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Cadmium Removal Using Eucalyptus Bark and Syzygium Cumini Bark as Adsorbents

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Abstract: "When there is a decision of Smart, for what reason to pick just better." Eucalyptus bark and syzygium barks are very abundant, inexpensive and forest residues. It was decided to do experiment with it as a potential adsorbent for the removal of certain metals in industrial waste water. The efficiency of eucalyptus bark and syzygium cumini bark as a low cost sorbents for removing cadmium ions from aqueous solution has been investigated in batch mode. In order to study the variables that define the process, the variables selected were: Time, metal ion concentration, pH variation, Adsorbent dosage and particle size. Batch mode experiments were conducted to observe the effects of selected variables. It was verified that all the variables studied had significant influence on the adsorption process. Maximum cadmium uptake was obtained at 70 minutes for Eucalyptus bark and 60 minutes for Syzygium cumini bark. The equilibrium data could be well described by the Langmuir isotherm but a worse fit was obtained by the Freundlich model.

Keywords: Eucalyptus bark, Syzygium cumini bark, adsorbent, cadmium, waste water.

I. INTRODUCTION

With the expansion of industrialization, contamination of water has been an significant issue of hazard to human beings. Heavy metals are normally happening components that assume significant parts in the industry. Although weighty metals have demonstrated to be useful in the industry, some have negative impact on both the environment and on man consequently the requirement for their expulsion from waste water. Research efforts have been made in the resolution of a cheap, easily accessible and replicated method of hard metal removal[12]. Heavy metal toxicity can have several health effects in the body. Heavy metals can damage and alter the functioning of organs such as the brain, kidney, lungs, liver and blood. Methods for heavy metal removal are consequently required and important to avoid this.

A. Adsorption

By considering the disadvantages related with conventional methods for metal removal there is a requirement for alternative, cost-effective methods. Lately, adsorption measures have been considered as productive, novel, economic, efficient and eco-friendly alternative treatment for the removal of heavy metals from contaminated waste water produced from different industries. The adsorption method is a relatively new process and is emerging as a potentially preferred alternative for the removal of heavy metals because it provides flexibility in design, high-quality treated effluent and is reversible and the adsorbent can be regenerated.

B. Adsorbents

Adsorbents are the solids which are taking up the solute from the solution which can be used to remove heavy metals from the aqueous solutions. Biological removal includes the use of microorganisms, plant derived materials, agriculture or industrial wastes, biopolymers, and so on. It is a reversible rapid process involved in binding of ions onto the functional groups present on the surface of the adsorbent in aqueous solutions.

II. MATERIALS AND METHODS

The experimental studies are conducted for the removal of cadmium using E*ucalyptus bark and Syzygium Cumini bark* as adsorbents. The cadmium concentration is estimated using UV-Visible Spectrophotometer.

A. Preparation of Cadmium Nitrate Stock Solution

All the standard solutions and required test samples were prepared with analytical reagents and distilled water. 2.744 grams of Cadmium nitrate tetra hydrate was dissolved in 1000ml volumetric flask to obtain 1000mg/L of cadmium stock solution. Samples of different concentrations of cadmium were prepared from this stock solution by appropriate dilutions.

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Solutions with different metal concentrations such as 30, 60, 90, 120, 150 and 180 mg/L were prepared. The pH of aqueous solution was adjusted to the desired value by addition of 0.1 N H_2SO_4 or 0.1 N NaOH.

B. Prepartaion of Adsorbents

The adsorbents selected for this work are Eucalyptus bark and Syzygium Cumini bark. Eucalyptus bark and Syzygium Cumini bark were collected in autumn 2021 from adult trees from the SV University campus in Tirupati and my home town palvancha, Kothagudem(Dt) repectively. The collected bark was washed with water several times to remove dirt particles and water soluble materials. The washing process was continued till the wash water contain no color. The washed materials were dried in sunlight for two days. The dried barks were cut into small pieces, crushed, and sieved to eliminate fine particles[9].

