USE OF PLANT BASED COAGULANTS FOR WATER TREATMENT

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ABSTRACT

Coagulation is one of the most important processes to remove colloidal particles and color from water and the chemicals used for the process are called coagulants. The most commonly used coagulant for water treatment is alum i.e.; aluminium sulphate. The use of Alum as a coagulant for the treatment of water has scientifically proven to be harmful to humans. Years and years of consumption of water treated with alum has proven to cause Alzheimer's disease, damage the nervous tissues, and many other ailments in several human beings. It also has a lot of cons; like it produces a lot of sludge, has a tendency to change the pH of water, tendency to corrode the pipes carrying treated water, etc. Also, the cost of importing alum is difficult for some developing countries. Here is where the use of plant based coagulants comes in. They are not harmful to humans, don't produce a lot of sludge and can be available even in developing countries. In this paper, plant based coagulants like Chickpeas, Palmyra Palm (Borassus flabellifer), Peanut seeds (Arachis hypogaea), and Aloe Vera are being used to treat water collected from Kadamprayar river. The coagulants were chosen on the basis of their easy availability. The characteristics of the water sample like pH, turbidity, TDS, BOD, electrical conductivity, hardness, chlorides etc before and after coagulation with plant based coagulants are compared with that of alum. The percentage efficiency of turbidity removal is also determined for each coagulant to determine which coagulant is the most efficient out of the six plant based coagulants that have been chosen.

Keywords:- *Plant based coagulants, alum, coagulation.*

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1. INTRODUCTION

One of the first of the several steps that municipal water suppliers use to prepare water for distribution is getting it as clear and as particulate-free as possible. To accomplish this, the water is treated with aluminum sulfate, commonly called alum, which serves as a flocculant. Raw water often holds tiny suspended particles that are very difficult for a filter to catch. Alum causes them to clump together so that they can settle out of the water or be easily trapped by a filter [1]. It has several disadvantages though. Alum only works within a certain pH range, large amounts are often required, and it produces a lot of sludge. Plus, the sludge it creates is not very easy to de-water because it becomes very gelatinous [2]. High carbon footprint, detrimental human health effects linked with presence of residual alum in treated waters, environmental pollution due to improper disposal of raw alum sludge, costly practices of sludge disposal as hazardous waste in sanitary landfills, and health and environmental impacts linked with bauxite mining activities are the other cons. This is where the use of plant based coagulants comes in. Plant-based coagulants represent a renewable, non-hazardous, degradable, potentially carbon-neutral option, and are receiving increased attention for replacing conventional coagulants. A drawback of plant-based coagulants for their application in process-scale-up is the increase of organic loads (as COD/BOD) in treated water particularly if non-purified extracts are used. Other challenges include production of sufficient amounts to replace conventional coagulants, and breakthrough in acceptability by potential investors for plant-based coagulants. The most conventional method of preparing the coagulant extract is through the use of distilled water (DW) as solvent [3].

2. METHODOLOGY

2.1 Location

Water samples were collected from Kadambrayar river. Rampant dumping and illegal discharge of sewage into the Kadambrayar is poisoning the ecosystem of one of the few freshwater sources remaining in the district. Kadambrayar starts from Kizakkambalam wetlands and receives about 40 minor streams to form a creek that runs to nearly 7.52 kilometres before joining the Chitrapuzha at Brahmapuram. It passes through Kizhakkambalam, Kunnathunadu, Maradu, Thiruvaniyoor, Chottanikkara, Tripunithura and Thrikkakkara. Kadambrayar is the source of water for nearby panchayats as well as a host of industries, including the Cochin Special Economic Zone at Kakkanad, apartment complexes and a leading water theme park near the water body.Several farmers and families of fishers had depended on Kadambrayar for their livelihood a few years ago. The arrival of Brahmapuram Diesel Power Plant has increased pollution in this river. The condition has become worse after the waste disposal plant came up. As there was no scientific solution for proper disposal, leachate, a black coloured liquid coming out of solid waste, was directed into Kadambrayar. Dumping tons of solid waste without any restriction has affected the natural flow of the water.

