JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Use of Mangifera Indica as a plant-based coagulant and its comparison with conventional coagulant for treatment of water

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Abstract **- It is necessary to remove excess hardness from water because it causes various health issues such as diabetes, reproductive failures, neural diseases and so on. Coagulation and flocculation by adding chemicals are the methods that are usually used for water treatment. These types of treatment facilities are difficult and also expensive. So, there is an increased demand for some innovative, low maintenance and energy efficient technology for water/wastewater treatment. This study is concerned with the coagulation activity of extracts of various plant-based coagulants. The aim is to ascertain the potential of plant-based coagulants in the influence of coagulation activity with respect to hardness removal/softening. The objective of this study also aim to assess the possibility of using natural coagulants as an alternative to the current commercial synthetic coagulant such as alum (aluminium sulphate), to compare the performance and to optimize the coagulation process. Hardness removal techniques through coagulation was carried out using a natural plant based Mangifera indica for various process constraints. The same was checked with alum, the conventional coagulant for the same process constraints. A combination analysis of Mangifera indica and alum in the 70-30 proportion was also carried out to ascertain the hardness removal efficiencies. Studies revealed that Mangifera indica had a 42.5% removal efficiency for a 400 mg/l hardness water, while alum showed a comparatively higher efficiency of 44%. However, the use of Mangifera and alum in combination was found to achieve an excellent efficiency of 74 % at a dosage of 400 mg/l. Application of low-cost plant-based coagulants are recommended for eco-friendly, nontoxic, simplified water treatment where rural and peri-urban people living in extreme poverty are presently drinking contaminated water.**

Index Terms – Alum, Coagulant Hardness, Mangifera Indica.

I. INTRODUCTION

Water supply is a basic need required for living creatures and human being specifically. In this world, the number of resources available to living creatures is limited. Safe drinking water is essential to the health and welfare of a community, and water from all sources must have some form of purification before consumption. Various methods are used to make water safe and attractive to the consumer. The method employed depends on the character of the raw water. When surface water is used for drinking water production, hardness removal is an essential part of the treatment process. It is generally achieved using coagulation with metal salts followed by aggregation of particles through flocculation and separation through sedimentation and filtration. Aluminium (e.g. $Al_2(SO_4)_3$ .18H2O) and iron salts are mostly used as coagulant reagents.

Natural methods of water treatment are the most preferred methods of water treatment due to their cost efficiency, environmental stability and easier availability especially in developing countries. Natural coagulants may help in reducing the health effects and costs of various chemical coagulants. Some of the common natural coagulants used in water purification include Moringa oleifera, Cicer arietinum, Dolichos lablab, Vigna unguiculata, Zea mays, Mangifera Indica etc. Out of them, the most preferred and efficient natural coagulants are the seeds of M. oleifera which possess polyelectrolytes containing cationic proteins thus helping in coagulation and water purification It has been observed that M. oleifera seeds and Mangifera indica can eliminate turbidity, hardness and heavy metals up to a larger extent, thus it can replace chemical coagulants like alum in water purification.
The present study shall therefore be carried out to explore further the potential of this multipurpose tropical plant as a new method for use in the softening of hard groundwater. The effect of pH in hardness removal, using dried Moringa oleifera seed and dried Mangifera indica shall also be studied.

Water treatment is a process were natural occurring water from various sources is put through a series of steps designed to purify it and make it potable for human consumption and industrial purposes **[1]**.

The ideal water should have some characteristics such as colourless, tasteless, odourless, pathogen free and non toxic in nature. This standard was set to prevent the occurance and the spread of the water borne disesases. To achieve this standard,

there is one common technique applied for water treatment process which is coagulation and flocculation [2].

Coagulation is the mechanism by which a given colloidal suspension or solution is destabilized. And flocculation refers to the incorporation of destabilizing particles to come together, make contact and thus form large mass, which can normally be separated by settling gravity [3].

The coagulation process is used widely in water and wastewater treatment, as it is effective for removing suspended solids, turbidity, hardness, organic matter, oil [4].

Commonly used artificial coagulants in water and wastewater treatment are alum, ferric chloride, ferric sulphate, copperas, etc.

Artificial coagulant in wastewater treatment is not that feasible because of the difficulty in assessing chemical coagulants and also, if they are used for longer periods, many health problems are caused [5].

Due to the drawback of the artificial coagulant, the use of natural coagulants has been studied as an alternative for water treatment, primarily due to their abundant availability, low cost, non-toxicity [6].

