



# Improving Drinking Water Quality using Organic Coagulants “Aloe Vera”

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## ABSTRACT

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. 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. Coagulation is a conventional step of water purification and bio coagulants are new horizon to go green, turbidity, Ph, hardness import a great problem in water treatment. The pH of human blood is strictly maintain the lungs and kidney spare nothing to keep the pH tightly controlled since the consequences of the blood pH changes would be life threatening. The coagulation–flocculation–sedimentation process is widely used for removal of suspended solids and water turbidity reduction. The most common coagulants used to conduct this process are aluminum sulfate and ferric sulfate. In this research paper, the use of Aloe vera as a natural-based coagulant for drinking water treatment was tested. The bio-coagulant was used in two different forms: powder as well as liquid; the latter was extracted with distilled water used as a solvent.

**KEYWORDS-** Organic Coagulants, Aloe Vera, Coagulation, Flocculation, Sedimentation, Water Treatment

## 1. INTRODUCTION

### 1.1 BACKGROUND OF THE STUDY

Water is a precious and essential natural resource, unevenly distributed on our planet. Freshwater represents only 2.5% of global supplies of water. About 70% of this freshwater quantity are either trapped under ice caps, or disseminated in the form of humidity or steam. Less than 1% of the world's freshwater, about 0.007% of planet's waters, are easily accessible to the various uses for development. 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*, *Aloevera* and *Cactus* as natural coagulants in river water treatment. Also its efficiency in improving other water quality parameters were also studied in this work. Water is a vital resource, but presents a worrisome depletion in recent times. Adequate water supply for human consumption is a concern, since most of this resource is found in oceans where the high salt content makes it unsuitable for drinking. Features such as growing population, increased

economic activities and industrialization have resulted in high demand for drinking water and the subsequent misuse of this natural resource, which is severe. This hinders the treatability process and increases water treatment costs. For these reasons, coagulation-flocculation procedures associated with other processes are of great importance in order to separate contaminating component sand achieving high degrees of drinking water quality. Coagulants are chemicals that water needs to help the process of precipitation of small particles that can't settle by themselves. Commonly, industrial treatment used inorganic coagulants such as alum, PAC, ferric chloride, ferric sulphate and cation polymer in their waste water treatment. Inorganic coagulants are more effective than organic coagulants, but in high doses, they may cause precipitates that are difficult to treat. This reason make organic coagulant as an alternative to replace inorganic one. Plant seeds are commonly used as organic coagulants raw material. *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 shortstemmed 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.

### 1.2 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.

### 1.3 NATURAL COAGULANTS:

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.

### 1.4 HISTORY OF ALOE VERA:

The several thousand years' history of Aloe vera plant is a fascinating and captivating as a best seller historical novel. Long know for its legendry therapeutic properties, it was considered by some civilizations as the God. The curative virtues of the aloe are already known during ancient times. Authentic facts, testimonial and legendary

narrations recount its history. In the Bible, the spices is frequently cited as being used in herbal medicine since the beginning of the first century AD, because it is mentioned in the New Testament (John 19:39- 40) and there came also Nicodemus, which at the first came to Jesus by night and brought a mixture of myrrh and aloe. Aloe vera also known as the medicinal plant is a species of succulent plant that probably originated in North America. "If Aloe vera was to be discovered today, and its remarkable healing properties investigated, it would be hailed as the "wonder drug of this century". Aloe vera, on the other hand, has always been a natural product in whatever forms it has been used. Derived directly from the plant's leaves, Aloe vera is so effective in its natural state that no compelling reason has been found to spend the time and the enormous sums of money necessary to develop a synthetic version. It is hardly surprising then, that the wonder plant, Aloe vera, might spring from this tradition of using natural botanicals. Since 1979, Aloe vera has been the subject of increasing, vigorous, scientifically based investigations. Aloe vera (L) a number of families Lilliaceae is a popular perennial succulent plant. Aloe vera is a semi tropical plant. There are over 250 species of Aloe grown around the world. It contains more than two hundred tonic ingredients including essential amino acids, minerals, vitamins, enzymes and steroids. Also contains the most essential components required by the human body. It is grown wild in hedge-rows in dry soil conditions and almost all parts of India. It can be grown even under constant drought conditions. Commercial cultivation and utilization of this plant with the application of technology can be of great value. Aloe vera is a succulent prickly plant of the Lily Family which grows in warm, frost-free climates and which has been known for centuries as a potent medicinal plant according the "folk medicines" of cultures around the world. Scientific and medical research teams have investigated Aloe in many countries but especially in the United States and Japan. Much of this research is of high quality, which underlines the considerable status that Aloe has attained as a herb with well proven medical attributes. At the same time one should call into question any claims for Aloe vera (or any other substance) for which there may be a lack of enough medical evidence.

