COMPARATIVE STUDY OF NATURALLY AVAILABLE COAGULANTS

Submitted in partial fulfilment of the requirements for
the degree of
Bachelor of Engineering

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CERTIFICATE

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This is to certify that the project entitled "Comparative Study Of Naturally Available Coagulants " is a bonafide work of Mohd Shayan Rais (16DCE80), Mazin Mukhlis Madoo (16DCE74), Namra Salim Sonde(16DCE84), Mohd Furqaan Sayyed (13CE46),submitted to the university of Mumbai in partial fulfilment of the requirement for the award of degree of "Bachelor of Engineering" in department of Civil Engineering.

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Project Report Approval for B. E.

This project report entitled “Comparative Study of Naturally Available Coagulants ” is a bonafide work of Mohd Shayan Rais (16DCE80), Mazin Mukhlis Madoo (16DCE74), Namra Salim Sonde (16DCE84), Mohd Furqan Saiyed (13CE46) is approved for the degree of “Bachelor of Engineering” in “Department of Civil Engineering’’

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Supervisors

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Chairman (Director)

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Date:

Declaration

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

In this study we evaluate the "comparative study of naturally available coagulants" by performance coagulation-flocculation for removing turbidity as well as hardness from various waste water sample. The jar test apparatus consists of six jars containing different dosages of natural coagulants such as Moringa olifera, Tamarind, Nirmali etc. The procedure of coagulation-flocculation is carried out simultaneously. Later an optimum dosage is obtained for each coagulants. Comparative study of naturally available coagulants is carried out considering factors such as amount of removal of turbidity and hardness from waste sample, amount of sludge generated from samples, funds required for the treatment , environment affection point of view etc.

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Keywords : Coagulation-Flocculation, Natural coagulants, Turbidity, Hardness..

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Abbreviation Notation & Nomenclature.

BOD – Biodegradable oxygen demand

COD – Chemical oxygen demand

PH – Potential Of Hydrogen

NTU – Nephelometric turbidity unit

ORP – Oxidation reduction potential

AL -Alum

Chapter 1 Introduction

1.1 Background

In ancient Greek and Sanskrit (India) writings dating back to **2000 BC**, water treatment methods were recommended. People back than knew that heating water might purify it, and they were also educated in sand and gravel filtration, boiling, and straining. The major motive for water purification was better tasting drinking water, because people could not yet distinguish between foul and clean water. Turbidity was the main driving force between the earliest water treatments. Not much was known about micro-organisms or chemical contaminants.

After **1500 BC**, the Egyptians first discovered the principle of coagulation. They applied the chemical alum for suspended particle settlement. Pictures of this purification technique were found on the wall of the tomb of AmnophesII and Ramses II

After **500 BC**, Hippocrates discovered the healing powers of water. He invented the practice of sieving water, and obtained the first bag filter, which was called the 'Hippocratic sleeve'. The main purpose of the bag was to trap sediments that caused bad tastes or odours.

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1.4 OBJECTIVES

The objectives of this study are:

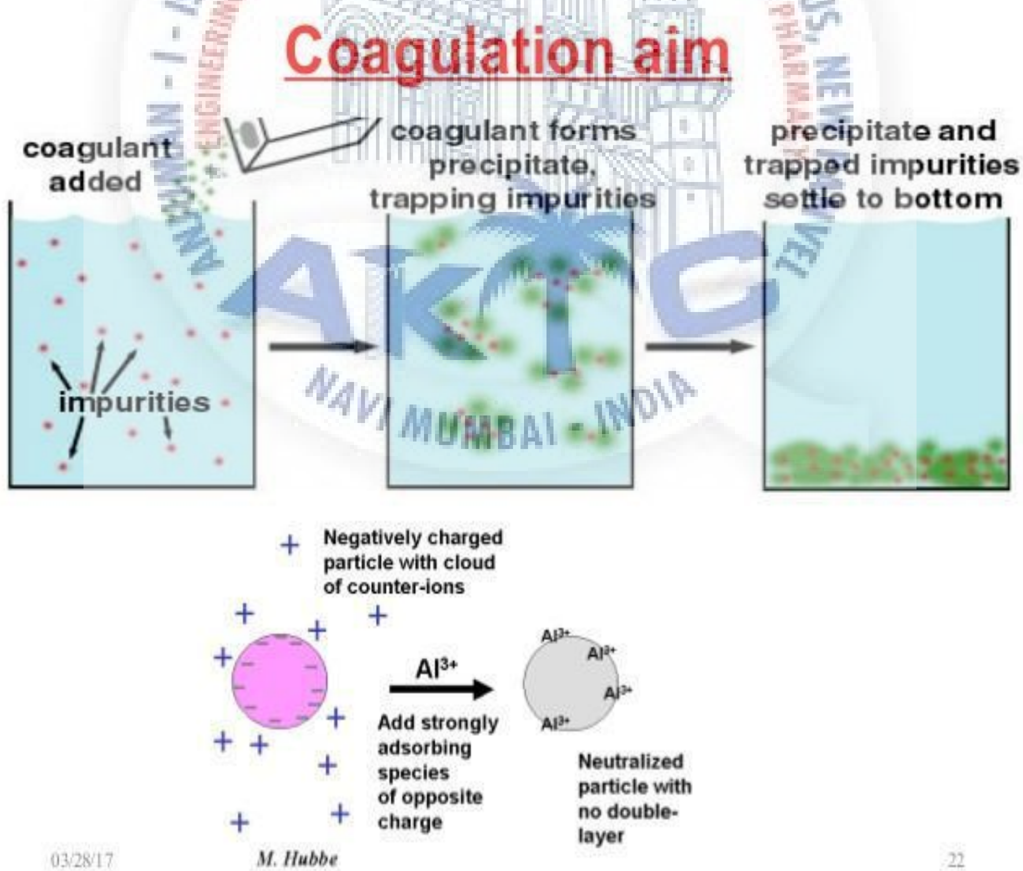
1. Study of different natural available coagulants.
2. To find the optimum dosage of coagulants
3. Comparative study of different natural coagulants
4. Cost analysis
5. Difference between natural coagulants and chemical coagulants.

