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EMERGING TRENDS IN THE USAGE OF BIO-COAGULANTS IN WASTE WATER TREATMENT

Krishnapriya G Nair[1], Mingul Pertin[1], Prince Philip Kadavil[1], Jency Nadayil[2]

[1]Under Graduate Student, Department of Civil Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

[2]Professor, Department of Civil Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

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Abstract - *Coagulants play an important role in the treatment of water and waste water. Natural coagulant is one of the alternative methods in minimizing the usage of chemical coagulant in waste water treatment. The study aimed to evaluate the efficiency of natural coagulants such as Rambutan (Nephelium lappaceum) seeds, papaya (Carica papaya) seeds, Lemon (Citrus limon) peels, Neem (Azadirachta indica) leaves and Tulsi (Ocimum tenuiflorum) leaves in waste water samples collected. Samples of waste water was collected from the outlet of canteen waste water disposing location of the campus. Coagulants were prepared and added in different dosages from 10 mg/L to 60 mg/L to assess their effectiveness and dosing level. Jar test was conducted and the treated samples were evaluated for pH, turbidity and COD. The results showed turbidity reduction of 96.67% for rambutan seeds, 83.75% for papaya seeds, 87.5% for lemon, 88.75% for neem and 94.16% for tulsi leaves. The reduction in COD was obtained as 46.18% for rambutan seeds, 45.79% for papaya seeds, 9.78% for lemon, 10.57% for neem and 40.38% for tulsi leaves. From the results obtained, Rambutan seeds exhibits the highest turbidity removal efficiency compared to the other bio-coagulants used with a removal efficiency of 96.67% at an optimum coagulant dosage of 20 milligrams per litre. All these could be used as effective natural coagulants since they are environment friendly and of low cost when compared to chemical coagulants.*

Key Words: Turbidity, pH, COD, Rambutan seed, Papaya seed, Lemon peel, Neem leaf, Tulsi leaf, Canteen waste water, Efficient, cost effective, Reduce Chemical

1. INTRODUCTION

The level of purity of water consumed by humans is crucial since it has direct effect on health. Despite the technological advancement in water treatment and supply, one major challenge faced by many developing countries today is lack of clean and safe drinking water for use by their citizens. Studies have shown that one major problem with the treatment of surface water is the large seasonal variation in turbidity. The consumption of highly turbid water may lead to water borne disease outbreak. However, for many developing countries, coagulation is an expensive process of water treatment because of the high cost involved in importing chemicals. Chemical coagulants have been used widely in conventional water treatment however, it exhibits several disadvantages such as, it requires pH adjustment before and after treatment, produce excessive toxic and non-biodegradable sludge as well as impose health risk to the consumer. The commonly used chemical coagulants are salts of aluminium and iron. Recent studies have pointed out several serious drawbacks of using aluminium salts, such as Alzheimer's disease and similar health related problems associated with residual aluminium in treated waters. Natural coagulants are one of the alternative techniques in minimizing the uses of chemical coagulant in water treatment. Also, the use of natural coagulants reduces the cost of treatment process. In this study, natural coagulants

like papaya seeds, tulsi leaves, neem leaves, rambutan seeds and lemon peels are suggested as a substitute for chemical coagulants. These coagulants are readily available and commonly recognizable in most urban and rural communities.

Coagulation is an essential process in which the dispersed colloidal particles agglomerate together. It involves removal of dissolved chemical species and turbidity from waste water. Bio-coagulants are naturally available coagulants which aids the coagulation process.

The research conducted by Zurina Zainal Abidin and Mohd fadzli Mohamed studied the performance of rambutan (Nephelium lappaceum) seed as a natural coagulant for turbidity removal. The coagulation test was carried out using jar test apparatus. The optimum pH for coagulation was found at pH<3 and the optimum coagulant dosage was 100mg/L. The turbidity removal achieved was 92%-95%. Rambutan seed coagulant exhibited faster sedimentation time due to bigger flocs formation and also smaller sludge volume than chemical coagulants.

The study conducted by Dhruva R and Suresh B showed the effect of Tulsi leaf for reduction of turbidity, COD and pH from sewage water. Optimum dosage for turbidity removal was found to be 150mg/L. A low coagulant dosage of 1.5mg/L, achieved a high COD removal percentage,89% at operational conditions of neutral pH and room temperature.