## 1.5 OBJECTIVES OF THE STUDY:

- To study the performance of abundantly available plant products such as aloe vera gel and alum mixture in water treatment.
- To study turbidity removal for raw water with different dosages of aloe vera and alum
- Also to study the pH changes with addition of alum

## 2. LITERATURE REVIEW

### [1] Study and Analysis of PAC And Aloe vera as A Coagulant for Wastewater Treatment

Rajpure Kiran S , Mule Rakesh B , Mande Viraj V, Shinde Rajaram.B [2019], This study focused on various treatment to treat the water efficiency. Among these process coagulation is the best process to remove the colloidal particles from the water. The raw water sample collected from sewage treatment plant (STP) situated in Daund area. The optimum dose which is used for the treatment is obtained by the jar test, and applied the dosage of PAC of 35 mg/l , 55mg/l and 45mg/l respectively and dosages are 1ml/l , 2ml/l and 3ml/l respectively. We have determine the physical and chemical properties. PH , BOD , COD , TDS , TSS of the wastewater before and after applied the STP .

### [2] USE OF ALOEVERA JUICE FOR WASTE WATER TREATMENT BY COAGULATION AND FLOCCULATION

Chinchu K Georgea , Anitha K [2018], In this paper natural coagulant Aloe vera gel has been used as a coagulant to treat the water. Waste water sample collected from dairy plant is used. pH, dosage, COD and turbidity and the effect of variation of dosage and pH were studied on turbidity and COD. The optimal dosage of each coagulant was determined in the beginning and this dosage was further used to find optimal pH. Turbidity and COD of all samples are studying and the efficiency of all the coagulants are recording.

### [3] Plant Based Coagulant For Waste Water Treatment

T.Subramani , C.Kathirvel , H.Harris Mohamed , M.Mohamed Nowfis , A.Niyasdeen [2018], Water is one of the essential things for human survival. In rural areas those people who were living in extreme poverty, they are drinking contaminated water because of high procurement cost of chemical coagulants and high cost of

water treatment process. Usage of plant based coagulant instead of chemical coagulant is the best solution for above mentioned problems Usage of plant based coagulants like "Mung bean, Peanut seeds, Cactus, has many like low procurement cost, and biodegradable sludge production. After several months of studies and investigations we come up with the solutions for waste water treatment, our project gives a new way to treatment of waste water by plant based coagulants.

