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Utilizing Natural Coagulants as Substitutes for Chemical Coagulants in the Treatment of Drain Water (Naala) in Birgaon, Raipur, C.G.

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ABSTRACT

Birgaon, a rapidly urbanizing locality, faces significant challenges related to wastewater management. Multiple open drains (Naalas) in the region discharge untreated effluents directly into nearby ponds, leading to the progressive degradation and contamination of these aquatic ecosystems. In response to the growing water scarcity in the area, the present study investigates a sustainable approach to wastewater treatment prior to its discharge.Drain water samples were systematically collected and subjected to comprehensive physicochemical analysis under controlled laboratory conditions.Varying dosages of MO seed powder were added to the wastewater samples. The treatment performance was assessed by comparing key water quality parameters before and after treatment. The results demonstrated substantial improvements, including reductions in pH (39.0%), total hardness (74.0%), total dissolved solids (60.0%), turbidity (85.0%), biochemical oxygen demand (63.0%), and chemical oxygen demand (97.0%).The effectiveness of Moringaoleifera(MO) is attributed to its bioactive cationic polyelectrolytes, which facilitate coagulation and exhibit antimicrobial properties.

Keywords: Open Drains, Moringa Oleifera (MO), Natural Coagulant, Turbidity Reduction, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Total Dissolved solids (TDS).

INTRODUCTION

Birgaon is an industrial township located along the Raipur–Bilaspur Main Highway, approximately 12 km from Raipur. The Birgaon Municipal Corporation encompasses six villages: Urla, Achholi, Rawabhata, Urkura, and Sarora, and is administratively divided into 40 wards across an area of 37 square kilometers. Geographically, Birgaon is bordered by Raipur Tehsil to the south, Tilda Tehsil to the north, Arang Tehsil to the east, and Abhanpur Tehsil to the west. The current population is estimated at approximately 131,000. Rapid urbanization and industrial expansion in Birgaon, combined with additional contributing factors, have led to a shortage of potable water. Therefore, the exploration of effective, low-cost, and sustainable water purification methods is crucial. In this context, local bio-based resources such as Moringaoleifera* (MO) are gaining attention as potential alternatives. Moringaoleifera, a monotypic genus of trees and shrubs widely cultivated across tropical regions, has long been utilized for nutritional, therapeutic, and land demarcation purposes. Its seeds, in particular, have been extensively studied as natural coagulants in surface water treatment [1,2,3]. MO seed extracts are highly effective in wastewater treatment due to their non-toxic nature and negligible side effects on human health [4,5,6,7]. Natural coagulants such as MO are cost-efficient, environmentally sustainable, and simple to apply, especially in developing regions. Their efficiency remains largely unaffected by raw water pH or the presence of antibiotics against various bacteria and fungi. Furthermore, the economic burden of employing natural coagulants is considerably lower compared to synthetic alternatives. However,[8] caution that while bio-coagulants may pose certain risks to aquatic organisms due to their inherent properties, the widespread use of aluminum-based chemical coagulants has been linked to severe neurological disorders, underscoring the importance of adopting safer, nature-based solutions.

Numerous researchers have investigated a wide range of natural coagulants, including gelatin, cellulose-based materials, and microbial polysaccharides [9], bio-wastes [10], chitosan [11], Moringaoleifera [12], and Moringa oil [13]. Owing to their cost-effectiveness in comparison to chemical coagulants, natural coagulants are widely applied as point-of-use solutions, particularly in underdeveloped and resource-constrained communities.

METHODOLOGY

A 1000 mL sample of drain water was collected from Ward No. 32, located behind the Birgaon Municipal Corporation office. To this sample, 1% Moringaoleifera seed powder (equivalent to 4 mL) was added. The mixture was subjected to vigorous agitation for 30 seconds, followed by continuous stirring for approximately 5 minutes. After stirring, the solution was allowed to settle undisturbed for a minimum of one hour to facilitate sedimentation. The supernatant (purified water) was then carefully decanted and subjected to physico-chemical analysis. Comparative evaluations were conducted on the drain water samples before and after treatment to assess the effectiveness of Moringaoleifera as a natural coagulant.