2.2 Sample collection

When collecting samples, one must follow predetermined sampling protocols which have been chosen to meet the purpose of the survey, and which are appropriate to the media being investigated. For lakes and the ocean, the sampling point will be selected after taking into consideration such factors as geography, whether there are freshwater (rivers or streams) or wastewater inflows, depth, tides, currents etc.

Water sampling can be done by grab sampling or composite sampling. In grab sampling, samples are collected at a particular time and space. They represent the composition at that time and place. When a source is known to vary in time e.g.in case of waste effluents, grab samples collected at suitable time intervals and analyzed separately. In composite sampling, composite samples are a mixture of grab samples collected at one sampling point at different times. The composite samples are useful for observing values. Individual samples are collected in wide mouth bottles every hour and mixed in volume proportional to the flow or by using specially designed automatic sampling devices.

The type of water sampling tool required will depend on the sampling site and the type of sample to be taken. Sampling can be achieved using buckets, open water grab samplers, or vertical and horizontal messenger activated samplers. The size and type of sample to be taken will determine the type of sample container required [4]. Here, 5 liter bottles were used to collect the samples. They were immediately brought to the laboratory and refrigerated.

Fig-1: Collection of water samples from Kadambrayar

2.3 Coagulants used and their preparation

2.3.1 Aloe Vera

Aloe Vera is a stem less or very short-stemmed 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. The margin of the leaf is serrated and has small white teeth. The flowers are produced in summer on a spike up to 90 cm (35 in) tall, each flower being pendulous, with a yellow tubular corolla 2–3 cm (0.8–1.2 in) long[5]. Aloe Vera was sourced locally and the fleshy part of the stem was cut into smaller pieces. The flesh was mixed in a mixer and 1ml of the solution was made up to 100 ml. This solution was then transferred to a beaker and placed onto a magnetic stirrer for the active extraction of ingredients.

Fig-2: Aloe Vera plant and its preparation

2.3.2 Chickpeas

The chickpea or chick pea (*Cicer arietinum*) is an annual legume of the family Fabaceae, subfamily Faboideae. Its different types are variously known as gram or Bengal gram, garbanzo or garbanzo bean, Egyptian pea, chana, and chole. Chickpea seeds are high in protein. It is one of the earliest cultivated legumes, and 7500-year-old remains have been found in the Middle East. The plant grows to 20–50 cm (8–20 in) high and has small, feathery leaves on either side of the stem. Chickpeas are a type of pulse, with one seedpod containing two or three peas. It has white flowers with blue, violet, or pink veins. Several varieties of chickpea are cultivated throughout the world. *Desichana* closely resembles both seeds found on archaeological sites and the wild plant ancestor of domesticated chickpeas, *Cicer reticulatum*, which only grows in southeast Turkey, where chickpeas are believed to have originated [6].

Chickpea powder was sourced from a local market in Aluva. 1 gram of the powder was weighed out onto a china dish. Few drops of water were added to make a fine paste. This was made up to 100ml using distilled water in a standard flask. This solution was then transferred to a beaker and placed onto a magnetic stirrer for the active extraction of ingredients. This is how chickpea coagulant solution was prepared from chickpea powder.

Fig-3: Chickpeas and its preparation

2.3.3 Palmyra Palm

These massive palms can grow up to 30 m (98 ft) high and have robust trunks with distinct leaf scars; in some species the trunk develops a distinct swelling just below the crown, though for unknown reasons. The fruits are 15–25 cm wide, roughly spherical and each contain 1-3 large seeds. Depending on species, fruit color varies from black to brown, yellow or orange; the fibrous pulp is aromatic and sweet to taste. Each seed is enclosed in a woody endocarp, which protects it when the fruit is consumed by elephants, monkeys and other frugivores. At germination, the young seedling extends downwards into the soil and only a few leaves are visible above ground; this provides some protection against frequent fires in its savanna habitat; after an indeterminate number of years (the establishment phase), the seedling forms a stem and quickly grows above the savanna vegetation, where it is then less vulnerable to fire. Palmyra palms are economically useful and widely cultivated, especially in South Asia and Southeast Asia. The Palmyra palm has long been one of the most important trees of Cambodia and India, where it has over 800 uses [7].

