iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.53211

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

A Case Study over Adsorption of Removal of CR(VI) by Prepared Activated Carbon

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Abstract: ***Currently, environmental pollution has become one of the most important issues faced by human beings. It has increased more rapidly in the past few years and reached alarming levels in terms of its toxic effects on living beings. Although pollution due to tanneries in India dates back 100 years, it received much attention only in therecent past. Toxic heavy metals are considered one of the strong pollutants that have a direct effect on humans and animals. Industrial wastewater containing heavy metals like lead, copper, cadmium, chromium, etc. can contaminate groundwater resources and thus lead to serious groundwater pollution problems. The present study isfocused on the removal of hexavalent chromium from an aqueous solution using an eco-friendly adsorbent, activated carbon prepared from the pods of the Delonix regime. The various parameters such as concentration, Activation time,and heavy metals (chromium is such metal which is to be found in the aqueous system in ionic form) are to be used.Adsorption has been advocated as the most promising among the currently known methods for wastewater treatment,especially for the removal of metals like copper, lead, chromium, and nickel.***
Keywords: Adsorption, Activated Carbon, Hexavalent Chromium, Physical Activation, Delonix Regia, Adsorbent

I. INTRODUCTION

The water of high quality is essential for human existence and agricultural, industrial, domestic, and commercial use and all these activities are also responsible for polluting the water. The majority of the industries are water-based anda considerable volume of wastewater originating from these is generally discharged into water sources either untreated or inadequately treated resulting in water pollution. A study conducted by the Centre for Science and Environment, New Delhi, India, has suggested that over 70% of available water in India is polluted (C.S.E. Survey, 1982). The contamination of water due to toxic heavy metals through the discharge of industrial wastewater is a global environmental problem. Recently much importance has been given to removal techniques and developments of new processes for heavy removal from wastewater.

There is a large number of industries that discharge chromium-containing waste, namely tanning, electroplating,textile cement and asbestos, refractories, cooling towers of thermal power stations, and many other industries.

Chromium has been considered one of the toxic pollutants because of its carcinogenic characteristics, it has become a serious health problem. Extensive use of chromium results in large quantitiesof chromium-containing effluents which need sufficient treatments. The infection of water because of poisonous heavy metals via the discharge of business wastewater is a global environmental problem. The heavy metals reachthe water in our bodies through many business activities. From the heavy metals chromium is such metallic that is tobe discovered in aqueous gadgets as both ionic bureaucracies i.e., Trivalent and Hexavalent chromium. They are not easily and widely available, therefore agricultural products and byproducts like crushed coconut shell sawdust, and peat mass have been employed, as these adsorbents have a distinct advantage over activated carbon because of their low cost and easy availability [10]. The present study is focused on the removal of hexavalent chromium from an aqueous solution using an eco-friendly adsorbent-activated carbon prepared from the pods of Delonix regia

A. Need For Study

Chromium (Cr) is one of these heavy metals Cr (VI) compounds are strong oxidizing agents and are highly corrosive. Strong exposure to Cr (VI) causes cancer in the digestive system and may cause epigastric pain, nausea, and vomiting, severe diarrhea. Thus it is essential to remove Cr (VI) from wastewater to avoid the hazardous effect. Industrial wastewater containing lead, copper, cadmium, chromium, etc. can contaminate groundwater assets and thus lead to extreme floor water pollutants issues. Cr (VI) compounds are robust oxidizing sellers and are enormously corrosive. Strong publicity of Cr (VI) reasons most cancers in the digestive system and may purpose epigastric ache, nausea, vomiting, severe diarrhea

B. Objectives

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To arrive at the low-cost adsorbent for removal of heavy metal i.e. hexavalent chromium.To study the physical and chemical properties of the prepared activated carbon.To determine the efficiency of the prepared activated carbon. Economical way to remove heavy metals from industrial wastewater