2. OBJECTIVE

The main objective of this project is to determine the treatment efficiency of bio-coagulants such as tulsi leaves, neem leaves, papaya seeds, rambutan seeds and lemon peels in the treatment of canteen wastewater collected from the college campus.

3. MATERIALS AND METHODS

The project began with the collection of bio-coagulants which were expected to be most suitable for waste water treatment. The sample was collected from the outlet of canteen waste water disposing location of Mar Athanasius College of Engineering, Kothamangalam. The samples were collected in sterilized bottles and were preserved in the refrigerator during storage. Sufficient care was taken to obtain a sample that was true representative of existing condition and to handle it in such a way that it does not deteriorate or become contaminated before it reached the laboratory. The initial characterization of the sample was done so as to determine the general chemical characteristics of the sample like, pH, COD, BOD, turbidity, acidity, alkalinity and chlorides. Jar test was done to determine the optimum dosage of coagulant for water treatment. Nephelometer was used to determine the initial & final turbidity of water. The characterization of the sample was repeated after bio- coagulation. The final characteristics such as pH, turbidity and COD were determined. The most efficient bio- coagulant among these five was identified. These bio-coagulants was then compared with a suitable chemical coagulant and their performance was analyzed.

Table -1: Characteristics of canteen waste water

PARAMETERS	VALUE
pH(25^{0}C)	8.02
Acidity	140 mg/L
Alkalinity	127 mg/L
Turbidity	240 NTU
COD	480 mg/L
Chloride	8.65 mg/L
BOD	337.58 mg/L

3.1 Preparation of coagulants

Lemon peels, Neem leaves, Tulsi leaves, Rambutan seeds and Papaya seeds were collected from various sources. The collected materials were grounded to fine powder and used in every experiment. To prepare the coagulant, 0.5g of each coagulant powder was blended with 100ml of distilled water at room temperature for several minutes in order to extract the active ingredients of the coagulants in a magnetic stirrer.

Fig 1: Rambutan seed powder

Fig 2: Neem leaf powder

Fig 3: Papaya seed powder

Fig 4: Tulsi leaf powder

Fig 5: Lemon peel powder

3.2 Preparation of Kaolin synthetic wastewater

Although the project is focused on the canteen wastewater, due to varying values of turbidity for each test it was decided to use kaolin suspension as the model wastewater. Stock kaolin suspension was prepared by dissolving 0.56g of Kaolin in 1 L of distilled water at room temperature. The suspension was stirred slowly at 20 rpm for 1hour in a jar apparatus for uniform dispersion of Kaolin particles. The suspension was then allowed to stand for 24 hours to allow for complete hydration of the Kaolin. The Kaolin suspension was used as the stock solution for the preparation of water samples of varying turbidities for the coagulation tests.

3.3 Jar Test Apparatus

The coagulation test was carried out using Jar floc test. The study involved steps such as rapid mixing, slow mixing and sedimentation in a batch process. Several beakers were filled with 300 mL of synthetic wastewater and coagulant dosage of 10, 20, 30, 40, 50 & 60 mg/l were added. A rapid mixing period of 4 minutes at 100 rpm followed by slow mixing at 40 rpm was done for the next 20 minutes. The sample was left for a sedimentation period of 30 minutes. After sedimentation, samples were filtered through filter paper, and the supernatant was collected to measure the final turbidity using Nephelometer.

Fig 6: Jar test apparatus and filtered sample

4. RESULTS AND DISCUSSIONS

Jar test was performed on the waste water samples. The optimum coagulant dosage was determined by varying the dosage of coagulant as 10, 20, 30, 40, 50, 60 mg/L. The turbidity of the sample was measured by using Nephelometer and pH using pH meter. The supernatant obtained from the sample corresponding to optimum coagulant dosage was collected and COD (Chemical Oxygen Demand) of the treated sample is determined.