A number of natural coagulants such as Moringa Oleifera, mangifera indica ,okra, and water melon seeds, cactus opuntia, consolea rubescens etc are found to have excellent coagulating properties.

Hard water is the common quality of water which contains dissolved compounds of calcium and magnesium. The term hardness was originally applied to waters that were hard to wash in, referring to the soap wasting properties of hard water. Hardness prevents soap from lathering by causing the development of an insoluble curdy precipitate in the water **[7].**

Among all the parameters, hardness is one of the prime factors, which is considered to be a significant etiological factor around the globe causing many diseases such as cardiovascular problems, diabetes, reproductive failure, neural diseases and renal dysfunction and so on [8].

One of the most widely operations in domestic wastewater treatment is coagulation.

Jar test is the most widely used experimental method for coagulation and flocculation. A conventional jar test apparatus was used in the experiments to coagulate sample of synthetic turbid water using coagulants [9].

The following studies have been carried out, elsewhere by researchers and a brief description of the findings have been presented below:

1.The study was conducted in Sri Lanka, by S.Nimesha et al., in the year 2021 indicating the effectiveness of natural coagulants in water and wastewater treatment. This study was elaborated on the nature and mechanisms and types of natural coagulants. 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 [10].

2.The study was conducted in Maharashtra, by Mr.Rahul Paigude and Mr.Ratankumar Patil in the year 2019 about the comparative analysis of natural and chemical coagulants. This study with use of the locally available natural coagulants is used to reduce turbidity of synthetic water. Natural coagulants worked better with high turbid water compare to medium or low turbid water [11].

3.The study was conducted by Abderrezaq Benalia et al., in the year 2021 about the use of aloe vera as an organic coagulant for improving drinking water quality. In this paper the use of aloe vera as a natural coagulant for drinking water treatment was tested. The obtained results showed that the use of natural coagulant reduced the water turbidity at natural pH by 28.23% [12].

4.The study was conducted by Arya chandran J et al., in the year 2018 to use papaya seed as a natural coagulant for water purification. In this study natural coagulant like papaya seed was suggested as substitute for alum. This study mainly focused on the removal of turbidity. The experiment was carried out with coagulant dosage of 0.2,0.4,0.6,0.8,1.0,1.2 g/l in raw water sample.89.14% turbidity removal efficiency was obtained from this study. Papaya seed also exhibited high efficiency in removing total suspended solids, alkalinity, total hardness, dissolved oxygen etc[13].

5.The study was conducted by S.N.Ugwu et al., in the year 2017 indicating the comparative study of the use of natural and artificial coagulants for the treatment of sullage. This experiment was carried out with dosages of 200,300 and 1000 mg/l. The effects of these dosage were tested against turbidity, pH, BOD, hardness. 100% moringa seed extract resulted in all the parameters except turbidity being with tolerable limits. The result of the comparative test showed that alum with its residual and health implications can be successfully replaced, partially or wholly with natural coagulants [14].

Closure:

Weighing the positives from the above studies, an attempt is being made to use the locally available natural coagulants to reduce the hardness of domestic water. The study also proposes a comparative study of the effectiveness of natural coagulants (moringa oleifera and mangifera indica) and artificial coagulants (alum) in domestic water treatment.

II. Materials and methods

To achieve the proposed objectives, the following methodology shall be adopted, which involves the following steps:

Preparation of synthetic hard water

A simulated solution of hard water of known strength shall be prepared adopting the standard protocols and the solution shall be stored in the refrigerator till its usage.

Collection of natural coagulants

The selected seeds shall be obtained from the fruits and thoroughly washed with tap water to remove the sticks adhered on their surface and stored for preparation.

Preparation of natural coagulants

The collected seeds shall be dried at a temperature of 105 degree centigrade for 24 hrs or in sunlight until its moisture content is completely removed. The oven dried seeds will be then grinded to a fine powder and stored in containers.

In the study Mangifera indica have been considered as natural coagulant for the hardness reduction from water. Fig 1 Shows the pictorial representation of mangifera indica shell while Fig 2 depicts the complete process methodology involved in the study.

Fig 1 Mangifera indica shell used for coagulation

Fig 2 depicts the complete process methodology involved in the study.