CHAPTER 2 REVIEW OF LITERATURE

2.1 Introduction

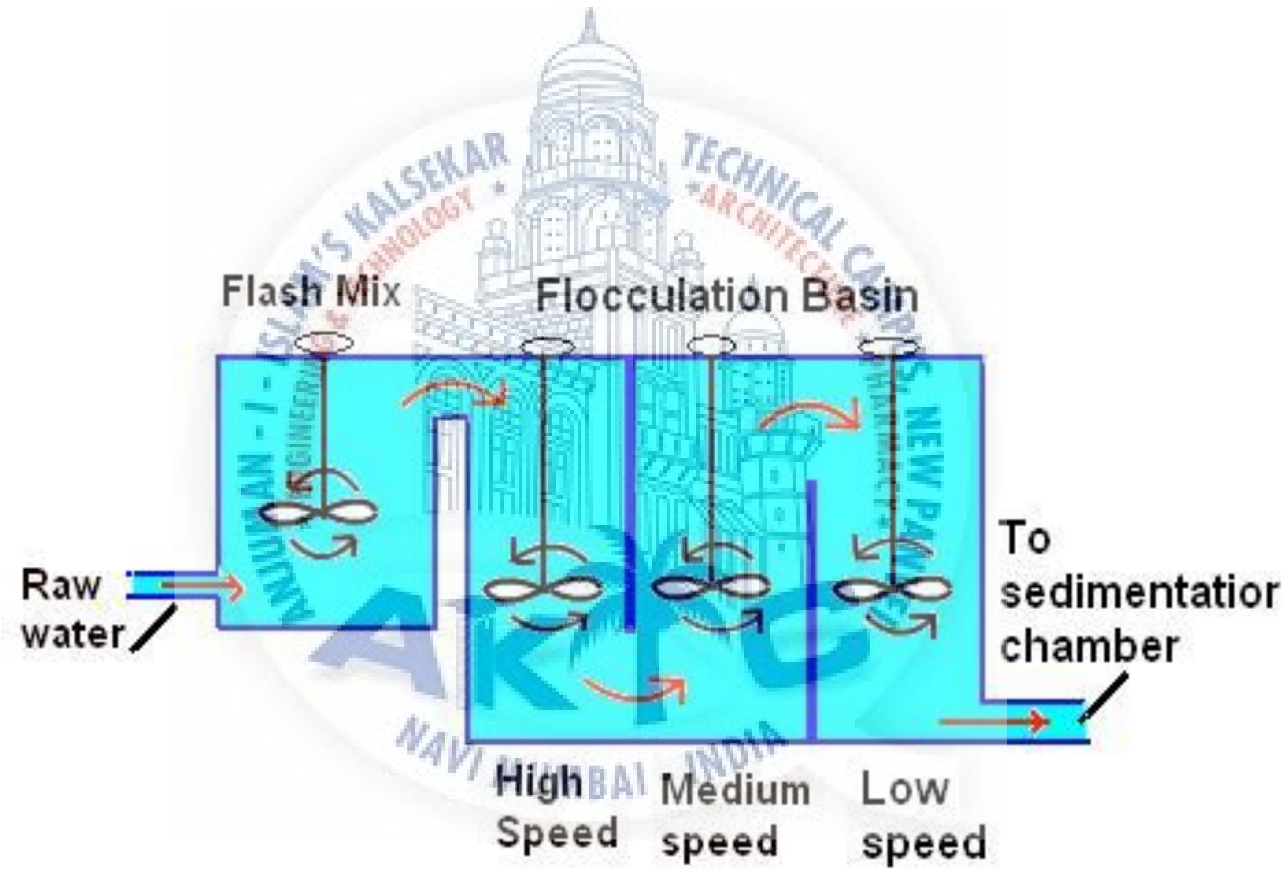
2.1.1 Coagulation

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. Coagulation is a chemical process that involves neutralization of charge whereas flocculation is a physical process and does not involve neutralization of charge. The coagulation-flocculation process can be used as a preliminary or intermediary step between other water or wastewater treatment processes like filtration and sedimentation. Iron and aluminum salts are the most widely used coagulants but salts of other metals such as titanium and zirconium have been found to be highly effective as well.



2.1.2 FLOCCULATION

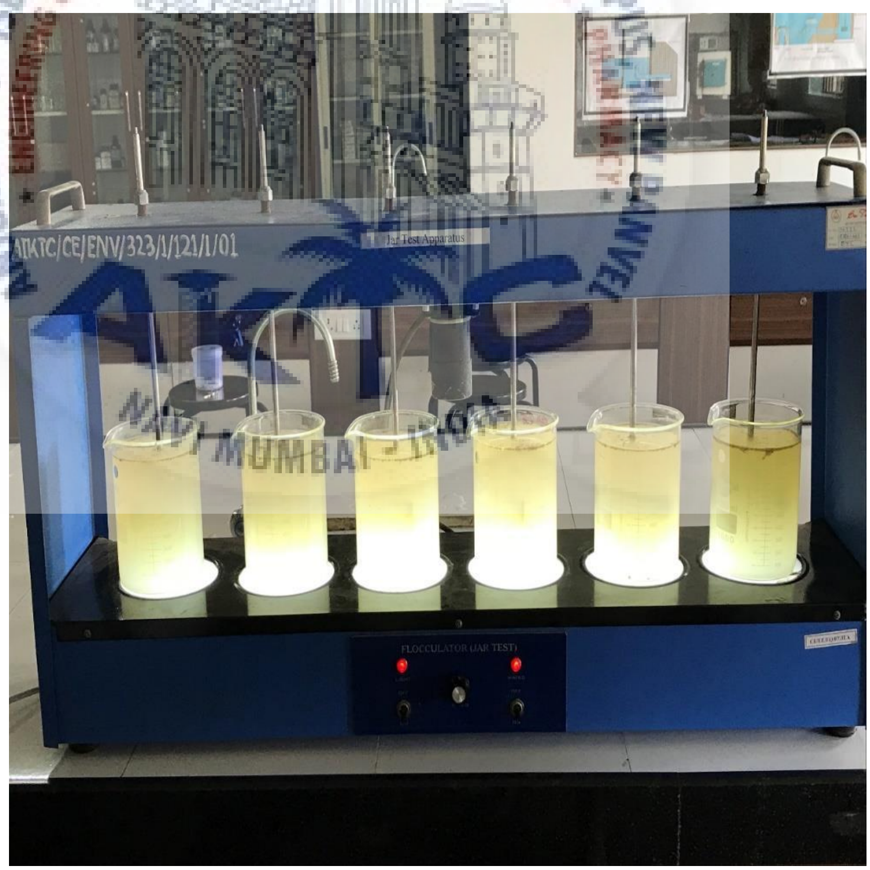
Now that the particles have a neutral charge and can stick together. The water flows into a tank with paddles that provide slow mixing and bring the small particles together to form larger particles called flocs. Mixing is done quite slowly and gently in the flocculation step. If the mixing is too fast, the flocs will break apart into small particles that are difficult to remove by sedimentation or filtration.



2.1.3 Sludge formation

In boilers, water evaporates continuously and the concentration of the dissolved salts increases progressively. When their concentrations reach saturation point, they are thrown out of water in the form of precipitates on the inner walls of the boiler. If the precipitation takes place in the form of loose and slimy precipitate, it is called sludge. On the other hand, if the precipitated matter forms a hard, adhering crust/coating on the inner walls of the boiler, it is called scale.

Sludge is a soft, loose and slimy precipitate formed within the comparatively colder portions of the boiler and collects in areas of the system, where the flow rate is slow or at bends. Sludge's are formed by substances which have greater solubility in hot water than in cold water



2.1.4 PH

So, what does pH mean for water? Basically, the pH value is a good indicator of whether water is hard or soft. The pH of pure water is 7. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5, and the pH range for groundwater systems is between 6 to 8.5. Alkalinity is a measure of the capacity of the water to resist a change in pH that would tend to make the water more acidic. The measurement of alkalinity and pH is needed to determine the corrosiveness of the water. In general, water with a pH < 6.5 could be acidic, soft, and corrosive. Acidic water could contain metal ions such as iron, manganese, copper, lead, and zinc. In other words, acidic water contains elevated levels of toxic metals. Acidic water can cause premature damage to metal piping, and have associated aesthetic problems such as a metallic or sour taste. It can also stain laundry and cause "blue-green" color staining on sinks and drains. More importantly, there are health risks associated with these toxins. The primary way to treat the problem of low pH water is with the use of a neutralizer. The neutralizer feeds a solution into the water to prevent the water from reacting with the household plumbing or from contributing to electrolytic corrosion. A typical neutralizing chemical is soda ash. Also known as sodium carbonate, soda ash works to increase the sodium content which increases pH. Water with a pH > 8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can also cause aesthetic problems. These problems include an alkali taste to the water (making that morning coffee taste bitter!), formation of scale deposits on dishes, utensils, and laundry basins, difficulty in getting soaps and detergents to lather, and the formation of insoluble precipitates on clothing.

According to a Wilkes University study, the association of pH with atmospheric gases and temperature is the primary reason why water samples should be tested on a regular basis. The study says that the pH value of the water is not a measure of the strength of the acidic or basic solution, and alone cannot provide a full picture of the characteristics or limitations with the water supply.

While the ideal pH level of drinking water should be between 6-8.5, the human body maintains pH equilibrium on a constant basis and will not be affected by water consumption. For example, our stomachs have a naturally low pH level of 2 which is a beneficial acidity that helps us with food digestion.