### [4] USE OF ALOE-VERA GEL AS NATURAL COAGULANT IN TREATMENT OF DRINKING WATER

Hitesh S. Patil , Sanket A. Shinde , Ganesh A. Raut , Nilesh P. Nawale , Prof. Ashish Hakke , Prof. Manoj Deosarkar [2020], Now a days India is developing country in the world. Water is the most important element of among the natural resources. In many developing countries, access to clean and safe water is a big critical issue. More than millions die people because of diarrhoea which is caused by polluted water. Developing countries pay cost high to import chemical for water treatment. In our country, we need to use our surface water sources therefore save our water bodies which are contaminated due to disposal of uncontrolled domestic and industrial waste water, so water treatment is a must duty to us. Coagulation is a conventional step of water purification and bio coagulants are new horizon to go green, turbidity, Ph, hardness import a great problem in water treatment. The pH of human blood is strictly maintain the lungs and kidney spare nothing to keep the pH tightly controlled since the consequences of the blood pH changes would be life threatening. Moringa oleifera and aloe vera where used as local locally available natural coagulant in this study to reduce turbidity, pH, hardness. Many chemicals are also associated with environmental problem and human health. So, there raised a voice to develop cost effective, easier and environmental friendly process of water clarification so, that's why natural coagulation are used such as a aloe-vera, moringa oleifera. Desirable to substitute this chemical coagulants with natural coagulant cost effective to outside the aforesaid disadvantages. So water treatment is a most used to us, aim of using all of these coagulant to make the mix proportion to treatment of the water.

## [5] Use of Aloe vera as an Organic Coagulant for Improving Drinking Water Quality

Abderrezzaq Benalia ,Kerroum Derbal, Amel Khalfaoui [2020], All the experiments conducted in this study were performed on natural raw water with an initial turbidity of 13 NTU obtained from a drinking water treatment plant. In this work, two forms of bio-coagulants obtained from Aloe vera were used. The obtained results show that the turbidity was reduced to 6.0 NTU at pH 6 and to 1.42 NTU at pH 7.5 when AV-Powder and AV-H2O were used, respectively. It can be highlighted that the residual turbidity from AV-H2O addition was less than 5 NTU and fulfills the quality standards of the Algerian drinking water law [37]. Moreover, the use of natural coagulants in water treatment had no significant effect on several parameters such as pH, total hardness, total alkalinity, and salinity, whereas the concentrations of organic matter increased. This experimental study has proved that Aloe vera can be successfully used as a natural coagulant for drinking water treatment. Both AV-Powder and AV-H2O can improve the final drinking water quality. Therefore metal-based coagulants, such as Aluminum sulfate, Ferrous sulfate, Ferric Chloride, etc., can be replaced with natural coagulants without reducing the process performance. This study opens new perspectives of research on the development of natural coagulants to treat surface water, groundwater, wastewater, and industrial water, as well as on extraction processes to obtain liquid coagulants from Aloe vera, and finally on the solvent recovery procedure after extracting process. However, further investigations in pilot and full-scale plants are necessary in addition to a cost-benefit analysis to comprehensively understand the potential of bio-coagulants in water treatment.

## 3. PROPOSED METHODOLOGY

### 3.1 MATERIALS USED

#### 3.1.1 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.



[Fig.3.1: Aloe Vera]

## 3.2 EXPERIMENTAL SETUP

### 3.2.1 Preparation of Aloe Vera gel

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 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.

### 3.2.2 Preparation of Aloe vera gel aqueous solution

50 mL of gel were introduced into 500 mL of distilled water and stirred using a magnetic stirrer, then strained through a sieve of 25 mm mesh. The filtrate collected was stored in refrigerator until the use which not exceeding one week.



[Fig.3.2: Preparation of Aloe vera gel aqueous solution]

### 3.2.3 Jar test Experiments (test of coagulation-flocculation)

The coagulation-flocculation was performed according to the protocol of "Jar Test". Increasing doses of Aloe vera were introduced in 500 mL of dairy waste water. After settling time, 100 mL of the supernatant were collected in the average of 2 and 3cm from the surface using a pipette and subjected to the same physicochemical analyzes of the dairy raw water.

