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A Comparative Evaluation on the Coagulation and Antibacterial activity of Activated charcoal and Aluminium sulphate

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Abstract

The study was conducted to evaluate the coagulative and antibacterial effect of Activated Charcoal and Aluminium sulphate (alum) in water purification. For this, Jar test was conducted to determine the optimum dosages of above-mentioned coagulants needed in the treatment of muddy water sample, which had a turbidity of 151 NTU. Because of high turbidity, the concentration of the dose selected for the jar tests were; 50mg/100ml, 100mg/100ml, 150mg/100ml, 200mg/100ml for all the two coagulants. The optimum dosages of Activated Charcoal and Aluminium sulphate needed in turbidity removal weredetermined to be 150mg/100ml. The water samples were analyzed for different physicochemical parameters such as the pH, Conductivity, total dissolved solids, Dissolved oxygen, Nitrate, phosphate and potassium. Coagulation depends on coagulant Dosage and also the pH. Aluminium sulphate removed turbidity most but also increased conductivity, total dissolved solids and made the water more acidic. Both the coagulants were able to reduce the level of nitrate, phosphate and potassium from the untreated water sample. Well diffusion assay was carried out to analyze antibacterial effect of coagulants on *Escherichia coli* and *Staphylococcus aureus*, in which both coagulants exhibited antibacterial effect but most effective one was Aluminium sulphate.

Keywords: activated charcoal, alum dosage,antibacterial activity,coagulation.

Introduction

Water shortage has become an increasingly difficult problem to manage. More than 40% of the world's population live in a region where the demand for water exceeds its supply. The imbalance between supply and demand, along with persisting issues such as climate change and exponential population growth, has made water reuse a necessary method for conserving water[1].The most cost-effective way of decoupling water use from economic growth, according to the scientific panel, is for governments to create holistic water management plans that take into account the entire water cycle: from source to distribution, economic use, treatment, recycling, reuse and return to the environment. Wastewater treatment is a process which helps to reclaim wastewater into an effluent that can be returned to the environment with minimum impact on it or enables direct reutilisation. There are a variety of methods used in the treatment of wastewater to ensure that it is safe to use for irrigation of food crops or drinking water.Conventional water treatment technology consists basically of aeration, coagulation, flocculation, sedimentation, filtration and disinfection.

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Turbidity becomes a major concern as most of the health risks are associated with suspended organic matter, bacteria and other microorganisms.As a result of these risks, turbidity removal continues to be a prime objective of coagulation operation[2]. Water from floods and rain run offs is muddy and contains lot of turbidity. With the addition of coagulants, turbidity can be removed and thus clear water may be obtained. This clear treated water could thus be used for washing purposes once it is free of debris and turbidity, reducing the pressure on clean drinking water as a resource[3].

In water treatment, coagulation 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. The coagulation/flocculation process is affected by pH, salts, alkalinity, turbidity, temperature, mixing, and coagulant chemicals.

Most industrial flocculation is done with aluminium sulphate (alum).It is also widely available in developing countries, sold in blocks of soft white stone. There are numerous ways to use alum as a flocculant, including to crush it into a powder before adding it to water, stirring and decanting or stirring the whole stone in the water for a few seconds and waiting for the solids to settle. The benefits of alum are that it is widely available, is proven to reduce turbidity, and is inexpensive. The drawback of alum is that the necessary dosage varies unpredictably. Laboratory studies have shown that alum is effective at reducing turbidity and chlorine demand [4].

Activated charcoal, also called activated carbon, is a form of carbon processed to have small, low-volume pores that increase the surface area[5][6] available for adsorption. Normally, activated carbons are made in particulate form as powders or fine granules less than 1.0 mm in size with an average diameter between 0.15 and 0.25 mm. Thus, they present a large surface to volume ratio with a small diffusion distance. The charcoal is used in both granular and powder form. It is commonly used to adsorb natural organic compounds, synthetic organic chemicals, turbidity and solids removal, and also brings biological stabilization in drinking water treatment. The charcoal and alum are easily available material and hence the project is economical.

