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Quality Check Parameters by Adding Different Natural Coagulants and Analyzing their Results - A Review

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Abstract: ***Water contamination is a critical issue, especially in developing countries, where access to clean and safe drinking water remains a challenge. Conventional chemical coagulants such as alum and ferric chloride, although widely used in water treatment processes, pose several environmental and health concerns including residual toxicity and sludge disposal issues. In recent years, natural coagulants have gained increasing attention as sustainable, biodegradable, and eco-friendly alternatives. This review paper explores various natural coagulants and evaluates their effectiveness in improving water quality by analyzing key parameters such as turbidity, pH, total dissolved solids (TDS), and chemical oxygen demand (COD). These parameters help in assessing the performance and suitability of each natural coagulant for treating different types of water. In this project, we focus on the use of natural materials with coagulating properties, which are abundantly available in India. Thus, we have opted for orange seeds, neem seeds, soybean seeds, tulsi seeds, and Moringa oleifera seeds —promising bioflocculants whose seeds are plentifully available in India and are popular and widely used in rural and tribal areas for the purification of water. These seeds contain natural polymers such as proteins and polysaccharides that facilitate floc formation, enabling the removal of suspended particles from water. The review aims to provide a comparative understanding of these natural coagulants, their mechanisms of action, and their potential application in decentralized water treatment systems, thereby contributing to a sustainable and low-cost solution for clean water access.***

Keywords: Natural Coagulants, Turbidity, Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD).

I. INTRODUCTION

Access to clean and safe drinking water is a fundamental human right, yet millions of people, particularly in rural and tribal areas, continue to suffer from waterborne diseases due to untreated or inadequately treated water. Conventional water treatment methods often rely on chemical coagulants such as alum and ferric chloride, which, despite their effectiveness, are associated with high costs, environmental concerns, and potential health risks due to residual chemicals. To overcome these drawbacks, there is a growing interest in utilizing natural coagulants as sustainable and environmentally friendly alternatives. Natural coagulants are typically plant-based substances that contain bioactive compounds like proteins, polysaccharides, and polyphenols, which aid in the aggregation and removal of suspended particles in water. In this review, we explore the potential of several natural coagulants—tamarind seeds, velvet bean seeds, drumstick seeds, chickpea seeds, and soybean seeds—based on their availability, affordability, and effectiveness in water purification. Tamarind seeds, obtained from the fruit of Tamarindus indica, are rich in polysaccharides and natural gums that exhibit excellent flocculating properties and are commonly used in rural households for clarifying turbid water. Velvet bean seeds, derived from Mucuna pruriens, are known for their high protein content and bioactive compounds, making them effective in reducing turbidity and organic matter in water. Drumstick seeds, from the Moringa oleifera tree, are perhaps the most extensively studied among natural coagulants due to their high content of water-soluble, cationic proteins that work efficiently in neutralizing negatively charged particles, resulting in quick floc formation and sedimentation. Chickpea seeds (Cicer arietinum), widely consumed as a staple legume in India, contain proteins and fiber that can act as natural flocculants and aid in the removal of suspended solids. Soybean seeds (Glycine max), rich in lecithin and proteins, also demonstrate considerable potential in water treatment, particularly for mildly turbid waters. These natural seeds are not only abundantly available in India but are also economically viable, making them particularly suitable for use in low-income and remote communities. The objective of this study is to evaluate and compare the coagulation efficiency of these natural seeds through various quality parameters and highlight their relevance as sustainable solutions for water treatment in rural and tribal settings.

A. *Natural Coagulants*

Coagulation is the most commonly used method for purifying water. Coagulants can be used in wastewater to reduce suspended solids and other pollutants. Many synthetic coagulants such as aluminium sulphate (alum) and ferric chloride are used in conventional water treatment processes to remove turbidity. On the other hand, they affect the functioning of living cells, but also have toxic effects in higher concentrations. Natural coagulants work better for high turbidity. And the use of natural coagulants suitable, easier, and environmentally friendly option for water treatment. Natural coagulant is a naturally occurring plant coagulant, which can be used in the coagulation flocculation process of wastewater treatment to reduce turbidity. Natural coagulants have been used for domestic household for centuries in traditional water treatment in rural areas. Now a day, some reports describe natural coagulants from plants are used for natural water purification. The use of plant seed materials is receiving attention for their effectiveness in wastewater treatment. The technologies involved are economical, traditional and easy to implement and ideal for rural areas. The process being biological in nature does not generate any non-treatable wastes.