4.1 EFFECT OF COAGULANT DOSAGE

4.1.1 Rambutan seed powder

Table -2: Variation of Turbidity and pH with varying dosages of rambutan seed powder

DOSAGE (mg/L)	TURBIDITY (NTU)	pH
10	22	8.68

20	8	8.2
30	25	8.02
40	23	7.76
50	20	7.59
60	34	7.43

The optimum dosage was found to be 20 mg/L with a turbidity value of 8 NTU. The percentage turbidity removal efficiency of Rambutan seeds was 96.67% and the optimum pH range can be found to be 7.43-8.68.

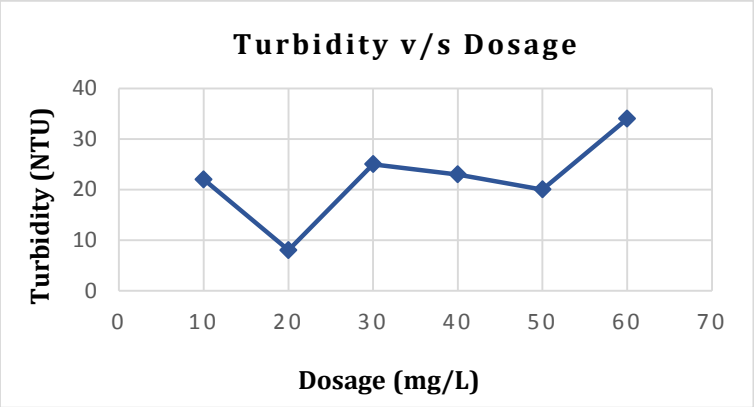

Chart-1: Variation of turbidity with varying dosages of rambutan seed powder

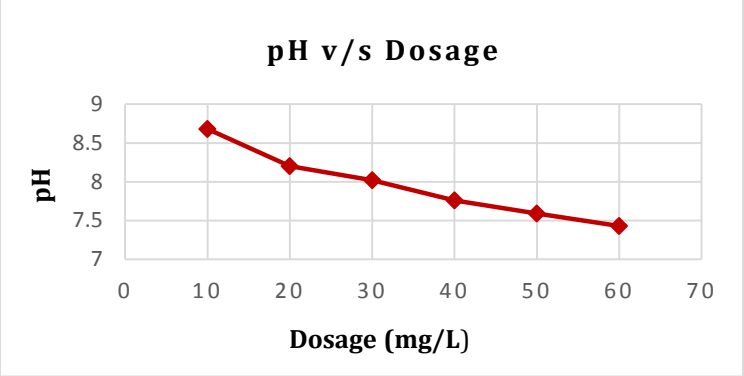

Chart-2: Variation of pH with varying dosages of rambutan seed powder

4.1.2 Papaya seed powder

Table-3: Variation of Turbidity and pH with varying dosages of papaya seed powder

DOSAGE (mg/L)	TURBIDITY (NTU)	pH
10	61	8.02
20	65	7.5
30	56	7.32
40	39	6.95
50	50	6.8
60	61	6.88

The optimum dosage was found to be 40 mg/L with a turbidity value of 39 NTU. The percentage turbidity removal efficiency of Papaya seeds was 83.75% and the optimum pH range can be found to be 6.8-8.02.

