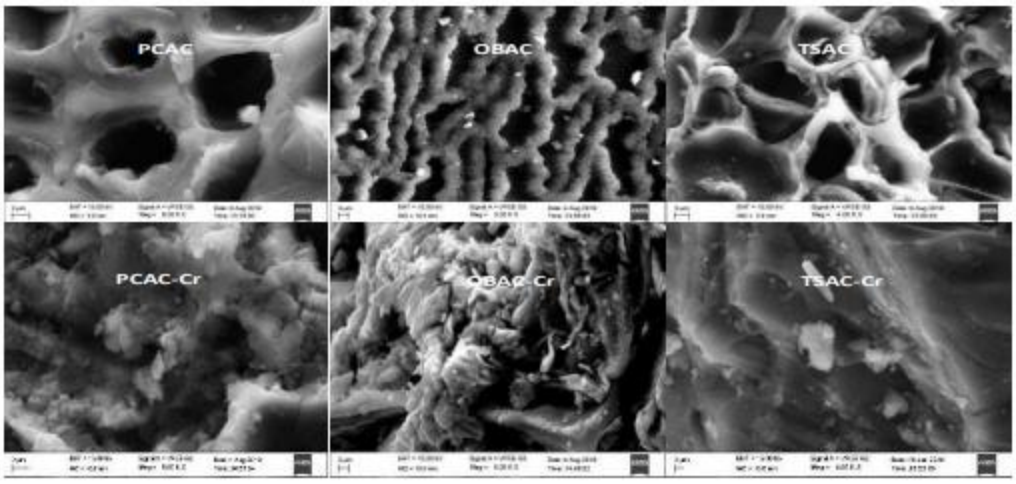
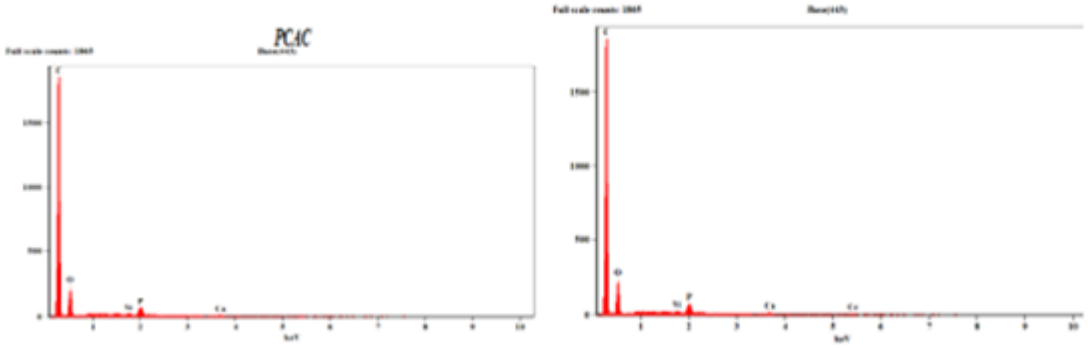
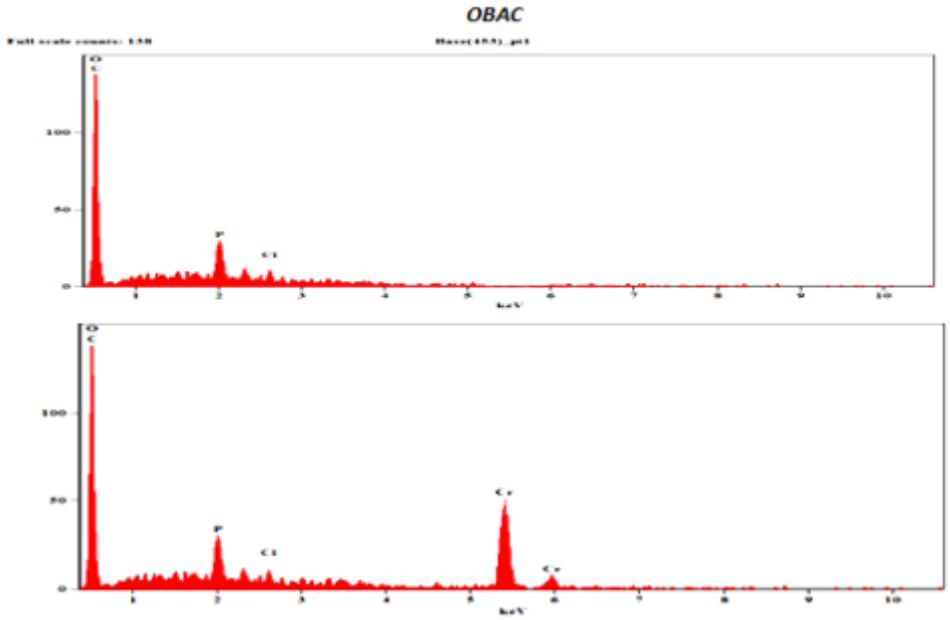


