Cost-Effective Treatment for Polluted Groundwater Using Eco-Friendly Bio-Coagulants

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Research Article

Keywords: Groundwater treatment, Coagulation process, Bio-coagulants, Cost-effective method

Posted Date: March 17th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1375291/v1

Abstract

Groundwater available in aquifers is one of the most important renewable natural resources. It supplies drinking water for more than 90% of the rural population. Most of the wastes from households and industries are dumped in open dumping yards. Due to this, groundwater gets polluted and quality gets deteriorated. The polluted groundwater in many areas is unfit for domestic and drinking purposes. In order to overcome this problem, many treatment methods are adopted in different parts of the world. In the present work, we have assessed the groundwater characteristics in a part of industrial city in southern India and treated the polluted groundwater by using natural bio-coagulants. We have used eco-friendly bio-coagulants such as Artocarpusheterophyllus (Jackfruit peel), Momordicacharantia (Bitter gourd seed), Musa paradisiaca (Banana flower leaf) and Cynodondactylon (Scutch grass). These coagulants are effective in removing the turbidity and maintaining the pH of the water. In addition, these natural coagulants reduce BOD, COD and salt content. After treatment, the groundwater can be used for domestic purposes. As it is a cost- effective and eco-friendly method it can be afforded by large population.

Introduction

Water is a resource that is essential to all living things. We use water for everything in our daily lives. (Antov et al. 2010; Arafat and Mohamed 2013; Antov et al. 2010; Arafat and Mohamed 2013). Nowadays, huma actions have polluted the water (Ahmad and Danish 2018; Alo et al. 2012). Once the water has been found to be polluted, it must be treated. (Azizul et al. 2014; Babu and Chaudhuri 2005; Azizul et al. 2014). Multiple factors, including chemical reactions between water and soil or sediment, biological processes, and surface water groundwater interactions, as well as human activities, can affect groundwater hydrochemistry (Balamaze et al. 2019; Barakat 2011; Gidde et al. 2012). Water pollution is a global issue that has contributed to harmful environmental and human health consequences. Waste water deposition had been increased due to rapid industrialization and population explosion at an alarming rate affecting the water quality (Saravanan et al. 2017). This has led to various water treatment techniques for the improvement of water quality. The main parameters which show the quality of the water are Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total suspended solids (TSS), and Total dissolved solids (TDS), Dissolved oxygen (DO), temperature and pH (Bhuptawat et al. 2007; Bina et al. 2009; Freitas et al. 2015; Venkatesan et al. 2020b; Venkatesan et al. 2020c). In wastewater treatment, Coagulation is a very traditional method to remove the suspended solids from the waste water and removing colloidal impurities and turbidity from the water (Swami et al. 2012; Veeramalini and Joshua 2012; Oladoja 2015). Coagulants are added to water to remove the forces that hold colloidal particles together, allowing them to float in the water (Gorde and Jadhav 2013; Venkatesan et al. 2020a; Hammer Mark 1975). When the coagulant is added to the water, the individual colloids clump together and grow larger, allowing the contaminants to settle to the bottom of the beaker and be separated from the water suspension. Coagulants made of aluminium and iron are widely employed in most sectors (Diaz et al.1999; Hansen et al. 2007; Jiang and Graham 1998; Torres et al. 2012). When aluminium is employed as a coagulant in waste water treatment, however, it has a number of negative impacts on human health, including intestinal constipation, memory loss, convulsions, abdominal colic, energy loss, and learning difficulties (Issa Etier et al. 2020; Jadhav and Yogesh 2013; Omar Lowko 2013). There is a need for a low-cost coagulant that does not alter the chemical properties of the waste water throughout treatment (Zurina et al. 2014; Rangana 1995; Jenin Rajasingh et al. 2017; Ullah and Haque 2008). As a result, there is a lot of focus these days on improving and implementing natural coagulants in wastewater treatment. Animals, microbes, and plants can all produce or extract natural coagulants (Robert and Bradley 2010; Kakoi et al. 2016; Kolekar 2017; Venkatesan and Subramani 2018; Natarajan et al. 2018). The natural coagulants employed in this study were Dolichas lablab, Azadirachta Indica, Moringa Oleifera, and Hibiscus Rosa Sinensis, which are all locally available from vegetables and flowers. (Venkatesan and Subramani 2019; Suleyman et al. 2004; Zouboulis et al. 2009; Sonal et al. 2012; Suleyman et al. 2004). Bio-flocculants are low-cost renewable sources with high removal capacity for suspended solids, turbidity, and colours, decreasing the impact on public health and pollution (Marobhe et al. 2007; Vera et al. 2005). Moringa oleifera is a non-hazardous (low concentration) suffocating plant whose seeds contain edible oil and a water-soluble chemical that is used for medicinal purposes (Teh et al. 2014; Zhou and Li 2008; Wolf et al. 2015; Lai Peng et al. 2007; Uma et al. 2016). Moringa is mostly used in urban areas as a provision and restorative resource. Mucilage (fibre) in cactus opuntia includes l-rhamanosei, l-arabinose, d-galactose, d-xyloose, galacturonic acid, and cassava peel (Namita and Alka 2017; Maruti and Rao 2013; Nalini and Prince 2017), (Lin and Sung 2001; Tolkou and Zouboulis 2014; Luvuyo et al. 2013; Mohd Ariffin et al. 2009; Nagmani 2015). Fresh cassava peels have three key advantages: they spread quickly, contain phytates, and contain a large amount of cyanogenic glycosides. The jackfruit (Artocarpus heterophyllus Lam) is a popular fruit crop with seeds that make approximately 10 to 15% of the total weight of the fruit and are heavy in carbohydrate and protein. Jackfruit seed powder can be used as an alternative to chemical coagulants because it is environmentally benign and inexpensive. Because of its low processing cost, water treatment is used in a variety of countries. (Venkatesan and Raj Chandar 2012; Sivakumar et al. 2014; Seghosime et al. 2017). Therefore, in this present study, the comparison of Four bio-coagulants Artocarpusheterophyllus (Jackfruit peel), Momordicacharantia (Bitter gourd seed), Musa paradisiaca (Banana flower leaf), Cynodondactylon (Scutch grass) with the aluminum sulphate (Alum) for the treatment of contaminated groundwater in vellalore dumping yard were investigated by using JAR apparatus test analysis under different process conditions in order to reduce the concentration of pH, Turbidity, TDS, etc.,

