To Study and Compare the Effect of Natural Coagulants in Conjunction with Alum in Domestic Water

Shruti.R.Bodke[1], Sanskurti.D.Adhav[2], Vivek.M.Telange[3], Vidhya.B.Jakkalwar [4], Tushar.B.Vyavahare[5]
Prof. M.D.Anap[6]

[1, 2, 3,4,5] *B. E Student, Department of Civil Engineering, JSPM Narhe Technical Campus, Pune-411041, Maharashtra, India*

[4]*Professor, Department of Civil Engineering, JSPM Narhe Technical Campus, Narhe, Pune-411041, Maharashtra, India*

***Abstract*— Water turbidity is one of the major concerns in domestic water treatment systems. Conventional chemical coagulants such as alum are widely used for turbidity removal; however, excessive use of these chemicals may lead to environmental and health-related issues. This study focuses on the use of natural coagulants in conjunction with alum for improving domestic water purification efficiency. Natural coagulants such as Moringa Oleifera, Cactus, and Okra seed powder were selected due to their biodegradable, economical, and eco-friendly properties.**

***Jar test experiments were conducted on synthetic turbid water prepared using locally available clay. Different parameters such as coagulant dosage, particle size variation, pH conditions, and settling time were analyzed to determine optimum turbidity removal efficiency. The experimental results indicated that the combined use of natural coagulants with alum significantly improved floc formation, reduced settling time, and minimized alum consumption. Among all natural coagulants tested, Moringa Oleifera exhibited the highest turbidity removal efficiency.**

The study concludes that natural coagulants can effectively act as coagulant aids and provide a sustainable, low-cost, and environmentally friendly solution for domestic water treatment, especially suitable for rural and small-scale water purification systems.

Keywords: Natural Coagulants, Moringa Oleifera, Alum, Turbidity Removal, Domestic Water Treatment, Jar Test, Coagulation, Water Purification, Sustainable Treatment, Eco-Friendly Coagulants.

I. INTRODUCTION

Water is one of the most essential natural resources required for human survival and development. Safe and clean drinking water is necessary for maintaining public health and preventing waterborne diseases. However, due to rapid urbanization, industrialization, and population growth, the quality of available water sources is continuously deteriorating. One of the major problems associated with water quality is turbidity, which is caused by the presence of suspended and colloidal particles such as clay, silt, organic matter, and microorganisms. High turbidity not only affects the appearance of water but also reduces the efficiency of disinfection processes and may lead to serious health hazards.

Conventional water treatment plants commonly use chemical coagulants such as alum (aluminium sulphate) for turbidity removal. Alum is effective in coagulation and flocculation processes; however, excessive use of chemical coagulants can increase treatment costs, produce large quantities of sludge, and may create environmental and health-related concerns due to residual aluminium content in treated water. Therefore, there is a growing need to identify sustainable, economical, and environmentally friendly alternatives for water treatment.

Natural coagulants have emerged as promising substitutes or coagulant aids in water purification processes. Various plant-based materials such as Moringa Oleifera, Cactus, and Okra seeds contain natural polymers and proteins capable of destabilizing suspended particles and enhancing floc formation. These natural coagulants are biodegradable, non-toxic, locally available, and comparatively low-cost, making them highly suitable for rural and small-scale domestic water treatment applications.

This study focuses on evaluating and comparing the

effectiveness of natural coagulants used in conjunction with alum for domestic water treatment. Jar test experiments were conducted on synthetic turbid water under varying conditions of dosage, particle size, pH, and settling time to determine optimum coagulation performance. The research aims to reduce chemical consumption while improving turbidity removal efficiency through the combined application of natural and chemical coagulants

1.1 Background of the Study

Turbidity is one of the major problems in domestic water treatment caused by suspended particles present in water. Chemical coagulants like alum are commonly used for turbidity removal, but excessive use may cause environmental and health-related issues. Natural coagulants such as Moringa Oleifera, Cactus, and Okra are biodegradable, eco-friendly, and economical alternatives. This study focuses on the combined use of natural coagulants with alum to improve turbidity removal efficiency and reduce chemical consumption for sustainable domestic water treatment.

II. AIM AND OBJECTIVES

A. Aim

To study and compare the effectiveness of natural coagulants used in conjunction with alum for turbidity removal in domestic water treatment.