Figure 1 SEM images of PCAC, OBAC, and TSAC before and after the adsorption of Cr(VI)



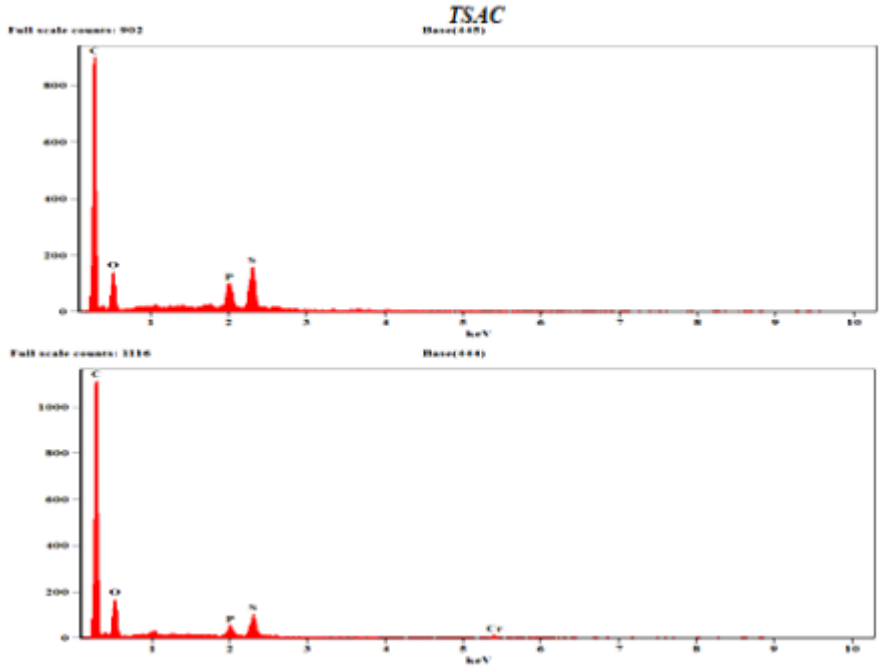
Element Line	Weight %	Weight % Error	Atom %
C K	77.68	±1.09	83.12
O K	19.93	±0.82	16.01
P L	0.19	±0.05	0.09
P K	---	---	---
Cl L	1.23	±0.12	0.51
Cl K	---	---	---
Cr K	0.54	± 0.11	0.13
Cr L	---	---	---
Cr L	100.00		100.00

Figure 2 (a) EDX of PCAC before and after the adsorption of Cr(VI)



Element Line	Weight %	Weight % Error	Atom %
C K	-51.46	± 1.20	-75.53
O K	7.62	± 0.56	5.77
P L	---	---	---
P K	1.51	± 0.41	1.00
Cl L	---	---	---
Cl K	0.29	± 1.32	0.03
Cr K	39.12	± 2.35	17.67
Cr L	---	---	---
Cr L	100.00		100.00

Figure 2 (b) EDX of OBAC before and after the adsorption of Cr(VI)



Element Line	Weight %	Weight % Error	Atom %
C K	72.89	± 1.63	79.73
O K	22.61	22.61	18.57
P L	1.05	± 0.16	0.45
P K	---	---	---
Cl L	2.44	± 0.18	1.00
Cl K	---	---	---
Cr K	1.00	± 0.13	0.25
Cr L	---	---	---
Cr L	100.00		100.00

Figure 2 (c) EDX of TSAC before and after the adsorption of Cr(VI)

FTIR

For the purpose of determining the functional groups that are present on the surface of adsorbents that are responsible for chromium ion adsorption, FTIR spectroscopy analysis is an essential means of

investigation. As shown in Figure 3, the FTIR spectrum reveals that the adsorption of Cr ions onto all three activated carbons results in the elimination of broad range peaks and the conversion of those peaks into acute peaks. After adsorption, the peaks at 1600 cm-1 and 1100 cm-1 in PCAC were less pronounced. This shift is connected with C=C stretching and salts of carboxylic acids, according to Machrouhi et al. (2018) and Coates (2000). A distinctive peak at 1700 to 1300 in the FTIR spectrum of OBAC, which is responsible for the carboxylate group and shows the adsorption of Cr (Coates 2000), may be found both before and after the adsorption process.