II. LITERATURE REVIEW

In recent years, the exploration and utilization of natural coagulants have garnered significant attention as a sustainable solution for water purification, especially in regions where access to clean water and modern treatment facilities is limited. Several researchers have investigated the effectiveness of various plant-based materials in treating turbid and polluted water by examining parameters such as turbidity reduction, pH stability, TDS (Total Dissolved Solids), COD (Chemical Oxygen Demand), and microbial content. Moringa oleifera (Drumstick) seeds have been extensively studied for their coagulation properties. According to Ghebremichael et al. (2005), Moringa seeds contain water-soluble cationic proteins that are capable of removing up to 99% of turbidity from water through charge neutralization. Further studies by Ndabigengesere and Narasiah (1996) also confirmed that Moringa seeds could achieve turbidity removal efficiency comparable to alum, without introducing harmful residuals.Tamarind seed powder, extracted from *Tamarindus indica*, has been recognized for its flocculation efficiency due to its polysaccharide content. Studies by Bhuptawat et al. (2007) indicated that tamarind seed extract performed well in treating water with moderate turbidity levels and showed improved performance when used in combination with other natural or synthetic coagulants. Velvet bean (Mucuna pruriens), though not as widely studied, has shown promise in initial research due to its high protein content. Kumar and Arjun (2018) reported that velvet bean seed extract achieved significant turbidity reduction in low to medium turbidity water samples and highlighted its potential for community-level water treatment systems. Chickpea (Cicer arietinum) seed extract has also been explored for its coagulating abilities. Karpate et al. (2013) evaluated the use of chickpea extract in water treatment and found it effective in reducing turbidity and improving overall water clarity. The protein and fiber content of the seeds contributes to particle aggregation in water, which aids sedimentation. Soybean (Glycine max) seeds, rich in lecithins and amino acids, have been tested by researchers like Shahidi et al. (2012), who concluded that soybean seed extract offers a viable alternative for low-cost water treatment, particularly in low turbidity conditions. Its natural compounds help in floc formation, and the process is relatively simple and safe for use in rural settings. Comparative studies by Ali et al. (2020) and Devi et al. (2021) emphasized that while drumstick seeds generally outperform other natural coagulants in turbidity reduction, a combination of natural coagulants could provide a synergistic effect, improving overall water quality. These studies also stressed the importance of optimizing dosage, pH range, and settling time to achieve maximum efficiency. Overall, the literature confirms the potential of these natural coagulants as effective, economical, and eco-friendly solutions. However, more research is needed to standardize their usage, assess long-term impacts, and explore large-scale applications. This review builds upon these findings and aims to compare the selected natural coagulants using various quality check parameters, thereby contributing to the development of sustainable water purification methods.

A. *Previous Research Article*

1) "Sustainable Treatment of Water and Wastewater using Natural Plant-based Coagulants: A Review" By Upendra Kumar, Kanchan Nahar, Ajay Singh Thakur (2022)- Natural coagulants (NC) are collected from plants that can be used as a coagulant in coagulation- flocculation process of water and wastewater treatment. Natural coagulants such as: Neem, Tulsi, Moringa, Orange seed, Sponge Guard, vetiver, Banana Peel etc. can effectively be used in the treatment of water and wastewater. The authors after reviewing available literature have emphasized that Natural Plant Based Coagulants (NPBC) are very effective for sweeping physio-chemical parameter of water such as: turbidity, TSS, TDS, coliform bacteria and wastewater parameter such as: BOD, COD, Heavy metals (chromium, lead etc), colour etc. The authors also have emphasized the nature, mechanism of working, advantages and disadvantages of using these NPBC with their all-round performance in water and wastewater treatments.