Selection collection and
preparation of Natural Coagulants
↓
Collection of water samples
↓
Preparation of synthetic water
↓
Sample Analysis Before Treatment
↓
Treatment with Natural Coagulants | Treatment with Conventional coagulant
↓
Effects of Parameter (Dosage, contact time)
↓
Sample Analysis After Treatment
↓
Determination of Optimum concentration
↓
Comparison of Treatment efficiencies of Natural Coagulant with Conventional Coagulant (Alum)
↓
Recommendation

Flowchart for the complete process methodology involved in the study is as shown in the fig 2

Fig 3 Methodology adopted for extraction of natural

coagulants

Removal of seeds from the fruits
↓
Washing and sun drying of the seeds
↓
Grinding the seeds
↓
Powdered seeds
↓
Filtration
↓
Rinsing of the solid residue (seed cakes) and oven dry
↓
Extraction of coagulant seeds
↓
The methodology adopted for extraction of natural coagulants is shown in Fig 3

Preparation of Synthetic hard water (hardness solution of 1000 ppm)

Dissolve 2.87 gms of Zinc Sulphate ($Zn\ SO_4.\ 7\ H_20$) in distilled water to make up to 1 litre in volumetric flask. This gives a hardness stock solution of 1000 ppm or mg/l as $CaC0_3$ as indicated in Table 1.

Table1.

Preparation of various dilutions/standards of hardness

1000 ppm	Direct stock
800 ppm	800 ml stock diluted to1000 ml with distilled water
600 ppm	600 ml stock diluted to1000 ml with distilled water
400 ppm	400 ml stock diluted to1000 ml with distilled water
200 ppm	200 ml stock diluted to1000 ml with distilled water

Preparation of coagulant dosage solution (hardness solution of 1000 ppm)

Dissolve 10 gms of Mango seed powder/alum in distilled water to make up to 1 litre in volumetric flask. This gives a 1 % coagulant stock solution of 1000 ppm or mg/l. Thus, 1ml = 10 mg as presented in Table 2.

Table 2: Preparation of coagulant dosage solution (hardness solution of 1000 ppm)

Coagulant dosage	Dilutions
Magnifera Indica/Alum	
1000 mg/l	Direct stock
900 mg/l	900 ml stock diluted to1000 ml with distilled water
800 mg/l	800 ml stock diluted to1000 ml with distilled water
700 mg/l	700 ml stock diluted to1000 ml with distilled water
600 mg/l	600 ml stock diluted to1000 ml with distilled water
500 mg/l	500 ml stock diluted to1000 ml with distilled water
400 mg/l	400 ml stock diluted to1000 ml with distilled water
300 mg/l	300 ml stock diluted to1000 ml with distilled water
200 mg/l	200 ml stock diluted to1000 ml with distilled water
100 mg/l	100 ml stock diluted to1000 ml with distilled water

Jar test apparatus set up

A laboratory procedure that simulates coagulation/flocculation with differing chemical doses. The purpose of the procedure is to estimate the minimum coagulant dose required to achieve certain water quality goals. Samples of water to be treated are placed in 6 jars. Various amounts of chemicals are added to each jar and stirred, and the settling of solids is observed. The lowest dose of chemicals that provides satisfactory settling is the dose used to treat the water as shown in Figure 4.

FIG 4: Jar Test Apparatus

III. RESULTS AND DISCUSSION

The determination of the total hardness of water is based on a complexometric titration of calcium and magnesium with an aqueous solution of the disodium salt of EDTA at pH value of 10. The primary factor for water purification by Mangifera

Indica is due to the action of Seed proteins. The mechanism of coagulation with seeds of Mangifera Indica consists of adsorption and neutralization of the colloidal positive charges that attract the negatively charged impurities in water.

Attempts to reduce hardness through coagulation was carried out using a natural plant based Mangifera indica for various process constraints. The same was checked with alum, the conventional coagulant for the same process constraints. A combination analysis of Mangifera indica and alum in the 70-30 proportion was also carried out to ascertain the hardness removal efficiencies. The study was carried out for various simulated strengths of hardness (200, 400, 600, 800 and 1000 mg/l) for different coagulant dosages (100 to 1000 mg/l in increments of 100 mg/l). The pH was studied both for the influent as well as every individual treated simulated hardness solutions. A common feature that was observed both with respect to mango seeds as well as alum was that various simulated hardness waters, the removal efficiency increased and decreased marginally till the optimum coagulant dosage of 700 mg/l. A huge removal spike was observed for all three cases and the hardness removal efficiencies (%) were found to be 45, 42.5, 41, 31.5 and 17.8 with respect to mango and 48, 43, 49.6, 48.5 and 31.8 % for alum. It is thus seen that the removal for waters with hardness values 200, 400 and 600 mg/l were quite good and it started to reduce at higher concentrations and the least removal efficiency for 1000 mg/l hardness solution. The optimum range was 400 mg/l as it started to decrease further with strength. Further, the final removal efficiencies at the final coagulant dosage of 1000 mg/l for mango was found to be 55, 56.5. 58, 45 and 19.2 %, while it was 57.5, 59, 64.6, 52.5 and 38.2 % for alum. Once again it was noticed that alum showed a marginally higher hardness removal in comparison with mango. of This also indicated that alum showed better removal efficiency, though it was only marginally higher than mangifera indica. However, the use of Mangifera and alum in combination was found to achieve a very good final efficiency of 74 % for a 400 mg/l hardness solution. Finally, it was also seen that a critical factor in coagulation, pH in the acidic range was found to achieve better results for all the cases. At a pH below 10, the Mangifera Indica seed proteins are positively charged and thus the seeds when added to water samples bind to the negatively charged particles if any in the samples. Tables 3,4 and 5 and illustrate the performance efficiencies for various strengths and dosages for all three cases analytically.