This paper aims at comparing the efficiency of alum and activated Charcoal as Coagulant and also to estimate the precise coagulant dose required otherwise overdosing can lead to charge reversal and restabilization of particles. Antibacterial activity of both are also examined and discussed.

Materials and Methods

The study was conducted in the department of zoology, CMS College Kottayam, Kerala, India.

Collection of Materials

- Thewater sample was collected from a muddy pond in Murani locality of Mallappally panchayat in Pathanamthitta district of Kerala state, India. The sample water was brought to the lab and different physicochemical parameters were analyzed.
- Activated charcoal powderandAluminium sulphate (alum) were purchased from Kottayam market, Kerala.
- The strains of *Escherichia coli* (Gram negative) and *Staphylococcus aureus* (Gram positive) were brought from Mangalam diagnostic Research center, Kottayam, Kerala.

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Experimental Procedures:

Coagulation test

The optimum dosage of Activated charcoal and alum to be used was determined by the jar test procedure. In which the jar test was performed using Magnetic stirrer, the collected pond water sample was very turbid therefore activated charcoal and alum in doses of 50mg, 100mg, 150mg and 200mg were used for the analysis. These different doses of activated charcoal were added to each 100 ml of water sample collected in different beakers. The beakers were initially stirred at 150 rpm for 1 minute, after which the speed was decreased to 50 rpm and stirred for 30 minutes. A settling time for 30 minutes was given after which the best coagulant dosage at which the most floc settled out was observed. Turbidity of each samples were examined using Digital turbiditymeterwhich helped in confirming the optimal coagulant dosage. The same procedure was carried with different doses of alum, in order to estimate its optimum dosage.

Determination of water quality

The physicochemical characteristics of pond water sample and treated samples were examined using EUTECH 650 Multiparameter water analyser. The parameters included pH, Conductivity, Total dissolved solids (TDS) and Dissolved Oxygen. For analysis of mentioned parameters, the untreated sample and treated samples were collected in a beaker into which EUTECH probe was immersed.Nitrate and Phosphate content were examined using standard APHA procedures and the values were measured using UV-VIS Spectrophotometer 117. Potassium was measured using Flame photometer 130.

Antibacterial activity assay

Well diffusion method was carried to evaluate the antibacterial activity of activated charcoal and alum with nutrient agar as media.*Staphylococcus aureus*and *Escherichia coli*were used as references for the antibacterial assay. A bacterial suspension (which has been adjusted to 0.5 McFarland standards) to be tested was used to lawn Nutrient agar plates evenly using a sterile swab and the plates were allowed to dry for 10 minutes at room temperature in the laminar airflow. Subsequently, wells of 6mm diameter were punched into the agar medium and filled with 30 mg each of alum and activated charcoal in two different wells created in the same plate. Similar replica plates were created and were then incubated at 37°C for 24 hours. After incubation, the diameters of the growth inhibition zones were measured in millimetre (mm) using sliding callipers and recorded. Data were expressed as mean.

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Result and Discussion

Table 1:The Turbidity of pond water before and after treatment with activated charcoal and alum.

Dosage mg/100ml	Mean Turbidity of pond water sample (NTU)	Mean Turbidity of Treated water (NTU)	
		Activated charcoal	Alum
50 mg	151	52.3	29.7
100 mg	151	16.1	3.3
150 mg	151	6.8	1.9
200 mg	151	8.4	18.3