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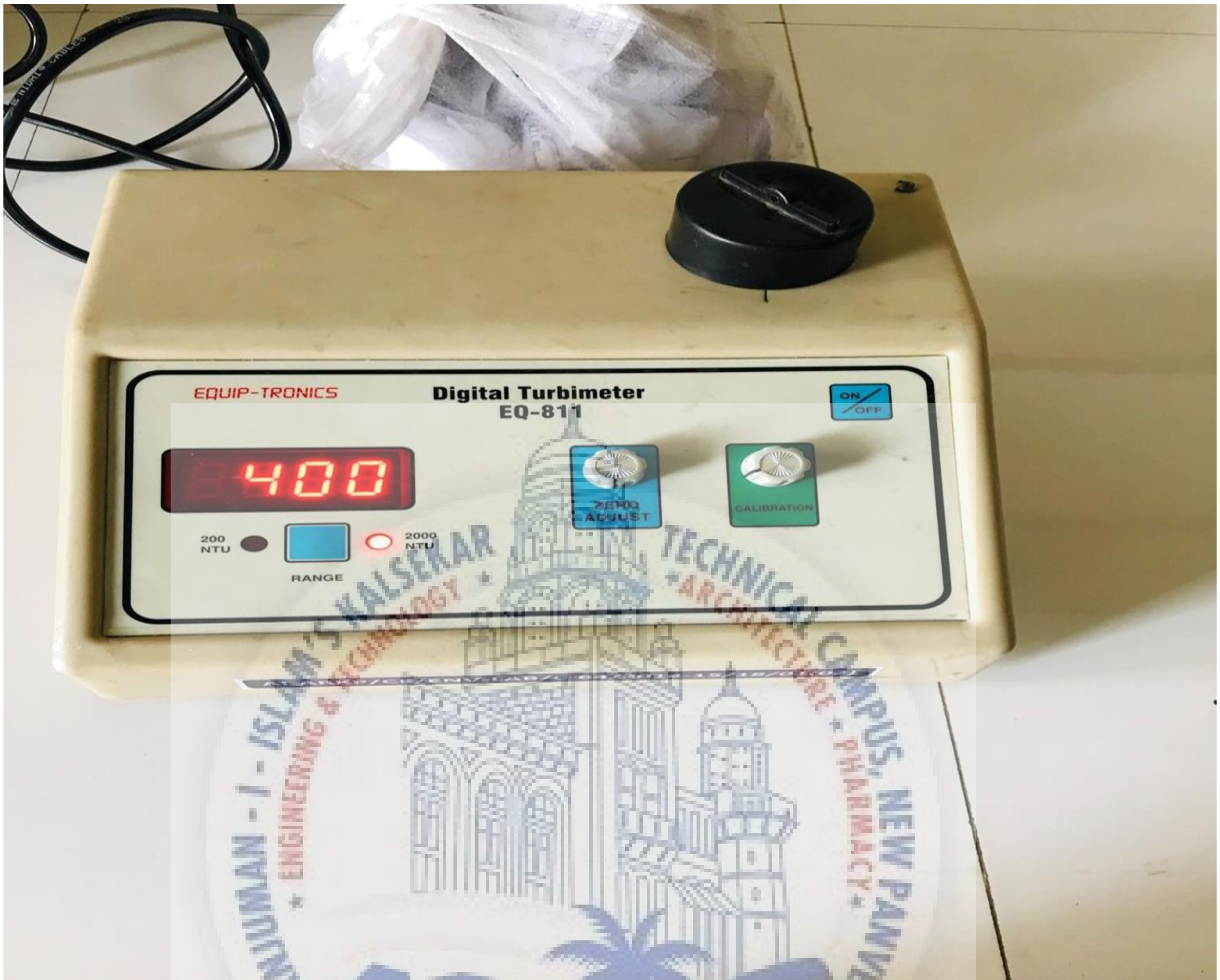
2.1.5 TURBIDITY

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates.

The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered as a good measure of the quality of water


EQUIP-TRONICS
Digital Turbimeter
EQ-811
ON
OFF
400
ZERO
ADJUST
CALIBRATION
200
NTU
RANGE
2000
NTU

2.1.6 HARDNESS

Hard water is a common quality of water which contains dissolved compounds of calcium and magnesium and, sometimes, other divalent and trivalent metallic elements.

The term hardness was originally applied to waters that were hard to wash in, referring to the soap wasting properties of hard water. Hardness prevents soap from lathering by causing the development of an insoluble curdy precipitate in the water; hardness typically causes the buildup of hardness scale (such as seen in cooking pans). Dissolved calcium and magnesium salts are primarily responsible for most scaling in pipes and water heaters and cause numerous problems in laundry, kitchen, and bath. Hardness is usually expressed in grains per gallon (or ppm) as calcium carbonate equivalent.

The degree of hardness standard as established by the American Society of Agricultural Engineers (S-339) and the Water Quality Association (WQA) is:

Degree Of Hardness	**Grains Per Gallon(GPG)**	**PPM or mg/L**
Soft	<1.0	<17
Slightly Hard	1.0-3.5	17-60
Moderately Hard	3.5-7.0	60-120
Hard	7.0-10.5	120-180
Very Hard	>10.5	>180

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2.1.7 Jar Test

A laboratory procedure that simulates coagulation/flocculation with differing chemical doses. The purpose of the procedure is to estimate the minimum coagulant dose required to achieve certain water quality goals. Samples of water to be treated are placed in six jars. Various amounts of chemicals are added to each jar, stirred, and the settling of solids is observed. The lowest dose of chemicals that provides satisfactory settling is the dose used to treat the water.

2.2 Review And Literature. :-

Various treatment methods are available for the treatment of PIWW. Many Chemical, physical and biological methods are generally used to remove colour, Chemical oxygen demand (COD), turbidity from the PIWW.
Various chemical Methods are Fenton-oxidation process, Photo Fenton oxidation process, electro Chemical oxidation, sequential batch reactor and physical treatment methods such as Adsorption, electro coagulation, etcthis technology(coagulation-flocculation) is used as physical and chemical treatment for water and wastewater Treatment as it is effective for removal of TSS, TDS, COD, BOD and colour for dairy, coffee, beverage, detergent, tar, vegetable tannery wastewater and lichgate. This treatment is not costly as a biological treatment and also required less time. Ballast flocculation is used in water municipal treatment for removal of suspended and dissolved particulate with micros and to enhance floc formation with polymer. As coagulation-flocculation as it is effective for TS, TSS, TDS, COD and colour removal or reduction this technology is used mostly used.

[G. Lofrano et al .,(2006)Toxicity Reduction in Leather Tanning Wastewater by Improved Coagulation Flocculation process., M. A. Aboulhassanet et al.(2008)studied Pollution reduction and biodegradability index Improvement of Tannery effluents. Zayas P´erez Teresa et al.,(2006) carried out Chemical oxygen demand Reduction in coffe wastewater through chemical flocculation and advanced oxidation processes]

Textile wastewater is generally characterized by high chemical oxygen demand (COD), biochemical oxygen demand (BOD), suspended solids (SS), conductivity and highly intense colors, which is to be treating before discharge in natural resources. Pei Wen Wong et al.,(2007) studied Efficiency of the Coagulation-Flocculation Method for the Treatment of Dye Mixtures Containing Disperse and Reactive Dye . Mohd Ariffin Abu Hassanet al., carrid out coagulation and flocculation treatment of wastewater in textile industry using chitosan for turbidity and COD removal. At varied ph, chitosan dose and mixing time the efficiency for COD and turbidity Removal was checked. Sample of textile wastewater was collected from a textile company.

For COD analysis the Reagent vials used were in high range (0 to 15 000 mg/l) and for turbidity HACH Ratio/XR Turbiditimeter were International Journal of Innovations in Engineering and Technology (IJIET).

Dairy wastewater is the high BOD and COD contents, high levels of dissolved or suspended solids including fats, oils and grease, nutrients such as ammonia or minerals and phosphates, color and therefore require proper treatment before disposal.

Baisali International Journal of Innovations in Engineering and Technology (IJIET) Sarkar et al.,(2006) studied Wastewater treatment in dairy industries- possibility of reuse in which they use membrane for treating the dairy wastewater and to make it fit for reuse. But with membrane they have to control the fouling and to improve the productivity and life of membranes, for that they gave the chemical treatment as coagulation-flocculation with electrolyte and for the pretreatment studies before membrane processing different types of coagulants like inorganic (alum and ferric chloride), polymeric (polyaluminium chloride) and natural organic (sodium carboxymethyl cellulose commonly known as Na-CMC, alginic acid, and chitosan) Were tested. And they observed that as alum and ferric chloride dosages of the coagulants were increasing, the formation of floc followed by settling was increases at pH 6.5 and 8.0 with 500 mg/l for alum and ferric chloride they observed variation of TDS.

when treated with 10 mg/L chitosan at pH 4. chitosan was found to have significant effect as coagulant for the dairy wastewater treatment It had lowered the TDS and COD values considerably at very low dosage as compared to the common coagulants.
And also conductivity not increased which help to design RO in present dairy treatment as a pre-treatment before RO to avoided fouling and increase life of membrane too.

CHAPTER 3 METHODOLOGY

3.1 Classification of Coagulants

3.1.1 Natural coagulants:-

The natural coagulants are used in wastewater treatments include microbial polysaccharides, starches, gelatine galactomannans, cellulose derivatives, chitosan, glues, and alginate. Coagulants which carry natural characteristics supposed to be harmless for human health, whereas existence of aluminium zest may provoke neurology & pathology diseases [11]. Natural coagulants are mixed with some artificial coagulants that are consumed as coagulant aid, their effectiveness as the key coagulant remains stays at early stages. The process of treatment in these coagulants composed of molecules bridging, adsorption, and charge balancing. Natural coagulants are capable for wastewater treatment following effluents discharge standard.