Fig-4: Palmyra Palm and its preparation

2.3.4 Peanut seeds

The peanut, also known as the groundnut, goober (US), or monkey nut (UK), and taxonomically classified as *Arachishypogaea*, is a legume crop grown mainly for its edible seeds. It is widely grown in the tropics and subtropics, being important to both small and large commercial producers. It is classified as both a grain legume and, due to its high oil content, an oil crop. World annual production of shelled peanuts was 44 million tonnes in 2016, led by China with 38% of the world total. Atypically among legume crop plants, peanut pods develop underground (geocarpy) rather than above ground [8].

Fig-5: Peanut seeds and their preparation

2.4 Experiments conducted

Characteristics like pH, turbidity, salinity, chlorides, hardness, conductivity, DO, BOD of the sample are determined soon after collection of sample. pH, turbidity, salinity and electrical conductivity of the sample of water are determined using a water analyzer. Chlorides, hardness, DO, and BOD are determined using titration analysis. After this the water is treated with the above mentioned coagulants using jar test apparatus and optimum coagulant dosage is determined. The characteristics of the optimum water sample are determined again and compared with the results obtained before coagulation. Based on this, the removal efficiency of turbidity (%) is found out.

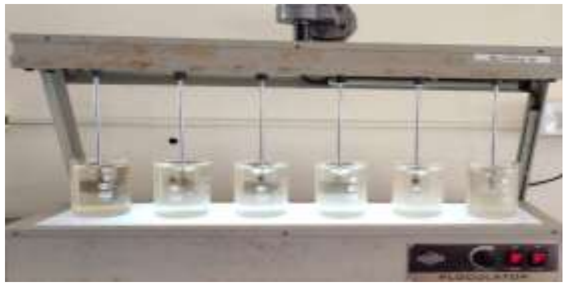

Fig-8: The jar test apparatus

3. RESULTS

3.1 Initial characteristics before coagulation

The initial characteristics of the sample of water were determined soon after it was brought to the lab, as shown in Table 1.

Table -1: Initial characteristics of water sample

Characteristic	Value
Turbidity	26 NTU
pH	6.43
Salinity	0.06 ppt
TDS	52.9 ppm
Conductivity	104µS
D.O	9.1 mg/l
Chlorides	95.97 mg/l
Hardness	63.82 mg/l
B.O.D	325 mg/l

3.2 After coagulation

3.2.1 After coagulation with Aloe Vera

Fig-9: Jar test using Aloe Vera

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. Aloe Vera 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.

Table- 2: Results of jar test using Aloe Vera

Coagulant dosage (ml)	Turbidity (NTU)
1 ml	7 NTU
2 ml	6 NTU
3 ml	3 NTU
4 ml	4 NTU
5 ml	6 NTU

