

COMPARATIVE STUDY OF EFFICIENCY OF LOCAL PLANTS IN WATER TREATMENT

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Abstract -

Coagulation is one of the main processes in water treatment systems. It is mainly done to remove colloidal as well as suspended particles that will not settle under plain sedimentation. Usually chemical coagulants like Alum and Ferric chloride are used for this purpose. Recent studies emphasis that these chemical coagulants are associated with Neurotoxicity and other polluting effects on environments. So here we were analyzed the efficiency of some locally available plants like Moringa, Cactus and Aloe vera for its coagulation efficiency. The improvement of water quality parameters like PH, Chloride, BOD, DO, and COD after treating with natural coagulants were also assessed. Moringa powder gave a removal efficiency of 97.5% with a dosage of 70mg/l and Cactus have 87.6% removal with 60 mg/l. Aloe vera could not give an efficient result that is necessary for an independent coagulant. It could give only 67% of removal efficiency in its optimum dosage. Coagulation is highly dependent on many physio chemical parameters like initial turbidity, P^H , temperature, contact time. For the complete analysis of natural coagulant as a substitute for conventional synthetic coagulants, all these factors should be considered in deep. So an optimisation study was done to find the optimum condition for getting economical and efficient results from natural coagulants. Optimisation study included the analysis of change in turbidity removal with initial turbidity, P^H , temperature, contact time. For that initial turbidity is varied artificially and it is tested for low (40 NTU), Medium (100NTU) and High(180NTU) turbidities. P^H is varied between 4 and 9. Temperature ranges of study was 10, 20, 35, 40°C. The contact time was varied as 0.5 to 1.5 hours. Optimisation study could improve the efficiency of natural coagulant to a very high extend.

Key Words: Chemical coagulant, Alum Neurotoxicity, Natural coagulant, Moringa, Cactus, Aloe vera, Sustainability

1. INTRODUCTION

Water, the elixir of life, is also the most abundant material in the nature, second to air. It has a paramount importance in almost all the natural and anthropogenic activities. For the development of human life as well as the ecosystems water carries a vital role. In the past times water is considered to

be infinite good, but currently misuse coupled with the drastic increase in demand has made this resource to shrink and lead to water scarcity. Only less than 1% of the whole water on earth is accessible to human and other living beings in the form of fresh water found in lakes, rivers and underground aquifers. About 97% is saltwater that fills the oceans and nearly 2% lies frozen in the Polar Regions. Water that exist on the earth can be in gaseous, liquid or solid state. As water has the ability to act as universal solvent, pure water is hard to found in nature. The major part of water contaminates due to inadequate treatment and disposal of wastes from human and also livestock, discharges from industries and over exploitation of these scarce resource.

Water is having a unique property of self-cleansing and self-purification by allowing pollutants to settle out through sedimentation and flocculation process. But very fine suspended particles present in the water which cannot be removed in plain sedimentation, may sometimes be settled by increasing their size by changing them into flocculated particles. For this purpose, a chemical compound (like alum, Ferric chloride and ferric sulphate) called coagulant is used. When these coagulant is added to the water to be treated, which on thorough mixing forms a gelatinous precipitate, called flocs. Fine mud particles and other colloidal particles get absorbed to this flocs, forming bigger size flocculated particles. The process of addition and mixing of coagulant called coagulation.

Chemical coagulants have superiority in clarifying the turbid water, still it lacking in terms of green chemistry and sustainability. Many studies pointed out the worse effects of chemical coagulants but all these studies are in its childish ages. Major problem is nothing but the increased amount of residual aluminium in treated water and is linked to serious health issues like Alzheimer's disease and Dementia. Presence of residual Al in treated water also reported to be concerned with reduced disinfecting efficiency. Increased volume of sludge produced is also make it difficult to handle and dispose it. These all factors are the background of these experimental study regarding natural coagulants and its optimum conditions. Here we have done the analysis of *Moringa oleifera*, Aloe vera and Cactus as natural coagulants in river water treatment. Also its efficiency in improving

other water quality parameters were also studied in this work.