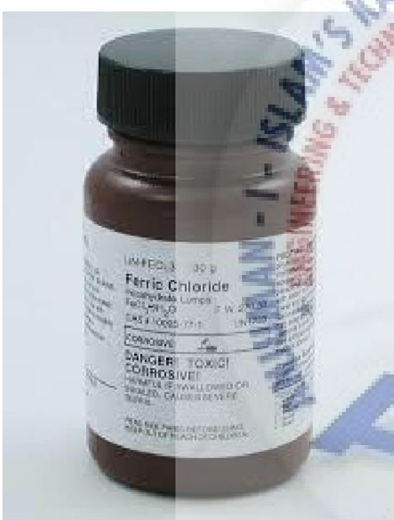
Moringa oleifera, is a non-hazardous (low concentrated) stifling plant whose seeds contain an edible oil and water soluble substance. It is widely known that this plant can be utilized for beneficial purposes. Moringa is most often consuming as provisions and remedial resource limited to urban areas . The most recommended coagulating agents with 12–14 kDa mass and about 10-11 isoelectric point (pI) are dimeric cationic proteins. Adsorption and charge neutralization its main coagulation method. Cationic protein having pI greater than 9.6 and mass, no less than 6.5 kDa. Conversely, Okuda argue that active elements from an aqueous extraction of salt that is not a polysaccharide or protein, actually they are organic polyelectrolyte having molecular mass of 3.0kDA . It is also discussed that bivalent cations are highly regarded (e.g. Ca^{2+} and Mg^{2+}) that raise the effect of moringa oleifera. It is known that interface provides strong adsorption in system, it also neutralized particles that may occur charge problem . Accumulation of cations can enhance the coagulant competency. Natural materials that are achieve from polyphenolic substructure are commonly known as tannin, such as Acacia, Castanea, or Schinopsis extracted from bark and wood. Applications of tannin are widely studies to treat water containing nitrogen atom with a lone pair and carbolic acid groups. Tannin gives 3meq/g charge density, since cationic in environment there is a single tertiary amine group per monomer .

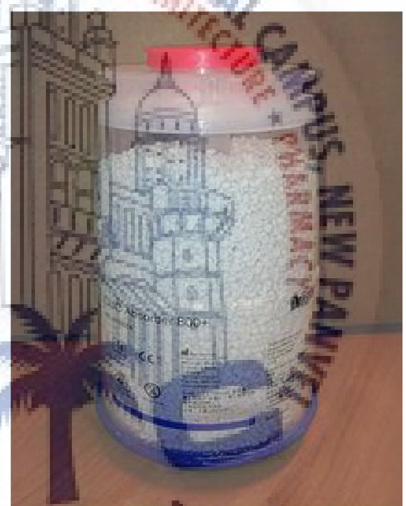
Tannis molecular weight ranges from 100 to 10,000 that is generally tanning agent in lather industry. However, such studies still can be explored in future. Furthermore, it also defines that tannin is impartial coagulant as aid that can be used to treat the water and wastewater treatment. It is general comprehension phenolic groups stabilized via resonance.

This gives attention that tannin structure is capable for coagulation. Most known cactus genus treating water 'nopal' in Mexico and 'prickly pear' in North America. This type of cactus is related with nutritional food sources & remedial characteristics. Beside opuntia cactus latifaria is widely used natural coagulant. The opuntia high coagulation ability recognized to the presence of mucilage assumes as complex carbohydrate and sticky, storage of these compounds in internal cactus and surface pads has high water retention capability. Mucilage in cactus opuntia has fiber such as l-rhamanosei, l-arabinose, d-galactose, d-xyloose, and galacturonic acid, predominantly during a bridging coagulation method solution particulates carry out indirectly contact from the cactus genus . The most capable coagulation and active element is galacturonic acid, it is wellknown 50% of turbidity removal . Another option of plant based coagulant using unexploded waste such as cassava peel. Fresh cassava peels have three main efficiencies: spread very rapidly, contain phytates, and huge amounts of cyanogenic glycosides. To shrink cyanogenic & phytate substance to maintain their natural value, altered methods are adopted in sinking cyanogenic glycoside like sun-drying, ensiling, and soaking + sun-drying. Peels are chopped to obtain good quality 2 cm for easy compression, and sagging for two days to decrease moisture substance from 70-75% to about 40% . After 21 days cassava peel silage was observe as light brown in appearance, with satisfying odour. The pH recorded as 4.4, and fungal growth was negligible.

3.1.2 Chemical Coagulants:-

The sedimentation process can be quickened by adding coagulants to the water. Chemical coagulants are commonly used in community drinking water treatment systems though some application in household water treatment occurs. The main chemicals used for coagulation are aluminium sulphate (alum), polyaluminium chloride (also known as PAC or liquid alum), alum potash, and iron salts (ferric sulphate or ferric chloride). Lime (Ca(OH2)), lime soda ash (Na2CO3) and caustic soda (NaOH) are sometimes used to "soften" water, usually groundwater, by precipitating calcium, magnesium, iron, manganese and other minerals that contribute to hardness.





3.2 Nirmali Seeds:-

Turbidity removal is one of the important steps in water treatment process and generally is achieved by using coagulation process. Turbidity is caused by the presence of suspended particulate matter or impurities that interfere with the clarity of the water such as clays, silts, finely divided inorganic and organic particles, soluble substances, plankton and other microscopic organisms in water.

Turbidity can also provide food for pathogenic microorganisms and particles of turbidity provide shelter for microorganisms by reducing their exposure to attack by disinfectants. Many coagulants have been widely used in conventional water treatment processes depending on their chemical characteristics.

The process of coagulation to clarify water using coagulant or coagulant aid is an ancient practice. Many developing countries can hardly afford the high costs of imported chemicals for turbid water and wastewater treatment.

In this context, environmental friendly coagulant presents a viable alternative for the treatment of wastewater and turbid water. The natural Strychnos potatorum (Nirmali seed) is widely used as coagulants to clarify turbid waters. In recent years natural and synthetically prepared organic nirmali seeds have been increasingly used in the coagulation of suspended matter in water and wastewater treatment.

The natural coagulants extracted from plants or animals can be workable alternatives too synthetic nirmali seeds as they are biodegradable, safe to human health and have a wider effective dosage range for flocculation of various colloidal suspensions.

3.2.1 Apparatus:-

Nirmali Seeds Powder, Jar test apparatus, Weighing machine, Measuring jar, Funnel, Stirrer.

3.2.2 Procedure:

MATERIALS AND METHODS

The tests were run on raw water from upper lake, Uhopal. Water samples of different turbidities were prepared by dispersing the clay and silt obtained from ihe bed of the lake. Nirmali seed used in these studies was obtained in a fresh condition from the local market. Water extract of the seed was prepared by taking one gram of the powdered seed in 200 ml. of water and mixing it at a high speed in a food blender for 10 minutes. The extract was made upto 1 litre and was preserved from batcterial decomposition by the addition of 1 ml. of concentrated hydrochloric aid (Sp. gr, 1.1) . The dosage of the extract was calculated as milligram of seed material per litre of sample. Jar tests were conducted with an electrically operated jar test machine, turbidimeter using glass tubes of 50 and 20 mm viewing depths. Analytical techniques used were those Riven in Standard Turbidity was measured in Hellige Methods."

NIRMALI SEED EXTRACT AS AN AID TO METAL COAGULANTS:

In a series of experiments the effectiveness of the extract as an aid to the conventionally used metal coagulants like alum, ferric chloride and ferrous sulphate was studied. Firstly, the optimum doses of the metal coagulants required for coagulating waters of different turbidity's were determined. Then, the dose of the metal coagulant was reduced to 1/2 to 1/3 of the optimum dose and varying doses of the extract were added as an aid. Jar tests were conducted as shown in Table 1.

Similar tests were carried out using FcCl3 and FeSO,. It was found that nirmali seed extract serves as an effective aid to all the conventional metal coagulants. A dose of 1 to 2 mg.-T of the extract reduced the amount of metal coagulant required to ^ to £ without affecting the efficiency of turbidity removal. It was further found that when nirmali seed extract is used as an aid (a) the Hoc formed was strong and not easily broken up in turbulent flow, and (b) the floe was coarse and settled quickly. The floe formation was more rapid. Further experiments' were conducted using alum as prime coagulant and extract as an aid.

EFFECT OF pH ON NIRMALI SEED EXTRACT AS AN AID

The pH of raw turbid water was varied from 3 to 11 by the addition of requisite amounts of mineral acid and alkali. The extract broadened the pH range of coagulation by alum, thereby increasing the flexibility of pH control. Floes formed by/alum and the extract in the pH range 3-11 were large and settled equally rapidly. The settling rate was found to be n,6t affected by the hydrogen-ion concentration of the raw water in the above range. At pH values less than 7 and greater than 9, there was significant deterioration in the quality of floe formed when alum alone was used as coagulant.

