

A Study ON Coagulant Efficiency Enhancement Of Alum And Ferric Chloride For CEPT Using Sea Water

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Abstract— In view of limited water resources available to meet the booming water demand, an advanced primary wastewater treatment technique is proposed. It is used for the treatment of low strength sewage higher dosages of coagulants where longer detention times are required. Here CEPT (Chemically Enhanced Primary Treatment) method is used for water treatment. Here introduce a new coagulant mix which includes conventional coagulant and sea water. Role of sea water in enhancing coagulation process has been thoroughly investigated. Alum and $FeCl_3$ were used as coagulants and it has been observed that coagulant performance has been enhanced with the introduction of sea water. In this paper includes the comparison between conventional coagulant and conventional coagulant with sea water. The experimental analysis conduct under the desirable limit as per IS 10500-2014. The CEPT supplemented by sea water is successful method in achieving better results for changing the characteristics of sample water. This focused strongly on the use of alum and $FeCl_3$ in wastewater treatment and then looks at the combined effect of seawater. The use of seawater certainly enhances treatment performances and these studies can therefore be considered catalysts for future research. Here the use of seawater is very carefully studied and considered for use in this paper

Keywords— CEPT using sea water, coagulation, sea water in water treatment

I. INTRODUCTION

Due to the ever increasing population and the blooming of industries, water pollution is increasing at an alarming rate and the need for an efficient waste water treatment plant is very important. Chemically Enhanced Primary Treatment (CEPT) is a technology that allows metal salts to increase suspended solids and other pollutant removal by coagulation and settling. The particle aggregates and flocs are formed which settle faster thereby enhancing treatment efficiency. It includes minimum energy use by treatment plant operating by CEPT principles and the small scale infrastructure needed. CEPT also increase the existing capacity of existing overloaded conventional treatment plants by retrofitting the treatment plant. A developing nation like ours cannot set up high cost water treatment plants due to economic and space restraints, thus the importance of CEPT. It offers a very cheap and efficient method of waste water treatment which satisfies the needs of a developing nation like India.

The advantages to using chemically enhanced primary treatment revolve mainly around large reductions in the volume and concentrations of required chemicals, ecological effects downstream, maintenance and operation labor demands, all of which translate into substantial economic savings. CEPT also allows the sedimentation basins to operate at higher overflow rates, while still maintaining ideal removal rates of BOD and TSS at approximately 55 and 85% respectively. The footprint of the treatment plant's infrastructure can therefore be significantly smaller, reducing capital costs. Since CEPT can be easily used to retrofit already existing secondary treatment processes (such as activated sludge basins for example), and reduce the BOD and SS load entering the secondary treatment process, these latter units are therefore made smaller and more efficient. Also, the addition of metal salts and polymers only require the installation of injection valves from storage tanks. Chemically Enhanced Primary Treatment (CEPT) is a wastewater treatment method that serves as an attractive alternative to conventional primary treatment and can also be used as an efficient preliminary step to biological secondary treatment (such as activated sludge and trickling filters). CEPT adopts the coagulation and flocculation processes and accomplishes a remarkable increase in the removals of common pollutants and contaminants such as BOD (biochemical oxygen demand), COD (chemical oxygen demand), TSS (total suspended solids), and TP (total phosphorous) present in the influent. The main advantage to CEPT therefore is to generate an effluent that can be efficiently and economically disinfected at a low cost compared to secondary treatment.