1.1 Coagulation and Chemical coagulants

In water treatment, coagulation is a process that occurs when a coagulant is added to water to "destabilize" colloidal suspensions. Conversely, flocculation involves the addition of polymers that clump the small, destabilized particles together into larger aggregates so that they can be more easily separated from the water. Coagulation is a chemical process that involves neutralization of charge whereas flocculation is a physical process and does not involve neutralization of charge.

Coagulation itself cannot reduce turbidity. In fact turbidity may increase during coagulation process due to additional insoluble compounds that are generated by coagulant addition. The coagulation-flocculation process can be used as a preliminary or intermediary step between other water or wastewater treatment processes like filtration and sedimentation. Since the recent studies emphasis the relation of chemical coagulant with Neurotoxicity, and is no biodegradability arises threat on sustainable future. So it the farthest time to move towards natural coagulants. The factors influence coagulation is the type of coagulant used, its dose and mass; pH and initial turbidity of the water that is being treated; and properties of the pollutants present. The effectiveness of the coagulation process is also affected by pretreatments like oxidation.

1.2 Draw backs of chemical coagulant

Previous studies shows that chemical coagulants can have worse effect on human and environments. Major problem concerning chemical coagulant is increased residual aluminium in the treated water which is likely to serious health issues like Alzheimer's disease and dementia. Presence of residual Al in treated water also reported to be concerned with reduced disinfecting efficiency. Chemical coagulant in majority consist of synthetic organic polymer like acrylamide have neurotoxicity and carcinogenic effects. Untreated chemical monomer and the byproducts of polymer in water can also cause detrimental effects on human health. In case of Iron salts, negligence in process controls will lead to highly visible rust or stains caused by hydrolysis of iron salts.

Other major drawback of hydrolyzing type of metal coagulant is generation voluminous oxide sludge. About 99% of Alum sludge contain water and is hard to dewater these sludge. Alum sludge also cause phosphorous uptake from plants due to inorganic phosphorous absorption which leads to aluminium phytotoxicity. All their drawbacks of chemical coagulants demands other potential alternatives for water purification to diminish the environmental damages and to protect human life. So here we were studied about natural coagulants.

1.3 Natural coagulant

In the current scenario majority of water clarification is done by using chemical or synthetic coagulants. Some of them are Aluminum based and some others are Iron based. Coagulation flocculation process can also be done with natural coagulants. Natural coagulant can be a plant part which is safe for life and having the efficiency of forming flocs in coagulation flocculation process and thereby removing the colloidal and suspended impurities naturally. Natural coagulants are safe, ecofriendly and generally nontoxic in contrast to chemical coagulants. Primarily the volume of sludge generated by the natural coagulants are about five times lower than that generated by chemical based coagulants and these sludge will have a high nutritional value. More over all the sludge produced by the natural coagulants are free of toxic residuals which may have polluting effects on environment also linked to Alzheimer's disease in human beings. Thus the sludge treatment and handling cost are lowered and making it a more sustainable option. The plant extract used as natural coagulant are locally available, hence it can be considered as a low cost alternative to chemical and synthetic coagulants.

2. Materials and Methodology

2.1 Materials

2.1.1 Moringa

Moringa oleifera is a fast growing multipurpose tropical tree. It can grow up to 10-12m and trunk diameter 45 cm. The bark has a whitish grey colour and is surrounded by thick cork. The tree has open crown of drooping, fragile branches and leaves built up of feathery foliage of tripinnate leaves. Mainly it is used as food and has a wide usage for medicinal, industrial and animal feeding purpose. Recently emerging studies emphasize the coagulative efficiency of *Moringa oleifera*.

It is a drought tolerant and nutritious tree. In Asia and Africa the cultivation of MO become increasingly popular and it also an economically valuable crop. The antibacterial properties of MO powder make it useful as a natural clarifier for water purification systems and fish ponds. Earlier studies have found the *Moringa oleifera* seeds are non-toxic, and recommended its use as coagulant in water treatment.

