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AI-Based Biochar Recommendation System for Soil Health & Carbon Enhancement

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Abstract: ***Soil health is very important for agricultural productivity, but many farmers face issues such as low fertility, poor soil structure, and reduced carbon content. Biochar is a sustainable solution that helps improve soil quality and increase carbon storage. This research focuses on developing an AI-based web application using Claude AI to recommend suitable bio-char usage for farmers. The system provides recommendations based on inputs such as soil type, crop type, and environmental conditions. The web application is simple and easy to use, allowing farmers to access it through mobile phones or computers. The main objective of this study is to help farmers improve soil health and enhance carbon sequestration using modern technology. By using this system, farmers can make better decisions regarding soil management practices. The application also promotes sustainable agriculture and reduces environmental impact. This study highlights how AI-based web applications can support farmers in solving real-life problems and improving productivity in an efficient and practical way.***

Keywords: AI, Biochar, Soil Health, Web Application, Claude AI

I. INTRODUCTION

Agriculture is an important part of the economy, especially in India. However, soil degradation has become a serious issue due to excessive use of chemical fertilizers, improper farming practices, and environmental changes. Poor soil health reduces crop productivity and affects farmers' income.



Fig.1.1. Soil Degradation

Biochar is a carbon-rich material made from organic waste. It improves soil fertility, increases water retention, and helps in storing carbon in the soil. This makes it useful for both agriculture and environmental protection[1].

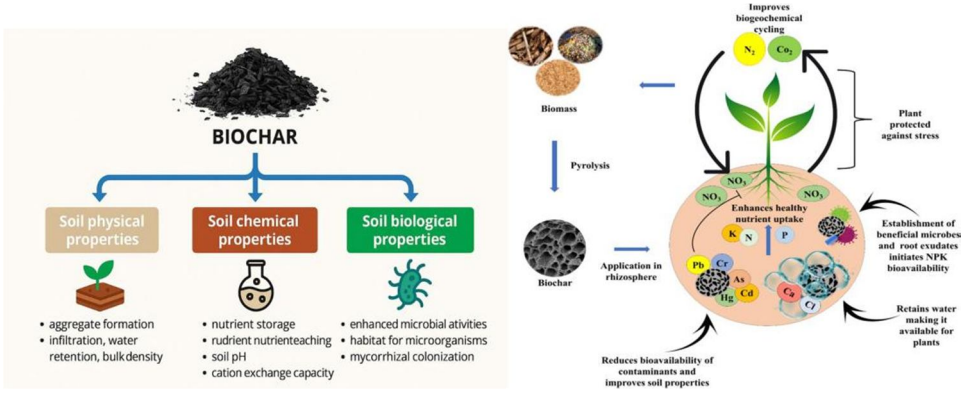


Fig.2.Biochar Material/Use

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With the help of modern technology, Artificial Intelligence (AI) can provide smart solutions for farmers. In this research, an AI-based web application is developed using Claude AI. The system takes user input such as soil type and crop type and provides recommendations for bio-char usage[2].

The aim of this project is to create a simple and effective digital platform that helps farmers improve soil health and adopt sustainable farming practices[3].

Agriculture is one of the most important sectors in the world and plays a major role in the economy of countries like India. A large number of people depend on farming for their livelihood. However, in recent years, agriculture has been facing many challenges such as soil degradation, climate change, water scarcity, and improper farming practices. Among these, soil health has become a major concern because it directly affects crop productivity and quality[4].

One of the important solutions to improve soil health is the use of Biochar. Biochar is a carbon-rich material produced from organic waste such as crop residues, wood, and biomass through a process called pyrolysis. It has gained attention in recent years due to its ability to improve soil properties and support sustainable agriculture[5]. Bio char helps in increasing soil fertility by improving nutrient availability and enhancing microbial activity. It also improves soil structure, making it more suitable for plant growth[6].

Another major benefit of bio-char is its role in carbon sequestration. Carbon sequestration refers to the process of capturing and storing carbon dioxide from the atmosphere[7]. Bio char stores carbon in a stable form in the soil for a long period of time, which helps in reducing greenhouse gas emissions and combating climate change. Therefore, bio-char is not only useful for improving agricultural productivity but also for protecting the environment[8].