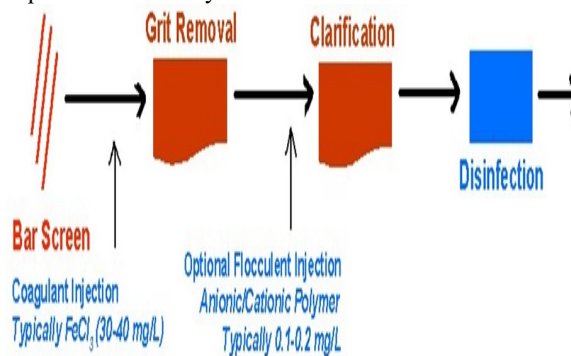


Fig.1 CEPT v/s Conventional primary treatment

The CEPT process is principally derived from conventional primary treatment since the influent in both processes passes through a bar screen (to remove large objects from the flow), grit removal chamber and clarifier both designed to

remove suspended solids. CEPT however enhances this process by injecting small doses of metal salts and/or cationic polymers prior to the grit removal process. An optional anionic polymer can also be added as a flocculent prior to clarification below describes the processes involved in both conventional and chemically enhanced primary treatment. The red processes are the conventional primary treatment and the blue additions explain the role that CEPT plays in treating the influent.

The injected chemicals act as coagulants/flocculants forming large heavy flocs that settle to the bottom of the clarifier and form a sludge layer than can be appropriately collected and removed. Particulate and colloidal settling are the processes responsible for the formation and settling of floc. Consequently, the BOD, TSS, and phosphorus removal efficiencies in CEPT have repeatedly been observed to be higher than those in conventional primary treatments and appreciably close to biological secondary treatment

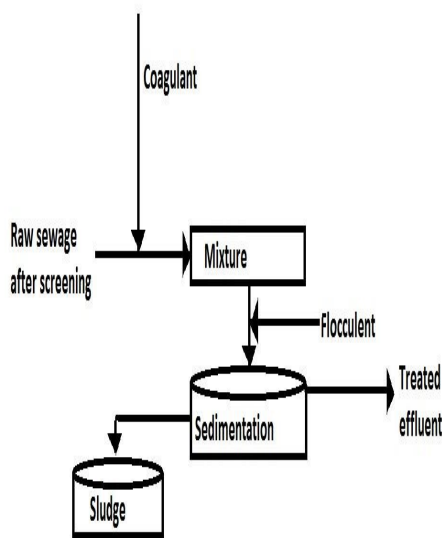


Fig.2. Process of CEPT

II. MATERIALS AND METHODS

A. Materials

The materials used in this project as follows

- Raw water sample collected from a pond near to Mayannur bridge
- Sea water collected from Chavakkad beach
- Alum -Ammonium Alum (Aluminium Ammonium sulphate) (AlNH₄(SO₄)₂. 12H₂O)
- FeCl₃-ferric chloride

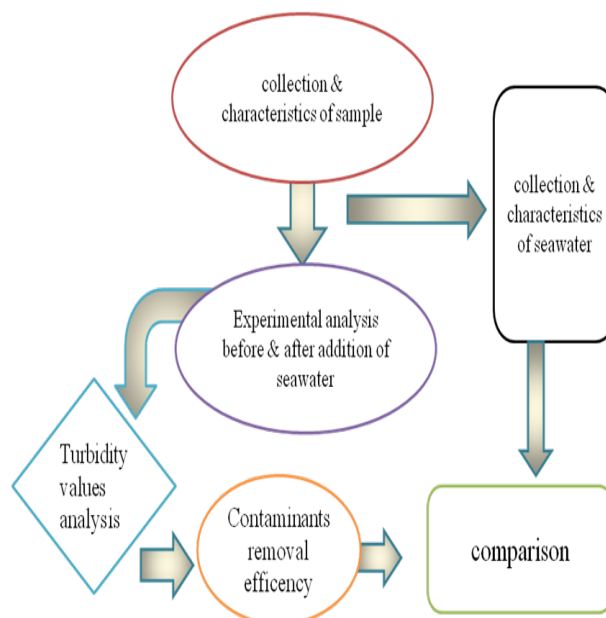
The code used for experimental analysis is 10500-2012



Fig .3 sample of waste water

B. Methodology

The flowchart for this project is described below:



Different doses of seawater ranging from 0.5 to 10% of seawater were also added to the samples to test the efficiency and feasibility of using seawater as a coagulant enhancement. The seawater was collected from a beach nearby at a measured salinity of 36 ppt (parts per thousand). In this project, seawater was added to the influent wastewater to test its efficiency as a coagulation enhancement mechanism. Seawater is naturally very abundant in chlorides that constitute slightly more than half of the percent by weight of dissolved ions. The reaction between chloride and silver sulfate creates silver chloride (AgCl). The reduction of silver sulfate correspondingly reduces the activity needed to oxidize straight chain hydrocarbons, a negative interference one would think. But the cloudiness of silver chloride precipitate causes a false positive absorbance value. Furthermore, the rigorous COD digestion can actually result in the reaction of dichromate with chloride to form chromic acid (and the elemental form of chlorine). Adding chlorine to the sample causes a positive interference. Chloride concentrations >2,000 mg/L cannot be corrected. Since the chloride content obtained is more than 2000 mg/l BOD test is preferred here in this project it is decided to compare conventional method of coagulation with new coagulant as sea water. For this, sea water is added with increasing percentages along with the alum or ferric chloride to enhance coagulation and the optimum

coagulation has to be find from the graph and then standard tests are to be carried out to find the characteristics of the treated water.

C. Collection and characteristics of sample and sea water

The sample is collected from the sewage pond. The selection and location of sewage pond is near to Mayannur bridge, Ottapalam. Its Latitude is 10.685062 longitude is 76.0422237

The chemical and physical characteristics of sample are determined by experimental analysis.

D. Sampling and location

The physical and chemical characteristics of sewage vary from top to bottom of sewage depth, as well as with time as from morning to evening. It therefore became difficult to obtain a truly representative sample. A fair compromise is therefore done in practice. Samples are taken at a point beneath the surface where the turbulence is thoroughly mixing up the sewage particles. This is called a grab sample. Such grab samples are mixed together, and the amount utilized from each specimen is proportional to the rate of flow at the time the specimen was collected. This composite sample is taken for testing, as it represents more nearly, the average true strength of sewage.

Here in this project, the sample was collected from a sewage pond near to Mayannur Bridge, Ottapalam. The characteristics of collected sample are tabulated below:

Table I
Sample characteristics

TEMPERATURE	31°C
pH	7.3
TURBIDITY	40.4 MG/L
DISSOLVED OXYGEN	6.1 MG/L
BOD	132.9 MG/L
TOTAL SOLIDS	686.6 MG/L

III. EXPERIMENTAL ANALYSIS

A. Jar test

Here alum and FeCl3 are the coagulants used. For different alum and FeCl3 dosages the obtained turbidity values are given in tables below.

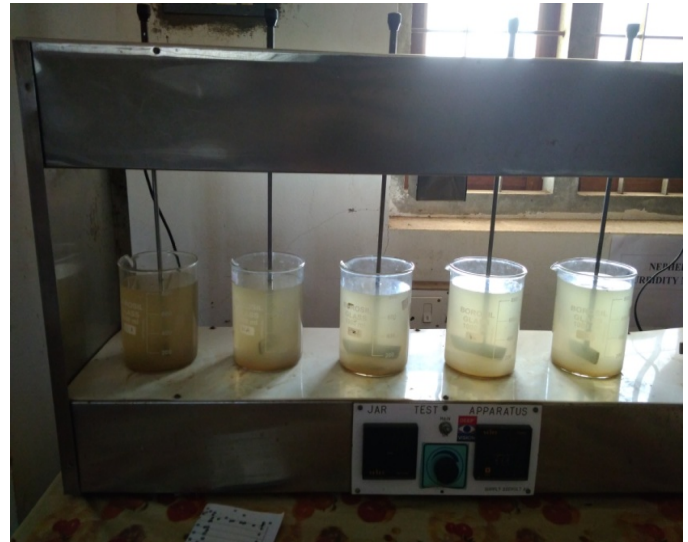


Fig 4 Jar test apparatus

Table .II
Turbidity values for different alum dosages

COAGULANT USED	ALUM					
DOSAGE(MG/L)	10	20	30	40	50	60
FLASH MIX TIME (MIN)	1	1	1	1	1	1
FLASH MIX SPEED(RPM)	100	100	100	100	100	100
SLOW MIX TIME (MIN)	30	30	30	30	30	30
SLOW MIX SPEED (RPM)	30	30	30	30	30	30
TURBIDITY (NTU)	23.4	7.1	3.2	2	2.9	4.2