B. Objectives

i. To study the effect of natural coagulants on turbidity removal.
ii. To study the effect of pH on coagulation efficiency.
iii. To optimize the dosage of natural coagulants with alum.
iv. To compare the performance of different natural coagulants for domestic water treatment.
v. To reduce the consumption of chemical coagulants by using eco-friendly natural coagulants.

III. LITERATURE SURVEY

1) Vijayaraghavan et. al. [1] studied of plant-based coagulant sources, processes, effectiveness and relevant coagulating mechanisms for treatment of water and wastewater. These coagulants are, in general, used as point-of-use technology in less-developed communities since they are relatively cost-effective compared to chemical coagulants, can be easily processed in usable form and biodegradable. These natural coagulants, when used for treatment of waters with low-to-medium turbidity range (50– 500 NTU), are comparable to their chemical counterparts in terms of treatment efficiency. Their application for industrial wastewater treatment is still at their infancy, though they are technically promising as coagulant for dyeing effluent as afforded by Yoshida intermolecular interactions.

2) Kazi et. al. [2] study presents Tanning industry is one of the oldest industry which is highly complex and is characterized by high BOD, COD, suspended solids, settleable solids, sulphide, chloride and chromium. Untreated tannery effluents when discharged directly into the water bodies or into the open lands cause irreversible damage to the environment. Coagulation–flocculation is one of the most important physicochemical treatment steps employed in industrial Waste water treatment to reduce the suspended and colloidal materials responsible for turbidity of the wastewater. During the last decade, more interest has been given on the use of natural coagulants in treating industrial wastewater. Natural coagulants are, in general, used as point-of-use technology in less-developed communities, since they are relatively cost-effective compared to chemical coagulants. Also they can be easily processed in usable form and biodegradable. Cicer arietinum, Moringa Oleifera, and Cactus were used as locally available natural coagulants in this study to reduce turbidity and COD of tannery wastewater. Among the natural coagulants used in this study maximum turbidity reduction of 82.02% and COD reduction of 90% was found with Moringa oleifera and Cicer aretinum, respectively.

3) Gidde et. al. [3] in their study showed Moringa Oleifera (M.O) seeds are used as a primary coagulant in drinking water clarification due to presence of a water–soluble cationic coagulant protein, which is able to reduce the turbidity of treated water. Seeds are powdered and added to the water directly or after preparing crude extract. The seed kernels contain significant quantities of series of low molecular

weight and water soluble protein, which carries positive charge to the solution. The protein is considered to act similar to a synthetic and positively charged polymer coagulant. When this protein is added to raw water, it binds with the predominantly negatively charged particulate making the raw water turbid. Under proper agitation these bound particulates then grow in size to form the flocks, which may be left to settle by gravity or removed by sedimentation. The study was carried out to observe the effectiveness of purification M. O. coagulant. The three forms of coagulants were used viz. Shelled blended, Deoiled powder and Protein powder. At optimum dosage, the percentage turbidity removal is found to increase with initial turbidity in case of all three coagulants. Among the three forms, protein powder has more removal efficiency than Deoiled and Shelled blended powder respectively.

4.) Nwaiwu et. al. [4] research examined to find out the optimum combination for MO and alum using alum as a coagulant aid in household treatment of natural pond surface water for domestic use. The physico-chemical properties investigated for in the raw, settled and filtered water were Ph, Total Dissolved Solids (tds), turbidity, color and total suspended solids (tss). The various coagulant combinations with which the raw water from the pond was treated include Moringa oleifera (MO) seed powder only (i.e., 100% MO), aluminium sulphate (alum) only (i.e., 100% alum), 20% alum and 80% Moringa oleifera seed powder, 40% alum and 60% Moringa oleifera seed powder, 50% alum and 50% Moringa oleifera seed powder; 60% alum and 40% Moringa oleifera seed powder; and 80% alum and 20% Moringa oleifera seed powder. Five of the seven used coagulant combinations gave acceptable turbidity reduction i.e., below 10 NTU. When Moringa oleifera seed powder was used as the sole coagulant, a filter was needed to obtain an acceptable turbidity value of 7.8 NTU but there was no need for pH adjustment or correction. Moringa oleifera seed powder can be used in treating household drinking water either as a sole coagulant or in combination with alum (using the alum) as a coagulant aid. The settling time for the MO seed powder is longer than that of the combined coagulants if the same results are to be obtained. The recommended ratio for the combined coagulant dose is 60% MO seed powder and 40% alum.