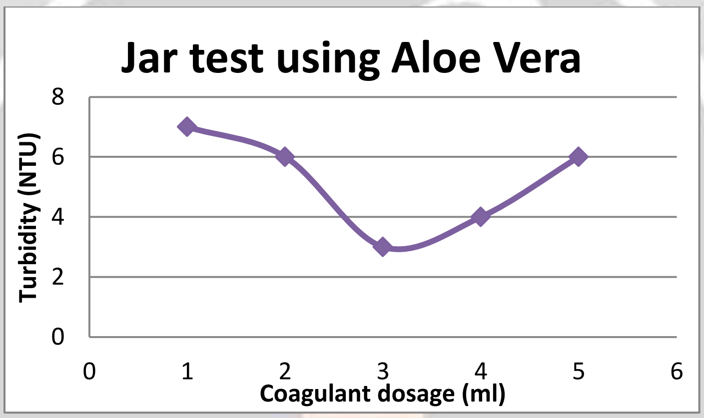

Chart-1: Jar test using Aloe Vera

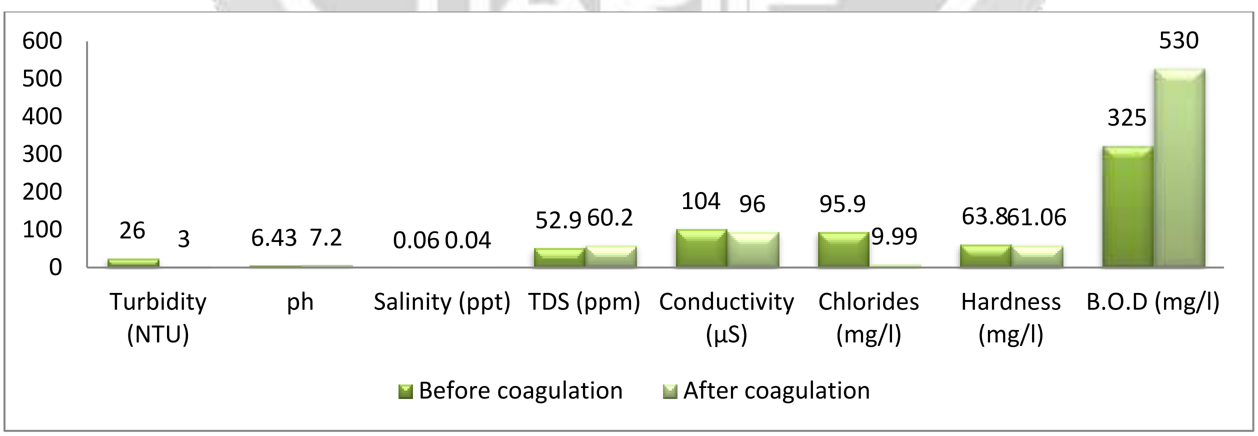

Chart-2: Graph showing the variation in the characteristics before and after coagulation with Aloe Vera

3.2.2 After coagulation with chickpeas

Fig 10: Jar test using chickpeas as coagulant

Jar tests were conducted using chickpeas as the coagulant. It's found that the optimum coagulant dosage was 2 ml, as shown in Table 2.

Table- 3: Results of jar test using chickpeas

Coagulant dosage (ml)	Turbidity (NTU)
1 ml	20 NTU
2 ml	11 NTU
3 ml	16 NTU
4 ml	21 NTU
5 ml	25 NTU
6 ml	30 NTU

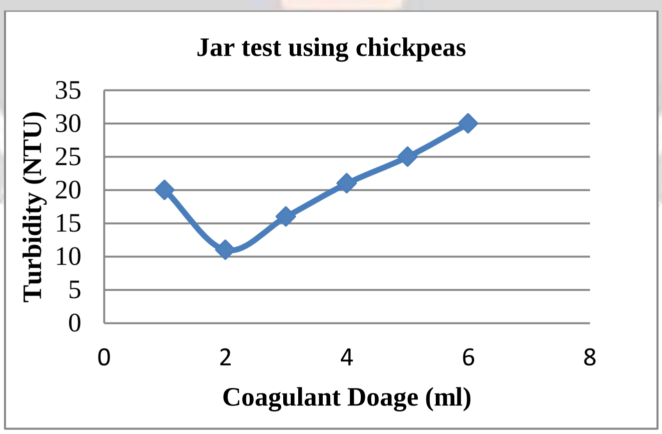

Chart-3: Optimum coagulant dosage when chickpeas were used as coagulant

Chickpea is capable of working in all the condition of this surface water without bringing major changes in the pH level. Moreover, it reduces colour and turbidity at a high rate with very less usage. So it definitely can be an alternative to the conventional synthetic coagulants.