II. LITERATURE REVIEW

1) Awoyale, A.A., Eloka Eboka, A.C. and Odubiyi, O.A Studied that the bamboo can be carbonized (pyrolyzed) at temperatures between 300oC 400oC and activated using ZnCl2 at 800oC to produce granulated activated charcoal. Adsorption of heavy metals from the refinery waste stream on the activated carbon SSSSSStime, carbon dosages, and pH, metal ion concentration before and after adsorption on the adsorbent were used in determining the amount absorbed and the removal efficiency (R%) of the metal ions. Thus the effective observation of using activated carbon produced from local bamboo for the adsorption process was quite efficient and could be employed for other adsorption purposes.
2) Khairiraihanna Johari, risking Saman, Shiow Tien Song, Cheu Siew Chin, Helen Kong, Hanapi Mat StudiedAdsorption enhancement of elemental mercury by various surface modified coconut husk as eco-friendly low-cost adsorbents. Coconut husk (CH), consisting of coconut pith (CP) and coconut fiber is abundant and cheap and has the potential to be used as an adsorbent for elemental mercury (Hg0) removal. CP and CF surfaces were modified by mercerization and bleaching methods and characterized using scanning electron microscopy(SEM), Fourier transforms infrared spectroscopy (FTIR), and analysis of moisture and ash. The surface morphology and surface functional groups of adsorbents significantly changed after treatments and resulted in different Hg0 adsorption performances. The experimental breakthrough data for all the adsorbents produced a good fit for the pseudo-second-order kinetic model.
3) Dr.U.Senthilnathan has conducted an experiment to test the adsorption kinetics of the removal of chromium from wastewater using acacia nilotica wood-based activated carbon. Adsorption Capacity for the elimination of Chromium from wastewater has been studied from the wood of Acacia nilotica-based activated carbon through various batch adsorption experiments. The adsorption kinetics of chromium using wood of Acacia nilotica was done by different factors such as the amount of carbon added, pH, and concentration levels of Chromium in wastewater. It was observed that the optimum dosage of wood of Acacia nilotica-based activated carbon to remove 80 mg/L of chromium from aqueous solution was 0.4 gms/150 mL, and the optimum contact time was 20 minutes. The isotherm data was found to be fitted with both Langmuir and Freundlich isotherms.
4) Mona Karnib, Ahmed Kabbni, Hanafy Holail, and Zakia Olama Studied Heavy metal pollution has become one of the most serious environmental problems nowadays. The removal of heavy metals from the environment is of special concern due to their persistence. Batch experiments were conducted to test the ability of activated carbon the removal of lead, cadmium, nickel, chromium, and zinc from water. The Langmuir and Freundlich adsorption isotherms were used to verify the adsorption performance. Nickel showed the highest removal percentages by activated carbon at all concentrations and the removal percentages decreased as the concentration of heavy metal increased. The obtained correlation coefficient (R2) for different adsorbents suggested poor fitting of the experimental data to Langmuir isotherm for Cd, Pb, Ni, and Zn, while R2 obtained using the Freundlich model for different adsorbents indicated that it fitted the experimental data well. Silica/activated carbon (23) composite was more efficient in the removal of nickel ions than activated carbon and silica nanoparticles. SEM pictures were taken for the three particles under test.
5) Jain, P. (2017). Partial Replacement of Fine Aggregate with Glass Using the DIC Technique with Waste Materials for Investigation of Crack Propagation. International Journal of Engineering Research and Application, 7(11), 5. https://doi.org/DOI: 10.9790/9622-0711056165
6) Jain, P. (2017). Determining Mix Proportion For The Marble Slurry Powder Recovered From Marble Slurry Replacing Fine Aggregate Of Concrete Used In Residential Construction Project In Udaipur, India, JERA, 710), 30-35. https://doi.org/DOI: 10.9790/9622-0710053035

III. METHODOLOGY

A. Selection of Material

To evaluate a feasible and economical low-cost treatment. To remove the heavy metal Cr (VI) present in a syntheticsample by using abundant available Pods of Gulmohar. By preparing activated carbon from this Gulmohar Pods (Delonix regia) as an adsorbent.
Properties of Gulmohar (Delonix regia)
Botanical classification [8]

KINGDOM	PLANTAE
DIVISION	PHANEROGAMS
CLASS	DICOTYLEDONEAE
SUBCLASS	POLYPETALAE |
SERIES	CALYCIFORM
ORDER	ROSALES
FAMILY	LEGUMINOSAE
SUBFAMILY	CAESALPINEACEAE
GENUS	DELONIX
SPECIES	REGIA

Botanical name Delonix regia
Common Name Gulmohar

Synonyms
Delonix regia var. flavida Stehle
Delonix regia var. genuine Stehle
Delonix regia var. genuine Stehlé
Poinciana regia Hook.
Poinciana regia Bojer

B. Preparation Of Activated Carbon

Preparation of activated carbon Pods of Delonix regia was collected from Avinashilingam Deemed University for Women campus, Coimbatore. The pods were cut into small pieces, dried in sunlight for 5 days, and further dried in a hot air oven at 60°C for 24 hours. The completely dried material was powdered well and chemically activated by treating it with concentrated sulphuric acid with constant stirring and kept for 24 hours. The carbonized material obtained was washed with water several times to remove excess acid and dried at 105-110°C for 24 hours. The adsorbent thus obtained was ground well and sieved through a 250 mesh and kept in an airtight container for furtheruse