Table 3: Softening simulated water using Mangifera Indica seeds Initial hardness (200, 400, 600, 800 ,1000 mg/L)

Dosage of coagulant added, mg/L	Residual Hardness mg/L as $CaCo_3$)					Final pH				
						1	2	3	4	5
0	200	400	600	800	1000	6.16	6.44	6.31	6.30	6.3
100	192	388	588	790	996	6.49	6.43	6.72	6.29	6.28
200	184	374	572	746	960	6.42	6.34	6.69	6.10	6.23
300	176	360	540	716	904	6.38	6.32	6.68	5.83	6.21
400	168	332	502	670	880	6.31	6.30	6.66	5.75	6.15
500	156	308	476	638	870	6.27	6.22	6.58	5.52	6.12
600	148	290	446	610	862	5.88	5.85	6.56	5.48	5.95
700	110	210	354	500	822	5.73	5.66	6.55	5.38	5.86
800	106	202	318	480	820	5.65	5.58	6.43	5.30	5.78
900	102	188	284	464	812	5.55	5.54	6.33	5.24	5.69
1000	90	174	252	440	808	5.45	5.45	6.28	5.19	5.58

Table 4: Softening simulated water using Alum Initial hardness (200, 400, 600, 800 ,1000 mg/L)

Dosage of coagulant added, mg/L	Residual Hardness mg/L as $CaCo_3$)					Final pH				
						1	2	3	4	5
0	200	400	600	800	1000	5.18	6.03	5.95	6.02	5.45
100	198	386	560	760	942	5.39	6.12	6.20	5.97	5.41
200	193	370	544	716	912	5.10	5.72	5.98	5.56	5.01
300	184	352	500	664	870	4.79	4.91	5.20	4.64	4.45
400	176	336	463	612	820	4.66	4.67	4.68	4.45	4.48
500	160	310	440	600	800	4.55	4.53	4.52	4.39	4.38
600	154	300	412	566	762	4.38	4.00	4.43	4.20	4.16
700	104	228	302	412	682	4.29	3.94	4.35	4.15	4.09
800	96	198	266	398	670	4.19	3.92	4.27	4.10	3.99
900	91	182	230	388	648	4.06	3.91	4.23	4.06	3.95
1000	85	164	212	380	612	4.97	3.87	4.21	4.02	3.89

Table 5: Results of Combination of Mangifera indica and alum (ratio of 70% and 30%)

Dosage of coagulant added, mg/L	Residual Hardness mg/L as $CaCo_3$)			Final pH		
				1	2	3
0	200	400	600	6.06	6.01	6.81
100	190	388	550	5.90	5.52	6.14
200	178	368	530	5.56	5.13	6.13
300	168	350	500	4.79	4.97	6.00
400	156	330	466	4.66	4.66	5.92
500	144	318	440	4.54	4.59	5.75
600	138	290	418	4.50	4.54	5.05
700	102	181	302	4.42	4.48	4.91
800	90	152	250	4.36	4.40	4.71
900	78	126	208	4.28	4.35	4.65
1000	64	104	188	4.21	4.29	4.58

IV. CONCLUSIONS

Attempts to reduce hardness through coagulation was carried out using a natural plant based Mangifera indica for various process constraints. The final removal efficiencies at a coagulant dosage of 1000 mg/l for mango was found to be 55, 56.5. 58, 45 and 19.2 %, while it was 57.5, 59, 64.6, 52.5 and 38.2 % for alum. Further, it was noticed that alum showed a marginally higher hardness removal in comparison with mango. of This also indicated that alum showed better removal efficiency, though it was only marginally higher than mangifera indica. However, the use of Mangifera and alum in combination was found to achieve a very good final efficiency of 74 % for a 400 mg/l hardness solution.