Despite these benefits, many farmers are not aware of bio-char or do not know how to use it properly[9]. The effectiveness of bio-char depends on several factors such as soil type, crop type, climate conditions, and method of application. Without proper guidance, farmers may not get the expected results. This creates a need for a system that can provide correct and timely recommendations to farmers[10].

With the advancement of technology, Artificial Intelligence (AI) has emerged as a powerful tool in agriculture[11].



Fig.3.AI in Agriculture

AI can analyze large amounts of data and provide accurate recommendations based on different conditions[12]. It can help farmers make better decisions related to soil management, crop selection, and resource utilization. AI-based systems are becoming popular because they provide fast, reliable, and easy-to-understand information[13].

In this research, an AI-based web application is developed using Claude AI to recommend suitable bio-char usage for farmers. A web application is chosen because it is easy to access and does not require installation. Farmers can use it on mobile phones, tablets, or computers with internet access. The application is designed in a simple way so that even users with basic knowledge of technology can use it without difficulty[14].

The system works by taking input from the user, such as soil type, crop type, and other relevant details. Based on this input, the AI model processes the data and provides recommendations for bio-char usage[15]. These recommendations may include the amount of bio-char, method of application, and expected benefits. The goal is to provide practical and useful suggestions that farmers can apply in real-life situations[16].

This research aims to combine the benefits of bio-char and modern AI technology to create an effective solution for improving soil health. By using this web application, farmers can gain knowledge about sustainable farming practices and make better decisions. It also helps in reducing dependency on experts and saves time by providing instant information[17].

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II. PROBLEM STATEMENT

1) Soil degradation is increasing due to excessive use of chemical fertilizers and improper farming practices.
2) Decrease in soil fertility and organic carbon content is affecting crop productivity and farmer income18.
3) Although bio char is useful for improving soil health and supporting Carbon Sequestration, many farmers lack awareness about its benefits and proper application methods19.
4) The effectiveness of bio char depends on multiple factors such as soil type, crop type, and environmental conditions, which makes decision-making difficult for farmers.
5) There is a lack of simple and accessible digital platforms that provide personalized guidance for bio char usage20.
6) Limited use of modern technologies like Artificial Intelligence in practical agricultural decision-making systems.
7) Farmers often depend on traditional knowledge or experts, which may not always be available or accurate[21].

III. OBJECTIVES OF THE STUDY

1) To develop an AI-based web application using Claude A: This objective focuses on creating a simple web platform that farmers can access easily. The application uses AI to generate recommendations based on user inputs.
2) To provide bio char recommendations based on soil and crop data: The system collects inputs like soil type and crop type from the user. Based on this data, it suggests suitable bio char usage for better soil management.
3) To improve soil health and fertility using bio char: This objective aims to promote the use of biochar to enhance soil quality. It helps in increasing nutrient availability and supports better crop growth.
4) To promote sustainable agriculture through Carbon Sequestration: Biochar helps in storing carbon in the soil, reducing environmental impact. This supports eco-friendly farming practices and long-term soil sustainability.
5) To demonstrate the role of Artificial Intelligence in agricultural decision-making: The system shows how AI can provide quick and accurate recommendations. It helps farmers make better decisions without depending only on experts.

IV. REVIEW OF LITERATURE

1) *Lehmann & Joseph (2015)*

Lehmann and Joseph explained the importance of bio-char in improving soil quality. According to their study, bio-char helps in increasing soil fertility and improves the physical structure of the soil. It also enhances water retention, which is useful in dry areas. Another important point is that bio-char stores carbon in the soil for a long time, which helps in reducing climate change. Their research shows that bio-char is a sustainable and eco-friendly solution for agriculture. This study is important for understanding the basic benefits of bio-char.

2) *Sohi et al. (2017)*

Sohi and his team studied the environmental benefits of bio-char. They found that bio-char plays a major role in carbon sequestration, which means capturing and storing carbon dioxide from the atmosphere. This helps in reducing global warming. The study also shows that bio-char improves soil microbial activity, which is important for plant growth. They suggested that bio-char can be used as a long-term solution for both soil improvement and environmental protection. This research supports the use of bio-char in sustainable farming.

3) *Jeffery et al. (2018)*

Jeffery and colleagues focused on the effect of bio-char on crop productivity. Their research found that the use of bio-char can increase crop yield in many cases. It improves nutrient availability in the soil, which helps plants grow better. The study also showed that bio-char works well when combined with fertilizers. However, the results may vary depending on soil type and climate. This study is useful in understanding how bio-char directly benefits farmers.