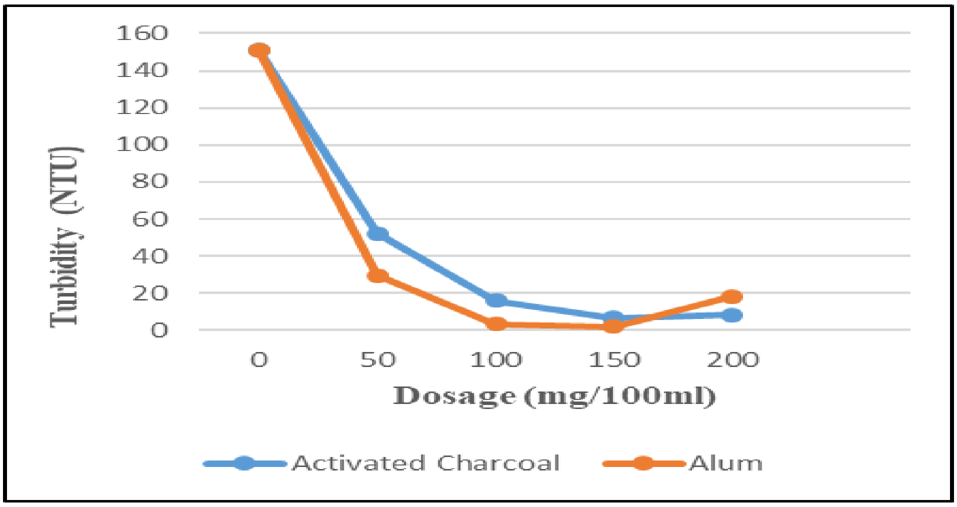

Figure 1: Showing the Turbidity valuesof pond water after treatment with Coagulants at different doses.

Turbidity of pond water was 151 NTU which after treatment with Activated Charcoal and Aluminium sulphate (alum)was drastically decreased. In case of both coagulants, theoptimum dose in this study was found to be 150mg/100ml.The turbidity levels of water at these concentrations were 6.8NTU and 1.9 NTU when treated with Activated Charcoal and alum respectively. Both the values were under the W.H.O standard of 5NTU. The water was turning turbid when treated with concentrations above the optimum dosage. This was becausealuminium salts hydrolyse in water and give a variety of products including cationic species, which can adsorb on negative charged particles, and thus neutralize their charge. The particles get destabilized and aggregation occurs. Over dosing of coagulant leads to charge reversal and particles start restabilising. A higher than the optimum dose of coagulant thus results in less turbidity removal [7].

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Table 2: The pH of pond water before and after treatment with activated charcoal and alum.

Dosage mg/100ml	Mean pH of pondwater sample	Mean pH of Treated water	
		Activated charcoal	Alum
50 mg	6.32	6.43	3.53
100mg	6.32	6.45	3.36
150 mg	6.32	6.47	3.28
200 mg	6.32	6.50	3.22

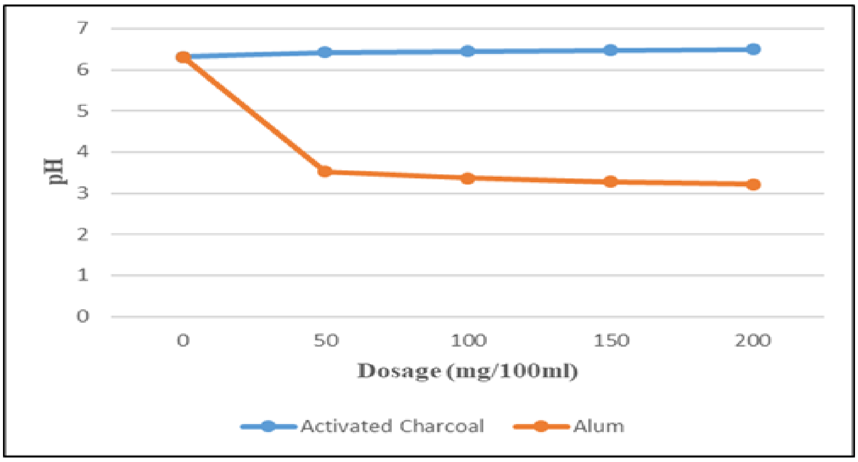

Figure 2: Showing the pH values of pond water after treatment with Coagulants at different doses.

Table 2 and figure 2 shows the declining pHvalues with the increasing concentrationsof alum, which may be dueto the fact that the alum in the treatment produced sulphuric acid which lowered the pH levels. The increase in acidity could be due to the trivalent cationic Aluminium which serves as a Lewis acid, thus, it can accept lone pair of electrons [8]. While on the other hand, activated charcoal increased thepH with increasing doses and for all doses the pHvalues were near the desirable limits of drinking water standards by BIS which is 6.5-8.5.