Fig.1: Taking Drain Water Samples located Behind Municipal Corporation Birgaon

EXPERIMENTAL ANALYSIS

Jar test analysis was conducted under controlled laboratory conditions to evaluate the coagulation efficiency of *Moringa Oleifera* (MO) seed powder. A 1% stock solution was prepared by mixing MO seed powder with clean water. From this preparation, an appropriate quantity was added to a 1000 mL drain water sample. The paste was subsequently diluted to the desired concentration, and insoluble materials were removed by filtration through a fine mesh screen or muslin cloth. The resulting milky-white suspension was then introduced into the turbid drainage water for treatment and subsequent analysis.

Fig. 2: Jar Test Analysis performed in Laboratory

Flocculation commenced upon the addition of *Moringa Oleifera* (MO) seed powder, which facilitated the aggregation and subsequent sedimentation of suspended particles. The mixture was subjected to continuous agitation for 5–10 minutes and then allowed to settle undisturbed for one hour. Following sedimentation, the clarified supernatant was carefully collected and subjected to physicochemical analysis.

RESULTS AND DISCUSSION

The sampling procedure was conducted in accordance with a grid plan established for a designated drainage channel within the Birgaon Municipal Corporation premises, extending approximately 200 meters in length. Based on this grid, eight water samples were collected at intervals of approximately 25 meters, covering the entire 200-meter stretch. Samples 1 through 8 thus represent a systematic coverage of the drain. Subsequent laboratory analyses were performed to determine key physicochemical parameters, including pH, total hardness, total dissolved solids (TDS), turbidity, biological oxygen demand (BOD), and chemical oxygen demand (COD). The detailed results of these analyses are presented below.

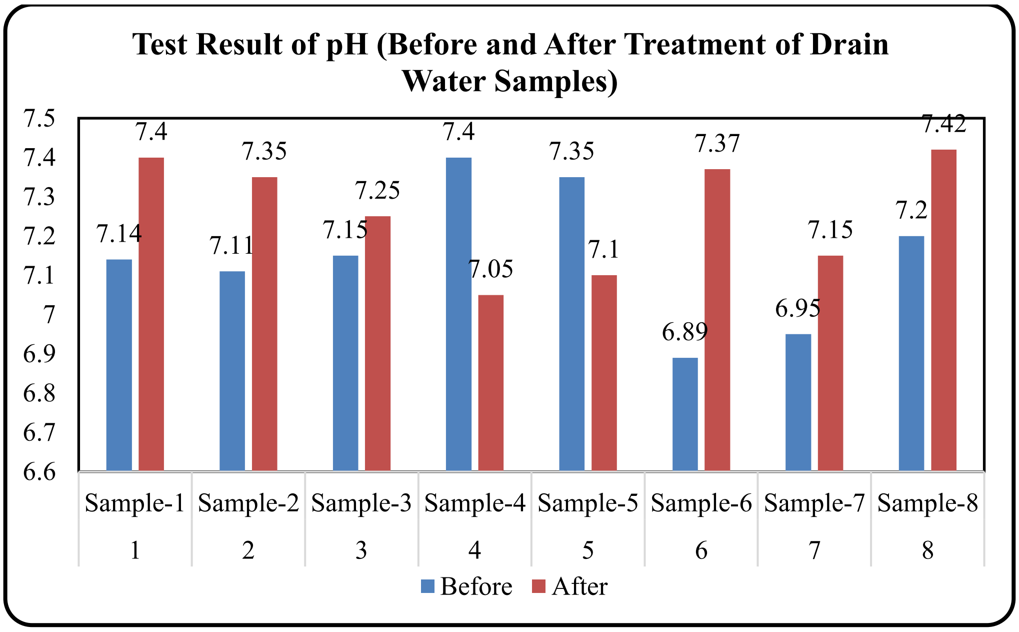

Fig. 3: Test Result of pH (Before and After Treatment of Drain Water Samples)

Table 1: Comparison by Paired T-Test for pH Samples Statistics

		Mean	No of sample	Std. Deviation	Std. Error Mean
Pair 1	pH before	7.1	8	0.17	0.06
	pH after	7.2	8	0.14	0.05

Interpretation: The mean pH increased from 7.1 (SD = 0.17) before treatment to 7.2 (SD = 0.14) after treatment, indicating a slight rise with low variability across samples.