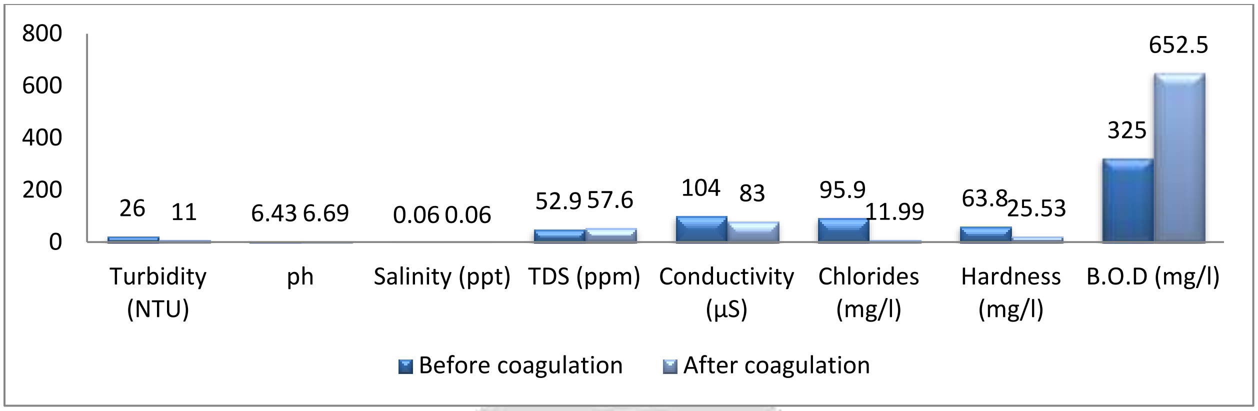

Chart-4: Graph showing the variation in the characteristics before and after coagulation with chickpeas

3.3.3 After coagulation with Palmyra Palm

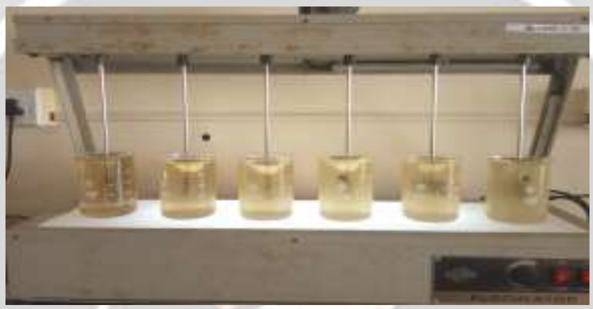

Fig-11: Jar test using Palmyra palm

Table-4: Results of jar test using Palmyra palm

Coagulant dosage (ml)	Turbidity (NTU)
0.5 ml	9 NTU
1 ml	8 NTU
2 ml	22 NTU
3 ml	39 NTU
4 ml	49 NTU
5 ml	72 NTU

1 ml was the optimum coagulant dosage for Palmyra palm as seen in Table 3. It is a coagulant and a rather successful flocculant. Furthermore, its natural origin makes it an economic and ecological agent because it is biodegradable, not toxic and generates less sediment than the use of alum. The casein from Palmyra palm acts as a good substitute or alternative to salts of aluminum and other synthetic polyelectrolyte in water treatment. The residual muds can be used as organic amendment on agricultural lands.