Table 3: The Conductivity of pond water before and after treatment with activated charcoal and alum.

Dosage mg/100ml	Mean Conductivity of pond water sample (μS/cm)	Mean Conductivity of Treated water (μS/cm)	
		Activated charcoal	Alum
50mg	239	202.7	522.4
100mg	239	188.7	916.8
150mg	239	201.6	1299
200mg	239	200.1	1464

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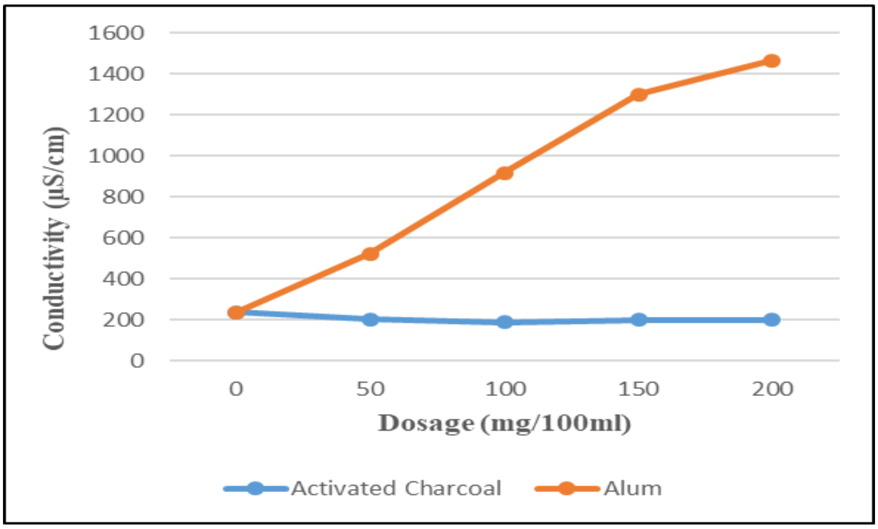

Figure 3: Showing the Conductivity values of pond water after treatment with Coagulants at different doses.

Table 4: The Total dissolved solids (TDS) of pond water before and after treatment with activated charcoal and alum.

Dosage mg/100ml	Mean TDS of pondwater Sample (ppm)	Mean TDS of Treated water (ppm)	
		Activated charcoal	Alum
50mg	119.6	101.4	261.2
100mg	119.6	94.48	458.4
150mg	119.6	103.3	649.5
200mg	119.6	104.3	732.2

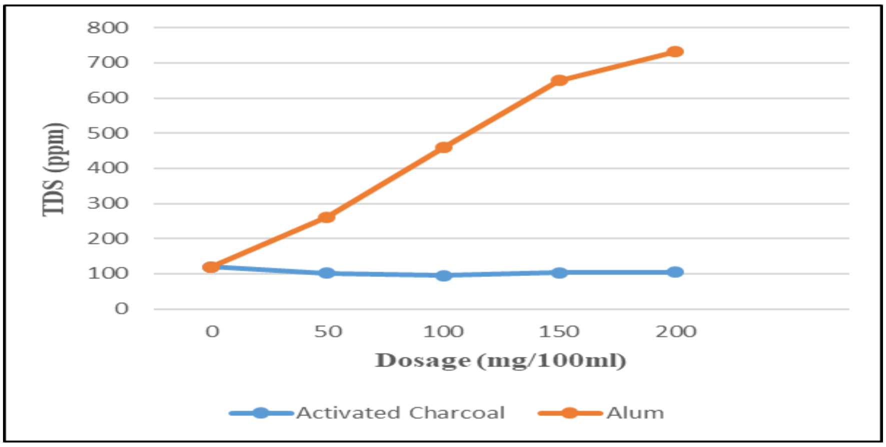

Figure 4: Showing the Total dissolved solids (TDS) levels of pond water after treatment with Coagulants at different doses.

