iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** XII **Month of publication:** December 2024

DOI: https://doi.org/10.22214/ijraset.2024.65862

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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 12 Issue XII Dec 2024- Available at www.ijraset.com

Removal of Methylene Blue from Water Using Tea Waste and Banana Peel

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Abstract: ***Methylene Blue (MB) is a synthetic dye widely used in various industries, particularly textiles. Its presence in wastewater poses significant environmental risks due to its toxicity to aquatic life and potential for bioaccumulation in the food chain. This report explores the efficacy of using natural, low-cost, eco-friendly ingredients tea waste and banana peel adsorbents for the removal of MB from water, alongside a discussion of the harmful effects of MB on plants and animals. MB has various side effects on living cell bodies, so this research helps to explore and eradicate the harmful effects.***
Keywords: Methylene blue dye, adsorption, Degradation mechanism, wastewater treatment

I. INTRODUCTION

A. *Harmful Effects of Methylene Blue*

Methylene Blue is known to have several detrimental effects on the environment:

1) *Aquatic Life:* MB can be toxic to fish and other aquatic organisms, leading to impaired growth, reproductive issues, and even mortality. Studies have shown that exposure to MB can disrupt cellular processes in fish, affecting their overall health and survival rates.
2) *Plants:* When introduced into soil or water systems, MB can inhibit seed germination and root development in plants. It can also lead to chlorosis (yellowing of leaves) due to its interference with chlorophyll production, ultimately affecting plant growth and yield.
3) *Microorganisms:* The presence of MB can adversely affect beneficial microorganisms in soil and water systems, disrupting nutrient cycling and ecosystem balance.

II. ADSORPTION MECHANISM

The adsorption of MB onto tea waste and banana peel involves various mechanisms:

1) *Tea Waste:* The organic functional groups present in tea waste facilitate interactions with MB through electrostatic attraction, hydrogen bonding, ion exchange, and π-π interactions. Research indicates that tea waste can achieve removal efficiencies exceeding 98% under optimal conditions without pH adjustment.
2) *Banana Peel:* Similarly, banana peel acts as an effective biosorbent for MB. The adsorption capacity is influenced by factors such as pH, particle size, and contact time. The optimal pH for maximum adsorption is around 6.

III. EXPERIMENTAL SETUP

Students conducted experiments to evaluate the effectiveness of tea waste and banana peel in removing MB from aqueous solutions. The following steps were involved:

1) *Preparation of Adsorbents:* Tea waste was dried and crushed, while banana peels were cleaned and processed into suitable sizes for adsorption.
2) *Batch Adsorption Experiments:* Different concentrations of MB solutions were prepared, and varying amounts of adsorbents were added to assess removal efficiency under controlled conditions.
3) *Measurement:* After a predetermined contact time, samples were analyzed using spectrophotometry to determine the concentration of MB remaining in solution.

IV. PROCEDURE

1) *Step1. Preparation of Methylene Blue Solution:*

Prepare a 100 mg/L stock solution of methylene blue by dissolving 0.05 g in 500ml of distilled water.

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2) Step 2. Tea Waste:
- Collect used tea waste.
- Wash thoroughly with distilled water to remove soluble impurities.
- Dry in an oven at 60–80°C for 4–6 hours.
- Grind into a fine powder and sieve to obtain uniform particle size (≤150 µm).

3) Step 3. Banana Peels
- Collect banana peels and wash thoroughly with distilled water.
- Cut into small pieces and dry in an oven at 60–80°C for 4–6 hours.
- Grind into a fine powder and sieve to obtain uniform particle size (≤150 µm).

Batch Adsorption Experiment:

4) Step 4: Initial Dye Concentration
- Take 100 ml methylene blue each in two beakers.

5) Step 5. Adsorbent Addition
- Add 0.5 g of tea waste powder to 100 ml methylene blue solution.
- Add 0.5 g of banana peel powder to another 100 ml methylene blue solution.

6) Step 6. pH Adjustment
- Adjust the solution pH using 0.1 M HCl or NaOH (optimum pH: 6–8).

7) Step 7. Stirring
- Stir the mixture using a magnetic stirrer at 120 rpm for 60 minutes (contact time can vary based on adsorbent).

8) Step 8. Filtration
- Filter the solution using filter paper to remove the adsorbent particles.

9) Step 9. Concentration Measurement:
- Measure the residual concentration of methylene blue in the filtrate using a UV-Vis spectrophotometer.