5.) Menkiti et. al. [5] studied the Factorial optimization and kinetics of coal washery effluent (CWE) coag-flocculation by Moringa oleifera seed has been investigated at room temperature based on standard method of bench scale jar test. Moringa oleifera coag-flocculant (MOC) was produced according to work reported by Ghebremichael. A 23 full factorial central composite design was employed for the experimental design and analysis of results with respect to optimization. The combined effects of pH, dosage and settling time on the particle (turbidity) removal were studied using response surface methodology. Kinetic data generated were confronted with specified kinetic models for the evaluation of functional kinetics parameters. The optimal values of pH, dosage and settling time were recorded at 8400 mg/l and 25 min, respectively. The minimum removal efficiency recorded was 95% at 3 mins of coag- flocculation. The results, while re affirming MOC as efficient coag-flocculant, confirmed that theory of perikinetics holds for the studied system at the conditions of the experiment.

6.)Muthuraman et. al. [6] study presents Coagulation-flocculation followed by sedimentation and filtration is the most commonly used water treatment process , in which turbidity or particles removal is strongly dependent on proper coagulant dosage, effect of pH ,effect of time, jar test and settling column tests were perform. In the method the seeds were treated with different solvents of NaCl and NaOH to extract the active coagulant agent has been investigated. In this study to evaluate the turbidity removal of the synthetic and real turbidity water has been investigated. The jar test was conducted on kaolin as a model wastewater. 0.5M Sodium chloride extract was found to provide a high turbidity removal of 99% compared to NaOH and distilled water extract. The optimum turbidity removal at different values of initial synthetic waste water turbidity from 100 to 500 NTU were investigated. The performance of natural coagulant after oil extraction was also investigated.

7.)Nougbode et. al. [7] research examined in laboratory scale and consisted of the using of aqueous Opuntia dillenii solution for the clarification of very turbid surface water (Turbidities varying between 186 NTU and 418 NTU). This plant from Cac- taceae family was used as a natural coagulant for the different

clarification tests. The preliminary phytochemical Screening of the powder of this plant showed that it contains tanins, saponins and mucilages. Flocculation and coagulation tests showed that Opuntia dillenii can be used in highly turbid water treatment. The removal efficiency varied from 89% to 93% for the turbidity and suspended solids, and from 4% to 15% for the obvious color in water when we used the optimum values of this natural coagulant (1 mL to 10 mL). The successive addition of this natural coagulant and the lime, gave a better elimination of turbidity and suspended solids, and a good reduction for the color. The removal efficiency of the turbidity and suspended solids became more than 95% and the one of the color between 67% and 94%.

8.) Ali [8] focused on developing an efficient and cost effective processing technique for Moringa oleifera seeds to produce natural coagulant for use in drinking water treatment. The produced natural coagulant can be used as an alternative to aluminum sulphate and other coagulants and used worldwide for water treatment. This study investigates processing Moringa oleifera seeds to concentrate the bio-active constituents which have coagulation activity. Isolation and purification of bio-active constituents using chromatography technique were used to determine the molecular weight of the bio-active constituents. The proposed method to isolate and purify the bio-active constituents was the cross flow filtration method, which produced the natural coagulant with very simple technique. The turbidity removal was up to 96.23 % using 0.4 mg/L of processed Moringa oleifera seeds to treat low initial turbidity river water between 34-36 Nephelometric Turbidity Units (NTU) without any additives. The natural coagulant produced was used with low dosages to get high turbidity removal which considered to be a breakthrough in this study and recommended to be scaled up for industry level. The product is commercially valuable at the same time it is minimizing the cost of water treatment.

9.) Yang et. al. [9] examined the effectiveness of cactus opuntia, a natural macromolecular coagulant, for turbidity removal was studied via jar test. The jar test was conducted to remove turbidity from two aqueous solutions, namely, surface water and landfill leachate. The surface water studied were estuarine and river water. Initial turbidity values measured at 499 NTU and 547 NTU for estuarine and river water respectively were reduced by as much as 98% (estuarine) and 70% (river). Other parameters such as pH as well as alkalinity were also studied. High turbidity removal effectiveness shown in this bench-scale study indicates that cactus opuntia has the potential to be utilized for surface water treatment applications. Turbidity removal was less effective in the case of landfill leachate (31.6 - 41.9%) but the removal percentage was observed to increase in the presence of Mn2 + (bivalent cation).