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Table 3 and figure 3 shows the Conductivity values, which were decreased by all doses of Activated Charcoal and all these values were within the permissible limits of CPCB, but opposite case was seen with alum. Alum increased the conductivity and also the TDS (Table 4 and figure 4) after treatment which might bedue to the presence of mineral elements, charged macromolecules and other ionic compounds that dissolved or dissociated into the treated water. Activated charcoal managed to decrease TDS values to only some extent. But all values were below The BIS permissible limit which is 2000 mg/l.

Table 5: The Dissolved oxygen(DO)levels ofpond water before and after treatment with activated charcoal and alum.

Dosage mg/100ml	Mean DO of pond waterSample (mg/l)	Mean DO of Treated water (mg/l)	
		Activated charcoal	Alum
50mg	4.52	3.40	4.57
100mg	4.52	3.32	4.56
150mg	4.52	3.27	4.55
200mg	4.52	3.26	4.55

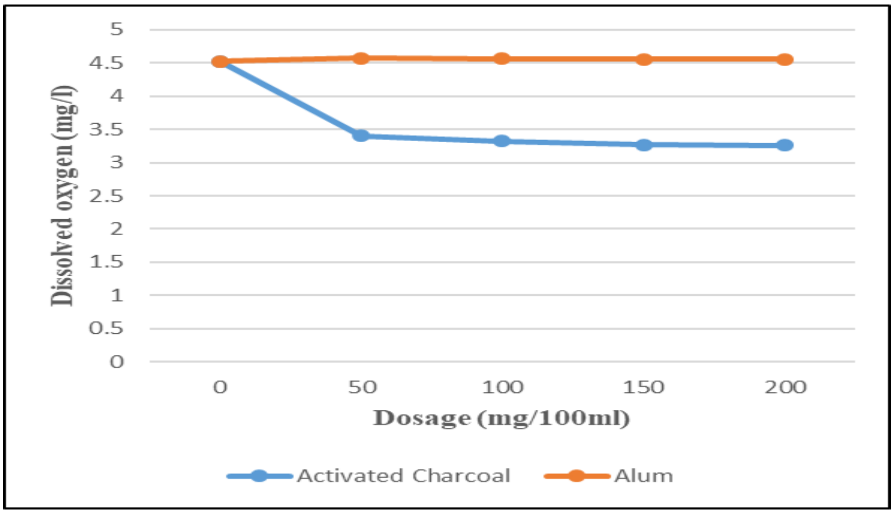

Figure 5: Showing the Dissolved oxygen (DO) levels of pond water after treatment with Coagulants at different doses.

Table 5 and figure 5 shows Dissolved Oxygen levels, which were maintained at approximate constant level by alum and were also within the desirable limits but in case of treatment withActivated Charcoal its level decreased with increasing doses.

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Table 6:Nitrate, Phosphate and Potassium levelsof pond water before and after treatment with activated charcoal and alum.

Dosage mg/100 ml	Pond water sample (mg/l)			After treatment with Activated Charcoal (mg/l)			After treatment with Alum (mg/l)		
	Nitrate	Phosphate	Potassium	Nitrate	Phosphate	Potassium	Nitrate	Phosphate	Potassium
50 mg	18.27	0.022	15.97	2.867	0.0079	13.97	5.734	0.0003	12.97
100 mg	18.27	0.022	15.97	1.075	0.0019	9.98	5.017	0.0006	12.97
150 mg	18.27	0.022	15.97	1.055	0.0013	11.97	7.52	0.0023	14.97
200 mg	18.27	0.022	15.97	1.030	0.0010	11.97	8.602	0.0036	15.97