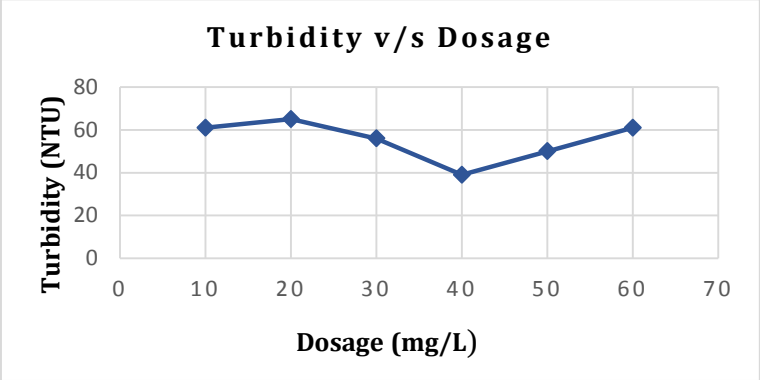

Chart-3: Variation of turbidity with varying dosages of papaya seed powder

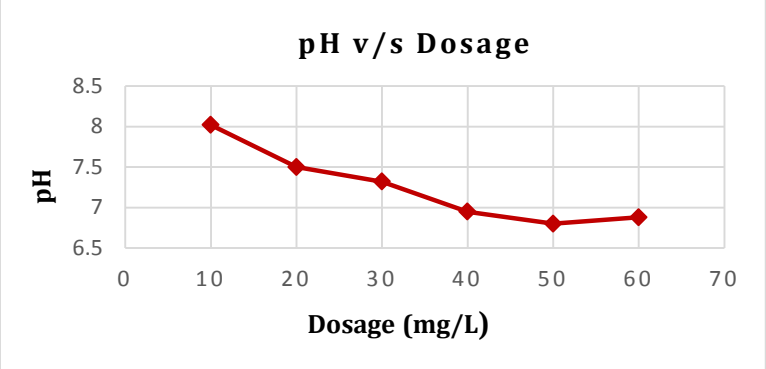

Chart-4: Variation of pH with varying dosages of papaya seed powder

4.1.3 Lemon peel powder

Table-4: Variation of Turbidity and pH with varying dosages of lemon peel powder

DOSAGE (mg/L)	TURBIDITY (NTU)	pH
10	47	7.6
20	54	7.42
30	46	7.38
40	44	7.37
50	35	7.34
60	30	7.32
70	64	7.3

The optimum dosage was found to be 60 mg/L with a turbidity value of 30 NTU. The percentage turbidity removal efficiency of lemon peels was 87.5% and the optimum pH range can be found to be 7.3-7.6.

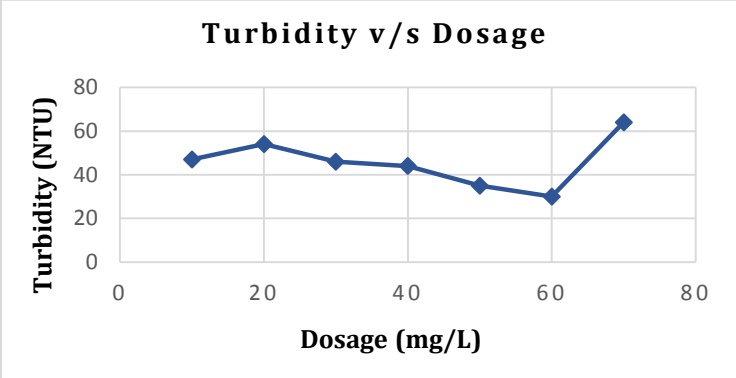

Chart-5: Variation of turbidity with varying dosages of lemon peel powder

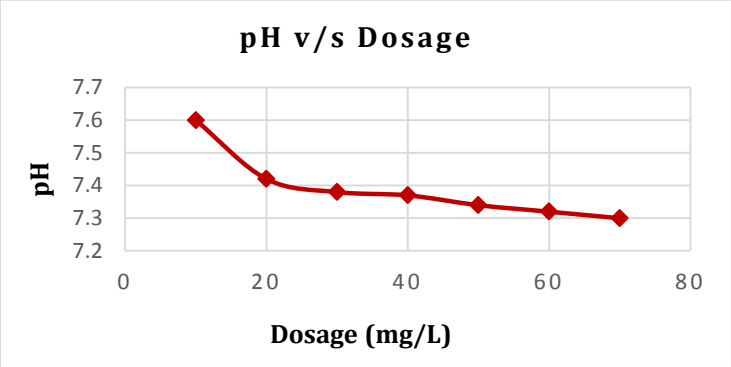

Chart-6: Variation of pH with varying dosages of lemon peel powder.

4.1.4 Neem leaf powder

Table-5: Variation of Turbidity and pH with varying dosages of neem leaf powder

DOSAGE (mg/L)	TURBIDITY (NTU)	pH
10	28	7.02
20	31	6.85
30	27	6.82
40	45	6.80
50	48	6.79
60	67	6.78

The optimum dosage was found to be 30 mg/L with a turbidity value of 27 NTU. The percentage turbidity removal efficiency of neem leaves was 88.75% and the optimum pH range can be found to be 6.80-7.02.