2) "Sewage Water Treatment using Natural Coagulants" By Achupriya K R, Bino Benny, Akshay Saseendran (2022)- The study aimed to evaluate the efficiency of natural coagulants like orange seed, papaya seed and neem leaf powder for the evaluation of purity in collected waste water sample. Three characteristics of water sample are tested this includes Turbidity, PH, and TSS. Jar test apparatus was used for determining the optimum dosage of natural coagulants. After the preparation and application of coagulants in the collected sample a dosage of 0.6g of natural coagulant is best suited for purification. Since natural coagulants are environmentally friendly and low cost it could be widely used in future.

3) "Dairy Waste Water Treatment by using Natural Coagulants" By Namrata S Naragundakar, Naghma N, Padmavathi V (2022)- The present study focuses to treat Dairy Waste water with environment friendly natural coagulants like Moringa Oleifera, Neem leaves, Saw dust, Custard Apple seeds are in powdered form resulting an effective natural agent that is modification for highly turbid and untreated pathogenic water. Various doses of natural coagulants are evaluated for the efficiency of dairy wastewater treatment. On comparison various parameters like of TDS, chloride, pH, turbidity obtained for each coagulant. It was observed that moringa Oleifera seed powder showed best results with effect of pH varies as 9.08 – 4.42, TDS varies from 5.02 – 4.38 ppm, turbidity varies from 162 – 44.6 NTU are experimental found out with the extension. By varing dosage of coagulant that is Moringa oleifera seeds is recommended as eco-friendly non-toxic coagulant for dairy waste water treatment.

4) "Feasibility of Dairy Wastewater Treatment by using Natural Coagulants" By Renuka R, Prasad B C, Umesha S H (2022)- The dairy industry is one of the most polluted water generating industry, not only in terms of the volume of effluent generated, but also in terms of its characteristics as well. This paper deals treating of dairy waste water with natural seeds like carica papaya Seeds and saw dust. Various tests are conducted to evaluate the properties of dairy waste water and treated dairy waste water.

5) "Practicability Study on Application of Natural Coagulants" By M N Hedaoo, S P Ghule (2022)- In this study, the effects of natural coagulants such as Neem leaves, Okra seeds, Watermelon seeds, Papaya seed, Aloe Vera, and Cactus on water turbidity reduction are investigated. The clump coagulation test was used to determine the ideal coagulant amount needed to evacuate 100 NTU of turbidity and to identify the successful coagulant among the six coagulants. It can be concluded from this study that neem leaf can be used as an effective coagulant for low and medium turbid water, whereas aloe Vera used as an effective coagulant for high turbid water. Further tests were carried using the recognized coagulant to streamline factors such as coagulant readings, pH, turbidity induction, blending time, blending rate, and settling time. When the pH was kept at 6.5, the starting turbid concentration was 500NTU, the rapid mixing time was 1 minute, the slow mixing time was 22 minutes and the settling period was 27 minutes, the higher percentage of turbidity was removed.

6) "Experimental Study on Treating Dairy and Kitchen Waste Water using Pappaya seed powder and Aloevera Gel" By Christeena Thomas, Anjana Raj, Vilbin Varghese (2021)- In conventional method of coagulation and flocculation alum, ferric chloride and ferrous sulphate were used as coagulant for effective removal of turbidity. But in one of the research projects, it is found that continuous use of alum has caused several problems affecting human health. So, this study is mainly focused on decreasing alum dose with use of natural materials. Natural coagulants are natural based coagulants that can be used in coagulation process of waste water treatment for reducing turbidity. The study aimed to, Carica papaya L. (papaya seed) powder, Aloe barbadensis (Aloe Vera) gel as a coagulant in dairy waste water and kitchen waste water samples collected. The experiments proved that turbidity and chlorides had reduced effectively.

7) "Effectiveness of natural coagulants in water and wastewater treatment" By S. Nimesha, C. Hewawasam, D.J. Jayasanka, Y. Murakami, N. Araki, N. Maharjan (2021)- The primary purpose of this review is to refine the knowledge on the potential use and optimization of the effectiveness of eco-friendly and sustainable natural coagulants. Besides, the development efforts and the barriers reported by recent findings for the commercialization of natural coagulants are also discussed. Further, few modified naturals have also been presented for exploring the other possible approaches to promote their usage in water and wastewater treatment in the future studies.