The removal efficiency of the analyzed parameters was determined by the formula below;

$$\text{Removal parameter in percentage} = 100 * (C_i - C_f) / C_i$$

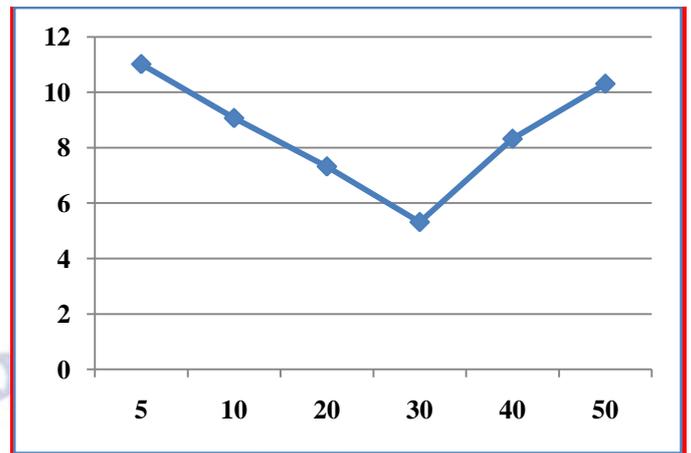
Where:  $C_i$  represents the concentration of the parameter in the raw water.

$C_f$  represents the concentration of the same parameter in the treated water.

## 4. RESULTS AND DISCUSSION

Table 4.1: Effect of alum as a coagulant in turbidity removal

S.No.	Residual Turbidity(NTU)	Alum dose (mg/l)
1.	5	11.02
2.	10	9.07
3.	20	7.32
4.	30	5.31
5.	40	8.32
6.	50	10.31
7.	60	13.01

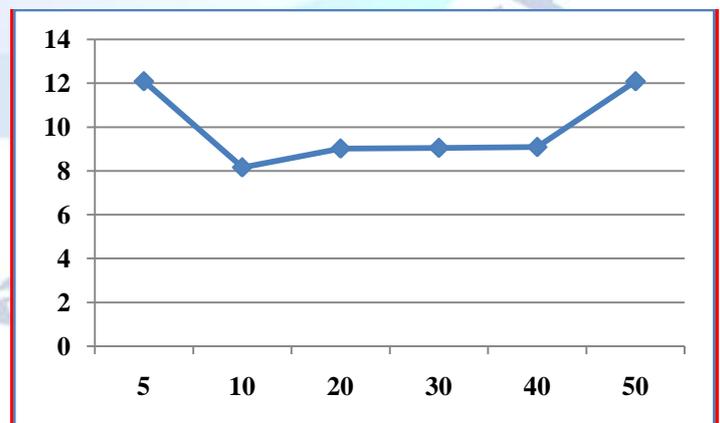


[Fig.4.1: effect of alum on turbidity]

Experiments were carried out using alum as coagulant for dairy waste water. Alum dose was varied in the range of 5- 60mg/l. In results it was found that for effective turbidity removal alum dose required was high. The maximum removal efficiency was found 91% for dairy waste water for alum dose of 30 mg/l . Fig.4.1 shows the effect of alum dose on turbid water.

Table 4.2: Effect of different percentage of aloe vera gel on turbidity

S.No.	Residual Turbidity(NTU)	Aloe Vera dose (%)
1.	0	12.08
2.	5	8.15
3.	10	9.01
4.	20	9.04
5.	30	9.08
6.	40	12.08
7.	50	11.09



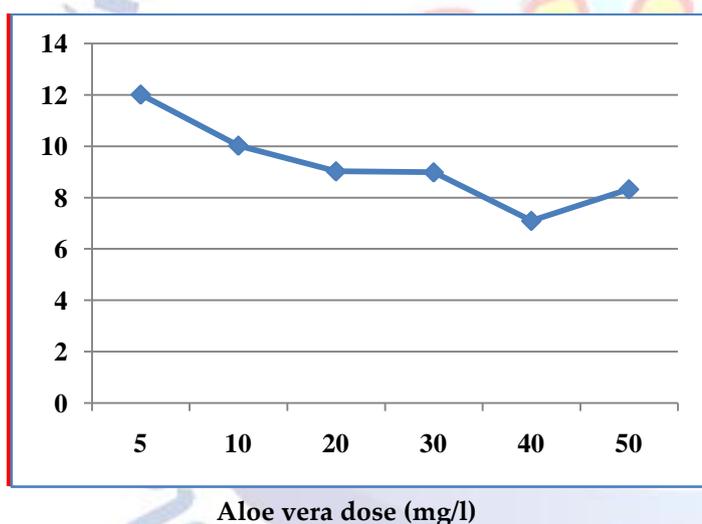
[Fig.4.2: effect of aloe vera dose on turbidity]