10.) Yang et. al. [10] examined coagulation is an important wastewater treatment process used to reduce water turbidity and normally precedes the more complex secondary and tertiary water treatment processes. In this study, the effectiveness of a natural macromolecular coagulant derived from a cactus species for turbidity removal from estuarine and river waters were evaluated using jar test. Initial turbidity values measured at 499 NTU and 547 NTU for estuarine and river waters respectively were reduced by as much as 98% (estuarine) and 70% (river). Other parameters such as pH as well as alkalinity were also studied. It was indicated that the coagulant did not have a considerable effect on final pH of the waters. The amount of cactus added was well correlated with the final turbidity and alkalinity of the waters. High turbidity removal determined in this study indicates that cactus opuntia has the potential to be utilized for surface water treatment applications.

11.) Al-Sameraiy et. al. [11] studied that turbidity is a characteristic related to the concentration of suspended solids particles in water and has been adopted as an easy and reasonably accurate measure of overall water quality. In this research, proposed approach was adopted on the basis of applying two sequent treatments that used coagulation, flocculation and sedimentation processes under certain operating conditions of mixing speed, mixing time and settling time for each treatment. The environmentally friendly natural coagulants of date seeds (DS) or pollen sheath (PS) from local Iraqi palm was used in the first treatment and alum was used in the second treatment at their predetermined optimum doses to treat low (75±10NTU), medium (150±10NTU) and high (300NTU) bentonite synthetic turbid water. Experimental results clearly show that the proposed

approach was superior in performance in terms of residual turbidity compared with conventional approach using both of (DS) and (PS) natural coagulants in which it achieved a significant reduction in turbidity to less of 5 NTU that meeting WHO drinking water guidelines for all tested synthetic turbid water.

12.) Olanrewaju et. al. [12] studied Coagulation – flocculation process remains a very essential part in the water treatment chain. It involves both physical and chemical phenomena and hence susceptible to high percentage of errors due to human factor. In order to reduce this percentage error and obtain optimal treatment efficiency, an intelligent coagulant dosing based on Artificial Neural Network (ANN) was proposed. Design of the Coagulant dosing using processed Moringa oleifera seed as coagulant was achieved through ANN that helps in water quality forecast and soft measure. Effort was made to suggest the optimization tips in the form of Artificial Intelligent tools that can be used for optimization of coagulation process. Such coagulant dosing based ANN will be a useful method to address most errors common in water treatment cause by human factors. Experimental results with simulated and real data show that the newly developed system is able to accurately predict coagulant dosage needed in water treatment for a small size rural community.

IV. METHODOLOGY

The following steps are to be followed:

A. Preparation of Synthetic Turbid Water
Synthetic turbid water was prepared by mixing locally available clay with tap water. The suspension was kept for settling and different turbidity ranges such as low, medium, and high turbidity water were prepared for experimental analysis.

B. Preparation of Natural Coagulants
Natural coagulants such as Moringa Oleifera, Cactus, and Okra seeds were collected, dried, and ground into fine powder. Different particle sizes were obtained using sieve analysis for experimental study.

C. Jar Test Experiment
Jar test experiments were conducted using a flocculator apparatus to evaluate coagulation and flocculation efficiency. Rapid mixing was carried out at 150 rpm for 5 minutes followed by slow mixing at 30 rpm for 20–30 minutes. After settling, supernatant water samples were collected for turbidity and pH analysis.

D. Experimental Parameters
The study was carried out by varying different parameters such as coagulant dosage, pH, particle size, and settling time to determine optimum conditions for maximum turbidity removal.

E. Comparative Analysis
The performance of Moringa Oleifera, Cactus, and Okra used in conjunction with alum was compared to identify the most effective and economical natural coagulant for domestic water treatment

V. RESULT AND DISCUSSION

The experimental study showed that natural coagulants used in conjunction with alum significantly improved turbidity removal efficiency in domestic water treatment. Among the natural coagulants tested, Moringa Oleifera exhibited the highest coagulation efficiency due to the presence of natural water-soluble proteins that enhanced floc formation.

