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Demystifying the wastewater treatment using natural coagulants

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Abstract
Wastewater treatment plays a pivotal role in environmental preservation and public health. Traditional chemical coagulants have been the go-to solution for flocculating and removing contaminants from wastewater. However, concerns about the environmental impact and the rising costs of synthetic chemicals have spurred interest in exploring natural coagulants as an eco-friendly and sustainable alternative. This research delves into the demystification of wastewater treatment using natural coagulants, shedding light on their mechanisms, efficacy, and practical applicability. By investigating a range of natural coagulants, such as plant extracts, biopolymers, and microbial agents, this study aims to provide insights into their coagulation performance, cost-effectiveness, and potential environmental benefits**.** Natural coagulant is a naturally occurred plants-based coagulant that can be used in coagulation-flocculation process of wastewater treatment for reducing turbidity. 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 a merely equalant coagulation comparing to commercial 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.

Keywords: Jar test, coagulation, flocculation, natural coagulants, turbidity, NTU

Introduction
Wastewater treatment is a crucial aspect of environmental stewardship, aiming to mitigate the adverse impacts of human activities on water resources. One innovative and sustainable approach in this domain is the utilization of natural coagulants for wastewater treatment. Natural coagulants are substances derived from plant or microbial sources that possess coagulation and flocculation properties, aiding in the removal of impurities from wastewater. The conventional wastewater treatment processes often involve the use of chemical coagulants, which may pose environmental risks and have associated costs. Natural coagulants, on the other hand, offer an eco-friendlier alternative. Examples of natural coagulants include plant extracts like *Moringa oleifera* seeds, chitosan from crustacean shells, and tannins from various plant sources. *Moringa oleifera*, commonly known as the drumstick tree, is one of the most studied natural coagulants. Its seeds contain cationic proteins that can effectively coagulate suspended particles in water, promoting the formation of flocs that can be easily separated. Chitosan, derived from chitin in crustacean exoskeletons, is another natural coagulant with excellent coagulation properties. Tannins, extracted from plants like Acacia and Myrobalan, also exhibit coagulation abilities (Aboulhassan, M. A., Souabi, S., & Yaacoubi, A. 2008) [1]. The process of wastewater treatment using natural coagulants typically involves the addition of the coagulant to the wastewater. The coagulant interacts with impurities, causing them to clump together and form larger particles known as flocs. These flocs can then be easily removed through sedimentation or filtration, resulting in a clearer and cleaner effluent. The advantages of using natural coagulants in wastewater treatment include their biodegradability, low toxicity, and potential for resource recovery. Additionally, the use of natural coagulants aligns with the principles of green and sustainable chemistry (Ghorai, S., Sarkar, A., & Raoufi, M. (2014) [11], Kumar, R., & Singhal, A. 2018) [15]. Despite these benefits, challenges such as variability in coagulant performance and dosage, as well as the need for further research to optimize processes, remain. Ongoing studies are exploring ways to enhance the efficiency of

natural coagulants and improve their applicability across different types of wastewaters. As the world faces escalating environmental challenges, the search for sustainable wastewater treatment methods is crucial. Natural coagulants offer a potential eco-friendly alternative to synthetic chemicals, which can contribute to reducing the environmental impact of wastewater treatment processes. This research can help assess the viability of such alternatives, thereby supporting sustainability goals. Natural coagulants may present cost-effective solutions for wastewater treatment. Investigating their performance and cost-effectiveness compared to traditional chemical coagulants can lead to potential cost savings for wastewater treatment facilities and municipalities, making it an attractive option for resource-constrained regions. Traditional chemical coagulants, like aluminum sulfate or ferric chloride, can introduce health risks when mishandled or when their residues enter the environment. Studying the safety and potential health benefits of natural coagulants can help protect the well-being of workers and nearby communities. Many natural coagulants are derived from locally available resources, such as plant extracts. Promoting their use can encourage the utilization of indigenous materials, which can be economically and socially beneficial, particularly in regions with abundant natural resources. Investigating the mechanisms and performance of natural coagulants can lead to a deeper understanding of their practical applications in wastewater treatment. This knowledge can contribute to expanding the toolkit of sustainable solutions available to environmental engineers and researchers. As environmental regulations become increasingly stringent, wastewater treatment facilities face the challenge of meeting stringent discharge standards. Research on natural coagulants can provide valuable insights into meeting these regulatory requirements while minimizing the use of potentially harmful chemicals. Effective wastewater treatment is essential to safeguard public health and maintain the quality of water bodies (Chandrashekhar, K. G., Senthilkumar, M., & Nambi, I. M. 2015) [8], El-Shafai, S. A., El-Gohary, F. A., Nasr, F. A., & van der Steen, N. P. 2007) [10]. Natural coagulants may enhance the removal of contaminants and pathogens, contributing to improved water quality and reducing health risks associated with polluted water sources. To conclude this research study is holding immense relevance. This research on demystifying wastewater treatment using natural coagulants is crucial due to its potential to promote environmental sustainability, cost efficiency, health and safety, local resource utilization, knowledge expansion, regulatory compliance, and the overall improvement of water quality and public health. This research has the potential to advance the field of wastewater treatment and address pressing global challenges. Accordingly, the statement of the research problem is given as under:

Statement of the problem: The wastewater treatment process is a critical aspect of environmental sustainability and public health. Conventional chemical coagulants, often used in wastewater treatment, can be expensive and pose environmental and health risks. Natural coagulants, derived from plant-based sources, offer a promising alternative; however, their practical application and effectiveness in different wastewater treatment scenarios remain poorly understood. To address this gap, this research aims to demystify the wastewater treatment using natural coagulants by investigating their efficiency, cost-effectiveness, and environmental impact, ultimately providing insights for sustainable and eco-friendly wastewater treatment solutions. The statement of the problem is as under:

"Wastewater Treatment using Natural Coagulants"

Objectives of the study: The objectives of the study are as under:

1) To study the usage of natural coagulants as alternatives to traditional chemical coagulants (such as aluminum sulfate or ferric chloride) to minimize the environmental impact of wastewater treatment.
2) To examine the environmental impact of using natural coagulants, considering factors such as biodegradability, toxicity and ecological footprint.

Research questions: Based on the procedure and purpose of this study, this research study speculates the below mentioned research assumptions:

1) How do the coagulation efficiency and performance of natural coagulants compare to traditional chemical coagulants in the context of wastewater treatment processes?
2) What are the environmental implications of incorporating natural coagulants into wastewater treatment, including their biodegradability, toxicity, and ecological footprint, in contrast to synthetic chemical coagulants?

Methodology: The methodology and procedure of this research is as under:

- **Material employed:** Wastewater was obtained from different sampling sites of Mumbai, Sivakasi as raw wastewater before entering into the nearby screening cum sedimentation tank. Coagulants were prepared from seeds and flowers of various plants by drying and powdering them and finally sieving them in 600 microns IS Sieves.
- **Procedure:** Jar Test was carried out to evaluate the initial and final turbidity values (in NTU) before and after the coagulation process using natural coagulation. The research in this study has conducted 3 tests to take the average turbidity value for every coagulant dosage.

Table 1: Showing the Wastewater Verses Alum

Initial Turbidity of wastewater = 28.8 NTU			
Dosage	**Turbidity**	**Dosage**	**Turbidity**
0.5 g	14.8 NTU	1g	26.9 NTU
1.5 g	27.1 NTU	2 g	27.9 NTU
2.5 g	31 NTU	`	32.3 NTU
0.5 g	14.8 NTU	0.6 g	13.8 NTU
0.7 g	12.9 NTU	0.8 g	11.6 NTU
0.9 g	23.6 NTU	1 g	26.5 NTU

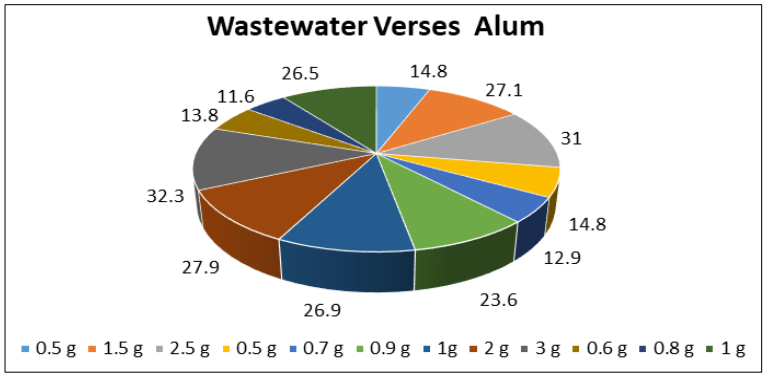

Fig 1: Showing the graphical representation of Wastewater Verses Alum

Table 2: Showing the Wastewater Vs Dolichas Lablab

Initial Turbidity of wastewater = 54.2 NTU			
Dosage	**Turbidity**	**Dosage**	**Turbidity**
5 g	52.8 NTU	10 g	47.9 NTU
15 g	43.7 NTU	20 g	46.3 NTU
25 g	46.8 NTU	30 g	46.9 NTU
15 g	43.6 NTU	16 g	33.9 NTU
17 g	37.00 NTU	18 g	37.6 NTU
19 g	42. 20 NTU	20 g	46.2 NTU