EFFECT OF PRE-CHLORINATION:

In many water works when treating raw water of low quality, pre-chlorination of -water is resorted to before it enters the flocculation chamber. It was therefore felt necessary to study the influence of pre-chlorination on the effectiveness of the Nirmali seed extract as an aid to alum. Chlorine doses upto10 mg/L were found to have no adverse effects on the coagulation by alum and the extract. On the other hand, chlorine had a beneficial effect. This finding is particularly interesting in view of the observation made by Pressman1 * that poly-electrolytes of the polyamine type water adversely allocated in normal Calcium hypochloric does of 11 mg of chlorine.

EFFECT OF FLOCCULATION TIME AND SETTLE TIME:

In another series of experiments, flocculation time and settling time were varied from 10 to 60 min. and 11 to 15 min. respectively keeping the mixing rate constant (60rpm). An increase in flocculation time upto30 min caused a general decrease in residual turbidity of settled water. Further increase in flocculation time decreased the efficiency of coagulation. The optimum flocculation time is in the range of 20 to 30min. As the settling time was increased upto15 min the final turbidity progressively decreased. However, the removal of a major portion of the turbidity took place in the first 10 min. Further experiment showed that the size and settleability of flocs were affected by the ionic concentration of water. Flocs were ill-formed in a poorly mineralised water.

REMOVAL OF COLOR

The colour of the raw water was increased from 8 to 40 units by adding different quantities of colour extract prepared by heating decaying straw, hay and leaves with water. Waters having different turbidities and varying intensities of colour were treated with required quantities of alum and the extract. Il was found that colour can be removed to a considerable extent from turbid waters by the extract in conjunction with alum. The extract was found to be not effective in removing colour caused by tannic acid. Pressman showed that cationic polyelectrolytes removed colour from water effectively. According to him the colour removal is due lo chemical inter-action or precipitation.

HIGH TURBIDITY (100 NTU)						
JAR	1	2	3	4	5	6
REDUCTION	15.5	14	13.4	12.3	11.6	11.1
AFTER FILTER	13.3	12	11.5	10.5	9.9	9.5
%	84.5	86	86.6	87.7	88.4	88.9
MEDIUM TURBIDITY (49 NTU)						
REDUCTION	17.1	16.7	16.3	15.9	15.8	15.6
AFTER FILTER	16.7	16.3	15.9	15.8	15.6	15.4
%	65.10	65.91	66.73	67.55	67.75	68.16
LOW TURBIDITY (35 NTU)						
REDUCTION	17.60	17	15.30	15	14.20	13.70
AFTER FILTER	17	16.7	15	14.8	14	13.20
%	49.71	51.42	56.28	57.14	59.42	60.85

3.3 Tamarind Seeds:-

Tamarind seeds contain high protein. This protein that acts as a natural polyelectrolyte whose utility is similar to synthetic coagulant. Chemical coagulant is more effective than natural coagulant but more expensive. Therefore a natural coagulant such as tamarind seeds becomes another consideration because it is relatively cheap and more environmental friendly. Natural coagulants have found to generate not only much smaller sludge volume of up to five times lower but also with higher nutritional sludge value. As such as sludge treatment and handling cost are lowered making it a more sustainable option. This study aimed to analyse the effectiveness of tamarind seeds as a natural coagulant in the treatment of traditional gold mine waste water.

A) Apparatus:-

Tamarind seeds, jar test apparatus, measuring jar, weighing machine, stirrer, funnel.

B) Procedure

Methodology:-

The methods employed in investigating the effectiveness of tamarind seed powder as a natural coagulant in the treatment of the wastewater obtained from a detergent industry are as outlined thus.

Collection and Preparation of Tamarind Seed Powder

Tamarind seeds were collected from a tamarind tree available at staff quarters of Abubakar Tafawa Balewa University, Bauchi, Nigeria. The tamarind seeds were soaked for about 24 hr before they were washed to separate the seeds from the pulp and rewashed to remove adhering pulps. The seeds were dried under atmospheric temperature first and, then, inside an oven for about eight (8) hours at 50 °C. This was carried out thus so as to make the tamarind seeds easy to been crushed. The crushing of the seeds was carried out for size reduction using mortar and pestle. The crushed seeds were ground using a blender to produce the tamarind seed powder that was sieved to form medium fine powder used as the coagulant.

3.3.1 Jar Test Experimental Procedure

The coagulation-flocculation test of this work was carried out using jar test experimental method, which is the most widely used experimental methods for coagulation-flocculation. The method was accomplished using the setup shown in Figure 1.

The experiments were carried out in three parts, viz. coagulation at varying pH, coagulation at varying time and coagulation at varying dosage. Six jars that were filled to 500 ml marked were used for each part of the experiments. pH adjustment was achieved by addition of 2 M sulphuric acid and 2 M potassium hydroxide.

For the first part, coagulation was carried out at varying pH. In this case, the pH was varied within 2-8 at interval of 1.5 with the sixth jar coagulated at the initial pH of the sample (pH unadjusted) while the other variables were fixed. Constant mixing speed of 140 rpm was applied for 3 minutes in order to have rapid mixing and 40 rpm for 7 minutes was applied for slow mixing. A constant dosage of 400 mg/L of the coagulant was also used. The pH that gave thebest turbidity removal efficiency and chemical oxygen demand (COD) removal was taken as the optimum one.

For the second part, the pH of the samples was adjusted to the optimum pH as determined from the experiment carried out at varying pHs. pH and coagulant dosage were kept constant at 7.25 and 400 mg/L respectively and the mixing time was varied. The rapid mixing speed of 140 rpm for 3 minutes were used for all the jars and slow mixing of 40 rpm was used at time intervals of 0, 5, 10, 15, 20 and 25 minutes in order to determine the optimum mixing time that would give the best turbidity removal efficiency and COD removal.

For the third part of the experiments, constant pH of 7.25 and mixing time of 140 rpm for 3 minutes and 40 rpm for 15 minutes were used while the coagulant dosage was varied from 100 to 3800 mg/L. The dosage that gave best turbidity removal efficiency and COD removal was taken as the optimum one in this case also.

3.3.2 Results and Discussion:-

Wastewater Characteristics The results obtained from the analysis of the wastewater collected from the detergent industry were as given in Table 1.

Table 1: Characteristics of wastewater obtained from the detergent industry

Sr.No.	Parameter	Value
1.	Turbidity (NTU)	1670
2.	Initial pH	12.68
3.	COD (mg/L)	1118.64

As can be seen from the results given in Table 1, the values of the characteristics of the wastewater were found to be higher than the acceptable limit of the water that could be discharged into a river directly without treating.

For instance, the pH of the water was found to be far from neutral, as can be noticed from the table. So, the need for the treatment of the wastewater was very obvious.

3.2 Coagulation-Flocculation by Varying pH

The results obtained for coagulation-flocculation carried out at various pH values with constant mixing time and dosage are given in Figures 2 and 3.

The constant values used for mixing speed were 140 rpm for 3 minutes and 40 rpm for 7 minutes while that of the dosage was 400mg/L.

From Figures 2 and 3that are showing the effect of pH on turbidity and COD removal when the coagulant dosage and the mixing speed were kept constant, it was observed that turbidity removal and COD removal were changing as the pH of the wastewater was also changing. The pH that gave the highest turbidity removal was found to be 7.25.

The results obtained in this case was found to be in line with the literature because [27]found an optimum pH of 8 for turbidity removal when wastewater from a textile industry was treated using tamarind seed powder as coagulant at constant dosage of 150 mg/L and mixing time of 100 rpm for 1 – 2 min rapid mixing and 30 – 40 rpm for 20 min for slow mixing.

HIGH TURBIDITY (95 NTU)						
JAR	1	2	3	4	5	6
REDUCTION	5.9	5.1	4.6	4.5	4.3	3.9
AFTER FILTER	5	4.3	3.9	3.8	3.6	3.3
%	93.78	94.63	95.15	95.26	95.47	95.89
MEDIUM TURBIDITY (49 NTU)						
REDUCTION	12.6	12.4	10.2	9.3	9.1	9
AFTER FILTER	10.8	10.6	8.7	7.9	7.8	7.7
%	74.28	74.69	79.18	81.02	81.42	81.63
LOW TURBIDITY (31 NTU)						
REDUCTION	19.39	18.99	18.42	17.63	17.39	16.44
AFTER FILTER	15.9	15.2	14.9	14.0	13.3	12.9
%	62.54	61.25	59.41	56.89	56.09	55.89

3.4 Moringa Oliefera:-

Besides synthetic chemicals, there are natural ingredients that can be derived from tropical plants which can be used as coagulants, including moringa seeds (*Moringa oleifera*). The use of natural ingredients from local indigenous plants to clear muddy water is not a new idea From existing reports, there were allegations that the powder of Moringa seeds has antimicrobial properties.

