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EVALUATION OF BANANA PEEL POWDER AS NATURAL COAGULANT

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ABSTRACT

This study evaluated Banana peel powder as a natural coagulant for treatment of wastewater. The demand for fresh water has continued to increase at a rapid pace due to the growing population, increasing urbanization and the constant economic growth. Fresh water scarcity can be overcome to an extent by using fresh water sources for drinking purposes and treated wastewater for various domestic purposes. Conventional treatment techniques are extremely expensive for developing countries like Nigeria. Therefore, an urgent need for cost effective methods of treatment and recycling of wastewater are highly desirable. The wastewater was gotten from Anthikad Pond and was used for the laboratory analysis. The Jar test was used to determine the optimum coagulant dosage of banana peel powder. Banana peels are capable of absorbing various metals and other pollutants present in industrial waste waters. This project also reports an investigation regarding activation of banana peels for this purpose. Banana peels were dried and burned at a specific heat. This experimental method found Banana peel powder coagulant optimum dosage to be 0.3mg/L.

Keywords: *Evaluation, Banana peel powder, turbidity, jar test*

espect to time

CHAPTER 1

INTRODUCTION

1.1 GENERAL BACKGROUND

Water is one of the essential requirements for life. All living things need water for their survival. Water is used for a variety of purposes, including drinking, food preparation, irrigation and manufacturing. Although water covers more than 70% of the Earth's surface, less than 1% of that resource is available as fresh water – and this is not evenly distributed throughout the world. More than one billion people worldwide, mostly in developing countries, lack safe drinking water. Apart from the scarcity of water, there are many other challenges in providing a safe, adequate and reliable water supply in many parts of the world. The numerous methods being used in treating wastewater is based on its toxicity in order to protect the aquatic systems such as coagulation, adsorption, dissolved air flotation, membrane technology, biological systems, filtration. Coagulation is an ancient practice which became necessary as sedimentation could only take care of those particles with a mass density higher than that of the surrounding water. The first use of coagulant in water treatment was recorded in 77 AD (internet). Coagulation originated from a Latin word ''coagular" which means to gather together in order to gain mass, that is to become denser. This process is aimed towards removing colloids, as well as suspended impurities in water, including organic and inorganic substances which are principal contributors to turbidity and colour.

Coagulation is a physical–chemical process to remove turbidity of drinking water and wastewater. Conventionally, chemical-based coagulants such as alum (AlCl3), ferric chloride(FeCl3), polyaluminium chloride and synthetic polymers (polyacrylamide) are used to remove the turbidity of water . Coagulation has been a vital mechanism in physio-chemical wastewater treatment processes, which involves the addition of chemicals. Most of these chemicals are commonly known as coagulants (polymeric, natural, organic and inorganic) responsible for destabilizing and agglomerating the contaminants . Generally, aluminum and iron-based coagulants are employed in pre-treatment processes in water and wastewater treatment facilities to efficiently reduce the organic load prior to subsequent treatment processes . However, these types of coagulants are associated with the formation of large volumes of sludge associated with complex metals. Generation of excessive non-biodegradable sludge is the major issue of using chemical coagulants for wastewater treatment. As a result, this poses great threat to agriculture, human health (memory loss, intestinal constipation, abdomen colic, spasms) and aquatic life if not treated before being disposed into the environment. An alternative greener and sustainable approach is use of natural coagulants for turbidity removal. Natural coagulants from plantbased materials or renewable sources are attracting a lot of attention due to their various advantages over chemical counterpart. They are biodegradable, non-toxic, non-corrosive and cheaper than chemical coagulants. Since they produce lesser sludge with high nutritional value , the sludge handling and treatment cost is minimal. Despite these advantages, natural coagulants are not commercialized so far (except few such as Moringa oleifera seeds) . Challenges in harvesting and processing of natural coagulants from plants might be the major factors limiting their commercialization. Waste or non-useful materials such as orange peel, banana pith and neem leaf powder have also been utilized as natural coagulants. Tones of lemon and banana peels were discarded and send to garbage as useless materials and it is very significant and even essential to find applications and uses for these peels, as the management of wastes nowadays is becoming a very serious environmental issue. These waste peels are low cost, non-hazardous and environment friendly bio-materials which can be used as coagulant in water treatment.