4) *Major et al. (2019)*

Major and his team studied the long-term impact of bio-char on soil. They found that bio-char remains stable in soil for many years and continues to improve soil quality over time. It helps in maintaining soil nutrients and reduces the need for chemical fertilizers. Their research also highlighted that bio-char can improve soil structure and reduce soil erosion. This study proves that bio-char is not only a short-term solution but also beneficial in the long run.

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5) Reddy & Rao (2022)

Reddy and Rao discussed the role of modern technologies like Artificial Intelligence in agriculture. They found that AI can help farmers make better decisions by providing accurate and timely information. Their study shows that digital tools can improve productivity and reduce risks in farming. They also highlighted that AI-based systems can analyze data and give useful recommendations. This research supports the use of AI in your web application.

6) Patil et al. (2021)

Patil and his team studied AI-based agricultural systems. They found that such systems help farmers by providing quick and reliable information. AI tools can analyze different factors like soil, weather, and crops to give better suggestions. The study also showed that farmers are slowly adopting digital solutions. This research is important because it supports the idea of using AI for smart farming solutions.

7) Gupta et al. (2020)

Gupta and colleagues analyzed the use of web applications in agriculture. They found that web apps are easy to use and can be accessed from anywhere using mobile phones or computers. Their study showed that farmers prefer simple and user-friendly systems. Web applications help in sharing knowledge quickly and effectively. This research supports the development of your AI-based web application.

8) Singh et al. (2022)

Singh and his team explored digital tools in agriculture. They found that technology helps in improving communication and knowledge sharing among farmers. Their study shows that AI-based platforms can provide better solutions to farming problems. They also highlighted that digital tools reduce dependency on traditional methods. This research supports the use of AI for modern agricultural practices.

9) Meena & Patel (2021)

Meena and Patel studied the adoption of digital platforms by farmers. They found that farmers prefer applications that are simple and easy to understand. Their research shows that user-friendly design is very important for technology adoption. They also suggested that digital tools should be available in local languages. This study helps in designing a better web application for farmers.

V. METHODOLOGY

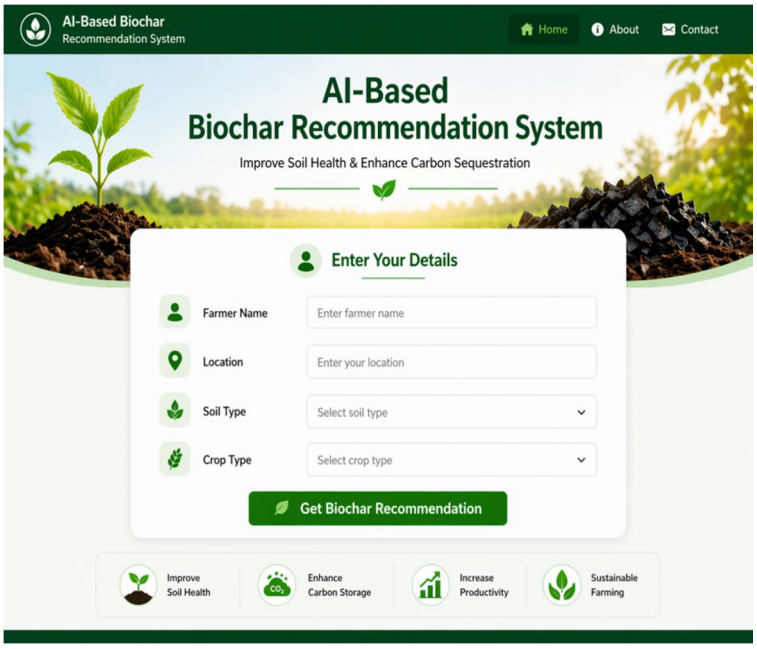
1) Problem Identification: The study begins by identifying issues such as soil degradation, low fertility, and lack of awareness about biochar usage. These problems reduce agricultural productivity and create the need for a smart recommendation system.
2) Data Collection: Information related to soil health, biochar, and farming practices was collected from research papers and agricultural sources. This data helps in understanding how biochar improves soil quality and supports Carbon Sequestration.
3) System Design Planning: The system is designed using a simple input–process–output model. This defines how user input (soil and crop data) will be processed to generate recommendations.
4) Web Application Development: The web application is developed using an AI-assisted approach with Claude AI. Interface design and logic are generated through AI prompts instead of manual coding. It provides a simple and user-friendly platform for farmers.
5) AI Integration: Claude AI is used to process user inputs and generate biochar recommendations. The AI helps in providing accurate and context-based suggestions for better soil management.
6) Input Processing: Users enter details such as soil type and crop type through the web interface. The system processes this information to understand the farming conditions.
7) Output Generation: Based on processed input, the system generates suitable biochar recommendations. The output is displayed in a simple format for easy understanding by users.
8) Testing and Evaluation: The system is tested with different inputs to check accuracy and usefulness. Improvements are made by refining AI prompts and responses.
9) Implementation: The final system is implemented as a working AI-based web application. It demonstrates the use of Artificial Intelligence in agriculture for decision support.