Materials And Methods

In the present study the Groundwater sample were collected near Vellalore dumping site area located in Coimbatore district, Tamil Nadu, India. Vellalore, a village near Coimbatore comes under Kinathukadavu constituency of Coimbatore District, which is a Garbage yard of Coimbatore Corporation. This trash leads to soil erosion in this region. Groundwater is contaminated due to the dumping of 850 tons of garbage in the yard of 650 acres of land at in and around vellalore region. In this study, we have collected groundwater samples near 1.5km from the Vellalore dumping site. In initial characteristics test (pH, Electrical conductivity, Calcium content, Magnesium content, Sodium and potassium content, Carbonate and Bicarbonate content, Chloride content, TDS content) were determined and the results were tabulated in Table 1.

The Natrual Bio- coagulants Artocarpusheterophyllus (Jackfruit peel), Momordicacharantia (Bitter gourd seed), Musa paradisiaca (Banana flower leaf), Cynodondactylon (Scutch grass) were collected from the local area market in Coimbatore city. The chemical coagulant (Alum) was collected in the form of white fine powder and used without any pre-treatment.

Preparation of Natural Coagulants

Coagulants were prepared from seeds and flowers of various plants by dried, powdered and finally sieved. The coagulants used in this research were Jackfruit peel, Bitter gourd seed, Scutch grass, and Banana flower leaf. Initially, the seeds were extracted from their respective plants and samples were laved with distilled water several times to remove dirt and contaminants, followed by drying under the sun light naturally for about 48 hours. Then the desiccated coagulants were ground to a fine powder. The powdered sample were sieved by using 0.45mm mesh IS Sieves and stored in an airtight container to avert the entry of moisture into it and the repercussion of the same. The fine powder was used as a coagulant for analysis. Distilled water was added to the powdered seed to get 1% suspension of it, and then shaken vigorously for 45 min by using a stirrer to enhance the water for extracting the proteins of coagulant, and then passes through the paper of filtration. This filtrated solution was used as dose of coagulant in the experiments. To avoid any effect, such as changes in viscosity, coagulation activity and pH that occur, the solution should be prepared daily and kept in refrigerator and have to be used after shaking it well.