Table 2: pH Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	pH Before and After	-0.11	0.27	0.09	-0.34	0.11	-1.14	7	0.28

Interpretation: The paired sample t-test revealed a mean difference of –0.11 (SD = 0.27) in pH values before and after treatment with Moringa Oleifera. The 95% confidence interval for the difference ranged from –0.34 to 0.11, and the observed t-value (–1.14, df = 7) was not statistically significant (p = 0.28). These findings indicate that the treatment did not produce a significant alteration in pH, thereby maintaining the water within a stable and neutral range suitable for consumption.

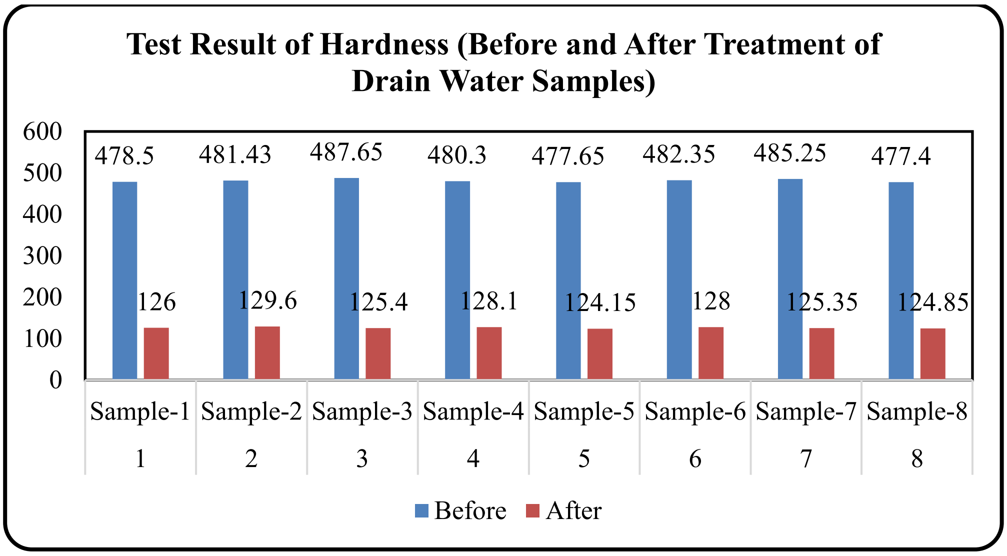

Fig. 4: Test Result of Hardness (Before and After Treatment of Drain Water Samples)

Table 3: Comparison by Paired T-Test for Hardness Samples Statistics

		Mean	No of sample	Std. Deviation	Std. Error Mean
Pair 1	Hardness before	481.31	8	3.67	1.29
	Hardness after	126.43	8	1.90	0.67

Interpretation: The mean hardness decreased from 481.31 (SD = 3.67) before treatment to 126.43 (SD = 1.90) after treatment, indicating a substantial reduction with low variability across samples.

Table 4: HardnessPaired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Hardness Before andAfter	354.88	3.95	1.39	351.58	358.18	254.04	7	0.00

Interpretation: The paired sample t-test revealed a mean difference of 354.88 (SD = 3.95) in hardness values before and after treatment with Moringa Oleifera. The 95% confidence interval for the difference ranged from 351.58 to 358.18, and the observed t-value (254.04, df = 7) was statistically significant ($p < 0.001$). These findings indicate that the treatment produced a substantial and highly significant reduction in hardness, thereby improving the overall quality of the water.