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VI. SYSTEM DESIGN / WORKING

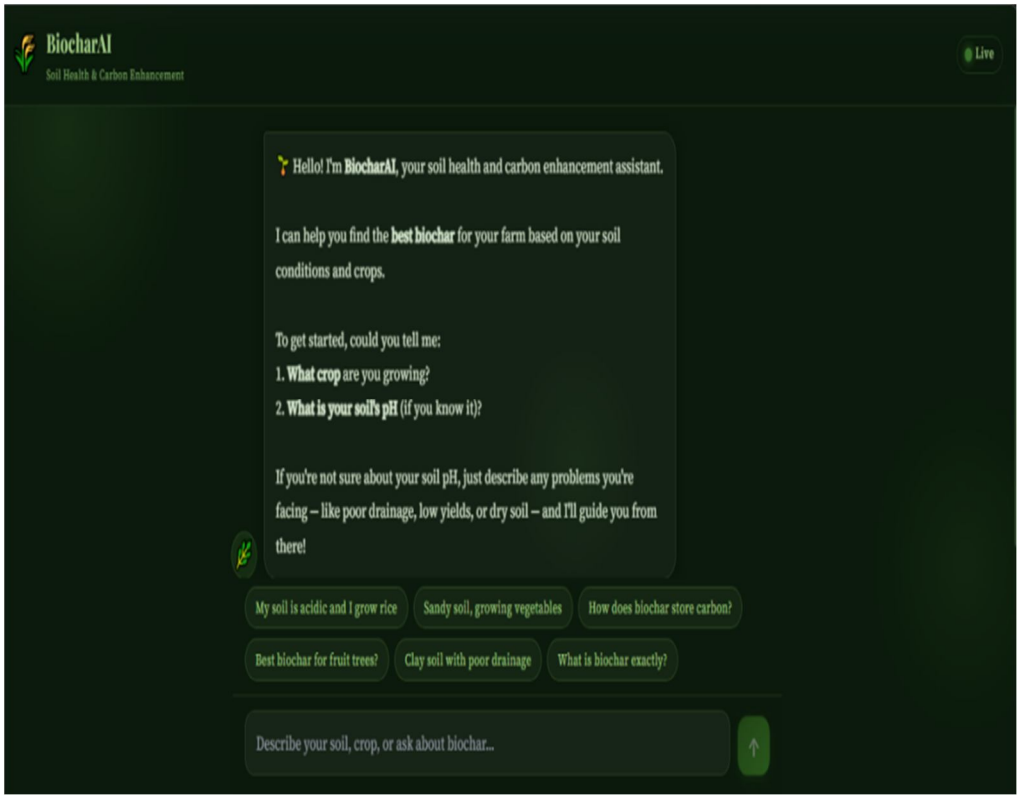
1) User Input Stage

The user opens the web application and enters details like soil type and crop type. This information is collected through a simple web form interface.



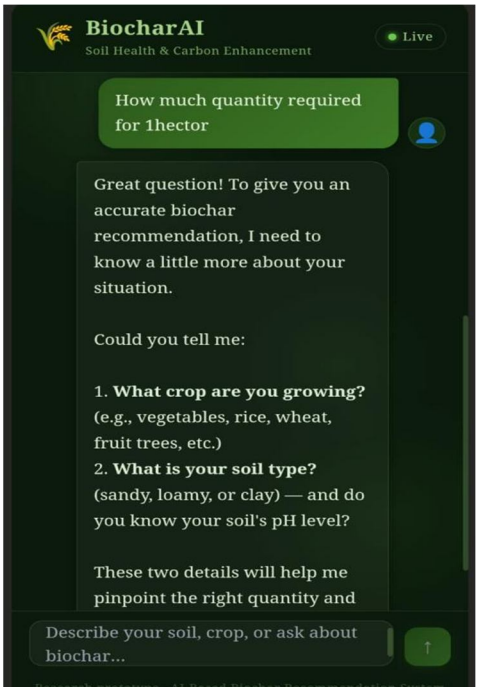
2) Data Processing Stage

The entered data is sent for processing using Claude AI. The AI analyzes the input and matches it with biochar knowledge.