2.1.2 Aloe vera

Aloe Vera specifically refers to the *Aloe barbadensis* Miller plant. Aloe Vera is the oldest medicinal plant ever known and the most applied medicinal plant Worldwide. This is a perennial tropical plant that can be cultivated in drought prone areas. In India, it is scattered in the wild, along the coast of southern India. It is a stem less or very short stemmed succulent plant growing to 60-100 cm (24-39 in) tall, spreading by offsets. The leaves are thick and fleshy,

green to grey-green, with some varieties showing white flecks on their upper and lower stem surfaces. Aloe Vera plant requires very less water for its growth as it contains 98% of water in its leaves. It contains around 75 nutrients and 200 active compounds including minerals, amino acids, enzymes and vitamins. Here the study is based on aloe leave extract is compared as natural coagulant with other natural coagulant plant parts.

2.1.3 Cactus

Opuntia ficus-indica is found in the plant family *Cactaceae*. This family comprising about 127 genera with some 1750 known species of the order Caryophyllales. In extremely hot and dry habitats and in most arid regions Cactus plant that can store large amounts of water and survive. There are around 2000 different species of cactus that differ in size, shape, color and type of habitat. Arid regions of South and North America consisting of almost all cacti species. Cacti can be seen in all over the world because of its attractive physiology. Over exploitation and habitat loss are major threats to the survival of cacti in the wild. Cactus *Opuntia* contains carbohydrates such as d-galactose, d-xylose and galacturonic acid. Galacturonic acid is the active ingredient that affords coagulation capability of *Opuntiasap*. It is highly possible that Galacturonic acid exist predominantly in polymeric form that provides a bridge for particles to adsorb on. The poly-galacturonic acid structure evidently indicates that it is anionic due to partial deprotonating of carboxylic functional group in aqueous solution.

2.2 Methodology

2.2.1 Coagulant preparation

Collected seed pods of *Moringa oleifera* are air dried for three to four days. Matured Pod shells were removed manually by using a knife; kernels were grounded in a domestic blender and sieved through 600 micron stainless steel sieve. This powdered form of moringa with varying dosage can be used as coagulant for water treatment. Prepared coagulants can be preserved in a refrigerator till the usage. At the time of experiment stock solution was prepared with different concentrations of moringa powder. This can be used as coagulant for water treatment. 20-100mg/l is taken for surface water samples.

Succulent Aloe Vera leaves were collected from some areas of paravur. The leaves were washed under the tap water to remove the dirt. Thick green cover or epidermis was carefully separated from the gel part. Then the gel part was blended in domestic mixer to form liquid and preserved in glass bottles in refrigerator. 1% dilution of aloe vera was made by using 1ml aloe vera gel in 100 ml distilled water similarly different percentage of aloe vera solutions were made to use as coagulant.

Fresh cladodes of *Opuntia ficus* was collected and washed. They were first dried to 80 degree Celsius and ground to powder. Sieved to obtain solids with diameter of 0.45 – 1.25 mm. The solids are then used as raw coagulant for surface water treatment.

2.2.2 Sample collection

Surface water was collected from Ithikkara River. Ithikkara River is a 56Km long river in Kerala, India. It originates in the Kulathupuzha hills in the Western Ghats and flows through the Kollam district, finally emptying into Paravur Lake. The village of Ithikkara is located on the river, 15Km from the port of Kollam. The river also flows through the settlements of Chathannoor and Pooyappally.

Surface water sample should be collected as per the standard procedures. Samples should be collected, as far as possible, from midstream at mid depths. Sampling too near the bank provide fictitious results. Sites should be selected preferably where marked quality changes occur and where there are important river uses such as confluences, major river discharges or abstractions. Sampling locations can be fixed by reference to significant features. In this connection use of reference maps may be helpful. The site should be reasonably accessible all the year round. Taking of samples from over the bridges is appropriate. Samples can also be taken from boats wherever feasible for rivers and lakes. Unsafe banks should be avoided. Wherever necessary, sampling should be made by a team using safety jackets. Sampling by wading, where the rivers are shallow, care being taken to collect samples upstream of the wader, who can disturb the bottom sediments.

2.2.3 Initial quality parameters

The physico chemical quality of sample water is first studied to determine the variations regarding this before after the commencement of experiments. For the assessment of quality of collected sample water parameter like initial turbidity, P^H , Total hardness, Chloride, BOD, DO, COD are studied.