The adsorption of cadmium using eucalyptus bark and syzygium cumini bark powders is studied using the batch technique. A set of labled conical flasks, containing 50mg/L of stock solution are taken and the initial pH of the solution is adjusted to the desired level by the addition of 0.1 N H_2SO_4 or 0.1 N NaOH solutions. A measured quantities 0.3 g of eucalyptus bark powder and 0.5 g of syzygium cumini bark powders are carefully added to the flasks, which are then agitated in incubator shaker rotated at a constant speed of 120rpm. Samples are collected at different time intervals (5,10,20,30,40,50,60,70,80,90 and 100min.), are filtered and the clear filtrate is analyzed using UV-Visible double beam spectrophotometer.
Capacity of adsorption and % removal efficiency can be calculated by following equations theoretically.

$$q_e = \frac{(C_0 - C_e)V}{m}$$

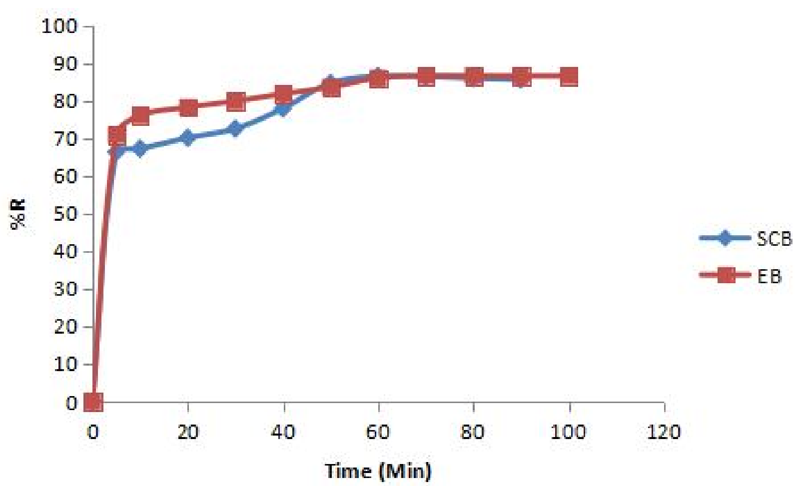
$$\text{Removal efficiency } (\%) = \frac{C_0 - C_e}{C_0} \times 100\%$$

III.RESULTS AND DISCUSSION

In the present investigation, the potential of EB and SCB for adsorption of cadmium nitrate present in aqueous solution is investigated. The effects of various parameters on adsorption are studied paragraphs must be indented.

A. Effect of Contact Time

Duration of equilibrium adsorption is defined as the time required for heavy metal concentration to reach a constant value during adsorption. The equilibrium agitation time is determined by conducting the adsorption experiments at different times 5, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 min by taking 50 ml of metal ion aqueous solution.
The Fig.1 shows the variation of %adsorption of cadmium with time of adsorption. In the first 5 minutes 70.899% and 66.38% of Cadmium for EB and SCB are adsorbed respectively and then the % Removal continued to increase upto 70min reaching 86.625% for EB and upto 60min reaching 86.50% for SCB, beyond 70 min for EB and 60 min for SCB %removal is constant indicating the attainment of equilibrium conditions.



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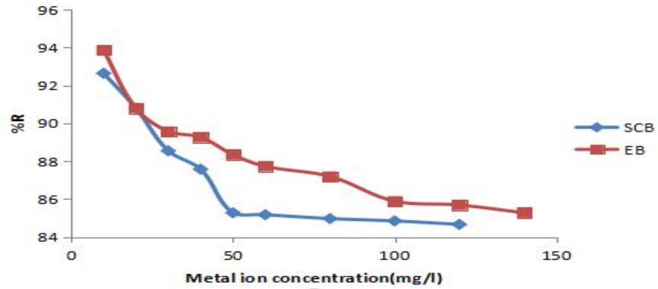
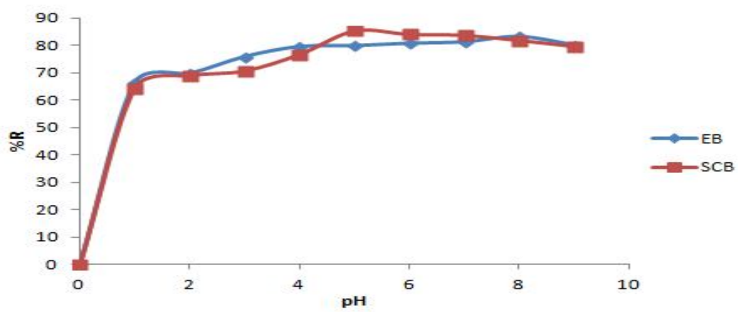
B. Effect of Metal Ion Concentration