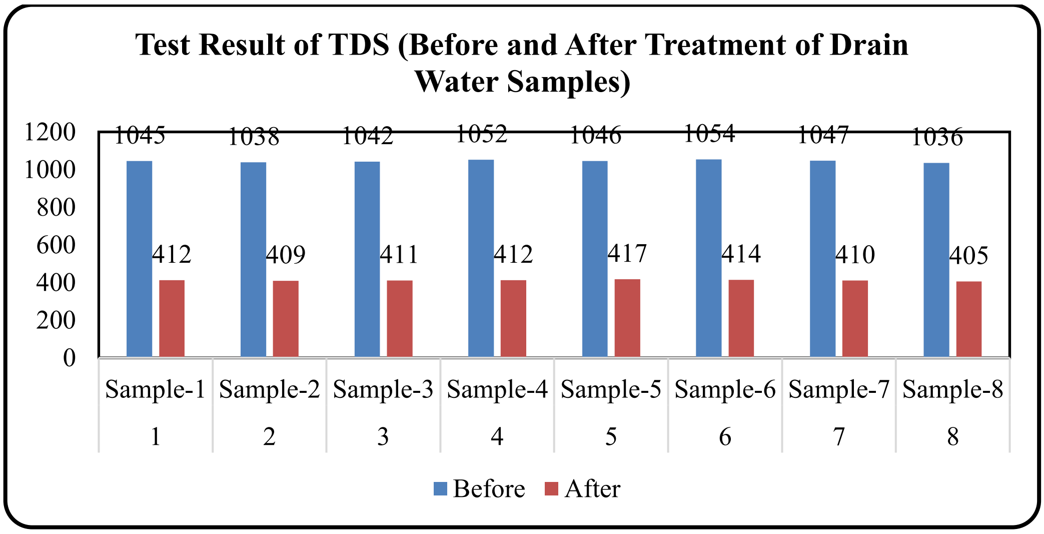

Fig. 5: Test Result of TDS (Before and After Treatment of Drain Water Samples)

Table 5: Comparison by Paired T-Test for TDS Samples Statistics

		Mean	No of sample	Std. Deviation	Std. Error Mean
Pair 1	TDS before	1045.00	8	6.25	2.21
	TDS after	411.25	8	3.53	1.25

Interpretation: The mean TDS decreased from 1045.00 (SD = 6.25) before treatment to 411.25 (SD = 3.53) after treatment, indicating a substantial reduction with low variability across samples.

Table 6: TDS Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	TDS Before and After	633.75	4.62	1.63	629.88	637.61	387.87	7	0.00

Interpretation: The paired sample t-test revealed a mean difference of 633.75 (SD = 4.62) in TDS values before and after treatment. The 95% confidence interval for the difference ranged from 629.88 to 637.61, and the observed t-value (387.87, df = 7) was statistically significant ($p < 0.001$). These findings indicate that the treatment produced a substantial and highly significant reduction in TDS, thereby enhancing the overall water quality.

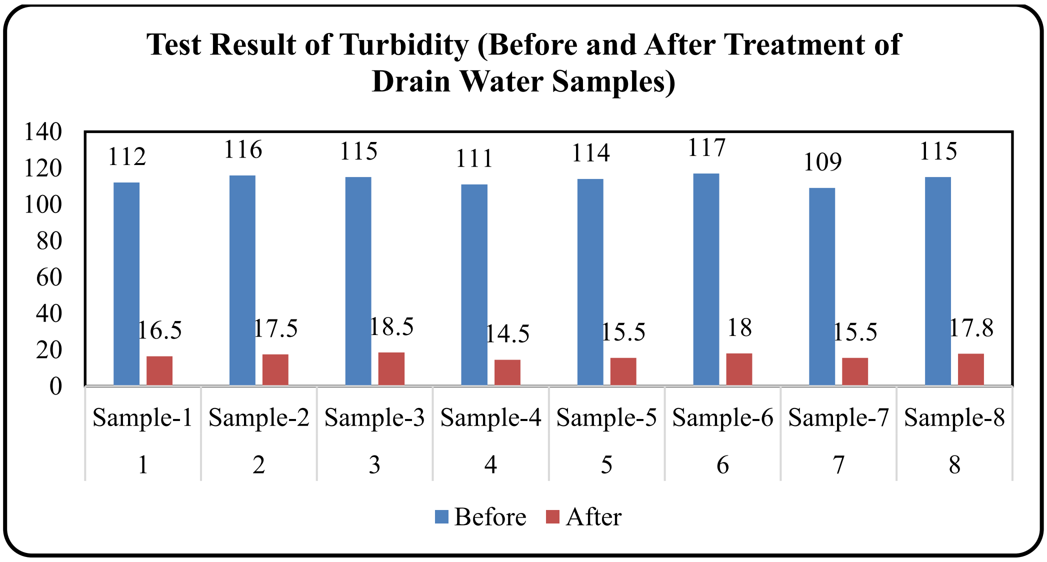

Fig. 6: Test Result of Turbidity (Before and After Treatment of Drain Water Samples)

Table 7: Comparison by Paired T-Test for Turbidity Samples Statistics

		Mean	No of sample	Std. Deviation	Std. Error Mean
Pair 1	Turbidity before	113.62	8	2.72	0.96
	Turbidity after	16.72	8	1.44	0.50

Interpretation: The mean turbidity decreased from 113.62 (SD = 2.72) before treatment to 16.72 (SD = 1.44) after treatment, indicating a substantial reduction with relatively low variability across samples.