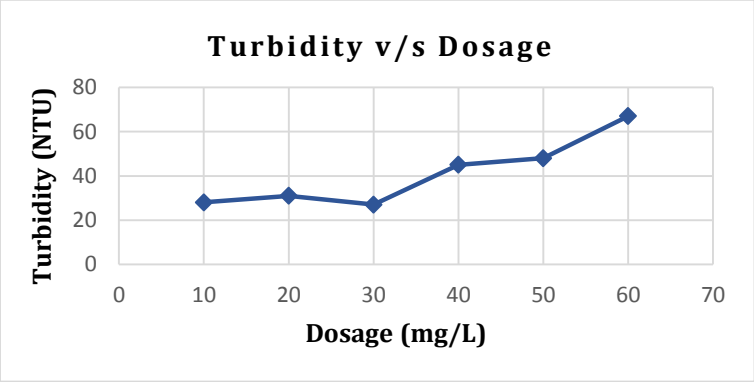

Chart-7: Variation of turbidity with varying dosages of neem leaf powder

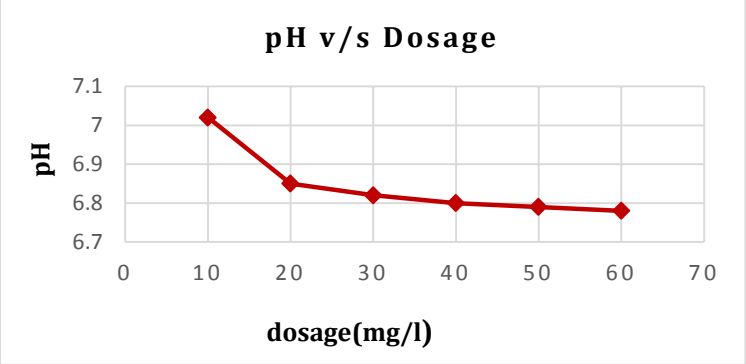

Chart-8: Variation of pH with varying dosages of neem leaf powder

4.1.5 Tulsi leaf powder

Table-6: Variation of Turbidity and pH with varying dosages of tulsi leaf powder

DOSAGE (mg/L)	TURBIDITY (NTU)	pH
10	47	9.06
20	25	9
30	14	8.46
40	39	8.7
50	20	8.66
60	23	8.48

The optimum dosage was found to be 30 mg/L with a turbidity value of 14 NTU. The percentage turbidity removal efficiency of neem leaves was 94.17% and the optimum pH range can be found to be 8.48-9.06.