The initial concentration of metal ions in aqueous solutions affected on metal adsorption[3]. The cadmium adsorption data are obtained in the initial concentration range of 10 to 140 ppm of the 50ml aqueous solution (pH 8(EB), pH 5(SCB)). The % adsorption of cadmium is shown in Fig.2. The percentage of adsorption of cadmium has decreased from 93.86% and 92.63% to 85.27% and 84.66% for EB and SCB respectively. Such behaviour can be attributed to the availability of limited number of active sites on the adsorbent. Thus %removal is the highest at the lowest initial concentration of cadmium.



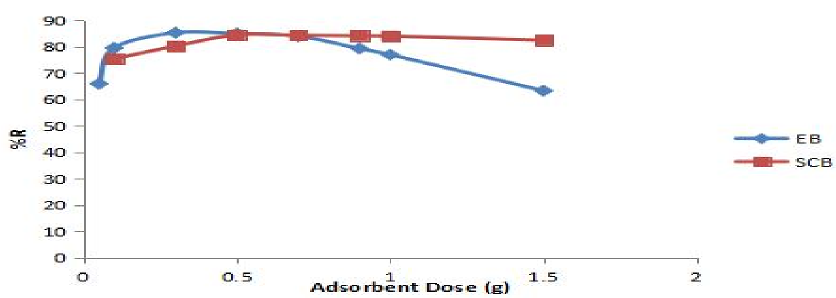
C. Effect of pH Variation

The variation of the solution pH is the one of the most important factors in the biosorption of the metal ions. The effects of pH solution on the biosorption of cadmium ion by using bark materials were studied and results are shown in Figure 3. There was an increase in cadmium ions removal with increasing pH from 1-8. The cadmium ions removal increased rapidly. The %adsorption of cadmium has increased from 66.25% and 64.41% for EB and SCB at pH 1 to 83.128% at pH8 for EB and 85.276% at pH5 for SCB and then decreased for the pH value above 8 and 5 respectively. The increase in % removal when pH1 to 8 and 1to 5 could be due to decrease in competition between hydrogen ions and metal species for appropriate sites on the adsorbent surface and also by the decrease in positive surface charge on the adsorbent.



D. Effet of Adsorbent Dosage

The effect of a variation of sorbent mass on the sorption of cadmium on eucalyptus and syzygium cumini barks is reported in figure 4. which shows the removal percentage of eucalyptus and syzygium cumini barks in the range of 0.05 to 1.5g. The sorption of cadmium increased with an increase in sorbent dosage. The percentage adsorption of cadmium for EB increased from 65.87% to 85.17% with an increase in adsorbent dosage from 0.05 to 0.3 g and for SCB increased from 75.33% to 84.32% with an increase in adsorbent dosage from 0.05 to 0.5g. After 0.3g of EB the % removal is decreased due to inactivation of the active sites. The % removal is almost constant beyond 0.5g of SCB.