Fig 1 : Methylene Blue

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V. RESULTS

The results indicated that both tea waste and banana peel are effective adsorbents for removing methylene blue from water. The removal efficiencies varied based on the initial concentration of MB, contact time, and the amount of adsorbent used.

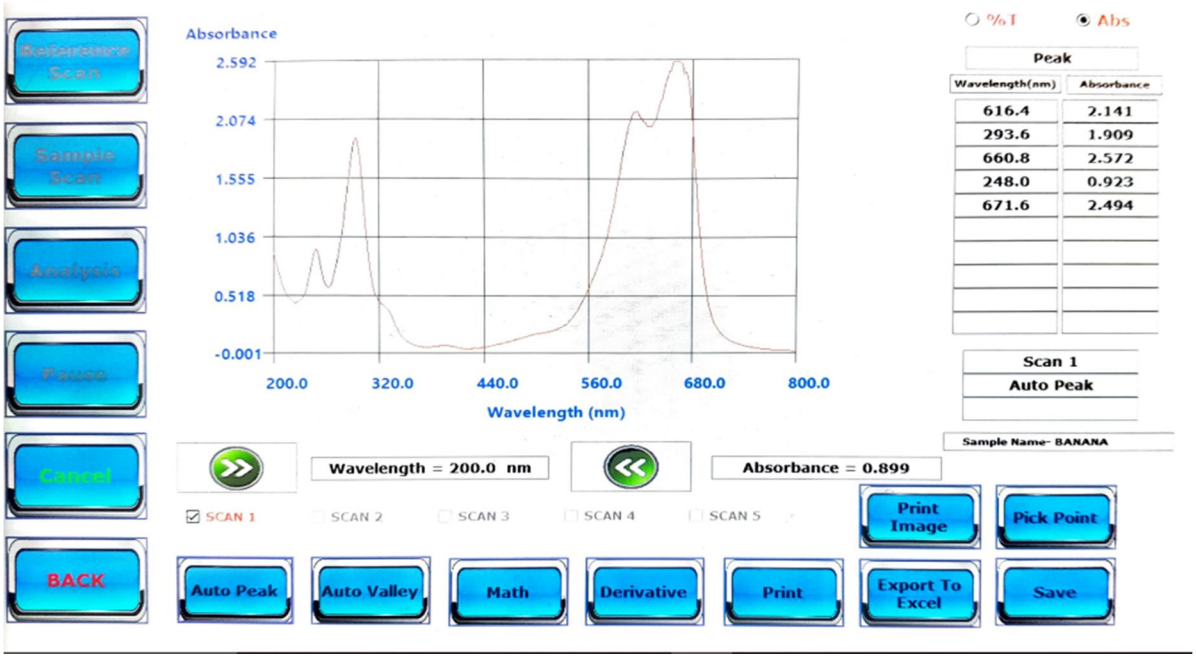


Fig 2: Treatment of tea waste with MB

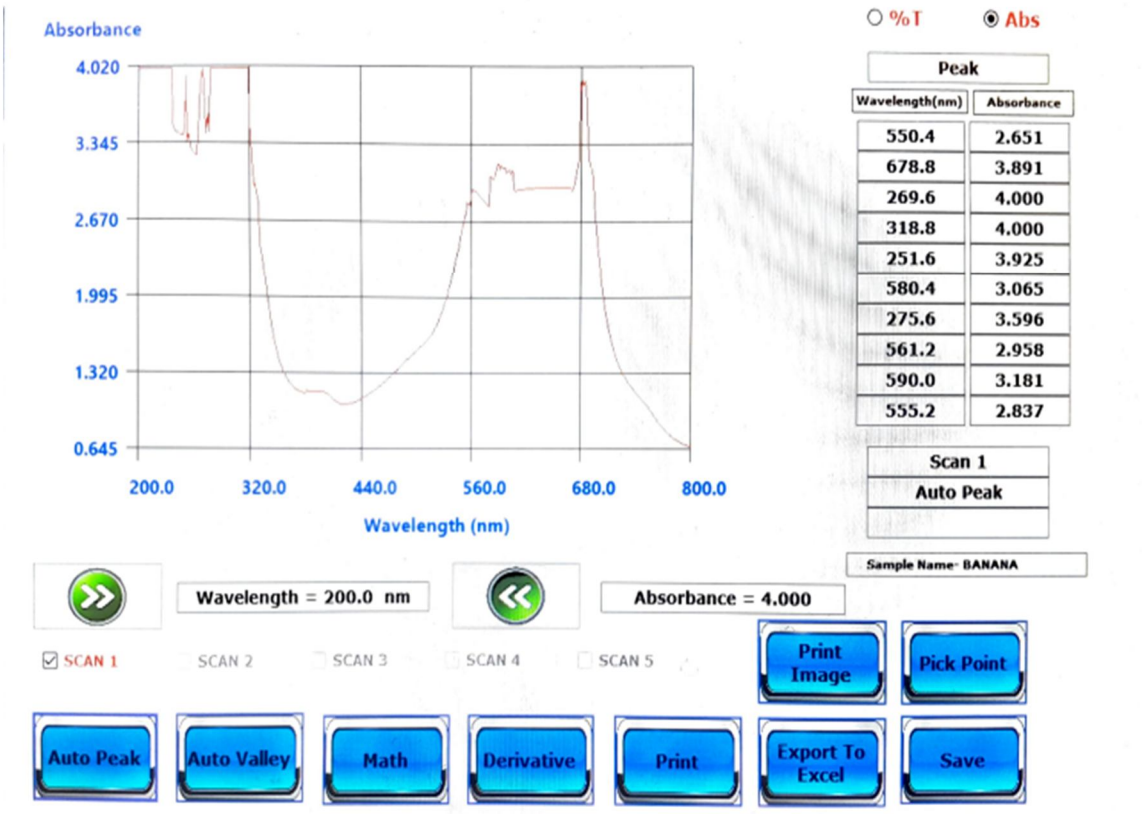
We can clearly see from the picture that the difference between original methylene blue solution and filtered solution's color significantly. This proves to be efficient in waste water treatment by the means of these adsorbents.

Graphs were obtained using UV-Visible spectrophotometer as follows.