Coagulation process - Jar Test Analysis

Coagulation and flocculation are the most common method used for the removal of turbidity, colour, suspended matters, microorganisms and other odour producing substances. The jar test is a common laboratory procedure used to determine the optimum operating conditions for water or wastewater treatment. This method allows adjustments in pH, variations in coagulant or polymer dose, alternating mixing speeds, or testing of different coagulant or polymer types, on a small scale in order to predict the functioning of a large-scale treatment operation.

Experimental Procedure

A conventional Jar test apparatus was selected for coagulation – sedimentation experiments. In this research, five coagulants were used. One chemical and Alum, Banana flower leaf, Bitter gourd seed, Jackfruit peel and Scutch grass were used as four natural coagulants. These natural coagulants used in different dosages like 2g, 4g, 6g, 8g, 10g, and 12g and the powder was fed to the respective samples. It was carried out as a batch test, accommodating a series of six beakers together with six-spindle steel paddles. Before fractionated into the beakers containing 500mL of suspension each, the samples of Groundwater and bio-coagulants were mixed homogeneously. Initially, rapid mixing was carried out for 2 minutes at 100 rpm followed by slow mixing for 25 minutes at 20 rpm. The sample after coagulation was allowed to settle for 30 minutes. The supernatant obtained was filtered and its characteristics (pH, turbidity, Conductivity and TDS) were determined. The procedure for the Banana flower leaf, Bitter gourd seed, Jackfruit peel and Scutch grass were also similar like the above-mentioned techniques. In the case of alum, it was directly used after being powdered. The experiment was carried out under room temperature (25^0C). In order to determine the residual Coagulants, 50 ml of sample was withdrawn from the top 2 cm of the water surface and filtered using paper filter after every experiments. Finally, the treated polluted water was tested (pH, Turbidity, Conductivity and TDS content) and the results were tabulated in Table 2.

Results And Discussion

We discovered that the groundwater around the Vellalore Dumping site is contaminated in our study. When operational conditions are optimal, coagulation and flocculation processes are primary and cost-effective processes in water treatment plants that can successfully eradicate turbidity from low to high turbidity in water. pH and coagulant dose optimization may improve coagulation efficiency while reducing sludge volume and, as a result, sludge management expenses. Coagulant aids may speed up the coagulation and turbidity removal process. The activities of coagulation and flocculation of bio-flocculant and alum were compared under various situations. Natural coagulants can also be utilised to remediate filthy wastewater, according to the findings. The turbidity and Total Dissolved Solid (TDS) content of the polluted water are also reduced by the natural coagulants. The initial characteristics of groundwater (pH, Electrical conductivity, Calcium, Magnesium, Sodium, Potassium, Chloride, Total Dissolved Solids, BOD, and COD) were evaluated, with the findings presented in Fig. 14, 15 and Table 1. Table 2 shows the results of the Jar test performed using Coagulant materials. in a variety of doses The optimal coagulant dose for groundwater was discovered by altering the coagulant dosage as 2g, 4g, 6g, 8g, 10g, and 12g. According to the findings, the best coagulant dosage for treating polluted groundwater is 8g.

Reduction of pH – Different Coagulant Dosages

The geochemistry of coagulant depends on the pH of any solution during the flocculation process. After groundwater treatment by coagulants with the initial value of 7.38. pH, the Fig. 16 shows the reduction of pH level at the coagulant dosage 2g. The graph shows the pH values for natural coagulant materials and the conventional alum as coagulant, which gave 33.47% pH removal effectiveness in alum. Figure 17 shows the lessening of pH level at the coagulant dosage 4g. The graph shows the pH values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of pH was 35.37% in alum. Figure 18 shows the reduction of pH level at the coagulant dosage 6g. The graph shows the pH values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of pH was 31.03% in Banana flower leaf. Figure 19 shows the reduction of pH level at the coagulant dosage 8g. The graph shows the pH values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of pH was 20.01% in Jackfruit peel. Figure 20 shows the reduction of pH level at the coagulant dosage 10g. The graph shows the pH values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of pH was 27.37% in Jackfruit peel. Figure 21 shows the reduction of pH level at the coagulant dosage 12g. The graph shows the pH values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of pH was 25.20% in Jackfruit peel. The maximum removal efficiency was obtained for pH reduction was 35.37% the optimum coagulant dosage at 4g in alum and the pH range was found to be 4.77 when compared to bio-coagulants.