Table -1: Initial quality of water

PARAMETER	INITIAL VALUE
Initial turbidity	50NTU
P^H	5.6
Total Hardness	140
Chloride	567.5mg/l
DO	2.2mg/l
BOD	1.4
COD	25ppm

2.2.4 Optimum dosage by jar test

Coagulation and flocculation are important unit processes in water and wastewater treatment plants. The purpose of coagulation/flocculation is to remove suspended matter, turbidity, color, microorganisms, and odor producing substances. Coagulation involves the addition of chemicals to destabilize the suspended particles, colloidal materials, and macromolecules. Some common coagulants used are aluminum sulfate (alum) and ferric sulfate. Here we had analyzed the various dosages of natural coagulants and its optimum dosages. Flocculation is usually defined as the aggregation of destabilized particles into larger flocs under slow mixing conditions. The flocs formed are subsequently removed by sedimentation and/or filtration. A useful laboratory experiment for the evaluation of coagulation/flocculation of an untreated water is the jar test. This test provides information on the effects of the concentrations of the coagulants, mixing of the raw water, and the water quality parameters such as pH and alkalinity on the coagulation process. The jar test is often used for the design of treatment facilities and in the routine operation of treatment plants.

Most extensively used method of coagulation-flocculation process is jar test analysis. The experiments were carried out batch wise in six number of beakers together with six number of rotating paddles. Sample was homogeneously mixed before conducting jar test experiments. Here the surface water sample that collected from itikkara river was used. Initial turbidity and other prominent physico chemical characteristics of water is assessed prior to this experiments. Natural coagulants like *Moringa oleifera*, *Cactus opuntia* and *Aloe vera* was prepared and the different concentrations added to the beaker. The rotating speeds for rapid mixing for one minute at 120 rpm and after that 20 minute of slow mixing at 40rpm were allowed. After that a settling time of 30 minutes is permitted. After all these steps the supernatant is collected using a pipette and final turbidity is measured in Nephelometer Turbidity Unit. Optimum dosage of a coagulant is that minimum dosage which corresponding to lowest residual turbidity.

2.2.5 Change in parameter after treatment

Table -2: Quality of water after treatment

Parameter	Change parameters after treatment		
	MO	Cactus	Aloe
Turbidity NTU	2	6	25
P ^H	6.8	7.2	6.6
Hardness mg/l	98	112	141
Chloride mg/l	201	556	567

DO mg/l	5.8	4.5	3.8
BOD ppm	nil	0.98	1.8
COD ppm	19	15	25

2.2.6 Optimisation study

Coagulation flocculation is highly dependent on many phyco chemical parameters like initial turbidity, P^H, temperature, contact time. The efficiency of a coagulant in removing the turbidity will depend on these characteristics. So the assessment of variations in result due to the change in the above mentioned parameters were incorporated with these project work. Thus to find the optimum conditions for the coagulation process so that we can have the most efficient result from natural coagulant. For the complete analysis of natural coagulant as a substitute for conventional synthetic coagulants, all these factors should be considered in deep. Optimisation study is refers to determine the most efficient natural coagulant that works economically and effectively.