C. Botanical Description

The flowers of Delonix regia are large, with four spreading scarlet or orange-red petals up to 8 cm long, and a fifth upright petal called the standard, which is slightly larger and spotted with yellow and white. They appear in corymbs along and at the ends of branches. The naturally occurring variety) has yellow flowers. The pods are green and flaccid when young and turn dark brown and woody. They can be up to 60 cm long and 5cm wide. The Pods are small, weighing around 0.4 g on average. The compound leaves have a feathery appearance and are a characteristic light, bright green, and are doubly pinnate. Each leaf is 30–50 cm long with 20 to 40 pairs of primary leaflets or pinnate, each divided into 10–20 pairs of secondary leafletsor pinnules.

D. Characteristics of GULMOHAR

Gulmohar is a flamboyant tree in flower some say the world's most colourful tree. For several weeks in spring and summer, it is covered with exuberant clusters of flame-red flowers, 45 in across. Even up close the individual flowers are striking they have four spoon-shaped spreading scarlet or orange-red petals about 3 in long, and one upright slightly larger petal (the standard) which is marked with yellow and white. The delicate, fernlike leaves are composed of small individual leaflets, which fold up at the onset of dusk. Gulmohar gets 3040 ft tall, but its elegant wide-spreading umbrellalike canopy can be wider than its height.

E. Figures Of Delonix REGIA



Fig 3.5 .Gulmohar (Delonix regia) Tree [1]

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com



Fig. 3.5 Gulmohar Pods [2]

F. Methods of Preparation of activated carbon

For the removal of hexavalent chromium from an aqueous solution adsorption technique was employed using activatedcarbon prepared from locally available Pods of Gulmohar (Delonix regia)

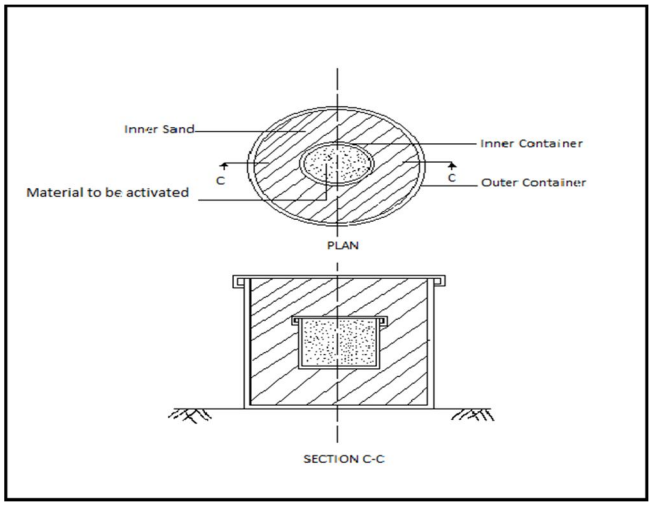
There are two methods to prepare activated carbon namelyPhysical Activation

Chemical Activation

In the present study, both physical and chemical activation are employed to prepare active carbon powdered Podsof Gulmohar (Delonix regia)

G. Physical Activation

The Pods of Gulmohar (Delonix regia), were broken into pieces and churned into powder form, washed in distilled water 2 to 3 times. The powder was then oven dried at 105±5oC for 24 hours. The oven-dried powder was filled in a small container in three layers, by compacting each layer without any air space to avoid the loss in weight of the powder otherwise it would result in the burning of the material directly, leaving behind only the ash. The small container was then placed into a bigger container, such that, sand surrounded the small container. The the lid of the bigger container was tightly fitted. Then the setup was kept in a muffle furnace at the temperature of 650oC. After attaining the required temperature, the furnace was allowed to cool for about 10 hours before the container was taken out.



H. Instruments

1) Spectrophotometer
2) PH Meter
3) MUFFLE FURNACE
4) OVEN
5) MAGNETIC STIRRER
6) WEIGHING BALANCE

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I. Solutions

1) Preparations of Synthetic Hexavalent Chromium Solution

Synthetic hexavalent chromium solution was prepared by dissolving 282.8 mg potassium dichromate in one liter of deionized and distilled water, such that each ml of solution contains 100µg ofchromium [5].

2) Titration Curve for Acidification of Chromium (VI) Solution

5 ml of chromium solution and 45 ml distilled water were taken in a beaker. 0.1 NH2SO4 was taken in the burette andslowly added, the resulting PH was wasted using a PH meter. The titration curve can be obtained by plotting pH versus 0.1 N H2SO4 added

IV. RESULTS AND DISCUSSIONS

The chapter deals with the study efficiency of prepared carbon for removing hexavalent chromium, the Effect of contact time, the Effect of carbon dosage, and the Effect of pH.