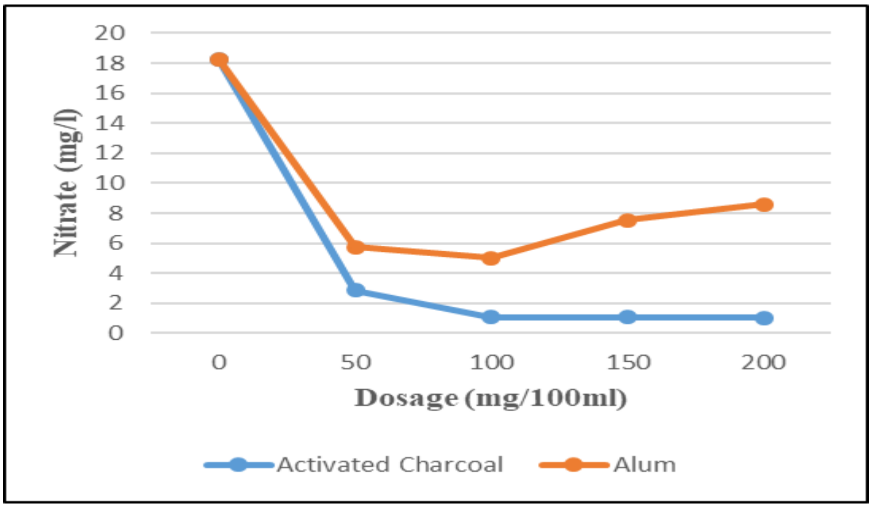

Figure 6: Showing the Nitrate levelsof pond water after treatment with Coagulants at different doses.

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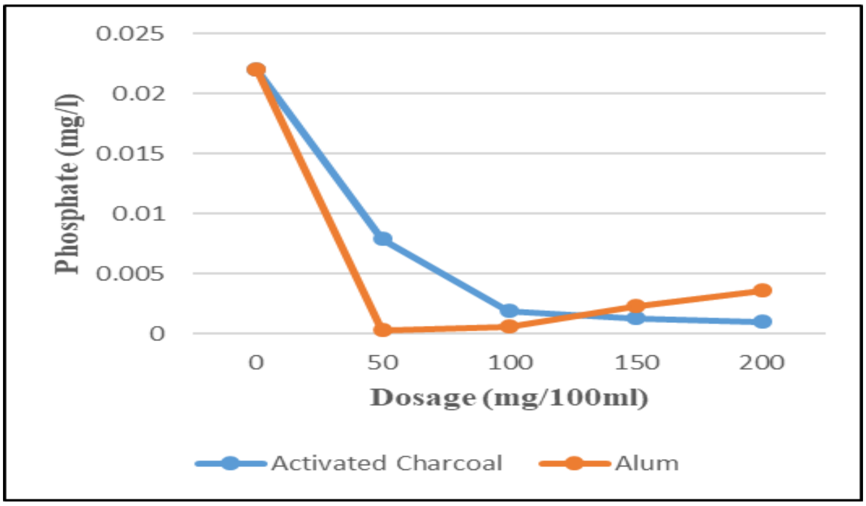


Figure 7: Showing the Phosphatelevels of pond water after treatment with Coagulants at different doses.

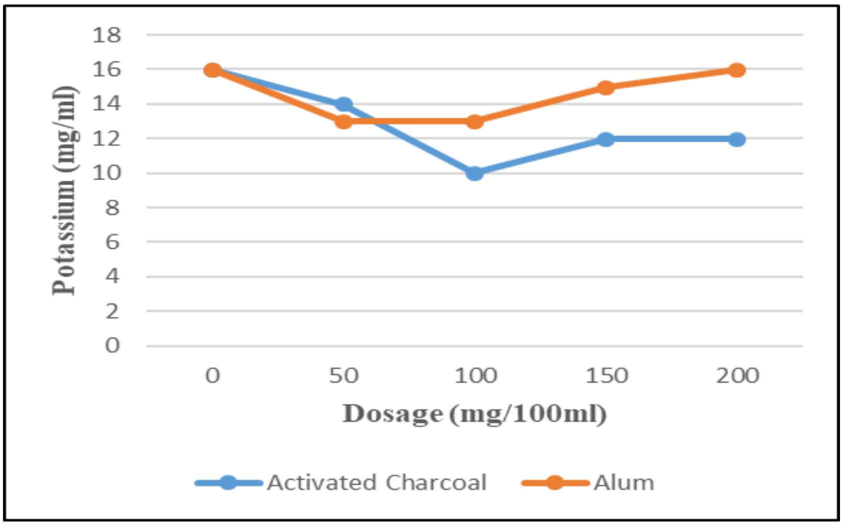


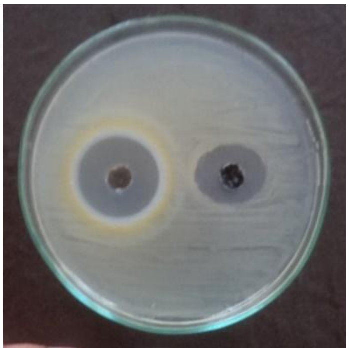
Figure 8: Showing the Potassium levels ofpond water after treatment with Coagulants at different doses.