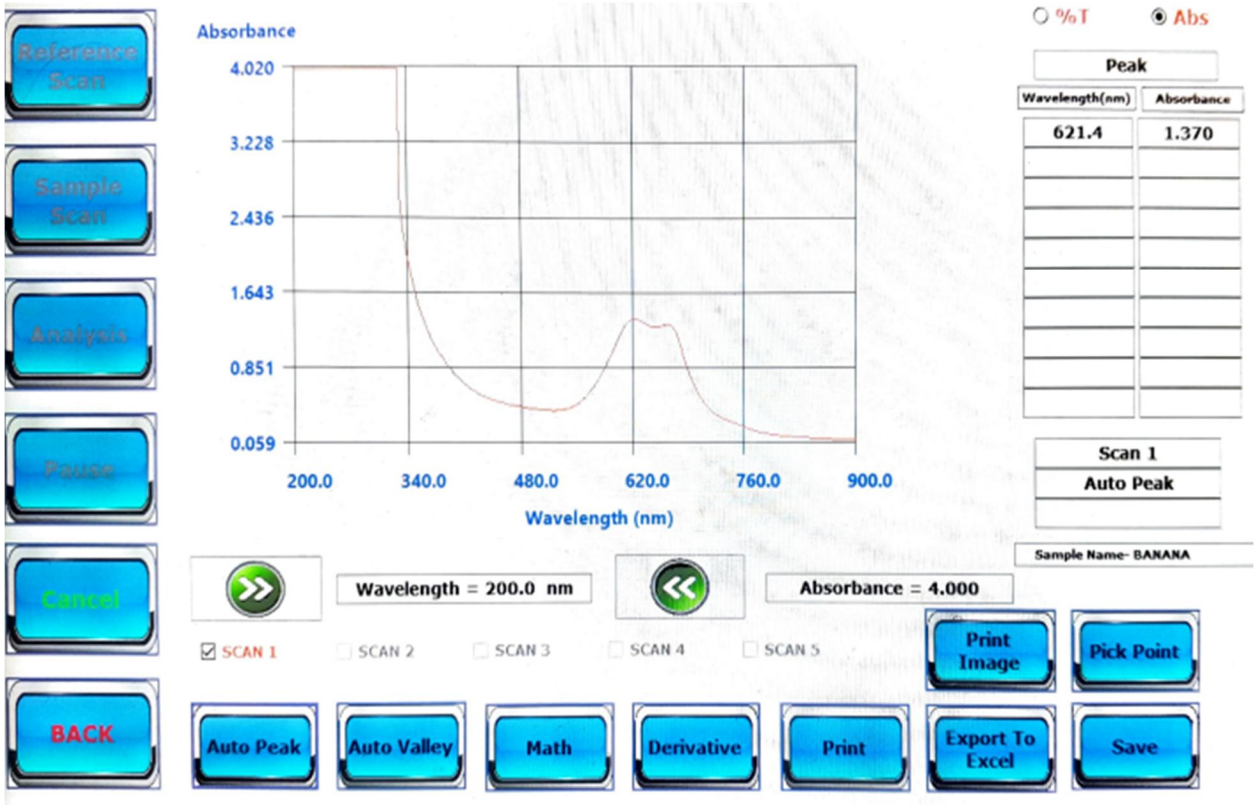
Graph 1: Methylene Blue



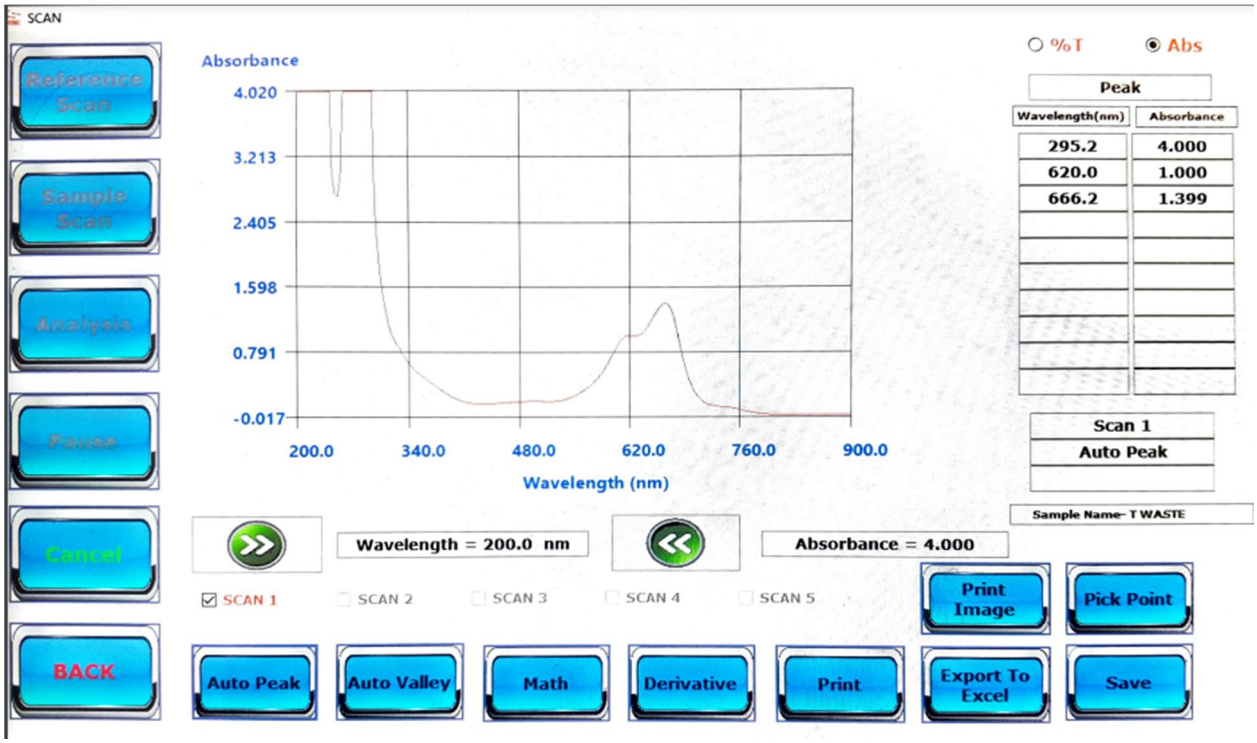
Graph 2: Glucose



Graph 3: Banana peels



Graph 4: Tea waste



VI. CONCLUSIONS

Sr. No.	Name of Sample	Max. Wavelength	Absorbance
1.	Methylene Blue	671.6	2.494
2.	Glucose	678.8	3.891
3.	Banana Peels	621.4	1.370
4.	Tea Waste	666.2	1.399

As we can see the absorbance of banana peel and tea waste is significantly lower than original solution. Hence the use of tea waste and banana peel as biosorbents presents a sustainable approach for treating wastewater contaminated with methylene blue. Their effectiveness not only aids in reducing environmental pollution but also promotes recycling agricultural by-products. Further research could optimize conditions for maximum efficiency and explore additional applications for these natural adsorbents. This report highlights the importance of addressing industrial dye pollution while utilizing eco-friendly materials that contribute to sustainable practices in wastewater management.