3.Result and discussion

3.1 Optimum dosage

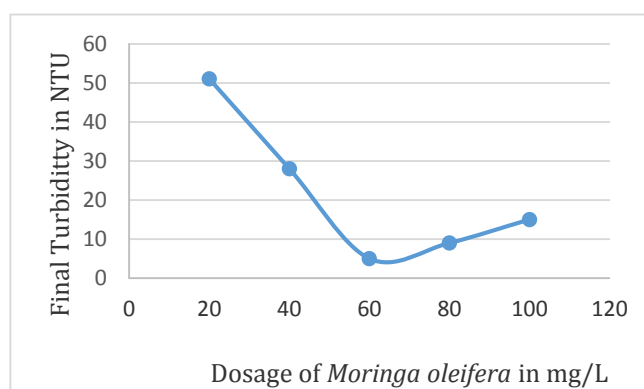


Chart -1: Turbidity variation with dosage of MO

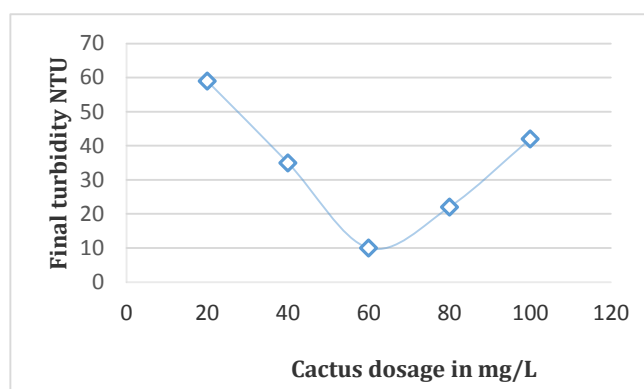


Chart -2: Turbidity variation with dosage of Cactus

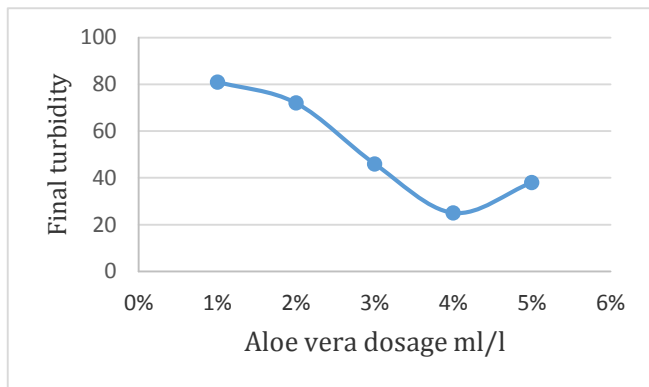


Chart -3: Turbidity variation with dosage of Aloe vera

For jar test analysis, water sample was collected from Ittikkara River. The initial turbidity of the collected sample in 82 NTU. This sample is taken for optimum dosage study. MO gave the most efficient removal of turbidity. The optimum dosage of MO was determined as 70mg/l with a maximum removal of 97.5%. Cactus also gave a comparable result with MO. The showed optimum dosage was 60mg/l with a maximum efficiency of 87.6%. Aloe vera is less efficient compared to the other two natural coagulants. 4% solution gave the maximum removal efficiency. The efficiency of removal is only 67%. So in short MO and Cactus were showed a comparable result with conventional chemical coagulants. But Aloe could not give an appreciable result in this surface water sample. So it cannot give a satisfactory result as an independent coagulant.

3.2 Optimisation study

Coagulation flocculation is highly dependent on many physio chemical parameters like initial turbidity, P^H , temperature, contact time. For the complete analysis of natural coagulant as a substitute for conventional synthetic coagulants, all these factors should be considered in deep. Optimisation study is refers to determine the most efficient natural coagulant that works economically and effectively.