Previous research found that Moringa is not toxic and recommended for use as a coagulant in developing countries. Various studies have been conducted and showed that moringa seeds are effective as biocoagulant to improve physico-chemical properties of contaminated water. *M.oleifera* functions as coagulant trough adsorption and neutralization mechanisms . *Moringa oleifera* is potential as organic pollutant absorber in simulation solution . *M. oleifera* is reported able to eliminate the turbidity and dissolved organic matters of river water . Damayanti *et a*(2011) made a membrane consisted of *M. oleifera*, PAC and zeolite for palm oil effluent treatment Therefore it is not difficult to use Moringa seeds as a natural coagulant or biocoagulant for water clarifying process.

The use of natural coagulants in water treatment process is expected to provide more advantages than the use of synthetic materials because they are natural and reported as safe to be consumed. The cost of using natural coagulants will be less expensive than that of alum. Effectiveness of natural coagulant for water purification will be tested also in the wastewater treatment process. Therefore, research should be conducted to find out the effectiveness of moringa seed in improving water quality.

Water quality parameters that need to be investigated are including turbidity, electrical conductivity, pH and temperature, metal absorbing capability, and ability to decrease microbial content. .

3.4.1 Apparatus:-

Moringa Olifera Seeds, Jar test , Weighing machine, Measuring Jar, Funnel, Stirrer.

3.4.2 Procedure:

MATERIALS AND METHODS

Seed sampling and preparation Seeds of moringa oleifera plant were obtained within Makurdi metropolis. The seedpods were allowed to mature and dry naturally to a brown colour on the trees before harvesting. To obtain the water extract of moringa, the finely crushed seed powder 10grams were mixed with 100ml of clean water to form paste. The insoluble material was removed by filtering the paste through a funnel containing cotton wool into 100ml containers.

JAR TEST

Varying amounts of water extract of moringa oleifera seeds (WEMOs) were flocculated rapidly and slowly for 15minutes. The settled turbidity and suspended solids were measured and correct coagulant dosages determined.

Determination of suspended solids (SS), turbidity, temperature and pH of water samples

Photometric method was adopted in the measurement of suspended solids as described by Baker (1980). For turbidity, a DR/2000 model 1990 spectrophotometer was adopted. A long stem thermometer was used by inserting into the water samples. The values of the temperatures were read after allowing in for 5 minutes. Similarly, pH readings were taken with a pH meter model 1– 125.

3.4.3 RESULTS AND DISCUSSION

The result of the jar test analysis gave optimum dosage as presented in figure 1.0. The analysis shows that 8 milliliters of the extract coagulant is capable of treating raw water that has slight to moderate turbidity not exceeding 250 NTU. Consequently, the assessed water parameters after 1 hour of settling time is presented as shown in figures 2 – 5. At 98rpm, 196rpm and 260rpm, 85 – 89%, 41 – 59%, 63 – 80% removal of suspended solids were observed. After two hours of detention period, the treatment efficiencies were increased for both parameter removals as shown in figures 6 – 9. The treatment indicates optimum performance in the removal of solids and turbidity at the low speed of 96rpm, and at 2 hours of detention time. Furthermore, the use of the extract coagulant is capable of reducing the pH of the treated water marginally, but not significant enough to affect the quality of the water.

HIGH TURBIDITY (100 NTU)						
JAR	1	2	3	4	5	6
REDUCTION	13.1	12.7	10.6	10	9.2	5.9
AFTER FILTER	11.2	10.9	9.1	8.6	7.9	5
%	86.9	87.3	89.4	90	90.8	94.1
MEDIUM TURBIDITY (48 NTU)						
REDUCTION	16.5	16.1	15.7	15.1	14.9	14.7
AFTER FILTER	14.1	13.8	13.5	12.9	12.8	12.6
%	65.62	66.45	67.29	68.54	68.95	69.37
LOW TURBIDITY (25 NTU)						
REDUCTION	19.8	18.1	18.8	17.5	16.9	16.2
AFTER FILTER	18.6	17.3	17.1	16.9	15.7	15.2
%	56	57.2	58	58.8	59.2	60

3.5 ALUM:-

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. .

Although concern over the safety of treating water with aluminum has often been voiced, there is no evidence that aluminum in water, whether it comes from the aluminum sulfate used in treatment or from other sources, is a health issue. Actually, most aluminum that we take in does come from other sources. One study showed that only between 0.4% and 1.0% of our lifetime intake of aluminum comes from alum used to prepare municipal water. Most aluminum intake is from aluminum that occurs naturally in foods, aluminum used in food packaging, and from products like deodorants and vaccines

3.5.1 Apparatus for Standard Proctor Compaction Test

Apparatus:

1. pH meter with electrode to monitor pH.
2. ORP meter with electrode to monitor the reduction reaction.
3. 300 ml – 400 ml Beakers, clear plastic or glass.
4. Magnetic Stirrer or equivalent.
5. Eyedroppers for adding chemical reagents.
6. Laboratory Type Filter.
7. Metals Test Kit or AA Spectrophotometer, etc

3.5.2 Procedure for Standard Proctor Compaction Test

SAMPLING

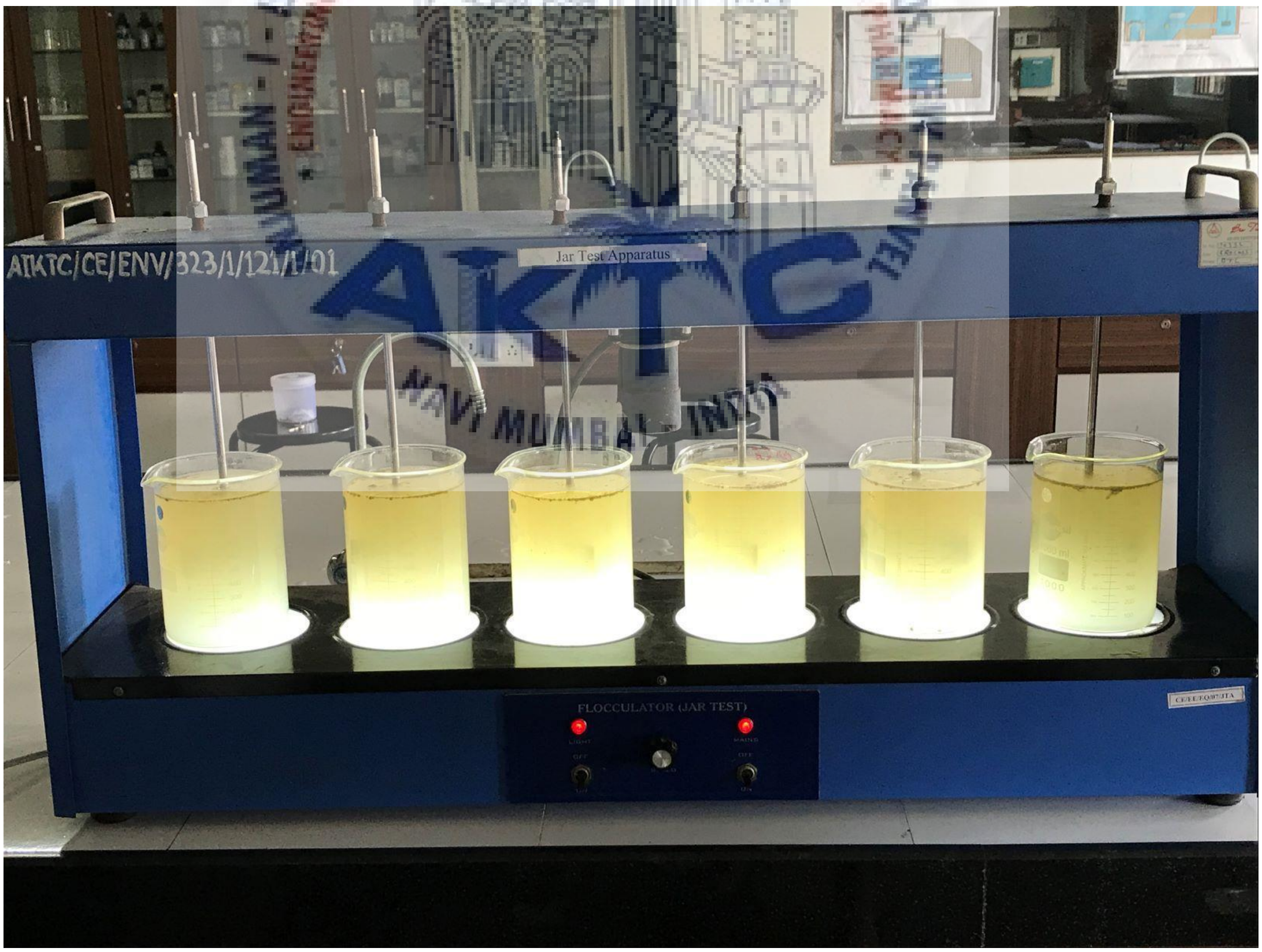
Water samples were collected from four stations at Canyon Lake on August 27, 2012, two locations in the Main Body and two locations in the East Bay. Samples from the main body of the lake (8 L) were collected from below the thermocline (i.e., in the hypolimnion). Samples from the east bay were taken at approximately 1 meter depth as the lake at these locations was not stratified. Samples were collected at the same CSUSB monitoring stations that have been used for the past 6 years. The main lake body stations were 7 (near the dam) and 8 (middle of main channel). Samples from the east bay (10 L) were collected at monitoring stations 9 and 10, from the middle of the channel adjacent to Road Runner and Indian beaches, respectively. All water samples were collected using a 4.2 liter vertical beta type van Dorn sampler (with acrylic tube, Wildlife Supply Company). Repeat grab samples were collected at the appropriate depths until the desired volume was obtained. Samples were transferred to precleaned 2.5 liter clear glass or 4.0 liter amber glass bottles. Samples were stored on ice in ice chests until returned to the lab, and then were stored in a walk-in refrigerator at 4°C until analyzed. Depth profiles at each station were measured at 1 meter intervals using a Hach Hydrolab DS-5 water quality sonde. Parameters measured included depth, temperature, electrical conductivity, ORP, and turbidity. Dissolved oxygen data were not obtained as the LDO probe on the Hydrolab was not functioning properly. Data from the depth profile at each station were used to determine in the field at what depth to take the samples.