Reduction of Turbidity – Different Coagulant Dosages

Figure 22 shows the reduction of turbidity level at the coagulant dosage 2g. The graph shows the turbidity values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of turbidity was 81.18% in Alum. Figure 23 shows the reduction of turbidity level at the coagulant dosage 4g. The graph shows the turbidity values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of turbidity was 80.06% in Alum. Figure 24 shows the reduction of turbidity level at the coagulant dosage 6g. The graph shows the turbidity values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of turbidity was 81.46% in Alum.

Figure 25 shows the reduction of turbidity level at the coagulant dosage 8g. The graph shows the turbidity values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of turbidity was 83.15% in Alum. Figure 26 shows the reduction of turbidity level at the coagulant dosage 10g. The graph shows the turbidity values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of turbidity was 83.43% in Alum. Figure 27 shows the reduction of turbidity level at the coagulant dosage 12g. The graph shows the turbidity values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of turbidity was 80.90% in Alum. The maximum removal efficiency was obtained for turbidity reduction was 83.15% the optimum coagulant dosage at 8g in alum and the turbidity range is found to be 60 NTU when compared to bio-coagulants.

Reduction of Electrical Conductivity – Different Coagulant Dosages

Figure 28 shows the reduction of Electrical Conductivity at the coagulant dosage 2g. The graph shows the EC values for natural coagulant materials and the conventional alum as coagulant, which gave the amputation efficiency of EC was 40.64% in Banana flower leaf. Figure 29 shows the amputation of Electrical Conductivity at the coagulant dosage 4g. The graph shows the EC values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of EC was 34.70% in Banana flower leaf. Figure 30 shows the reduction of Electrical Conductivity at the coagulant dosage 6g. The graph shows the EC values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of EC was 31.05% in Banana flower leaf.

Figure 31 shows the reduction of Electrical Conductivity at the coagulant dosage 8g. The graph shows the EC values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of EC was 36.76% in Banana flower leaf. Figure 32 shows the lessening of Electrical Conductivity at the coagulant dosage 10g. The graph shows the EC values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of EC was 21.69% in Banana flower leaf. Figure 33 shows the reduction of Electrical Conductivity at the coagulant dosage 12g. The graph shows the EC values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of EC was 20.10% in Banana flower leaf. The maximum removal efficiency was obtained for Electrical Conductivity reduction was 40.64% the optimum coagulant dosage at 8g in Banana flower leaf and the Electrical Conductivity range can be found to be 2.60 S/m when compared to alum.

Reduction of TDS – Different Coagulant Dosages

Figure 34 shows the lessening of TDS at the coagulant dosage 2g. The graph shows the TDS values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of TDS was 81.45% in Bitter gourd seed. Figure 35 shows the reduction of TDS at the coagulant dosage 4g. The graph shows the TDS values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of TDS was 82.16% in Bitter gourd seed. Figure 36 shows the lessening of TDS at the coagulant dosage 6g. The graph shows the TDS values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of TDS was 83.95% in Bitter gourd seed.

Figure 37 shows the reduction of TDS at the coagulant dosage 8g. The graph shows the TDS values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of TDS was 86.80% in Bitter gourd seed. Figure 38 shows the reduction of TDS at the coagulant dosage 10g. The graph shows the TDS values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of TDS was 86.09% in Bitter gourd seed. Figure 39 shows the reduction of TDS at the coagulant dosage 12g. The graph shows the TDS values for natural coagulant materials and the conventional alum as coagulant, which gave the removal efficiency of TDS was 84.66% in Bitter gourd seed. The maximum removal efficiency was obtained for TDS reduction was 86.80% the optimum coagulant dosage at 8g in Bitter gourd seed and the TDS range can be found to be 370 mg/l when compared to alum.

Alum as coagulant material

Upon treating with Alum, optimum Coagulant dosage was obtained at 4g for polluted groundwater. The pH reduction was 35.37% and the optimum pH range can be found to be 4.77. The removal efficiency of turbidity was 83.43% at 10g of optimum coagulant dosage and the optimum turbidity range can be found to be 59 NTU. The electrical conductivity of treated water in groundwater at 8g of optimum coagulant dosage value and the removal efficiency was 4.11% with the optimum value of alum was 4.2s/m. The

TDS of groundwater in after treatment process the removal efficiency was 76.81% at 8g of coagulant dosage with 650mg/l optimum value.