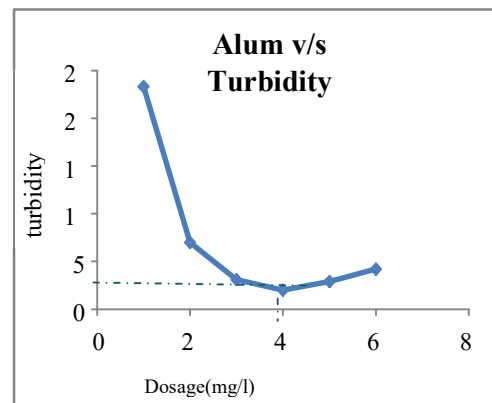


Fig.5 Alum dosage vs. Turbidity graph

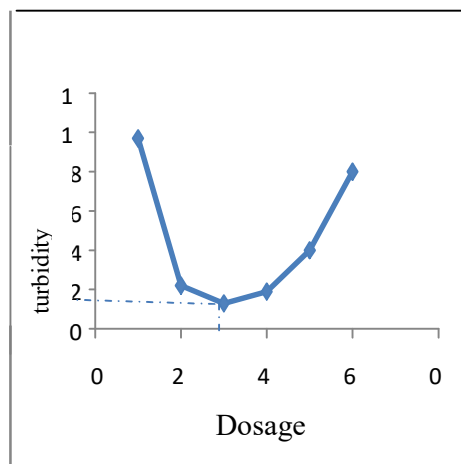


Fig 6 FeCl₃ dosage v/s Turbidity graph

From these graphs, it is clear that 40mg/l optimum alum dosage and 30mg/l optimum FeCl₃ dosage are obtained. Turbidity of sample after treated with 40mg/l of alum and 30mg/l of FeCl₃ are 2 NTU and 1.3 NTU respectively. As per IS 10500-2012 the optimum coagulant dosage between 5-85 mg/L. The obtained value of coagulant dosage for alum is 40 mg/L and for FeCl₃ is 30 mg/L. The sample is used for domestic purpose.

B. Dissolved Oxygen

The quantity of dissolved oxygen present in the given sample (s) by using modified Winkler's (Azide modification) method. Dissolved oxygen (DO) levels in natural and wastewaters are depended on the physical, chemical and biological activities prevailing in the water body. The analysis of D.O is a key test in pollution control activities and waste treatment process control. Improved by various techniques and aided by instrumentation, the Winkler (or iodometric) test remains the most precise and reliable titrimetric procedure for D.O analysis. The test is based on the addition of divalent manganese solution, followed by strong alkali to the water sample in a glass-stoppered bottle. D.O present in the sample rapidly oxidizes in equivalent amount of the dispersed divalent manganous hydroxide precipitate to hydroxides of higher valency states. In the presence of iodide ions and upon acidification, the oxidized manganese reverts to the divalent state, with the liberation of iodine equivalent to the original D.O content in the sample. The iodine is then titrated with a standard solution of thiosulphate. D.O of sample is 6.2mg/L. As per IS 10500-2012, the acceptable limit of dissolved oxygen in domestic water is 4-8mg/L. The obtained value is within the limit.