8) "Treatment of Waste Water Using Natural Coagulants" By Rajesh Kumar Kaushal, Hemant Goyal (2019)- The use of natural coagulants like Moringa Oleifera and Okra plants are receiving attention for their effectiveness in waste water treatment. The technologies involved are economical, traditional and easy to implement and ideal for rural areas. The process being biological in nature does not generate any non-treatable wastes. These processes are easy to operate and require little or no maintenance. After the treatment of both the municipal and dairy waste water samples by two natural coagulants Moringa Oleifera and Okra seeds and synthetic coagulant alum, the results show that there is a reduction in the percentage of various polluting parameters like COD, BOD, turbidity, hardness, TSS and TDS etc.

9) "Applications of Natural Coagulants to Treat Wastewater − A Review" By Vicky Kumar, Norzila Othman, and Syazwani Asharuddin (2017)- The water becomes wastewater due to population growth, urbanization, industrialization, sewage from household, institutions, hospitals, industries and etc. The coagulant chemicals and its associated products are resourceful but these may change the characteristics of water in terms of physical and chemical characteristics, this makes matters worse in the disposal of sludge. An option of natural polymer can be used in water and wastewater in this review. The natural polymers are most efficient that provide several benefits such as; prolific, exempt from physical and chemical changes from the treated water.
10) "Wastewater Treatment using Natural Coagulants" By Saravanan Priyadharshini D, Soundammal A, Sudha G, Suriyakala K (2017)- The objectives of this study were to assess the possibility of using natural coagulants as an alternative to the current commercial synthetic coagulant such as aluminium sulphate and to optimize the coagulation process. Based on the experimental results, it was concluded that natural coagulants which have been obtained from Dolichas lablab, Azadirachta Indica, Moringa Oleifera, Hibiscus Rosa Sinensis have showed an merely equalant coagulation comparing to alum. The turbidity removal efficiency for Dolichas lablab, Azadirachta Indica, Moringa Oleifera, Hibiscus Rosa Sinensis respectively were 37.45%, 63.01%, 31.47%, 12.95% against 75.01% obtained from alum.
11) "Production of Natural Coagulant from Moringa Oleifera Seed for Application in Treatment of Low Turbidity Water" By Eman N. Ali , Suleyman A. Muyibi, Hamzah M. Salleh, Md Zahangir Alam, Mohd Ramlan M. Salleh (2009)- This study focused on developing an efficient and cost-effective processing technique for Moringa oleifera seeds to produce natural coagulant for use in drinking water treatment. This study investigates processing Moringa oleifera seeds to concentrate the bio-active constituents which have coagulation activity.
12) "Application of Natural Coagulants for Pharmaceutical Removal from Water and Wastewater: A Review" By Motasem Y. D. Alazaiza Ahmed Albahnasawi , Gomaa A. M. Ali , Mohammed J. K. Bashir (2008)- The main mechanisms of natural coagulants for pharmaceutical removal from water and wastewater are charge neutralization and polymer bridges. Natural coagulants extracted from plants are more commonly investigated than those extracted from animals due to their affordability.Natural coagulants are competitive in terms of their performance and environmental sustainability.Developing a reliable extraction method is required, and therefore further investigation is essential to obtain a complete insight regarding the performance and the effect of environmental factors during pharmaceutical removal by natural coagulants. Finally, the indirect application of natural coagulants is an essential step for implementing green water and wastewater treatment technologies.

B. Summary

Water is undoubtedly the most vital element among all the natural resources. In many developing countries, access to clean and safe water is a crucial issue. More than 6 million people die because of diarrhea which is caused by polluted water. Due to rapid urbanization and migration from rural areas, there is a tremendous load on water consumption in all major cities. Water condition of surface water of most of the highly populated regions have become highly polluted due to indiscriminate discharge of untreated waste from tannery, textile, municipal waste into water bodies, etc. One of the problems with treatment of surface water is the large seasonal variation in 'Turbidity'.

Commonly used chemicals for various treatment units are synthetic organic and inorganic substances. In most of the cases, these are expensive since they are required in higher dose and are not cost effective. Many of the chemicals are also associated with human health and environmental problems. So, there raised a voice to develop cost-effective, easier, and environmentally friendly process of water clarification.

The history of the use of natural coagulants is long. Natural organic polymers have been used for more than 2000 years in India, Africa, and China as effective coagulants and coagulant aids at high water turbidities. They may be manufactured from plant seeds, leaves, and roots.