Table 8: TurbidityPaired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Turbidity Before and After	96.90	1.83	0.64	95.36	98.43	149.71	7	0.00

Interpretation: The paired sample t-test revealed a mean difference of 96.90 (SD = 1.83) in turbidity values before and after treatment. The 95% confidence interval for the difference ranged from 95.36 to 98.43, and the observed t-value (149.71, df = 7) was statistically significant ($p < 0.001$). These findings indicate that the treatment produced a substantial and highly significant reduction in turbidity, thereby improving the overall quality of the water.

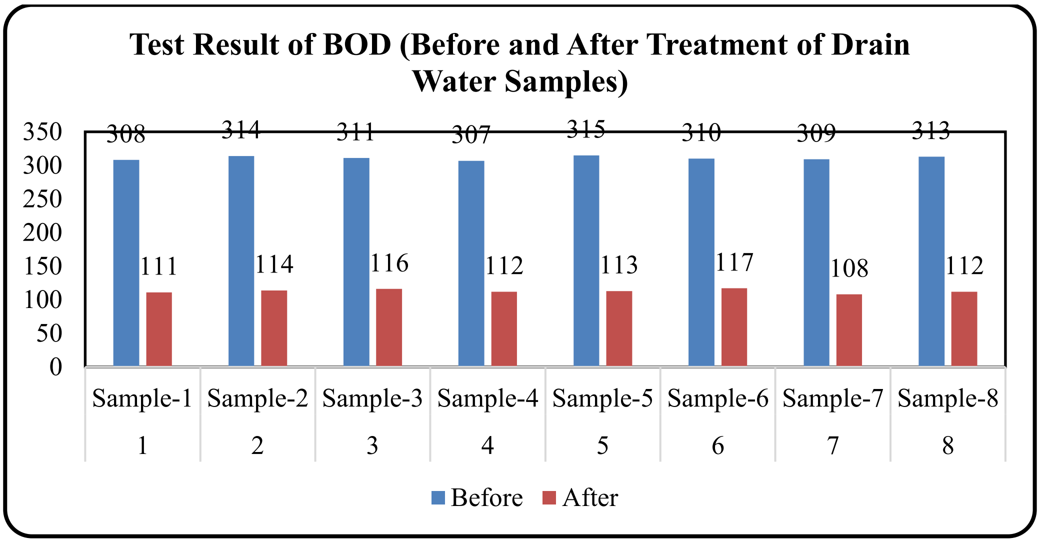

Fig. 7: Test Result of BOD (Before and After Treatment of Drain Water Samples)

Table 9: Comparison by Paired T-Test forBOD Samples Statistics

		Mean	No of sample	Std. Deviation	Std. Error Mean
Pair 1	BOD before	310.87	8	2.90	1.02
	BOD after	112.87	8	2.85	1.00

Interpretation: The mean BOD decreased from 310.87 (SD = 2.90) before treatment to 112.87 (SD = 2.85) after treatment, indicating a substantial reduction with relatively low variability across samples.

Table 10: BOD Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	BOD Before and After	198.00	3.42	1.21	195.13	200.86	163.62	7	0.00

Interpretation: The paired sample t-test revealed a mean difference of 198.00 (SD = 3.42) in BOD values before and after treatment. The 95% confidence interval for the difference ranged from 195.13 to 200.86, and the observed t-value (163.62, df = 7) was statistically significant ($p < 0.001$). These findings indicate that the treatment produced a substantial and highly significant reduction in BOD, thereby enhancing the overall quality of the water.