Thus, the effectiveness of using Alum as coagulant cannot be denied as it is very effective in removing hardness Following that, the percentage removal by using Mangifera Indica as coagulant is also seen to be considerably good.

Mango seeds are non- toxic. It is eco-friendly and cheap and can be used in the rural areas where no facilities are available for the drinking water treatment. After the treatment the sludge settled at the bottom of tank, can be used as bio-fertilizers is an added advantage of this method in rural areas. Mangifera seed is environmentally friendly material the sludge can be used as a bio fertilizer/ bio compost.

The use of conventional varieties of Mangifera is effective in generation of pure drinking water in developing countries where purchase of routine chemical coagulants is not affordable. Besides reducing the number of suspended particles drastically, it also reduces the microbial count to a larger extent, thus, reducing water-borne diseases greatly. The plantation of Mango should be encouraged especially at rural level.

REFERENCE

[1] Solomon, J.R., Aminu, N.M., and Wilfred-Ekprikpo, P.C (2020).Comparative study on the coagulation potentials of alum and moringa oleifera in raw water treatment, vol 6, Pp.90-100, ISSN 2734-2158.

[2] Muhammed., and Jibril Jiya (2019). Artifical coagulant(alum) for water treatment, A project report submitted to the department of chemical engineering federal university of technology, Minna Nigeria.

[3] Wendesen Mekonin Desta., and Million Ebba Bote (2021).Wastewater treatment using natural coagulant (Moringa oleifera seeds):optimization through response surface methodology, https://doi.org/10.1016/j.heliyon.2021.e08451.

[4] Motasem Alazaiza Y.D., Ahmed Albahnasawi., Gomaa Ali A.M., Mohammed Bashir J.K., Dia Eddin Nassani., Tahra Al Maskari., Salem S. Abu Amr., and Mohammed Shadi S.Abujazar (2022).Application of Natural coagulants for pharmaceutical removal from water and wastewater: A Review, https://doi.org/10.3390/w14020140.

[5] Abirami.M., and Rohini.C (2017). A comparative study on the treatment of turbid water using moringaoleifera and alum as coagulants,E-ISSN:2348-8352,Pp.41-www.internationaljournalssrg.org.

[6] Karina Cardoso Valverde., Edneia Aparecida de Souza Paccola., Armando Mateus Pomini., Natalia Ueda Yamaguchi., and Rosangela Bergamsco (2018).Combined water treatment with extract of natural moringa oleifera lam and synthetic coagulant, article doi:10.4136/ambi-agua.2135.

[7] Mohd.Shayan Rais., Mazin Mukhlis Madoo., Namra Salim Sonde., and Mohd Furqan Saiyed (2019). Comparative study of naturally available coagulants.

[8] Dr.Pallav Sengupta (2013). Potential health impacts of hard water,4:866-75.

[9] Md.Asrafuzzaman., A.N.M.Fakhruddin., and Md.Alamgir Hossain (2011). Reduction of turbidity of water using locally available natural coagulants, doi:10.5402/2011/632189.

[10] Nimesha S., Hewawasam C., Jayasanka D.J., Murakami Y., Araki N., and Maharjan N(2022). Effectiveness of natural coagulants in water and wastewatertreatment,doi:10.22034/giesm.2022.01.08,Pp.101-116.

[11] Mr.Rahul Paigude., Mr.Ratankumar Patil (2019).Review on comparative analysis of natural and chemical coagulants,ISO 9001:2008,Pp.1706-1707.

[12] Abderrezzaq Benalila., Kerroum Derbal., Amel Khalfaoui., raouf Bouchareb., Antonio panico., corrado Gisonni., Gaetano Pirozzi., and Antonio Pizzi(2021) Use of Aloe Vera as an Organic Coagulant for Improving Drinking Water Quality, https://doi.org/10.3390/w1315024.Pp.2-15.

[13] Arya Chandran J., and Duithy George(2015) Use of Papaya Seed as a Natural Coagulant for Water Purification ,Paper ID: IJSER172323.Pp41-46.

[14] Samson Ugwu., Boniface obinwanne Ugwuishiwu., Emmanuel Amagu echiegu., and Christopher C Enweremadu(2017) Comparative Study of the use of natural and artificial Coagulants for the treatment of Sullage(domestic Wastewater),https:/doi.org/10.1080/23311916.2017.1365676. Pp.2-14.