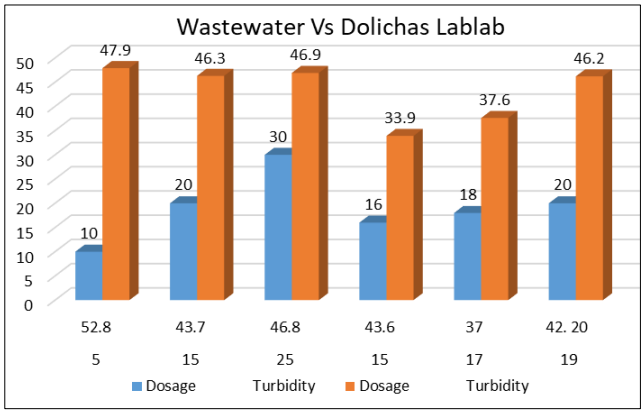

Fig 2: Showing the graphical representation Wastewater Vs Dolichas Lablab

Table 3: Showing the Wastewater Vs *Azadirachta indica*

Initial Turbidity of wastewater = 26.5 NTU			
Dosage	**Turbidity**	**Dosage**	**Turbidity**
2 g	18.2 NTU	4 g	17.2 NTU
6 g	10.4 NTU	8 g	11.2 NTU
10 g	15.3 NTU	12 g	18.4 NTU
6 g	10.4 NTU	6.5 g	9.8 NTU
7 g	10.5 NTU	7.5 g	10.8 NTU
8 g	11.2 NTU	-	-

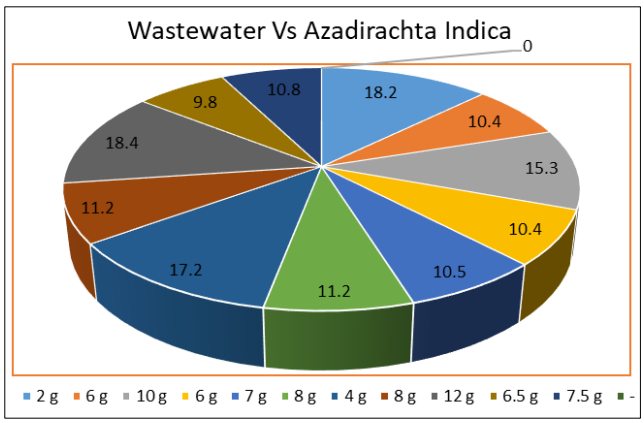

Table 4: Showing the Wastewater Vs *Moringa oleifera*

Initial Turbidity of wastewater = 44.8 NTU			
Dosage	**Turbidity**	**Dosage**	**Turbidity**
1 g	39.2 NTU	2 g	37.1 NTU
3 g	30.7 NTU	4 g	35.1 NTU
5 g	36.8 NTU	6 g	38.2 NTU

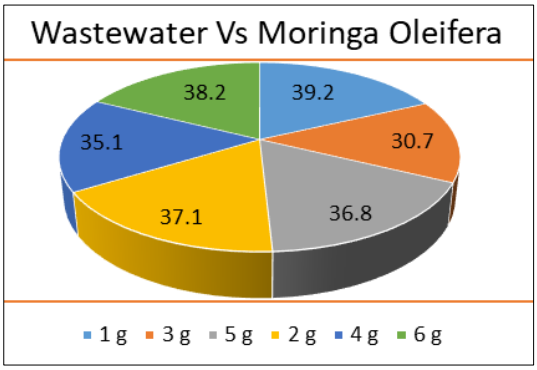

Fig 4: Showing the graphical representation of Wastewater Vs *Moringa oleifera*

Table 4: Showing the Wastewater Vs *Moringa oleifera*

Initial Turbidity of wastewater = 33.2 NTU			
Dosage	**Turbidity**	**Dosage**	**Turbidity**
0.5 g	31.1 NTU	1 g	28.9 NTU
1.5 g	29.2 NTU	2 g	29.6 NTU
2.5 g	29.8 NTU	3 g	30.2 NTU

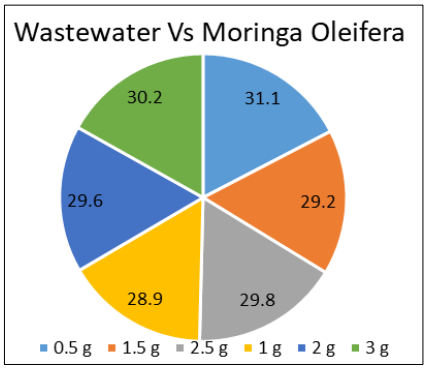

Fig 4: Showing the graphical representation of Wastewater Vs *Moringa oleifera*

Conclusion

From the experimental results, we have concluded that among the chosen natural coagulants, *Azadirachta indica* showed a better coagulation and turbidity removal for given paper mill wastewater. Effect of pH, temperature can also be

experimentally found out with the extension of current study, which may further improve the turbidity removal efficiency of the natural coagulants. Since, we have collected the wastewater from a smaller paper mill; we suggest that, by using *Azadirachta indica* as a coagulant instead of commercial alum, for sedimentation process. In conclusion, the investigation into wastewater treatment using natural coagulants offers compelling insights and solutions for sustainable and eco-friendly water purification.

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