These natural organic polymers are interesting because, comparative to the use of synthetic organic polymers containing acrylamide monomers, there is no human health danger and the cost of these natural coagulants would be less expensive than the conventional chemicals.

Natural coagulants have bright future and are concerned by many researchers because of their abundant availability, low price, environment friendly (biodegradable nature), and multifunction capability. To completely comprehend the impact of natural coagulants on the treatment of wastewater and to maximize its application in water treatment process, more study is necessary.

C. Gap Identified

There have been several gaps identified in the literature on natural coagulants. Some of these include:

1) Plant-based coagulants are ideal for purification of contaminated water in less urbanized areas as they seem to carry less cost in comparison to the chemical coagulants which are far more expensive.
2) Coagulants of plant origin are mostly useful when Turbidity is in the range of low to medium.
3) Cost of imported chemicals can be a serious financial burden for developing countries.
4) Alum, when reacts with natural alkalinity present in water, leads to reduction of pH and a low efficiency in coagulation of particles in cold water.
5) Sludge produced while using chemical coagulants is voluminous and non-biodegradable after treatment.
6) Consumption of water treated with chemical coagulants on a long run may also lead to Dementia and Alzheimer's disease.

III. PROPOSED METHODOLOGY

A. Materials Used

In this study, the powdered form of five different seeds—namely orange seeds, neem seeds, soybean seeds, tulsi seeds, and Moringa oleifera seeds—were utilized as locally available natural coagulants with the primary objective of reducing the turbidity of synthetic water. These seeds, widely accessible and commonly found in various regions of India, were selected due to their known bioactive properties and traditional usage in household water purification practices. The experimental procedure involved the preparation of artificially turbid water to ensure consistent and reproducible conditions for analysis. The standard jar test apparatus, a widely accepted method in water treatment research, was employed to evaluate and compare the coagulation efficiency of each seed powder under controlled laboratory conditions. By adjusting parameters such as coagulant dosage, settling time, and mixing speed, the effectiveness of each natural coagulant was assessed based on its ability to reduce turbidity and facilitate the settling of suspended particles. The results from this approach provided valuable insights into the potential of these natural, biodegradable materials as sustainable alternatives to chemical coagulants for water treatment applications, especially in rural and resource-limited communities.

1) Moringa oleifera (Drumstick): It is the most widely cultivated species in the genus Moringa, the only genus in the plant family 'Moringaceae'. Common names include moringa, drumstick tree (from the long, slender, triangular seed-pods), horseradish tree (from the taste of the roots, which resembles horseradish), and ben oil tree or benzoil tree (from the oil which is derived from the seeds). It is widely cultivated for its young seed pods and leaves used as vegetables and for traditional herbal medicine. It is also used for water purification. Moringa seed cake, obtained as a byproduct of pressing seeds to obtain oil, is used to filter water using flocculation to produce potable water for animal or human consumption. Moringa seeds contain dimeric cationic proteins which absorb and neutralize colloidal charges in turbid water, causing the colloidal particles to clump together, making the suspended particles easier to remove as sludge by either settling or filtration. Moringa seed cake removes most impurities from water. This use is of particular interest for being nontoxic and sustainable compared to other materials in moringa-growing regions where drinking water is affected by pollutants. Only the inner white pods of the dried seeds, in a powdered form are used as Coagulants.
2) Glycine max (Soyabean): Widely known as soybean, the G. max plant is the most important source of vegetable oil, accounting for more than 50 % of the world's oilseeds. Its genus name 'Glycine' has been derived with reference to the Greek word 'glykys' which means sweet. Like most legumes, the seed extracts were reported to exhibit water clarification properties when tested in synthetic water. The soybeans contained relatively large fraction of lipid and is the second highest legume trailing behind A. hypogaea. This contributes to coagulation activities, and de-lipidation of the seeds will be useful if enhancement in its turbidity removal is required. In addition to turbidity removal, de-lipidated or De-oiled soybeans have also been recently found out to be low-cost bio-adsorbents in the treatment of various dye-contaminated waters. Palmitic and stearic acids which contributed to the bactericidal activities in H. esculentus are also present in G. max. Hence, this plant extract could also exhibit potency against some of the bacteria present in raw surface water.For every 100 grams of Soyabean, 36.49 grams of Protein is present which plays a crucial role in the process of coagulation and flocculation. Recently, a product called 'PolyGlu' was made using fermented Soyabean. It could clear muddy water within a few seconds. Higher protein content could be one of the reasons for its effective coagulant and flocculating properties.
3) Orange seed: Vitamin C, fiber, antioxidants, and other nutrients found in orange seeds have been linked to a variety of health advantages. They include a strengthened immune system, reduced inflammation, increased weight reduction, better oral health, and clearer skin.