C. Total Solids

Total solids are considered to be the sum of dissolved and suspended solids. In potable water, the dissolved solids that are usually predominate, consist mainly of inorganic salts, small amount of organic matter and dissolved gases. The suspended solids contain much of organic matter. The total solids content of potable water usually varies from 20 to 100mg/L. In wastewater, suspended solids increases with pollution. One of the major objectives of determining solids in wastewater is to obtain the measure of the organics content. This is accomplished by ignition at 600°C, in which organic matter is converted to water and CO₂. The

determination of total solids is made by evaporation and drying of a measured sample in an oven at 105°C for a period of 1hr. Since water for potable use contains small amounts of suspended matter, it is usual to filter a sample of water and determine solids in the filtrate by the foregoing method. The difference between total solids in unfiltered and filtered samples is taken as a measure of the suspended solids present. For purpose of analysis, total solids are also classified as volatile or organic solids and fixed or inorganic solids. Volatile solids are found by igniting the dried residue till the volatile portion is burnt off, the loss on ignition representing the amount of organic solid. The final residue remaining is the fixed or organic solids. The settled solids are determined with the help of an Imhoff cone. The sewage sample is allowed to stand there in for 2hrs. The approximate volume of settled solids can then be observed directly.

TABLE III

Total suspended, dissolved solids, and total solids after treatment

COAGULANT	SAMPLE	ALUM(40 MG/L)	FECL3 (30 MG/L)
TOTAL SUSPENDED SOLIDS (TSS)(MG/L)	626	321	226
TOTAL DISSOLVED SOLIDS(TDS)(PPM)	60.8	88.4	90.7
TOTAL SOLIDS (TS)(MG/L)	686.6	409.4	316.7

As per IS 10500-2012 the acceptable value of total solids for domestic purpose is 500 mg/L. The obtained value of sample is 686.6 mg/L and after the treatment value changes into 409.4 and 316.7 mg/L for alum and FeCl₃ respectively.

D. Biological Oxygen Demand

Biochemical oxygen demand is defined as the amount of oxygen required by bacteria while stabilizing biodegradable organic matter under aerobic conditions. BOD test described herein is an empirical test in which standard laboratory procedures are used to determine relative oxygen requirements of wastewaters, effluents and polluted waters. It is an oxidation process in which diverse group of living organisms serve as the medium for the oxidation of organic matter to carbon dioxide and water. The BOD test is based on mainly bioassay procedure, which measures the dissolved oxygen consumed by microorganisms while assimilating and oxidizing the organic matter under aerobic conditions. The sample is sufficiently diluted using prepared dilution water, which contains nutrients and seeding organisms. It is then incubated for 5 days in an airtight bottle, in dark at a specified temperature at 20°C when the organisms oxidize the organic matter using part of oxygen present in the sample. The oxygen remaining in the sample can be determined. The difference between oxygen remaining and that present in the original sample is the 5-day BOD of the sample. The BOD of sample obtained was 132.9 mg/l before treatment. After treating with optimum alum and FeCl₃

dosages around 55 and 50 percentages of BOD respectively are removed.
 As per IS 10500-2012 the BOD value for drinking water should be nil.

IV. EXPERIMENTAL ANALYSIS OF SEA WATER

In this project, seawater was added to the influent wastewater to test its efficiency as a coagulation enhancement mechanism. Seawater is naturally very abundant in chlorides that constitute slightly more than half of the percent by weight of dissolved ions. The reaction between chloride and silver sulfate creates silver chloride (AgCl). The reduction of silver sulfate correspondingly reduces the activity needed to oxidize straight chain hydrocarbons, a negative interferent one would think. But the cloudiness of silver chloride precipitate causes a false positive absorbance value. Furthermore, the rigorous COD digestion can actually result in the reaction of dichromate with chloride to form chromic acid (and the elemental form of chlorine). Adding chlorine to the sample causes a positive interference. Chloride concentrations >2,000 mg/L cannot be corrected. Since the chloride content obtained is more than 2000 mg/l BOD test is preferred here.

Different doses of seawater ranging from 0.5 to 10% of seawater were also added to the samples to test the efficiency and feasibility of using seawater as a coagulant enhancement

A. Chloride Test

If water containing chlorides is titrated with silver nitrate solution, chlorides are precipitated as white silver chloride. Potassium chromate is used as indicator, which supplies chromate ions. As the concentration of chloride ions approaches extinction, silver ion concentration increases to a level at which reddish brown precipitate of silver chromate is formed indicating the end point.