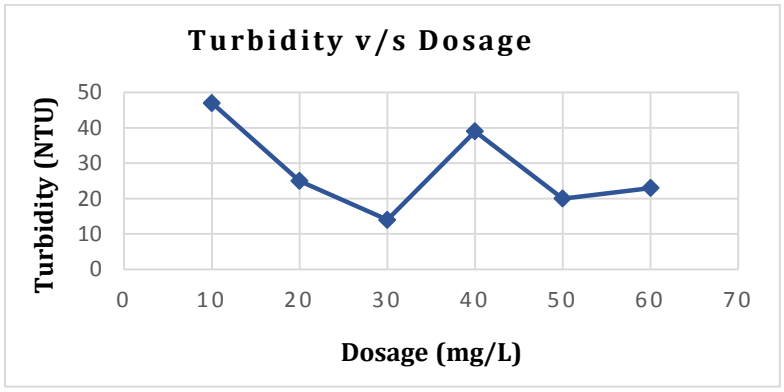

Chart-9: Variation of turbidity with varying dosages of tulsi leaf powder

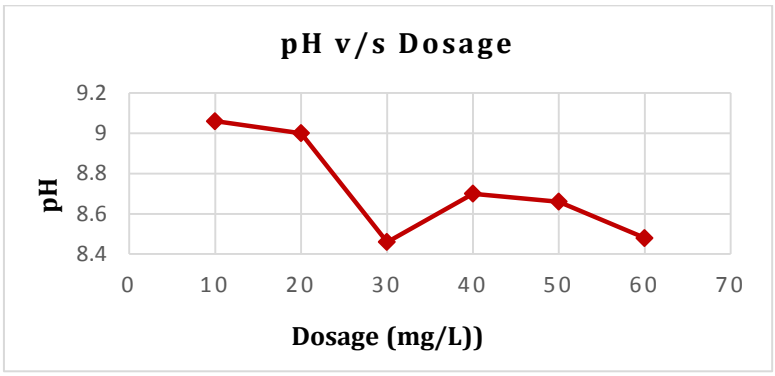

Chart-10: Variation of pH with varying dosages of tulsi leaf powder

4.2 COD REDUCTION

COD of the treated waste water sample was determined corresponding to optimum coagulant dosage. For rambutan seed powder as coagulant, COD of the collected supernatant was found to be 258.31 mg/L and thus 46.18% in reduction in COD was obtained. Using papaya seed powder as coagulant, COD of the collected supernatant was found to be 260.19 mg/L and thus 45.79% in reduction in COD was obtained. For lemon peel powder as coagulant, COD of the collected supernatant was found to be 433.027 mg/L and thus 9.78% in reduction in COD was obtained. For neem leaf powder as coagulant, COD of the collected supernatant was found to be 429.25 mg/L and thus 10.57% in reduction in COD was obtained. Similarly, using tulsi leaf powder as coagulant the COD was found to be 286.165 mg/L and a reduction of 40.38% was achieved.

4.3 COAGULATION USING ALUM

Table-7: Variation of turbidity with varying dosages of alum

DOSAGE (mg/L)	TURBIDITY (NTU)
10	2
20	1
30	1
40	0
50	0
60	0

The optimum dosage was found to be 40 mg/L with a turbidity value of 0 NTU. The percentage turbidity removal efficiency of neem leaves was 100%.

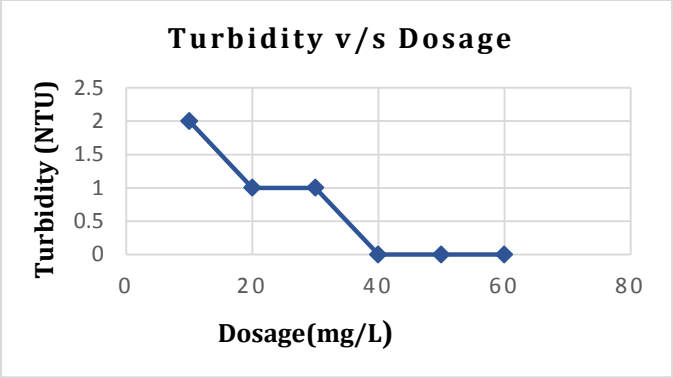

Chart-11: Variation of turbidity with varying dosages of alum

Table-8: Characteristics of waste water sample at optimum coagulant dosage

PARAMETERS	RAMBUTAN SEED POWDER	PAPAYA SEED POWDER	LEMON PEEL POWDER	NEEM LEAF POWDER	TULSI LEAF POWDER
pH	8.2	6.95	7.32	6.82	8.46
Turbidity (NTU)	8	39	30	27	14
COD (mg/L)	258.31	260.19	433.027	429.25	286.165

5. CONCLUSION

In this study we mainly analyzed the turbidity removal efficiency of bio coagulants such as rambutan seed powder, papaya seed powder, lemon peel powder, neem leaf powder and tulsi leaf powder. Using rambutan seed powder as coagulant, turbidity reduction of 96.67% at optimum dosage of 20 mg/L was obtained. Also, COD reduction of 46.18% was achieved. Using papaya seed powder as coagulant, turbidity removal efficiency of 83.75% at optimum dosage of 40 mg/L was obtained. Also, COD reduction of 45.79% was achieved. Using lemon peel powder turbidity removal efficiency of 87.5% at optimum dosage of 60 mg/L was obtained. COD reduced by 9.78%. Using neem leaf powder turbidity reduction of 88.75% at optimum coagulant dosage of 30 mg/L was obtained. COD reduced by 10.57%. Using tulsi leaf powder as coagulant turbidity reduction of 94.16% at optimum dosage of 30 mg/L was obtained. Also, COD reduction of 40.38% was achieved. On comparison with alum, it is observed that rambutan seed powder gives the highest turbidity removal efficiency compared to the other bio-coagulants used with a removal efficiency of 96.67%.

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