A. Effect of Particles Size on Adsorption

Adsorption is a surface phenomenon; as such the extent of adsorption is proportional to a specific surface area. Hence the amount of adsorption per unit weight of solid adsorbent is greater in the more finely divided and more porous material. The rate of adsorption depends mainly on particle size. Finer the particle, the higher the rate of adsorption, and vice versa. However, there is a limitation for particle size, if the particle size is less than 175 µ, Each particle having a small surface area acts as an individual entity for the removal of adsorbate from aqueous solution. Hence in the present study experiments were carried out using an effective particle size of 300µ for removal of chromium (VI).

B. Effect of Contact Time

Contact time has a great influence on the adsorption process. The effect of contact time on the removal of chromium (VI) for a synthetic sample at pH 2±0.02 using physical carbon of Pods of Gulmohar (Delonix regia)in Figure No. 4.1and model values are shown in the Figure No. 4.1 from it is observed that contact time differs for different carbonsMi.e. for physically activated carbons. It is further authenticated by studying the pore diffusion of carbons. As time passes, pore diffusion increases, Hence adsorption also increases.

C. Effect of Adsorbent Dosage

Adsorption is a process in which there is a continuous transfer of a solute from solution to adsorbent until the residual concentration of solution maintains an equilibrium with that adsorbed by the surface of the adsorbent at constant contact time. The effect of adsorbent dosage is studied and a graph of the percentage of chromium removal versus dosage is plotted as shown in Figure No. 4.2. From the graph it is observed that, as the doses of carbon increases, the amount of residual chromium (VI) decreases sharply and attains minimum. The point where maximum removal is attained is taken as the optimum dosage. After this much change in adsorption is observed even after increasing the amount of carbon. The optimum dosage for all prepared carbon is listed in 4.2.

D. Effect of pH On Hexavalent Chromium Removal

The pH of a solution has an influence on the extent of adsorption removal efficiency of chromium (VI) by preparing activated carbon at different pH values are shown in 4.3 and

4.3. From the shown it is observed that chromium (VI) is removed more effectively in the acidic range. As pH increases, the removal efficiency decreases appreciably. This is due to the possibility of precipitation of carbon surfaceby nucleation.

$2H+ + 2HCrO- \leftrightarrow 2H2CrO4 \leftrightarrow 2H2O + Cr2O-2 + 2H+ \leftrightarrow 2CrO3 + H2O$

E. Batch Sorption Experiment

In batch sorption, a predetermined amount of adsorbent is mixed with the sample, stirred using a magnetic stirrer fora given contact time and subsequently separated by filtration. The powdered adsorbent is more sui for the batch-type contact process.

F. Selection of Optimum Contact Time

The adsorption is strongly influenced by the contact time. For the study of the effect of contact time, 100 ml of 10 mg/L hexavalent chromium solution of PH2±0.02 was mixed with 100mg of activated carbon and stirred at different contacttimes. Then the filtrate was analyzed for chromium (VI) concentration using a spectrophotometer.

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G. Determination of Optimum Dosage Adsorbent

To determine the optimum dosage of activated carbon, it was added to a conical flask in different dosages containing aknown concentration of chromium (VI) solution (10 mg/ L) and adjusted to pH 2.0. The solution in the conical flask was subjected to stirring for optimum contact time, filtered, and analyzed for residual chromium concentration.
The dosage which gives minimum residual concentration is chosen as the optimum dosage.

H. Effect of pH on Hexavalent Chromium Removal

The extent of adsorption is strongly influenced by the pH at which adsorption is carried out. The effect of pH on hexavalent chromium adsorption was studied by performing equilibrium adsorption tests at different pH. The initial pH of the solution was adjusted by using 0.1 N H2SO4. The pH at which maximum chromium (VI) removal forms is called optimum pH.

I. Sorption Kinetics

The beakers containing 100 ml of hexavalent chromium solutions of concentration 10 mg/L (adjusted to pH 2.0± 0.02) and a known amount of optimum prepared activated carbon from Pods of Gulmohar (Delonix regia) were stirred. The samples were withdrawn at different intervals and filtered supernatant was analyzed.