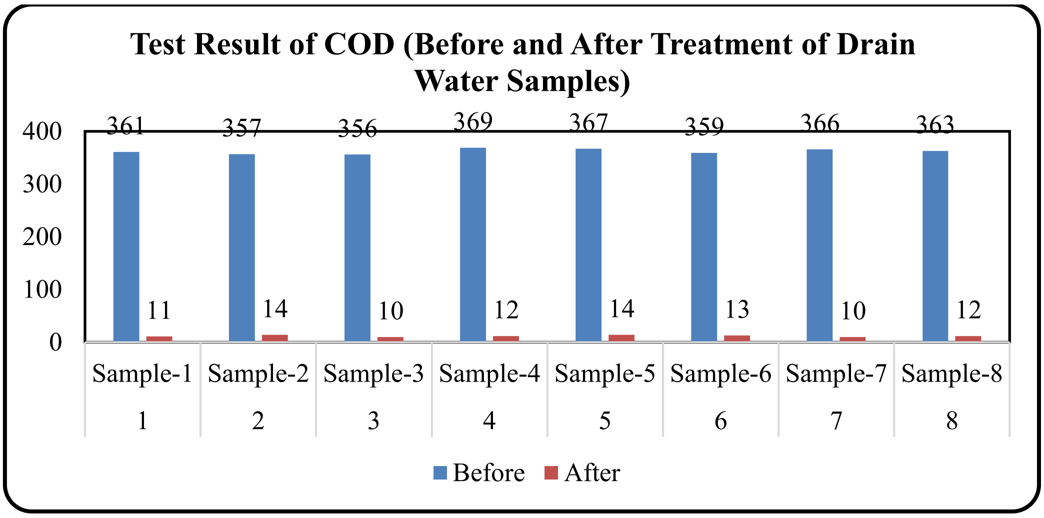

Fig. 8: Test Result of COD (Before and After Treatment of Drain Water Samples)

Table 11: Comparison by Paired T-Test for COD Samples Statistics

		Mean	No of sample	Std. Deviation	Std. Error Mean
Pair 1	COD before	361.75	8	4.97	1.76
	COD after	12.00	8	1.60	0.56

Interpretation: The mean COD decreased from 361.75 (SD = 4.97) before treatment to 12.00 (SD = 1.60) after treatment, indicating a substantial reduction with relatively low variability across samples.

Table 12: COD Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	COD Before and After	349.75	5.17	1.82	345.42	354.07	191.14	7	0.00

Interpretation: The paired sample t-test revealed a mean difference of 349.75 (SD = 5.17) in COD values before and after treatment. The 95% confidence interval for the difference ranged from 345.42 to 354.07, and the observed t-value (191.14, df = 7) was statistically significant ($p < 0.001$). These findings indicate that the treatment produced a substantial and highly significant reduction in COD, thereby improving the overall quality of the water.

CONCLUSION

The findings unequivocally indicate that the application of Moringa Oleifera (MO) seed powder resulted in an 85% reduction in turbidity and a 97% decrease in COD. This effect can be attributed to the antimicrobial properties and cationic water-soluble proteins (polyelectrolytes) present in MO seeds, which exhibit effective coagulative capabilities for the treatment of contaminated water. The fundamental mechanism underlying the water purification potential of MO seed powder is associated with its protein content. The seed kernels of Moringa Oleifera contain approximately 37% protein, including water-soluble, low-molecular-weight, cationic proteins that function in a manner comparable to synthetic coagulants. When MO seed powders are introduced into untreated water, these proteins bind to negatively charged particles, promoting their aggregation into flocs. These flocs can then be effectively removed by filtration or allowed to settle by gravity, thereby enhancing water clarity and quality.

In regions where the cost of conventional chemical coagulants is prohibitive, MO seeds represent a sustainable and economical alternative for generating potable water. Increasing emphasis is being placed on identifying accessible, cost-effective, and environmentally friendly natural coagulants, and MO has emerged as a promising candidate for wastewater treatment. Its applications extend beyond water purification to include industrial uses and nutritional benefits. Importantly, Moringa Oleifera exhibits no adverse side effects, and its seeds provide a safe, non-toxic, and eco-friendly solution. In addition to serving as natural coagulants, MO seeds act as cost-effective adsorbents and a valuable source of plant-based proteins, underscoring their multifaceted potential in water treatment technologies.

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