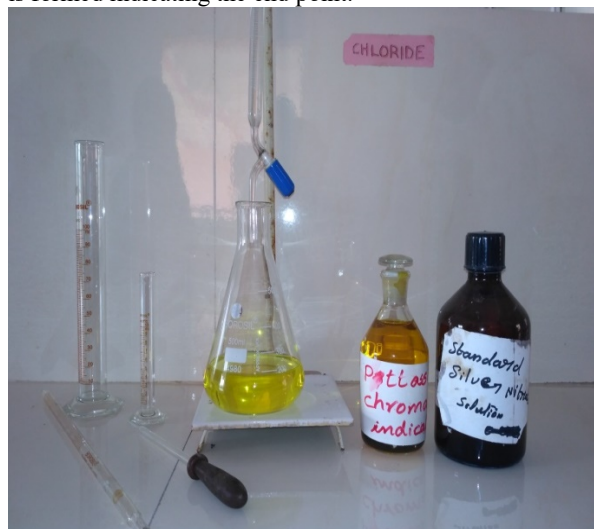


Fig 7. Chloride test after addition of indicator



Fig 8. Reddish brown precipitate obtained

Chloride content of sea water is 2318 mg/l.

B. Jar test

Keeping a constant alum content (optimum) different percentage by volume of sea water is added and again the jar test is conducted. The table shows the results obtained.

Table IV

.Turbidity values for different percentages of Alum and sea water

ALUM (40 MG/L) + SEAWATER (%)	0.5	1	2	4	6	8
TURBIDITY (NTU)	11.6	2.7	0.9	1.8	2.3	3.2

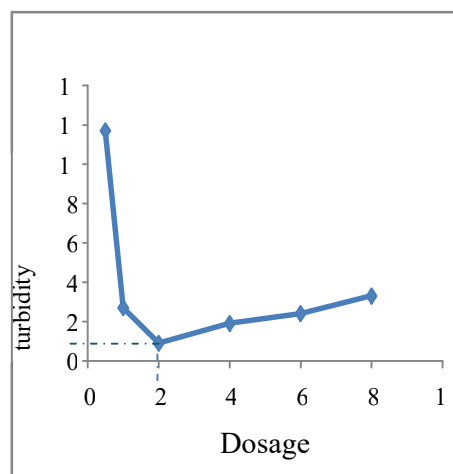


Fig 9.(Alum + Seawater) v/s Turbidity graph

Table V
Turbidity values for different percentages of FeCl₃ and seawater

FeCl ₃ (30 MG/L) + SEAWATER (%)	0.5	1	2	3	5	10
TURBIDITY (NTU)	4.1	3.4	2.1	1.4	0.8	1.1

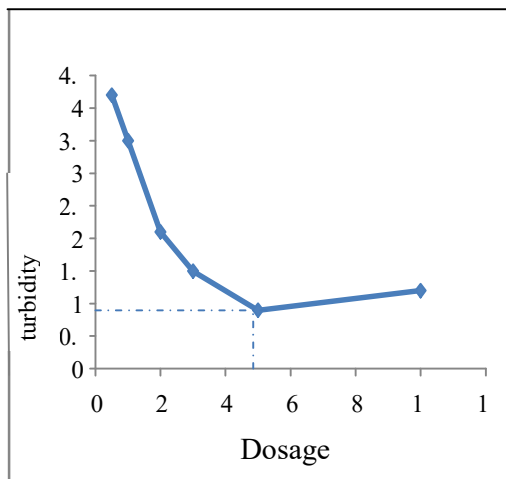


Fig.10 (FeCl₃+Seawater) v/s Turbidity graph

The results show that 2% and 5% by volume of sample are the optimum sea water percentages for 40mg/l alum and 30 mg/l FeCl₃ respectively. Also a significant reduction in turbidity value is obtained, that means the removal efficiency of coagulant is increased by the addition of sea water.