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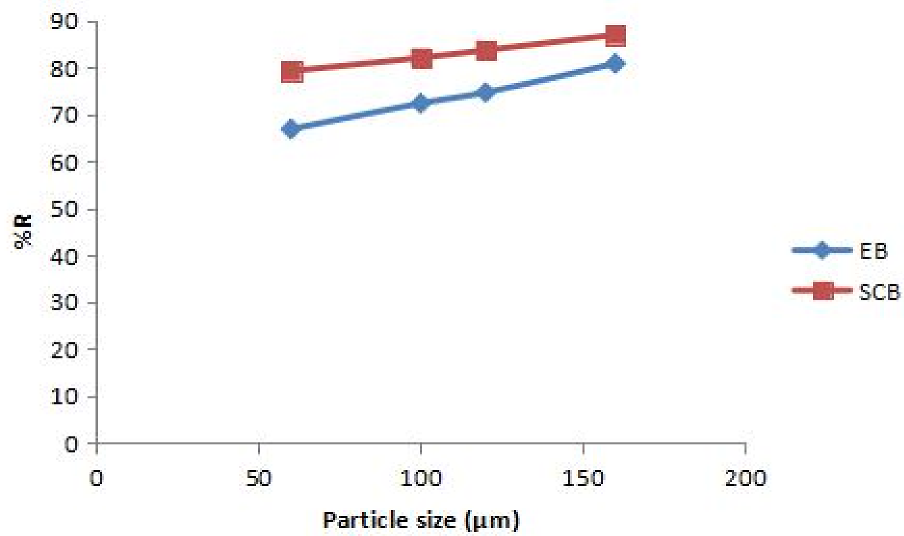
E. Effect of Particle Size

50ml of aqueous solution containing initially 100mg/L (EB) and 50mg/L (SCB) of cadmium contacted with 0.3g and 0.5 g of EB and SCB respectively of different sizes from 60 to 160µm. Solution pH is 8 for EB pH 5 for SCB and contact time 70 and 60min maintained respectively. The percentage of cadmium ions removal of eucalyptus and syzygium cumini bark powders at different particle sizes is shown in Fig.5. The %adsorption of cadmium is the highest (80.85% and 86.97%) with the smallest particle studied and decreased with increasing particle size.

The phenomena is expected, as the size of the particle decreases, surface area of the adsorbent increases; thereby the number of active sites on the adsorbent also increases.

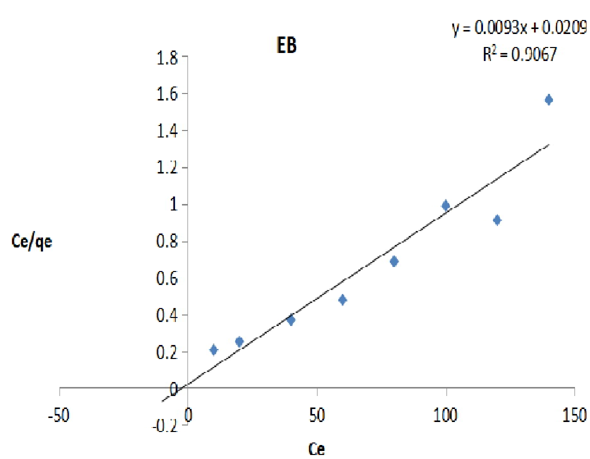


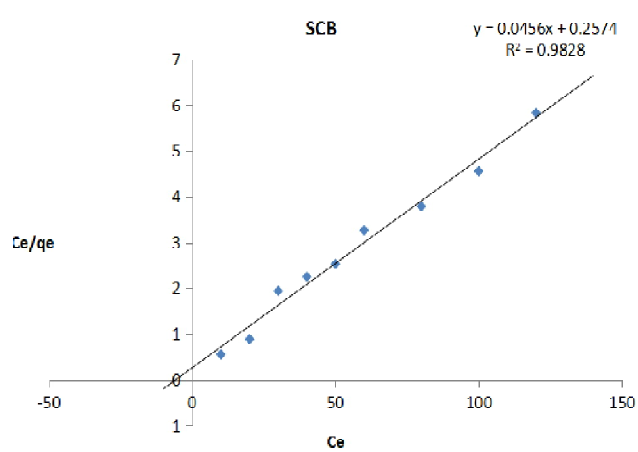
F. Langmuir Isotherm

The most widely used isotherm model I adsorption process is Langmuir model based on the assumption that there is a finite number of binding sites which are homogeneously distributed over the adsorbent surface, these binding sites have the same affinity for adsorption of a single molecular layer and there is no interaction between adsorbed molecules.