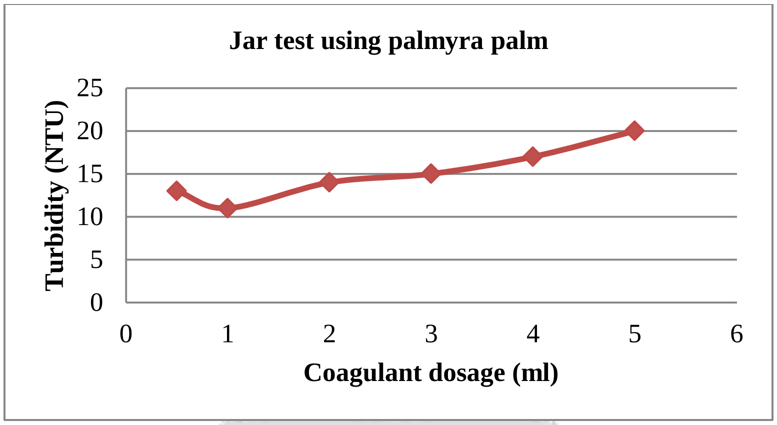

Chart-5: Jar test using Palmyra palm

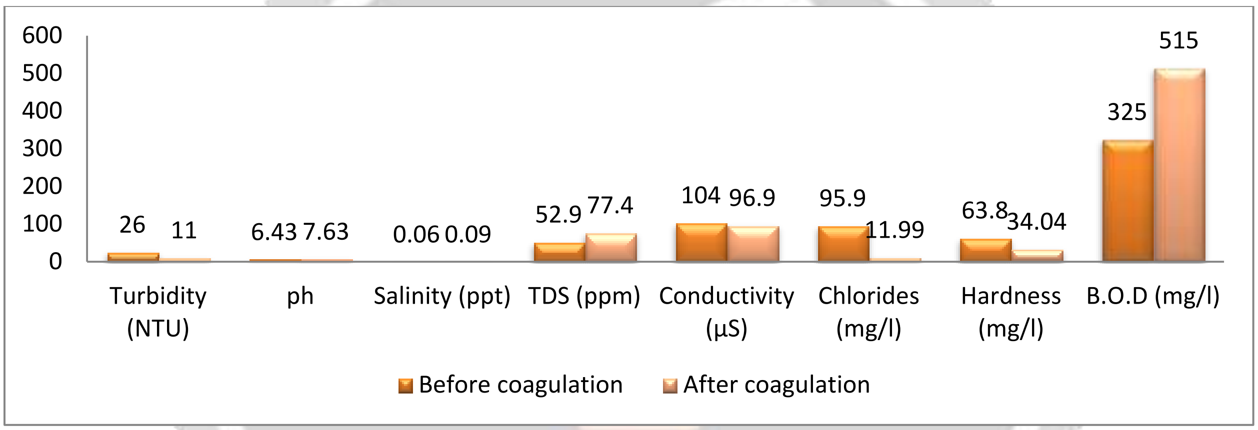

Chart-6: Graph showing the variation in the characteristics before and after coagulation with Palmyra palm

3.3.4 After coagulation with Peanut seed

Fig-12: Jar test using Peanut seed powder

Attracting attention in recent decades is the use of the dried, crushed seeds as a coagulant. Even very muddy water can be cleared when crushed seeds are added. Solid matter and some bacteria will coagulate and then sink to the bottom of a container. The cleaned water can then be poured off and boiled. The improvement of turbidity removal implied improvement in coagulation activity, as shown in Table 5. This could be losing-up of the protein associations leading to more soluble and coagulation active species in solution, which means that addition of salt solution enhanced the breaking of protein associations, leading to increased protein solubility.

Table- 5: Results of jar test using Peanut seed

Coagulant dosage (ml)	Turbidity (NTU)
0.5 ml	9 NTU
1 ml	8 NTU
2 ml	22 NTU
3 ml	39 NTU
4 ml	49 NTU
5 ml	72 NTU