3) Recommendation Generation Stage

Based on the analysis, the system generates suitable biochar usage suggestions. These recommendations help improve soil health and productivity.



4) Output Display Stage

The final result is shown on the web page in a simple text format. The output is easy to understand and useful for farmers.

5) System Accessibility Stage

The web application can be accessed through any browser without installation.
It supports quick and easy decision-making using Artificial Intelligence.

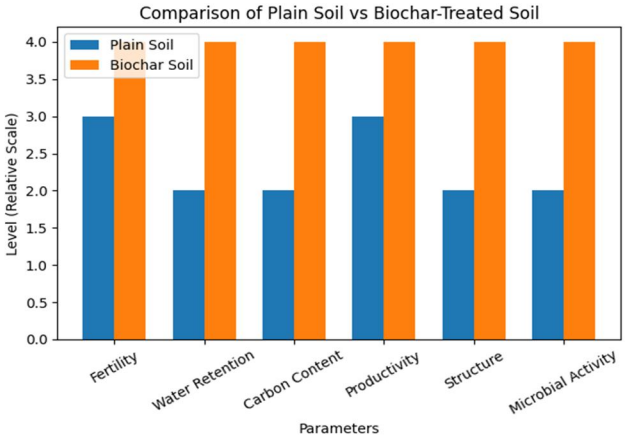
VII. RESULTS AND ANALYSIS

The AI-based biochar recommendation system was tested using different input conditions such as soil type and crop type. The system successfully generated suitable biochar recommendations based on user input. The results show that the application provides quick, simple, and useful suggestions for improving soil health.
To better understand the impact of biochar, a comparative analysis was prepared between plain soil and biochar-treated soil.

A. Comparative Analysis

Parameter	Plain Soil	Biochar-Treated Soil
Soil Fertility	Moderate	High
Water Retention	Low	High
Carbon Content	Low	High
Crop Productivity	Moderate	Improved
Soil Structure	Weak	Improved
Microbial Activity	Low	High

Table 1.Comparative analysis of plain soil & biochar treated soil



Comparison between plain soil and biochar treated soil

VIII. ADVANTAGES / APPLICATIONS

1) The system helps in improving soil fertility and crop productivity.
2) It provides quick and accurate biochar recommendations based on user input.
3) The web application is simple and easy to use, even for beginners.
4) It saves time by giving instant results.
5) It reduces dependency on agricultural experts.
6) It supports sustainable farming practices.
7) It helps in increasing carbon content in soil (environmental benefit).
8) It can be accessed on mobile, tablet, or computer.
9) It promotes the use of Artificial Intelligence in agriculture.
10) The system provides results in a clear and understandable format.

IX. LIMITATIONS

1) The system depends on correct user input for accurate results.
2) It uses limited parameters (only soil type and crop type).
3) It requires an internet connection to work.
4) It may not handle complex real-world farming conditions.
5) It does not use real-time soil data.
6) The recommendations are general, not field-tested.
7) It does not consider weather conditions.

X. FUTURE SCOPE

1) Integration with real-time soil sensors for better accuracy.
2) Addition of weather data to improve recommendations.
3) Support for regional languages (Marathi, Hindi, etc.).
4) Development of a mobile application with offline access.
5) Expansion to include fertilizer and irrigation suggestions.
6) Use of advanced AI/ML models for more precise results.
7) Integration with government schemes and agricultural databases.
8) Adding voice input/output for easy use by farmers.

XI. CONCLUSION

This project developed an AI-based web application that helps farmers use biochar properly to improve soil health. The system gives quick and easy recommendations based on soil and crop type, making it useful even for beginners.

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The results show that biochar improves soil fertility, water retention, carbon content, and crop productivity compared to normal soil. It also supports sustainable farming and helps protect the environment.