Langmuir adsorption model is used for the estimation of maximum metal adsorption on to adsorbent and is expressed as

$$\frac{C_e}{q_e} = \frac{1}{K_L q_m} + \frac{C_e}{q_m}$$





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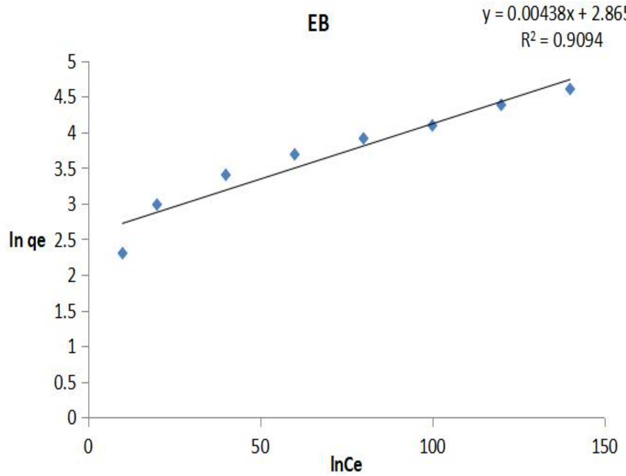
G. Freundlich Isotherm

The Freundlich isotherm model is not limited to formation of monolayer and can be used for adsorption on heterogeneous surface with interaction between adsorbed molecules. The linearized form of Freundlich equation is given as

$$\ln(q_e) = \ln(K_F) + \frac{1}{n}\ln(C_e)$$



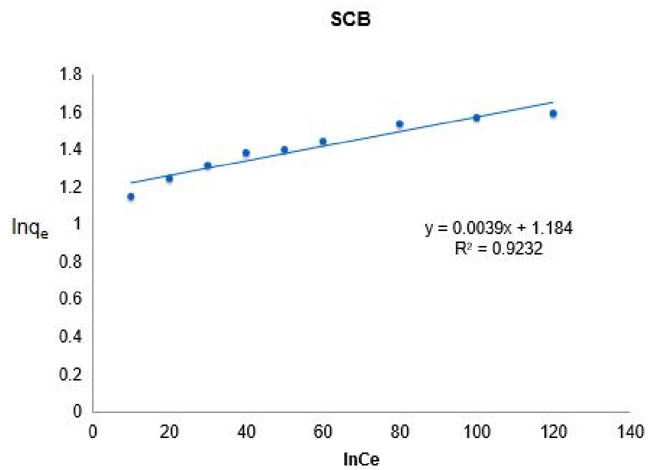


TABLE 1

Isotherm	Parameter	EB	SCB
Langmuir	qm, mg/g	66.6	28.57
	KL	0.1727	0.046
	RL	0.054	0.30
	R2	0.9067	0.9828
Freundlich	1/n	0.00438	0.0039
	Kf, mg/g	17.563	3.267
	R2	0.9094	0.9232

IV. CONCLUSIONS

The barks of eucalyptus and syzygium cumini trees are uesd as adsorbents, which are waste products from agriculture, is environmental friendly and shows they can adsorb cadmium ions from aqueous solutions. The maximum removal of Cd is found to be at 70 mins for EB and 60mins for SCB. The % Removal decreases with increase of metal ion concentration. At pH 8 for eucalyptus bark and at pH 5 for syzygium cumini bark, the cadmium metal removal leveled off at maximum level. The optimum adsorbent dosage is found to be 0.3g for EB and 0.5g for SCB. The % removal of Cd is increased with decreasing of particle size. Equilibrium process was best described by the langmuir isotherms model, with maximum biosorption capacities for eucalyptus and syzygium barks of 66.6 and 28.57 mg/g respectively.