JAR TEST

Jar tests were performed on the collected samples using 1.0 L samples, on a six stirrer Phipps and Byrd programmable jar test apparatus (Figure 1). Jar test were performed as follows: The appropriate amount of 10,000 ppm alum stock was added to each sample, and flash mixed at 220 rpm for 1.25 minutes, then followed by flocculation at 25 rpm for 30 minutes. The samples were then allowed to settle for 2-3 hours until all of the floc had fully settled. Before and after treatment samples were measured for pH, temperature, turbidity, conductivity, dissolved aluminum concentration, total organic carbon (TOC), total nitrogen and total phosphorus. The goal of the testing was to identify the dose of alum required to achieve a turbidity of less than 1.0 NTU. The tests were performed at doses of 0 (control, before), 10, 25, 50, 75, and 100 mg/L Alum. Based upon the results of the initial testing, two additional alum concentrations were tested, 125 and 150 mg/L.

Water Quality Analyses

In the laboratory all water quality parameters were measured using methods and protocols as described in standard EPA methods or in Standard Methods for the Examination of Water and Wastewater, 21st edition [4]. The temperature, pH and conductivity were measured using a WTW 350i multiparameter field probe. Turbidity was measured with a HF Scientific MicroPTW portable turbidimeter. TOC was measured on a Teledyne Tekmar Apollo 9000 combustion TOC analyzer. The total nitrogen (TN) and total phosphorus (TP) were measured on a LACHAT Quickchem 8500 Flow Injection Analysis (FIA) system. Samples were processed using the LACHAT method of persulfate digestion followed by simultaneous TN/TP analysis. The dissolved aluminum concentrations before and after treatment were measured using a Perkin Elmer AAnalyst 600 graphite furnace atomic absorption spectrophotometer, using the EPA Method 200.9 protocol [5]. Because of the critical nature of the dissolved aluminum concentrations, blank samples (i.e., deionized water) were subjected to the entire jar testing procedure to ensure that there was no aluminum contamination introduced by either laboratory cleaning and handling procedures or the testing apparatus. None of the blank samples analyzed showed detectable levels of aluminum.



RESULTS and DISCUSSION

Field Data

The results of the parameters measured in the field are shown in Tables 1-4. The results show that station 7 in the deepest part of the lake near the dam was well-stratified, as usual for that the time of year. Station 8 also in the main channel of the Lake was not really stratified with a thermocline appearing at approximately 1.5 meters above the bottom. Samples were collected at 8.5 meters and at 5.5 meters for stations 7 and 8, respectively. Plots of the temperature depth profiles for stations 7 and 8 are shown in Figures 2 and 3. Samples were collected at stations 9 and 10 at approximately 1 meter below the surface.

Laboratory Water Quality Data

The results of the laboratory water quality analyses are shown in Tables 5-9. For the hypolimnion samples from stations 7 and 8, a dose of 25-50 ppm alum is sufficient to achieve a turbidity of ≤1.0 NTU. However, doses of 100 ppm are required to achieve the lowest dissolved Al concentrations, and maximum phosphorus removal. For the east bay water samples, it appears that a dose of 100 ppm alum is required to achieve both turbidity reduction and the lowest dissolved Al concentrations, and maximum phosphorus removal. It is noteworthy that the pH of the sample from station 10 (farthest into the east bay) dropped almost two pH units with a 100 ppm alum dose. However, pH and turbidity measurements taken after 24 hrs showed that pH had gone back up by 0.6 pH units while turbidity dropped slightly.

These initial results show that alum is very effective in reducing the turbidity and phosphorus, and to lesser extent nitrogen content of the waters from throughout the lake, but the residual aluminum concentrations exceed the EPA chronic ambient water quality criterion for protection of aquatic biota, which is 87 µg/L for chronic toxicity (the acute toxicity criterion is 750 µg/L) [6]. In response to the initial results showing dissolved Al concentrations above the chronic criterion, two additional concentrations of alum were evaluated, 125 and 150 mg/L alum. The results of the higher concentrations showed that an alum dose of 150 mg/L was able to reduce the residual dissolved Al concentrations significantly to a range of 89-106 ḡ/L. This is only slightly above the chronic criterion and thus these residual concentrations may be acceptable.

SUMMARY OF RESULTS

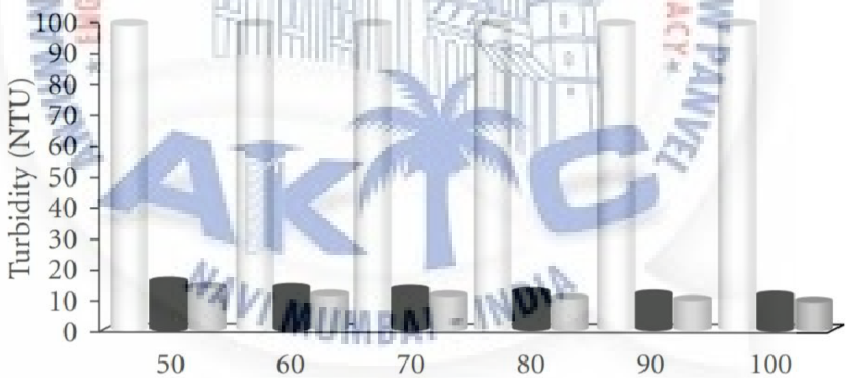
The results of this study show that in-lake treatment with alum may be an effective way to remove both existing turbidity and nutrients from Canyon Lake water. The removal of nutrients will reduce the potential for future water quality problems in the lake. For Stations 7 and 8 below the thermocline, and for Station 9, an alum dose of 50 mg/L was sufficient to drop turbidity to less than 1.0 NTU. This dose also resulted in reductions in total nitrogen of 6%, 36%, and 28% for stations 7, 8 and 9 respectively. Even greater relative reductions in total phosphorus were achieved; with reductions of 86%, 86%, and 74% for stations 7, 8 and 9, respectively. The water samples from station 10 required a higher alum dose of 100 mg/L to drop the turbidity to less than 1.0 NTU. The 100 mg/L alum dose resulted in reductions in total nitrogen and total phosphorus of 64% and 92%, respectively. All of the alum doses studied resulted in residual dissolved aluminum concentrations below the EPA acute toxicity criterion 7 for the protection of aquatic life, 750 µg/L. An alum dose of at least 150 mg/L is required to reduce the residual dissolved aluminum concentration in the treated waters to levels close to the EPA chronic ambient water quality criterion for the protection of aquatic life. Even higher doses of alum may be effective in lowering the residual Al concentrations, but practical doses are limited by the drop in pH and the natural alkalinity of the lake. While the results of these laboratory studies are promising, limited in-lake treatment studies should be conducted to determine the actual effects of alum treatment on the in situ water quality in Canyon Lake.