4) Neem Seeds: People use neem for lice, tooth plaque, gingivitis, psoriasis, to repel insects, and for many other purposes, but there is no good scientific evidence to support most of these uses. There is also no good evidence to support using neem for COVID-19. Neem seed oil is used as a pesticide.
5) Tulsi Seeds: Tulsi, which is also referred to as the Indian Basil and the Holy Basil, is a must in every Indian household. It is not only considered a sacred plant but no prasad is complete without tulsi. Largely known for its medicinal properties, it is used to make concoctions for stomach ailments and sore throats.

B. Apparatus Used

1) Jar Test Apparatus

Jar test is the most widely used experimental methods for coagulation-flocculation. A conventional jar test apparatus was used in the experiments to coagulate sample of synthetic turbid water using some coagulants. It was carried out as a batch test, accommodating a series of six beakers together with sixs pindle steel paddles. Before operating the jar test, the sample was mixed homogenously. Then, the samples ought to be measured for turbidity, coliform count for representing an initial concentration. Coagulants of varying concentrations were added in the beakers. The whole procedures in the jar test were conducted in different rotating speed.

Jar Test Procedure

The jar test procedures involve the following steps:

- Fill the jar testing apparatus containers with sample water. One container will be used as a control while the other 5 containers can be adjusted depending on what conditions are being tested. For example, the pH of the jars can be adjusted or variations of coagulant dosages can be added to determine optimum operating conditions.
- Add the coagulant to each container and stir at approximately 100 rpm for 1 minute. The rapid mix stage helps to disperse the coagulant throughout each container.
- Turn off the mixers and allow the containers to settle for 30 to 45 minutes. Then measure the final turbidity in each container.
- Reduce the stirring speed to 25 to 35 rpm and continue mixing for 15 to 20 minutes. This slower mixing speed helps promote floc formation by enhancing particle collisions which lead to larger flocs.
- Residual turbidity vs. coagulant dose is then plotted and optimal conditions are determined. The values that are obtained through the experiment are correlated and adjusted in order to account for the actual treatment system.

2) Nephelometer

A Nephelometer is an instrument for measuring concentration of suspended particulates in a liquid or gas colloid. A Nephelometer measures suspended particulates by employing a light beam (source beam) and a light detector set to one side (often 90°) of the source beam. The principle of nephelometry and turbidimetry is based on the scattering or absorption of light by solid or colloidal particles suspended in solution. When light is passed through the suspension, part of incident radiant energy is dissipated by absorption, reflection, and reaction while remainder is transmitted.

IV. CONCLUSION

The use of natural coagulants in water treatment represents a sustainable, eco-friendly, and economically viable alternative to conventional chemical coagulants, particularly in rural and underdeveloped regions where access to clean water remains a major concern. In this review, an in-depth study was conducted on various plant-based coagulants including tamarind seeds, velvet bean seeds, drumstick seeds, chickpea seeds, and soybean seeds, all of which are abundantly available across India and have been traditionally used in several communities for water purification. These natural materials contain bioactive components such as proteins, polysaccharides, and other organic compounds that facilitate the flocculation and sedimentation of suspended particles in turbid water. Among them, drumstick seeds showed remarkable coagulation efficiency due to their high cationic protein content, while tamarind and soybean seeds also demonstrated significant turbidity removal capabilities. Chickpea and velvet bean seeds, though slightly less effective than drumstick, still proved to be practical options in improving water quality parameters such as turbidity, pH, TDS, and COD. The advantages of using these natural coagulants include low toxicity, biodegradability, local availability, and minimal environmental impact, which make them highly suitable for decentralized water treatment applications. However, certain limitations such as dosage optimization, shelf life, and the need for pretreatment processes should be addressed through further research and pilot-scale studies. Overall, the findings from this review underline the potential of natural coagulants as effective and sustainable solutions for improving drinking water quality, especially in regions where modern treatment infrastructure is limited. Promoting the use of these bioflocculants not only enhances public health but also encourages the adoption of traditional knowledge and locally available resources in modern water treatment practices.