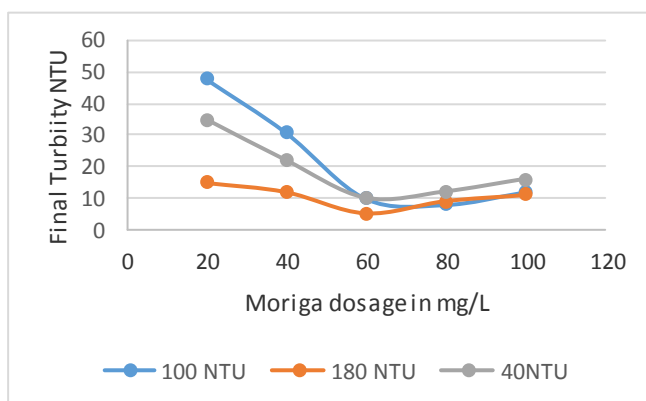


Chart -4: Variation of turbidity reduction with initial turbidity for MO

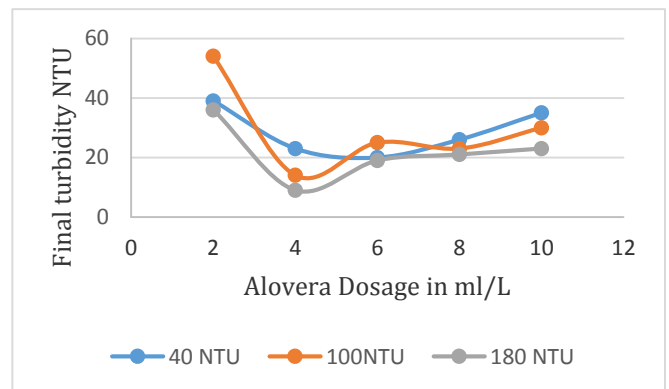


Chart -5: Variation of turbidity reduction with initial turbidity for Aloe vera

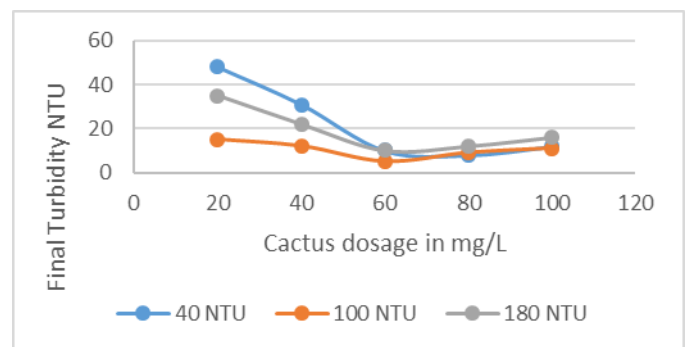


Chart -6: Variation of turbidity reduction with initial turbidity for Cactus

Turbidity removal efficiency variation for low, medium and high turbidity was studied. A turbidity range of 40-180 NTU were considered in analysis. Low turbidity 40 NTU, Medium turbidity 100 NTU and High turbidity 180 NTU water samples were considered. Itthikkara river water show wide range of turbidity throughout the seasonal variations. So it became necessary to study the influence of turbidity removal of natural coagulant. For low turbidity, removal efficiency of all natural coagulants were found to be low. As initial turbidity increases removal efficiency also increases. In low turbid ware MO show maximum of 75% of removal and for high turbidity it show 97.2% of efficiency in removing turbidity. In case of Aloe, similar to MO, it is less efficient in removing turbidity from low turbid water. Removal efficiency of Aloe in low turbid water is 50% and medium turbidity is 60%. It could give removal efficiency of 65% in high turbid water. Cactus gave 95% of removal efficiency in high turbid water and in low turbidity, it can gave only 70% of result. All the graph show an increase in final turbidity after optimum point, it was because excess amount of coagulant also could decrease removal efficiency.

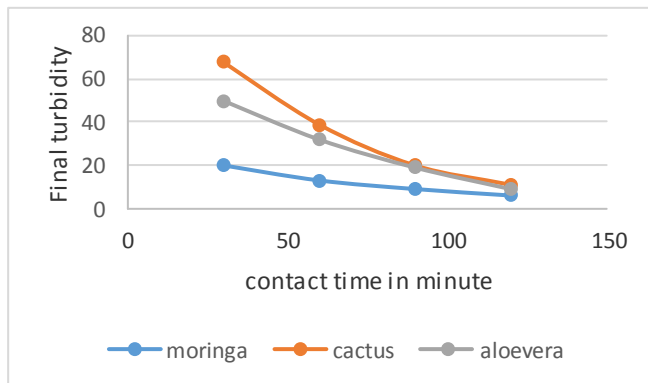


Chart -7: Variation of turbidity reduction with contact time

Contact time is an important factor that affect the removal of turbidity. Normally all coagulants will show increasing efficiency as contact time increases. But the rate of removal would go on decreasing as time passes. All the natural coagulants follow similar profiles in this experiment. As contact time increases removal of turbidity also increases. But too much contact time did not increase the overall efficiency of treatment system.