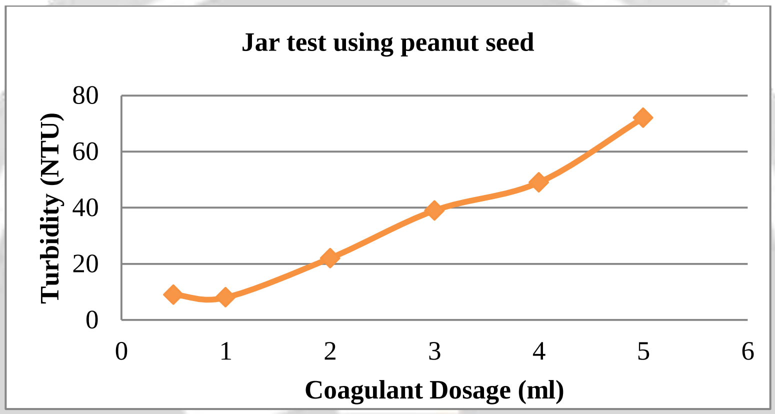

Chart-7: Jar test using Peanut seed

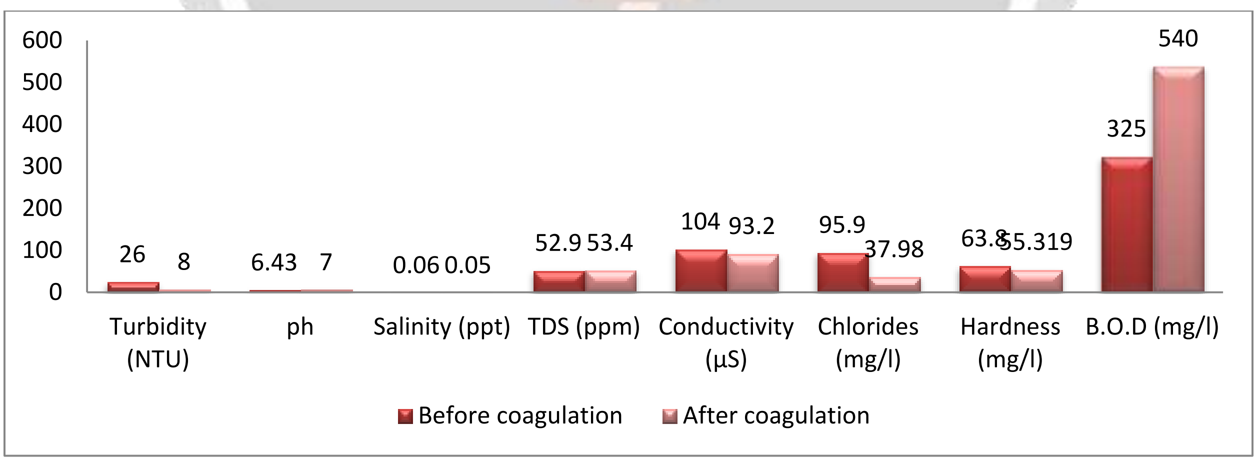

Chart-8: Graph showing the variation in the characteristics before and after coagulation with Peanut seed

3.3.5 After coagulation with Alum

Fig-13: Jar test using Alum

Microorganisms present in drinking water include viruses, bacteria (e.g., E. coli), and protozoa (e.g., Cryptosporidium and the beaver fever causing organism, Giardia). At low levels, these organisms can cause sickness and disease (incl. severe diarrhea) and are generally very difficult to remove from water. Water treatment with aluminum sulphate is, however, effective at removing these parasites when used in a chemical treatment process called coagulation.

Table- 6: Results of jar test using Alum

Coagulant dosage (ml)	Turbidity (NTU)
3 ml	7 NTU
4 ml	1 NTU
5 ml	1 NTU
6 ml	0 NTU
7 ml	2 NTU

Alum is commonly used in municipal water supply purification because it helps to remove particulate matter. However, cities have to carefully filter and monitor levels of aluminum left behind because of its toxicity. At low levels, aluminum in food, air, and water is not likely harmful to your health. However, at high concentrations or with long term regular exposure, there is evidence linking aluminum to effects on the nervous system, with possible connections to several diseases, such as Parkinson's, Alzheimer's, and Lou Gehrig's disease.