Jackfruit peel as coagulant material

Upon treating with jackfruit peel powder, optimum coagulant dosage was obtained at 4g for treated water. The pH removal efficiency was 27.77% with optimum pH value can be found to be 5.33. The removal efficiency of turbidity was 55.90% at 8g of optimum coagulant dosage and the optimum turbidity range can be found to be 157 NTU. The electrical conductivity of treated water in groundwater at 2g of optimum coagulant dosage value and the removal efficiency was 10.73% with the optimum value of alum was 3.91s/m. The TDS of groundwater in after treatment process the removal efficiency was 80.02% at 8g of coagulant dosage with 560mg/l optimum value.

Banana flower leaf as coagulant material

Upon treating with Banana flower leaf powder, optimum coagulant dosage was obtained at 6g for treated water. The pH removal efficiency was 31.03% with optimum pH value can be found to be 5.09. The removal efficiency of turbidity was 71.07% at 4g of finest coagulant dosage and the optimum turbidity range can be found to be 103 NTU. The electrical conductivity of treated water in groundwater at 2g of optimum coagulant dosage value and the removal efficiency was 40.64% with the optimum value of alum was 2.60s/m. The TDS of groundwater in after treatment process the removal efficiency was 76.81% at 6g of coagulant dosage with 650mg/l optimum value.

Bitter gourd seed as coagulant material

Upon treating with Bitter gourd seed powder, optimum coagulant dosage was obtained at 10g for treated water. The pH removal efficiency was 23.98% with optimum pH value can be found to be 5.61. The removal efficiency of turbidity was 62.36% at 2g of optimum coagulant dosage and the optimum turbidity range can be found to be 134 NTU. The electrical conductivity of treated water in groundwater at 8g of optimum coagulant dosage value and the removal efficiency was 6.39% with the optimum value of alum was 4.10s/m. The TDS of groundwater in after treatment process the removal efficiency was 86.80% at 8g of coagulant dosage with 370mg/l optimum value.

Scutch Grass as coagulant material

Upon treating with Scutch Grass powder, finest coagulant dosage was obtained at 10g for treated water. The pH removal efficacy was 24.80% with optimum pH value can be found to be 5.55. The removal efficiency of turbidity was 61.24% at 2g of optimum coagulant dosage and the optimum turbidity range can be found to be 138 NTU. The electrical conductivity of treated water in groundwater at 2g of optimum coagulant dosage value and the removal efficiency was 10.73% with the optimum value of alum was 3.91s/m. The TDS of groundwater in after treatment process the removal efficiency was 71.82% at 8g of coagulant dosage with 790mg/l optimum value.

Conclusions

Natural coagulants have the ability to treat the waste water. The comparison of pH, turbidity, Electrical conductivity, Total Dissolved solids removal efficacy between the conventional chemical coagulants with bio-flocculants in different process conditions was determined in this research. The outcome of this research is identified that it reduces the turbidity, pH and TDS content from the unclean groundwater. Besides that, the treated water can be used directly for agricultural purposes and watering plants. Since the treated water colour has to be reduced, Alum or Ferric sulphate in smaller quantities can be used. The treatment of groundwater shows the reduction in percentage of various polluting parameters like pH, turbidity, Electrical conductivity, Total Dissolved solids by alum coagulant the reduction of percentages of pH, turbidity, Electrical conductivity, Total Dissolved solids were found to 35.37%, 83.43%,4.11% and 76.81%. By Jackfruit peel coagulant the reduction of percentages of pH, turbidity, Electrical conductivity, Total Dissolved solids were found to 27.77%, 55.90%, 10.73% and 80.02%. By Banana flowers leaf coagulant, the lessening of percentages of pH, turbidity, Electrical conductivity, Total Dissolved solids were found to 31.03%, 71.07%, 40.64% and 76.81%. By Bitter gourd seed coagulant, the reduction of percentages of pH, turbidity, Electrical conductivity, Total Dissolved solids were found to 23.98%,62.36%,6.39% and 86.80%. By Scutch Grass coagulant the reduction of percentages of pH, turbidity, Electrical conductivity, Total Dissolved solids were found to 24.80%, 61.24%, 10.73% and 71.82%. Bitter gourd seed has a very significant effect on the removal of total dissolved solids (TDS) instead of traditional coagulant (alum). Natural coagulants do not change the pH while the alum increases the acidity of waste water. The utilization of bio-flocculants helps to reduce the health and environmental concerns on chemical coagulants. The use of renewable sources of low cost agricultural or household waste biomass which might requires little processing to produce bio-flocculants which is considered as a better choice for this purpose.