VII. ACKNOWLEDGMENT

We are thankful to Pimpri Chinchwad college of engineering nigdi Pune for providing chemistry lab with chemicals, apparatus for completion of experimental work. Also expressing our gratitude to Falguni S. Bhavsar mam for necessary guidance during the journey of research.

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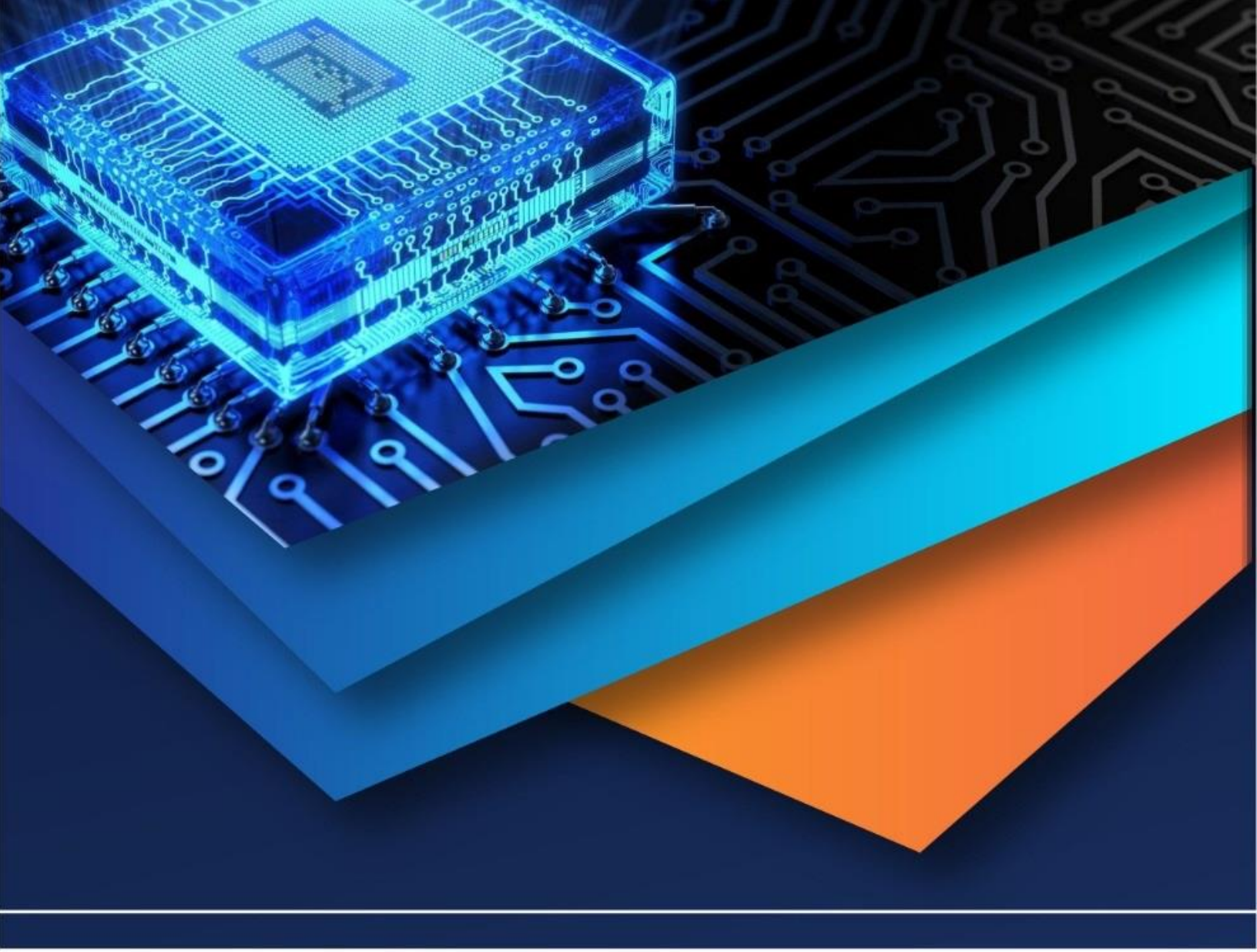
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