Jar tests were carried out for different percentage of dilution of Aloe Vera gel such as 1%, 4%, 5%,

7%,10%,15% . For dairy turbid water the alum dose was kept constant of 10mg/l, 40ml/l of Aloe Vera dose was given from each of diluted solution made. For dairy waste water 5% dilution of Aloe Vera gel was found to be effective. For dairy waste water removal efficiency found was between 75-80% . Following graph shows the variation of different percentage of Aloe Vera gel on dairy waste turbid water.

**Table 4.3: Effect of Aloe Vera gel as coagulant aid with alum for turbidity removal**

S.No.	Residual Turbidity(NTU)	Aloe Vera dose (mg/l)
1.	0	12.01
2.	5	10.02
3.	10	9.02
4.	20	8.98
5.	30	7.09
6.	40	8.32
7.	50	10.02



**[Fig.4.3: effect of aloevera dose with 10mg/l constant alum dose]**

From the above results it was shown that 7% dilution of Aloe Vera gel was found to be effective. Jar tests were performed for the 10 mg/l of constant alum dose and various doses of Aloe Vera gel for turbid water. In results it was found that for 10mg/l of alum dose and 30ml/l of Aloe Vera dose maximum turbidity removal efficiency was achieved. For dairy waste turbid water it varied between range of 76- 81% . In fig the effect of Aloe Vera gel on turbid water was given below.

#### FUTURE SCOPE

The usage of plant based natural coagulants represents a fundamental development in sustainable environmental

technology for the improvement of quality of life for communities. In an era of increasing environmental concerns, water scarcity admits the draw backs of chemical coagulants and poor sanitary facilities in most low income earning countries, the need to further develop natural coagulants as alternative environmentally favorable water purifying chemicals is exigent. The usage of bio-coagulants derived from plant based sources represents a vital development in 'grassroots' sustainable environmental technology through cost effectiveness. Design natural water purification techniques using plants extracts for bioremediation of turbid water. Application of this lowcost protocol will be recommended for simplified, point-of-use, low risk water treatment where rural and peri-urban people living in extreme poverty are presently drinking highly turbid and microbiologically contaminated water. The ultimate purpose of proposed research study is to come up with a compendium of plant coagulants that could be used as a technology that is cost effective and ecofriendly. It is felt that further research can be conducted by using the information described in this review as a platform to discover other plant species which are non-toxic and can be mass produced.

#### 5. CONCLUSION

At the end of our study, Aloe vera can be used as natural flocculant for water treatment. It was also found that the use of this plant even in low doses can rid the highly charged water of their suspended materials therefore their turbidity. For optimal doses, the percentages of reduction are high, 75% for turbidity and 91% but this reduction is low for the apparent color. The use of Aloevera, whose pharmacological properties have already been demonstrated, would be a possible alternative to chemical flocculants for the same treatment of drinking water in rural areas, only that it could increase the organic matter in the water account given its high levels in this element (approximately 81.05% organic matter).

The results showed that the amount of alum required was high for effective removal of turbidity. Aloe Vera can be used as natural flocculent for water treatment. Use of Aloe Vera gel as coagulant aid with alum can effectively reduce the amount of alum required. Owing to various problems associated to alum, use of Aloe Vera gel with alum as a coagulant aid can be new alternative for

drinking water treatment. For dairy waste water removal efficiency was found to be 76- 80%. For 7% dilution of Aloe Vera gel optimum 40ml/l of Aloe Vera dose was found more effective. Also it was found that Aloe Vera have less effect on other water quality parameters like pH, EC, hardness, COD. As a conclusion, Aloe Vera gel is proven to be effective coagulant aid which can be used in rural areas where Aloe Vera plant availability is more.

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#### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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