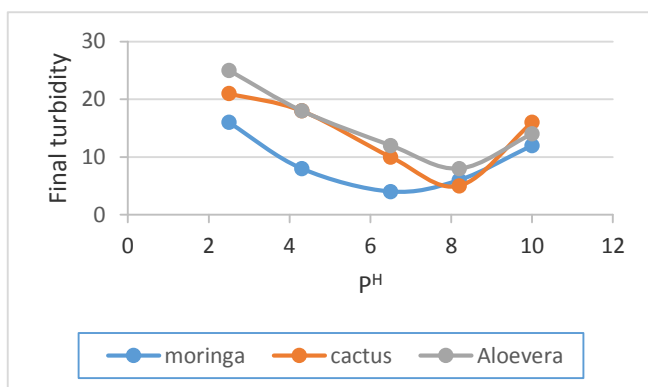


Chart -8: Variation of turbidity reduction with P^H

P^H is another vital factor in coagulation process. The data show a low degree of turbidity reduction at extreme temperatures. All the chemical coagulant have its own range of P^H for efficient performance during coagulation. Alum is having a very narrow range of P^H for good floc formation. The effective range of P^H for Alum is 6.5 to 8.3. So P^H adjustments should be done before the coagulation process commences. It also add to the overall cost of treatment and treated water quality. Ferric sulphate have a p range of 4 to 7 and above 9. Performance of natural coagulants are found to be good for a wide range of P^H. So adjustment is not necessary in n natural coagulants.

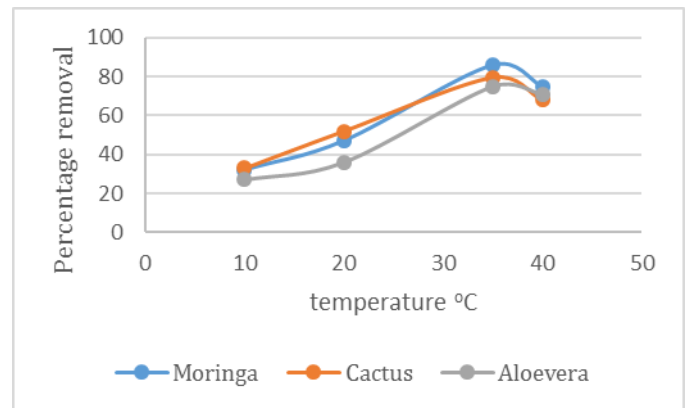


Chart -9: Variation of turbidity reduction with temperature

All natural coagulant that we considered in this study show low removal efficiency in low temperatures. We had studied 10°C, 20 °C, 35 °C and 40 °C. Efficiency of turbidity removal increase with increase in temperature. The best result obtained at 35 °C then coagulation activity get retarded. It may be because of the disintegration of flocs at higher temperature. Lower temperatures can also cause breakage of flocs that formed during coagulation. But higher temperatures are also not suitable for natural coagulants. It is because natural coagulants are basically proteins. High temperature can hamper the activity of proteins. Alum is less efficient in low temperatures. But natural coagulants could give much improved results than Alum.

4. Conclusion

- From these studies MO is found to be the most efficient natural coagulant with a removal efficiency of 97.5 % with an optimum dosage of 70 mg/l, cactus with an optimum dosage of 60mg/l, show 87.6% of removal. These two are comparable result with the alum. But aloe vera is less efficient and gave only 67% of removal efficiency.
- Natural coagulant work well in 35° C and which is normal temperature of surface water. Extremely high and low temperature was also got affected the coagulation of chemical as well as natural coagulant.
- The optimum P^H in case of alum is 6.5 – 8 which is a very narrow range. The P^H showed have to be adjusted before coagulation process. But natural coagulation are efficient in wide range of P^H. The experiment showed a low degree of removal at extreme P^H.
- Increase in contact time also increases efficiency. Maximum removal was found at 120 minutes. As time increased, rate of removal decreased. But too much increase in contact time cannot contribute to the removal efficiency.

- So natural coagulant like MO and Cactus can independently use as in coagulation procedure. It can give better results in all conditions. But Aloevera can only be used as coagulant aid. It can give a sustainable solution for the problems associated with chemical coagulants.
- Further study is required in this field for analyzing parameters like mixing speed, method of extraction of coagulant and influence of these parameters in coagulation efficiency.

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