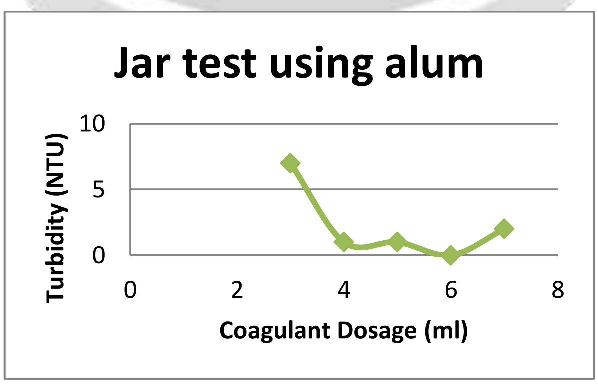

Chart-9: Jar test using Alum

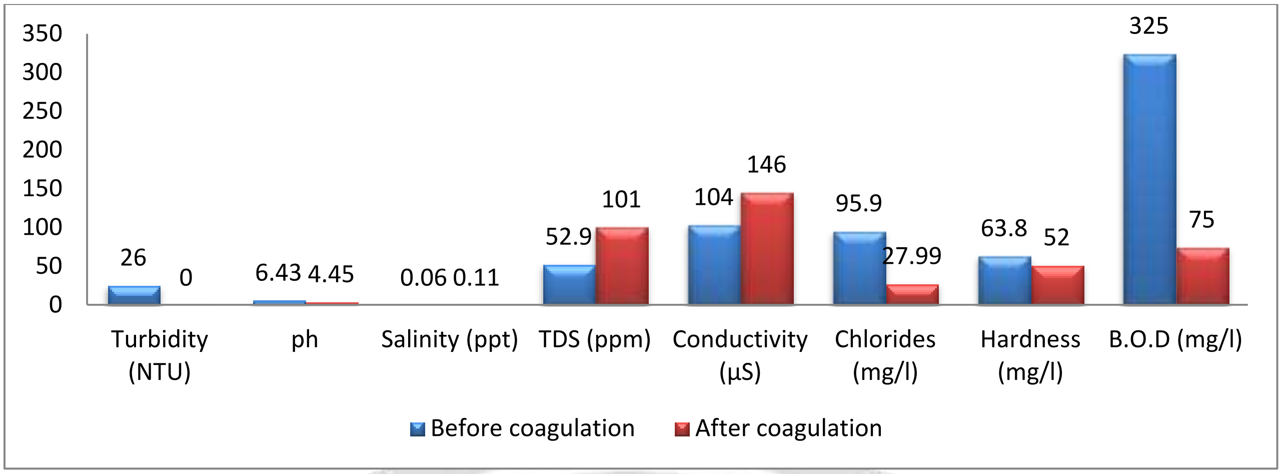

Chart-10: Graph showing the variation in the characteristics before and after coagulation with Alum

4.CONCLUSIONS

Coagulation and flocculation have been used as primary treatment of water. Metal salts such as aluminium sulphate and ferric chloride and prehydrolised, and prehydrolized coagulant such as polyaluminium chloride (PAC), polyferrous sulphate (PFS), and polyferric chloride (PFC) have been widely used to treat water. Although these coagulants give great perfomance in water treatment, there are some disadvantages such as reduction in pH to acidic, potential cause of health problems when the water is consumed, relative high coagulant cost, and large sludge volume.

The present study evaluated the feasibility of using natural coagulants from low-cost materials viz. Aloevera, Chickpeas, palmyra palm, and peanut seed to clarify the riverwater. The maximum coagulation activities (turbidity removal efficiencies) were found to be 88 %, 57%, 69%, 57%. It indicates that Aloevera as natural coagulant has tremendous potential for turbidity removal. Result shows that by using plant based coagulants the amount of BOD increases, this will be a disadvantage to them.

5. REFERENCES

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