Overall, this study shows that using AI in agriculture can help farmers make better decisions. With future improvements, this system can become even more useful for smart farming.

XII. ACKNOWLEDGEMENT

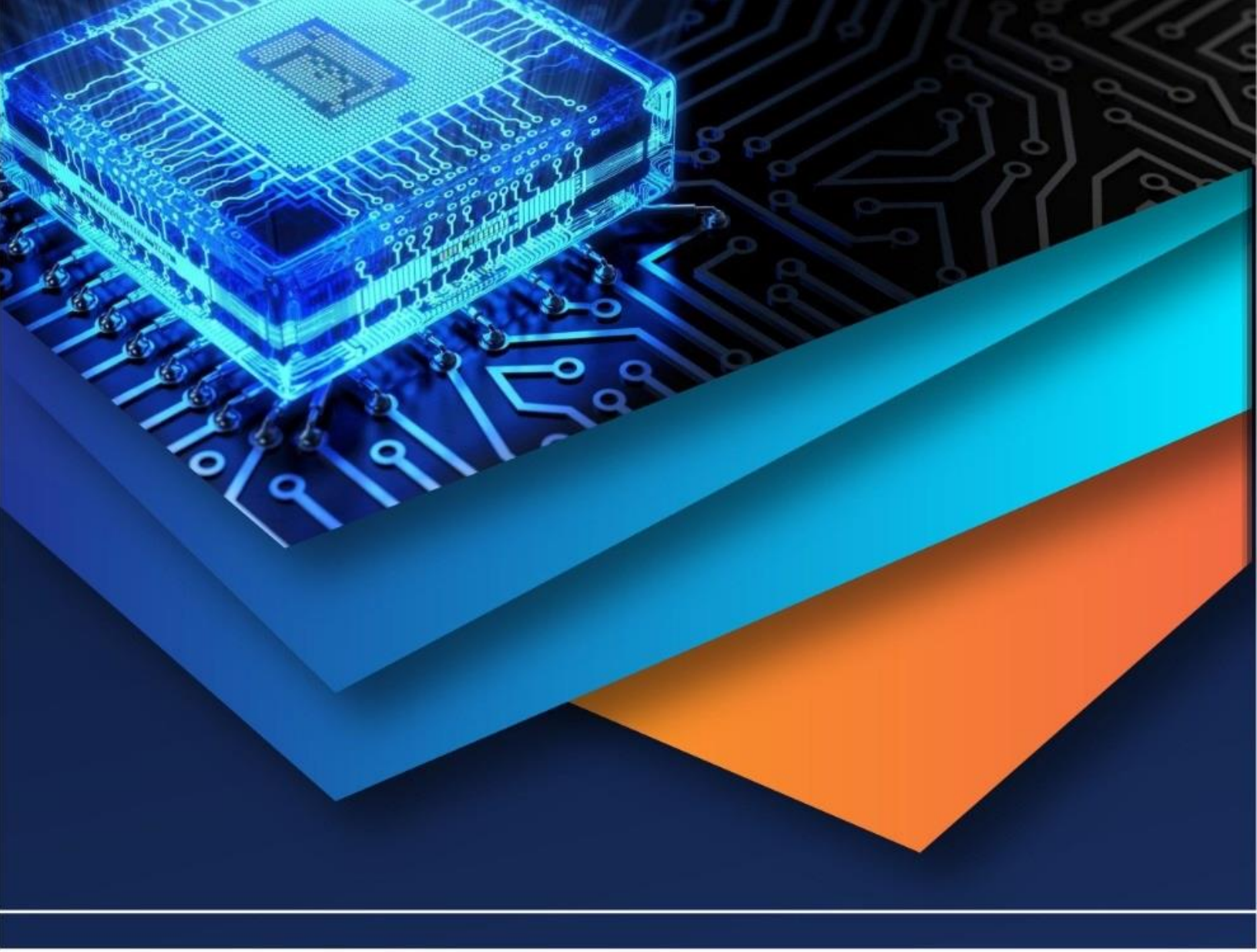
We would like to express our sincere gratitude to everyone who supported us in completing this project successfully. We are especially thankful to our guide and faculty members for their valuable guidance, encouragement, and continuous support throughout the research work.

We also thank our institution for providing the necessary resources and environment to carry out this project. Our gratitude extends to all researchers and authors whose work helped us in understanding the concepts of biochar and Artificial Intelligence.

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