Chapter 4

4.Result and Discussion

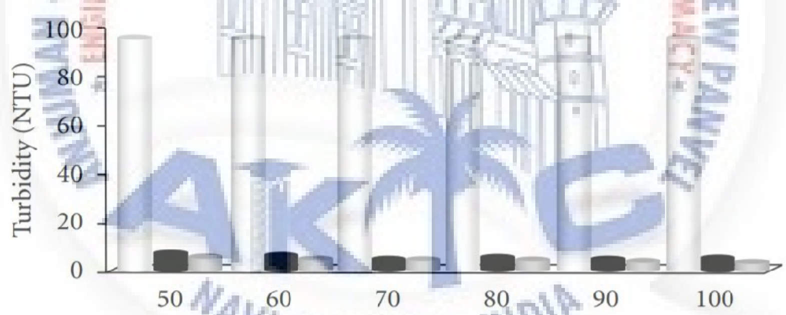
4.1 Nirmali Seed.

HIGH TURBIDITY (100 NTU)						
JAR	1	2	3	4	5	6
REDUCTION	15.5	14	13.4	12.3	11.6	11.1
AFTER FILTER	13.3	12	11.5	10.5	9.9	9.5
%	84.5	86	86.6	87.7	88.4	88.9
MEDIUM TURBIDITY (49 NTU)						
REDUCTION	17.1	16.7	16.3	15.9	15.8	15.6
AFTER FILTER	16.7	16.3	15.9	15.8	15.6	15.4
%	65.10	65.91	66.73	67.55	67.75	68.16
LOW TURBIDITY (35 NTU)						
REDUCTION	17.60	17	15.30	15	14.20	13.70
AFTER FILTER	17	16.7	15	14.8	14	13.20
%	49.71	51.42	56.28	57.14	59.42	60.85



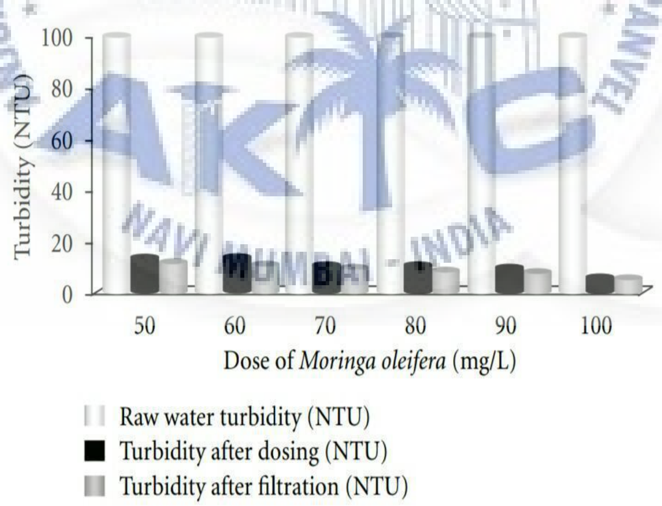
4.2 Tamarind Seed.

HIGH TURBIDITY (95 NTU)						
JAR	1	2	3	4	5	6
REDUCTION	5.9	5.1	4.6	4.5	4.3	3.9
AFTER FILTER	5	4.3	3.9	3.8	3.6	3.3
%	93.78	94.63	95.15	95.26	95.47	95.89
MEDIUM TURBIDITY (49 NTU)						
REDUCTION	12.6	12.4	10.2	9.3	9.1	9
AFTER FILTER	10.8	10.6	8.7	7.9	7.8	7.7
%	74.28	74.69	79.18	81.02	81.42	81.63
LOW TURBIDITY (31 NTU)						
REDUCTION	19.39	18.99	18.42	17.63	17.39	16.44
AFTER FILTER	15.9	15.2	14.9	14.0	13.3	12.9
%	62.54	61.25	59.41	56.89	56.09	55.89

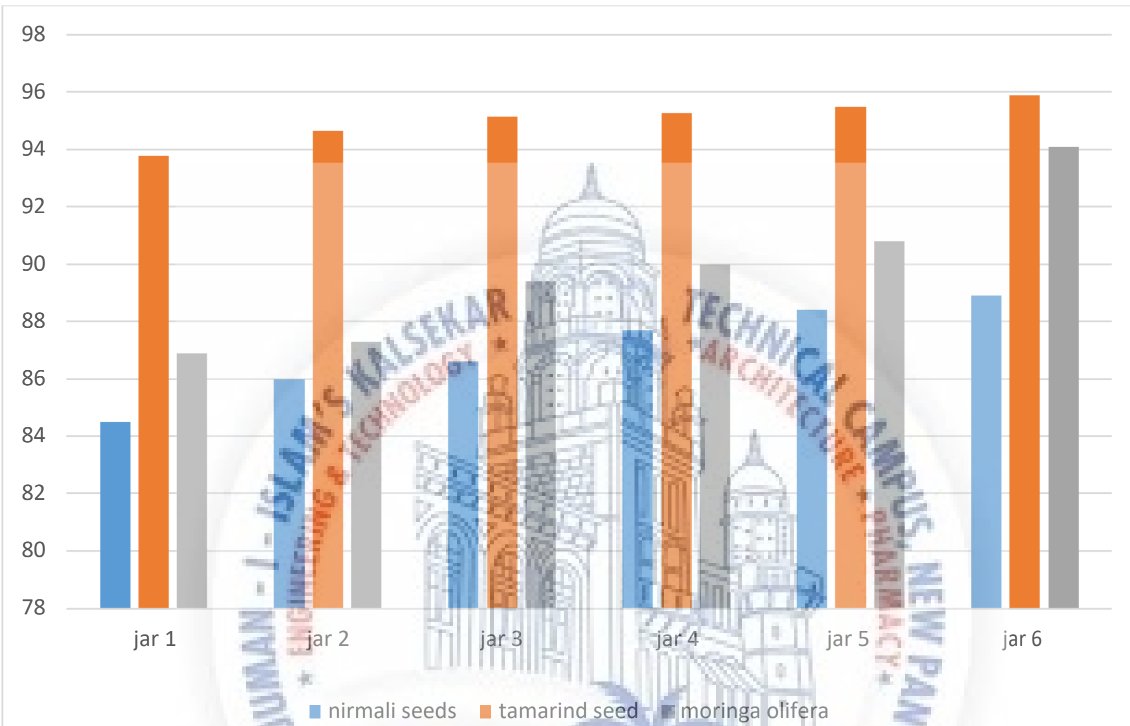


4.3 Moringa Oliefera

HIGH TURBIDITY (100 NTU)						
JAR	1	2	3	4	5	6
REDUCTION	13.1	12.7	10.6	10	9.2	5.9
AFTER FILTER	11.2	10.9	9.1	8.6	7.9	5
%	86.9	87.3	89.4	90	90.8	94.1
MEDIUM TURBIDITY (48 NTU)						
REDUCTION	16.5	16.1	15.7	15.1	14.9	14.7
AFTER FILTER	14.1	13.8	13.5	12.9	12.8	12.6
%	65.62	66.45	67.29	68.54	68.95	69.37
LOW TURBIDITY (25 NTU)						
REDUCTION	19.8	18.1	18.8	17.5	16.9	16.2
AFTER FILTER	18.6	17.3	17.1	16.9	15.7	15.2
%	56	57.2	58	58.8	59.2	60



4.4Optimum Dosages



Optimum dosage for turbidity 100NTU = jar 3

Chapter 5
Conclusion

5.1 Concluding Remark

Natural coagulants are obtained from several natural sources, when functional as coagulants primary or auxiliary coagulation/flocculation present as feasible and economical alternatives. There are two types of coagulants are found natural and synthetic. Function of coagulants in wastewater treatment is to remove various parameters. Coagulants are present in two form, first is plant based coagulants (PBC) and second is non-plant based coagulants. The preparation of natural coagulants is consisting over three steps for the substitution of the dosage of the coagulant in treating wastewater. The treatment through bio coagulants signifies to a vital development in viable environment for better worth of eco-system particularly for less urbanised area. An attempt is using eco-friendly coagulant as a natural coagulant for the process of coagulation to treat wastewater. New coagulant processing technique such as composite polymerization and impregnation method can be incorporated in producing coagulants with enhanced capability. This review highlighted that many potential advantages in using natural coagulants from various sources of plants, animal or biomass..

5.1 Future scope

Natural coagulant gains the advantage over chemical coagulant due to various reasons. One of the reasons are natural coagulant are safer than chemical coagulant. When using coagulant for water treatment, there will be possibilities of residue coagulant present in the water after the treatment. Chemical coagulant residue such as alum is harmful because it can cause Alzheimer disease if consumed . On the other hand, if natural coagulant was used, the residual coagulant would not be harmful. Likewise, natural coagulant is much cheaper compared to chemical coagulant. Chemical coagulant such as alum, need coagulant aid to effectively treat high turbidity water, thus making it more expensive and difficult to be used in poor countries. Whereas natural coagulants are much cheaper and can be extracted from various plant wastes which greatly reduce the treatment cost . Nevertheless, an abundance and locally available resource must be met to use natural coagulant commercially

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