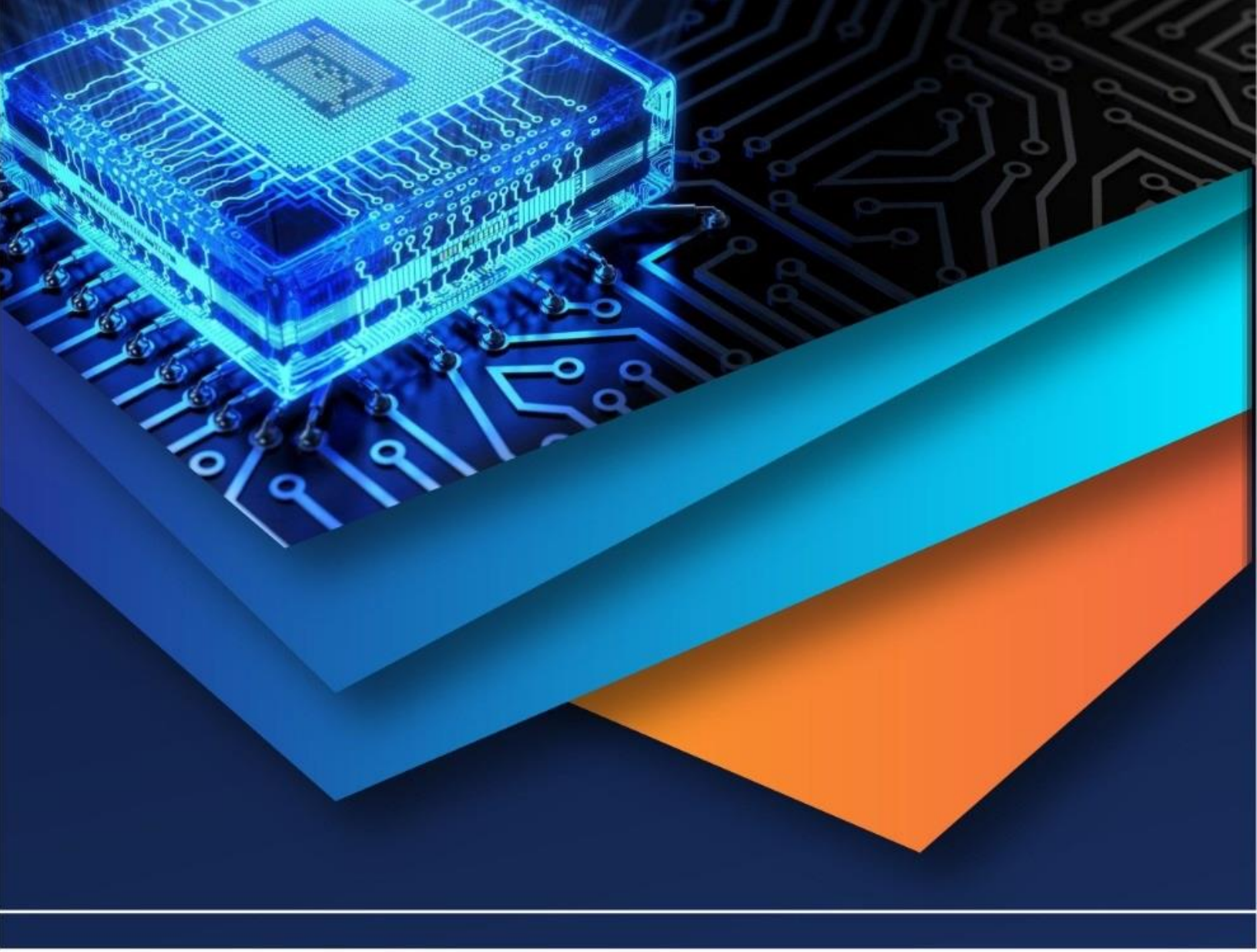
V. CONCLUSION

Based on the present study, the following conclusion can be drawn. The raw material of Pods of Gulmohar (Delonix regia) has low efficiency in Cr (VI) removal. Pods of Gulmohar (Delonix regia) can be effectively used for the preparation of activated carbon. Column study may be considered with this adsorbent. The adsorption of Cr (VI) is pH dependent. The removal efficiency of the adsorbent increased with a decrease in the pH value of the solution. Maximum adsorption takes place at pH=2. From the kinetic studies, it is observed that the adsorption of Cr (VI) is very rapid up to 45 minutes and decreases while approaching equilibrium. At an optimum time of 50 minutes, the optimum dosage of 100 mg, and optimum pH =2 physically. Activated carbon made from Pods of Gulmohar (Delonix regia) has shown a good Cr(VI)removal efficiency of 65%. The pods of Gulmohar (Delonix regia) are good sources for the preparation of low-cost adsorbent. Seeds of Gulmohart Royal Poinancios) is a good source for the preparation of low-cost adsorbent and require less time and energy for the production of highly porous nontoxic AC from Gulmohar fruit shells which is a throw-away waste thus converting it into a highly useful product

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