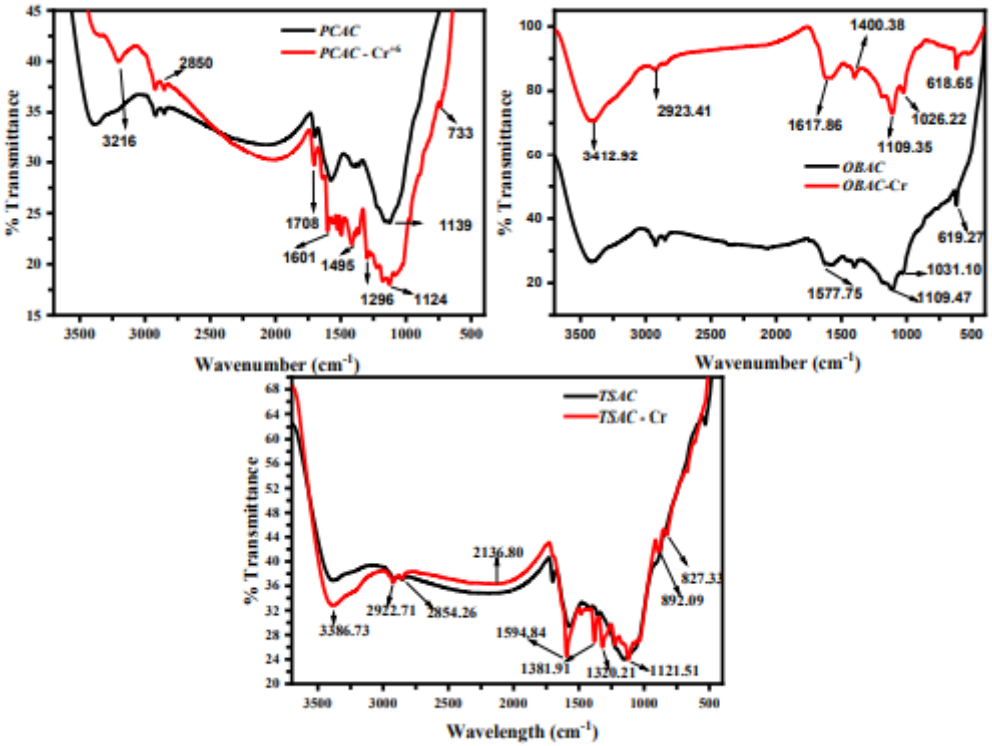


Figure 3 FTIR of adsorbents before and after adsorption of Cr(VI)

In the TSAC spectra, the strong peaks that were detected after the adsorption of Cr were identified as occurring at 1594 cm-1 (C=C), 1382 cm-1 (COO), and 1320 cm-1 (CN). According to Coates (2000), the peak that may be found at 894, 821 cm-1 corresponds to peroxides stretches in TSAC. A confirmation of the adsorption of Cr+6 onto PCAC, OBAC, and TSAC is provided by the difference in peak heights as well as the altered position of the peaks.

CONCLUSION

For the adsorption of dyes and chromium, the optimal contact time in optimal process conditions needed fifty minutes for PCAC, sixty minutes for OBAC, and forty minutes for TSAC. This was necessary in order to fulfill the goal of achieving the optimal removal % of contaminants. For the removal of dyes (MB, RB, and R6G) and Cr+6, the maximum adsorption efficiency of PCAC, OBAC, and TSAC was determined to be 95.8 percent, 96.55 percent, and 99.06% ±0.5 percent, respectively, for MB, 87.68 percent, 93 percent, and 94.59% ± 0.5 for RB, 98.57 percent, 93.18 percent, and 98.08% ±0.5 for R6G, and 87.45 percent, 83.33 percent, and 93.45% ± 0.5 for Cr+6 per 100 mg L-1 contaminated solution,

respectively. When compared to PCAC (7.024 m2 g-1) and OBAC (6.664 m2 g-1), TSAC has a greater surface area of 161.911 m2 g-1, which allows it to remove dyes and Cr more effectively than the other two systems. The RSM, which is built by utilizing a well-known CCD design, was utilized in order to model the experimental samples. The interaction of contaminants with adsorbents was also investigated using an analysis of variance (ANOVA) model.

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