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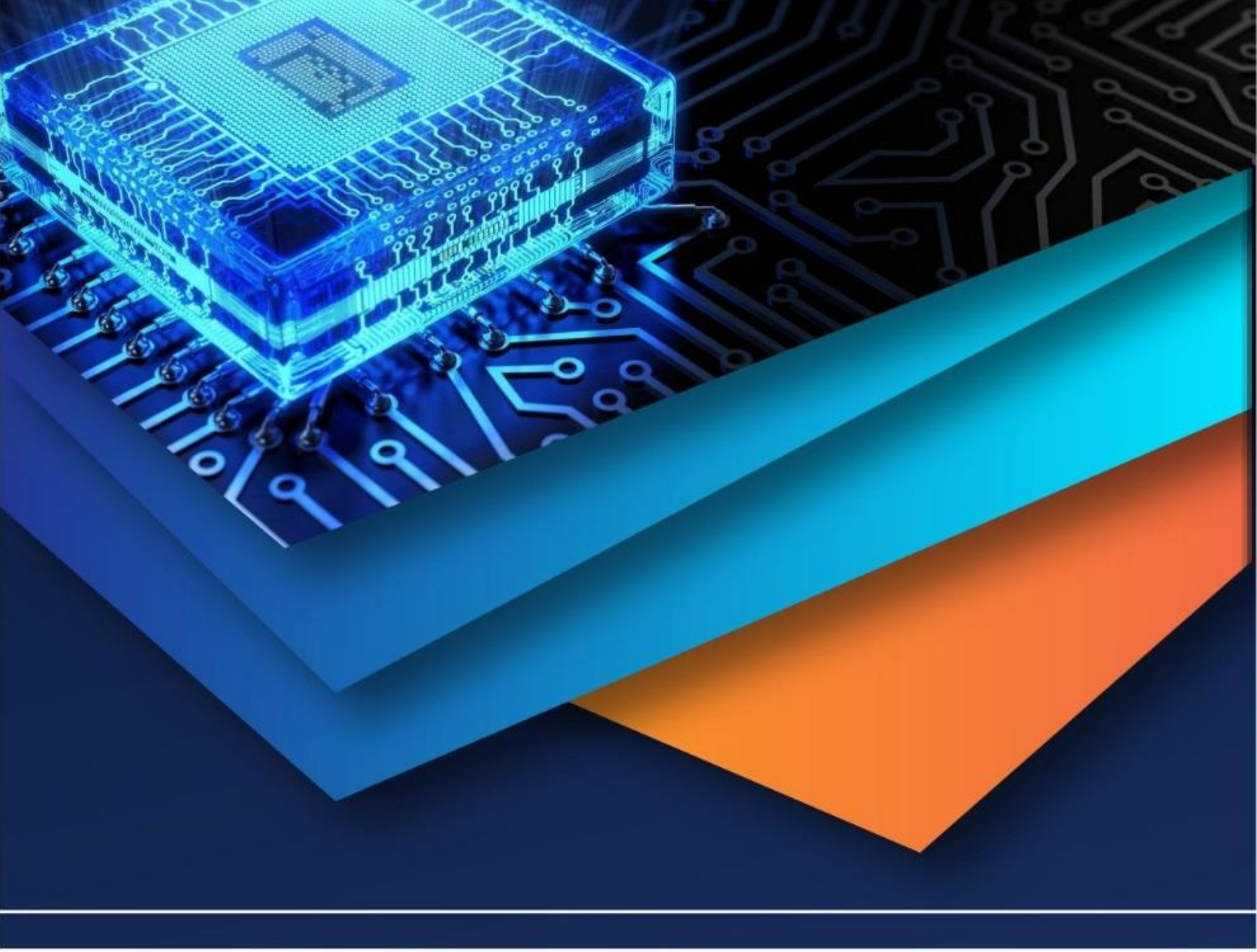

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