During the present investigation nitrate values were found ranging between1.030mg/l to 8.602mg/l(Table 6, figure 6). WHO (1993)[9] has fixed the value of nitrate in drinking water to be 50 mg/l and BIS[10] has set a desirable limit of nitrate in drinking water to be 45 mg/l and permissible value has been prescribed to be 100 mg/l. In the present study nitrate values were found to be less than the standard permissible limits of BIS and WHO (1993). Phosphate values were decreased by both coagulants (Table 6, figure 7), WHO has fixed phosphates permissible limit to be 0.1 mg/l and If level becomes too high, plant growth can accelerate resulting in the dense growth of algae and plants in the water. In thisexperiment the levels were lowered down to good extent, making itexist only in trace amount and which were below the permissible limits.

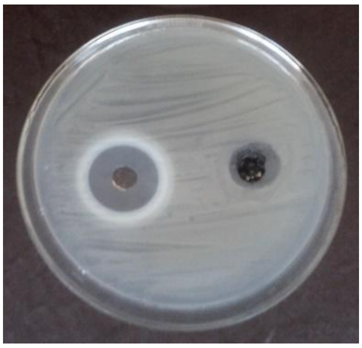
According to WHO standards Potassium levels in drinking water should be 12mg/l, treatment with activated charcoal produced results similar to WHO standards. But treatment with alum in lower doses (50mg/100ml and 100mg/100ml) helped to obtain values near to WHO Standards but when the dose was increased above 150mg/100ml, the level of potassium also raised (Table 6, figure 8).

Table 7:Antibacterial activity analysis of Activated Charcoal and Alum using well diffusion assay

Compound used	Mean Diameter of inhibition zone (mm)	
	Staphylococcus aureus (Gram positive)	*Escherichia coli*(Gram negative)
1) Activated Charcoal	21	16
2) Alum	28	24



Picture 1: *Staphylococcus aureus*



Picture 2:*Escherichia coli*

Figure 9: Picture 1 showing zone of inhibition on*Staphylococcus aureus* culture plate and Picture 2 showing zone of inhibition on *Escherichia coli* culture plate. The Right sided well in each plate consists of alum and left sidedone with activated Charcoal.

The results of antimicrobial activity against *Escherichia coli*and *Staphylococcus aureus* are presented in table 7 and figure 9. Both the coagulants showed antibacterial effect against both the strains but Aluminium sulphate (alum) showed significant activity whereas, a lesser inhibition zones were obtained in wells treated with activated charcoal.

Conclusion

From the above analyses, it could be concluded that both Aluminium sulphate (alum) and Activated charcoal powder served as primary coagulants in water purification. The muddy water with 151NTU turbidity when coagulated, proved that maximum turbidity removal was witnessed using alum dose of 150mg/100ml with a sedimentation time of 30 min.Both of themgave clear water, but Aluminium sulphate gave clearer water than Activated charcoal powder.So, it could be concluded that Aluminium sulphate remain a better coagulant in turbidity removal than Activated

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charcoal but it increased the TDS and Conductivity values. Alum maintained the Dissolved oxygen level to the constant state but, unlike Activated charcoal samples, Alum produces acidity which requires neutralization. Nitrate, phosphate and potassium levels were brought down by them within the permissible ranges. Both of them exhibited antibacterial activity against the selected gram-positive and gram-negative strains, but aluminium sulphate performed best. This experiment helps in understanding that instead of wasting tons and tons of water for agricultural, landscaping and washing vehicles, the muddy water obtained during rain and runoffs can be collected and treated with these coagulants, which latercan be used for these purposes. In this way these coagulants can help in water conservation.

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