It was observed that turbidity removal increased with optimum coagulant dosage and proper pH conditions. The combined use of natural coagulants with alum reduced the settling time and improved the clarity of treated water. Smaller particle size of coagulants also showed better performance because of increased surface area for coagulation.

The study further indicated that the use of natural coagulants reduced the overall requirement of alum, thereby minimizing sludge production and potential environmental impacts. Cactus and Okra also showed satisfactory turbidity removal efficiency, although comparatively lower than Moringa Oleifera.

The results confirm that natural coagulants can effectively act as coagulant aids and provide an economical, eco-friendly, and sustainable solution for domestic water purification, especially suitable for rural and small-scale water treatment systems.

VI. CONCLUSION

The study concludes that natural coagulants used in conjunction with alum are effective for domestic water

treatment and turbidity removal. Among the natural coagulants tested, Moringa Oleifera showed the highest coagulation efficiency compared to Cactus and Okra. The combined use of natural coagulants with alum improved floc formation, reduced settling time, and minimized the requirement of chemical coagulants.

The experimental results proved that natural coagulants are economical, biodegradable, eco-friendly, and suitable for sustainable water purification. The use of natural coagulants can reduce environmental impacts and provide a low-cost treatment method for rural and small-scale domestic water supply systems.

REFERENCE

[1] Vijayaraghavan et al. (2011), "Application of Plant Based Coagulants for Wastewater Treatment", Journal of Water Process Engineering.

[2] Kazi et al. (2013), "Natural Coagulants for Tannery Wastewater Treatment", International Journal of Environmental Engineering.

[3] Gidde et al. (2012), "Use of Moringa Oleifera Seeds as Natural Coagulant for Water Treatment", International Journal of Engineering Research.

[4] Nwaiwu et al. (2012), "Combined Use of Moringa Oleifera and Alum in Household Water Treatment", Journal of Water Resource and Protection.

[5] Menkiti et al. (2014), "Optimization of Coagulation-Flocculation Process using Moringa Oleifera", International Journal of Multidisciplinary Sciences and Engineering.

[6] Muthuraman et al. (2014), "Turbidity Removal from Water using Natural Coagulants", International Journal of Civil Engineering Research.

[7] Nougbode et al. (2013), "Clarification of Turbid Surface Water using Opuntia dillenii", Journal of Environmental Science and Technology.

[8] Ali et al. (2010), "Processing of Moringa Oleifera Seeds for Water Purification", Water Science and Technology Journal.

[9] Yang et al. (2010), "Cactus Opuntia as Natural Coagulant for Surface Water Treatment", Environmental Technology Journal.

[10] Al-Sameraiy et al. (2012), "Use of Date Seed Coagulants for Turbidity Removal", Journal of Water Supply and Treatment.

[11] Pritchard et al. (2010), "Natural Coagulants for Groundwater Purification in Rural Areas", Water and Environmental Journal.

[12] Zheng et al. (2011), "Coagulation-Flocculation Performance in Wastewater Treatment using Polymeric Coagulants", Journal of Hazardous Materials.

[13] Baghvand et al. (2010), "Evaluation of Alum and Ferric Chloride in Turbidity Removal", Iranian Journal of Environmental Health Science and Engineering.

[14] Patale et al. (2015), "Efficiency of Coccinia indica Mucilage as Natural Flocculent for Turbid Water Treatment", International Journal of Innovative Research in Science and Engineering.

[15] Diaz et al. (2007), "Natural Coagulants Derived from Cactus and Prosopis juliflora Seeds", Water Research Journal.

[16] Zhang et al. (2006), "Coagulation Performance of Cactus as Natural Macromolecular Coagulant", Chemical Engineering Journal.

[17] Gaurang et al. (2015), "Turbidity Reduction in Dairy Wastewater using Natural Coagulants", International Journal of Environmental Sciences.

[18] Matthew et al. (2014), "Coag-Flocculation Behaviour of Natural Coagulants in Brewery Effluent", International Journal of Scientific Research.

[19] Devesa-Rey et al. (2011), "Calcium Lactate as Coagulant-Flocculant for Turbid Water Treatment", Journal of Environmental Management.

[20] Olanrewaju et al. (2013), "Artificial Neural Network Based Coagulant Dosing in Water Treatment", International Journal of Advanced Engineering Research.