Declarations

Author contribution

Venkatesan Govindaraj. conceived, designed, conducted, analysis interpretation of data and drafted the manuscript. Kalpana Manoharan. conducted the literature search and drafted the manuscript. Manimaran Govindarajan. was involved in the analysis interpretation of data. All authors read and approved the final manuscript.

Funding

No funding agency support.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests, the authors declare no competing interests.

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Tables

Table 1: The Initial Characteristics Result

S. No.	Name of the Parameter	Initial Characteristics
1	pH	7.38
2	Turbidity (NTU)	356
3	Electrical conductivity (S/m)	4.38
4	Calcium (mg/lit)	7.28
5	Magnesium (mg/lit)	7.92
6	Sodium (mg/lit)	6.8260
7	Pottasium (mg/lit)	1.1794
8	Carbonate (mg/lit)	-
9	Bicarbonate (mg/lit)	0.88
10	Chloride (mg/lit)	2.0
11	Sodium Adsorption Ratio	2.470
12	Res.Sodium Carbonate (mg/lit)	14.32
13	Total Dissolved Solids (mg/lit)	2803.2
14	COD (mg/lit)	61.2
15	BOD (mg/lit)	88.7

Table 2: Characteristics of treated water

Table 2.1: pH table for treated water for different coagulant dosages

Dosage of Coagulant	pH for different Coagulant Material				
	Alum	Jackfruit peel	Banana flower leaf	Bitter gourd seed	Scutch Grass
2g	4.91	5.5	5.58	5.90	5.92
4g	4.77	5.33	5.20	5.80	5.82
6g	5.70	5.60	5.09	5.71	5.82
8g	6.64	5.90	6.09	6.54	6.69
10g	6.56	5.36	5.94	5.61	5.55
12g	7.46	5.52	5.53	6.46	6.50

Table 2.2: Turbidity table for treated water for different coagulant dosages

Dosage of Coagulant	Turbidity of Coagulant Material (NTU)				
	Alum	Jackfruit peel	Banana flower leaf	Bitter gourd seed	Scutch Grass
2g	67	126	146	134	138
4g	71	122	103	229	145
6g	66	450	153	460	216
8g	60	157	127	165	265
10g	59	608	155	601	392
12g	68	996	237	380	390

Table 2.3: Electrical Conductivity table for treated water for different coagulant dosage

Dosage of Coagulant	Electrical Conductivity of Coagulant Material (S/m)				
	Alum	Jackfruit peel	Banana flower leaf	Bitter gourd seed	Scutch Grass
2g	4.7	3.91	2.60	4.31	3.91
4g	5.7	3.95	2.86	4.30	4.24
6g	5.6	4.11	3.02	4.30	4.57
8g	4.2	4.01	2.77	4.10	3.87
10g	6.50	4.25	3.43	4.36	4.84
12g	7.16	4.34	3.50	4.39	4.92

Table 2.4: TDS table for treated water for different coagulant dosage

Dosage of Coagulant	TDS for different Coagulant Material (mg/lit)				
	Alum	Jackfruit peel	Banana flower leaf	Bitter gourd seed	Scutch Grass
2g	800	870	980	520	820
4g	810	800	870	500	810
6g	708	660	650	450	800
8g	650	560	780	370	790
10g	700	610	780	390	800
12g	730	730	800	430	1000

Table 3: Removal Efficiency of Coagulants

Parameter	Removal Efficiency of Coagulants				
	Alum	Jackfruit peel	Banana flower leaf	Bitter gourd seed	Scutch Grass
pH	35.37%	27.77%,	31.03%,	23.98%,	24.80%,
Turbidity, NTU	83.43%	55.90%,	71.07%,	62.36%,	61.24%,
Electrical conductivity, S/m	4.11%	10.73%	40.64%	6.39%	10.73%
TDS, mg/l	76.81%	80.02 %.	76.81 %.	86.80%	71.82 %

Figures

Figures 1-39 are available in the Supplemental Files section.

Supplementary Files

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