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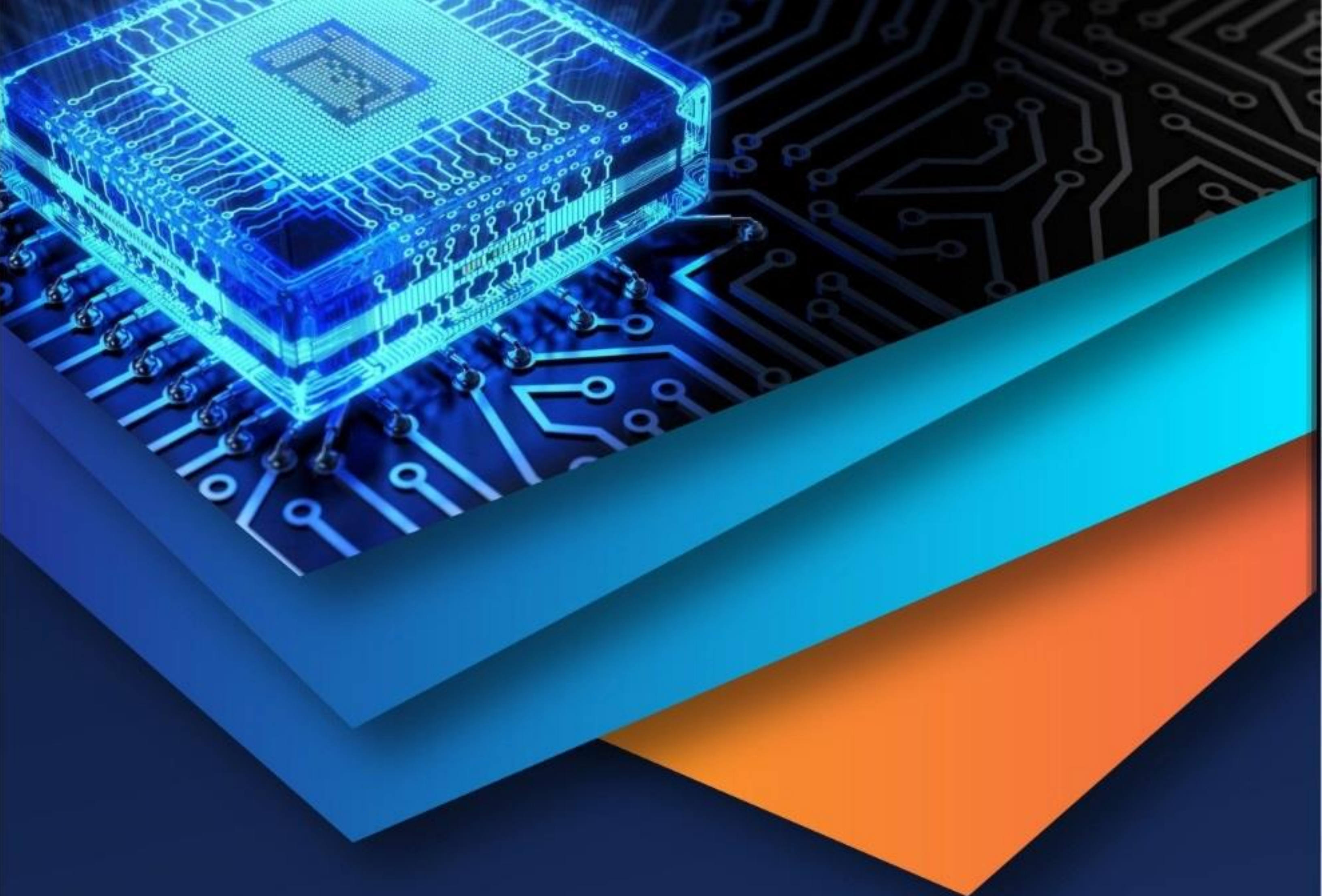

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