C. Total Solids

After the addition of 2% and 5% of sea water by volume of sample with 40mg/l of alum and 30mg/l of FeCl₃ respectively, the total solids are again checked. The obtained results are tabulated below

Table.VI
Total solids for optimum coagulant + seawater combination

	ALUM(40 MG/L)+ 2% SEA WATER	FeCl ₃ (30 MG/L)+ 5% SEA WATER
TOTAL SUSPENDED SOLIDS (MG/L)	302	212
TOTAL DISSOLVED SOLIDS (MG/L)	71	76
TOTAL SOLIDS(MG/L)	373	288

D. Biochemical Oxygen Demand

After getting the optimum concentrations of coagulant and sea water combination, the biochemical oxygen demand was again tested.

Table VII
BOD readings

DESCRIPTION	CONCENTRATION	DISSOLVED OXYGEN (MG/L)		DO OF DILUTION SEED BEFORE 3 DAYS (MG/L)	DO OF DILUTION SEED AFTER 3 DAYS (MG/L)
		INITIAL DO D1	FINAL DO D3		
SAMPLE TREATED WITH ALUM (40 MG/L) +2% BY VOLUME OF SEA WATER,	1%	6.7	3.4	6.2	3.3
TREATED WITH FeCl ₃ (30 MG/L) + 5% BY VOLUME OF SEA WATER,	1%	6.4	3.2	6.2	3.3

Sample when treated with alum (40mg/l) and 2% of sea water by volume, the BOD value obtained was 42.9 mg/l. And also when treated with FeCl₃ (30mg/l) and 5% of sea water by volume the obtained BOD value was 32.9 mg/l.

V. RESULTS AND DISCUSSIONS

Table VIII
Summary of results

ITEM	SAMPLE	ALUM(40MG/L) +2% SEA WATER	FeCl ₃ (30 MG/L)+5% SEA WATER
TURBIDITY (NTU)	40.4	0.9	0.8
TSS(MG/L)	626	302	212
TDS(MG/L)	60.8	71	76
TS(MG/L)	686.8	373	288
BOD(MG/L)	132.9	42.9	32.9

The turbidity of the sample is reduced from 40.4 mg/l to 2 mg/l and 1.3 mg/l respectively when treated with alum and FeCl₃ alone. The removal efficiencies are found to be increased when the coagulants are supplemented by sea water. A slight increase was observed in total solids after the addition of sea water. But it is still under the desirable limit as per IS 10500-2012.

When the sample is treated with 40mg/l (optimum) of alum, around 55% of BOD is removed. But when alum was again tested along with 2% sea water the removal efficiency was increased from 45% to 60%. Similarly the removal efficiency of 30 mg/l of FeCl₃ was around 55%, but it is increased to 70% when supplemented by sea water (5%).

VI. CONCLUSIONS

The chemically enhanced primary treatment supplemented by sea water is successful in achieving better results for removing turbidity, total solids, and BOD. The optimum coagulant dosages are found to be 40mg/l when treated with alum and 30mg/l when treated with FeCl_3 . In the next step all the tests were conducted for different percentages by volume of sea water. 2% and 5% by volume of sample of sea water with optimum alum and FeCl_3 are the optimum concentrations obtained.

The turbidity of the sample is reduced from 40.4 mg/l to 2 mg/l and 1.3 mg/l respectively when treated with optimum alum and FeCl_3 alone. But the removal efficiencies are found to be 97% when the coagulants are supplemented by sea water.

The amounts of total solids in sample are found to be increased when 2% and 5% sea water by volume of sample are added with the optimum coagulant dosages. Due to the fact that the sea water contains large number of dissolved solids, it will increase the total solids present in low strength wastewater, and thereby increases the ease of settlement.

Around 55% of BOD is removed when the sample is treated with 40mg/l (optimum) of alum. But when the alum is supplemented by 2% by volume of sample of sea water, the removal efficiency is found to be increased to 60%. Similarly the removal efficiency of 30 mg/l of FeCl_3 is around 55%, but it is increased to 70% when supplemented by 5% sea water.

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