Therefore, the improvement of the coagulation process by the use of costeffective or biodegradable or natural coagulants is worth investigating, since there is limited information and studies on natural coagulants used for wastewater treatment. This study design to evaluates the usefulness of banana peel as a coagulant in waste water treatment.

1.2 Objective

1. The objectives is to investigate absorption capacity and application of Banana peel and its combusted product in removal of colour and turbidity from wastewater and also to investigate the application of banana peel as a potential coagulant to reduce impurities in wastewater by adding different dosage of banana peel powder to the wastewater sample.
2. To conduct the standard jar test for determining the performance of extracted banana peel with respect to its coagulation activity.
3. To determine the most effective dosage of this coagulant.

1. 3 Scope Of Study

Amongst the wide range of existing methods accessible for wastewater treatment, coagulation and flocculation process is the most preferable. This treatment is commonly being practiced as it is cost effective, reliable, simple and best regarded as low-energy consuming process. This established physicalchemical process removes colloidal, suspended and soluble particles efficiently by prompting aggregation of macro and micro particles into larger size proceeded by sedimentation. In conventional treatment processes, various types of coagulants are often used depending on chemical traits of the contaminants present in the wastewater. The inorganic and synthetic organic polymer coagulants include alum, ferric chloride, calcium carbonate as well as polyaluminium chloride were generally used in the wastewater treatment. Despite that, such treatment leads to disposal problems as the sludge obtained after the treatment using aluminium salts risks accumulation in the environment. At the same time, synthetic organic polymers like acrylamide possess carcinogenic and neurotoxic effects. The alternative solution to these problems is replacement of metal and synthetic coagulants with natural coagulants which are more environmental friendly.

CHAPTER 2

LITERATURE SURVEY

2.1 Water Quality Constituents

Pure water is colourless, tasteless and odourless amongst other qualities. (Ababio 1990). As earlier said it is strong solvent and as a result dissolves many minerals it mixes with. This is why there is no such thing as 'pure water' in nature.

2.2 Impurities in Water

The impurities in natural water can be grouped under the following groups (Quasim, Motley & Zhu 2008).

1. Dissolved Organic and Inorganic Particle – these include:

(a) Cation and Anions, such as Ca2+, Mg2+ , Na+ , K+ , CI- , SO4 2- , Fetc

i. Natural Organic matters that contain substances like hydroxyl and carboxyl groups which give hydrophilic properties.

ii. Colloids – They are very small to be seen with unaided eyes. They have diameter range that mis greater than 1mm and less than 10-3 mm. Examples includes microorganism like bacteria fungi, protozoa, parasitic worms etc.

(b)Suspended Particles – they include floating substances like leaves, debris, silt sand etc.

2.3 Water Quality Characteristics

Several water quality parameters are used to describe properties of water that is indicative of treated and quality water. G.N. Gray in his work "water Technology" grouped the parameters as follows:

• Physical Parameters: These include – turbidity, colour, odour, taste, temperature, total dissolved solids (TDS), dry solid content, conductivity etc.

• Chemical Parameters: To include cations, anions, molecules alkalinity, acidity, hardness, radioactivity, agressivity dissolved oxygen, penols etc.

• Microbiological Parameters: Water has long served as a medium of transmission of diseases. The most important of the water borne diseases are those of the intestinal tracts including typhoid fever, dysentery, cholera and some parasitic worms all caused by microorganisms content in water.

2.4 Turbidity

Turbidity is a measure of the light-transmitting properties of water. It is also a measure of the cloudiness of water and the cloudier the water, the greater the turbidity. It is a unity of measurement quantifying the degree to which light traveling through a water column is scattered by the suspended particles in wastewater discharges and natural waters. The measurement of turbidity is based on comparison of the intensity of light scattered by a sample to the light scattered by a reference suspension under the same conditions (Standard

Methods, 1998). Formation suspensions are used as the primary reference standard. The results of turbidity measurements are reprted as nephelometric turbidity units (NTU).

2.5 Nutritional Value Of Banana Peel Powder

Banana is one of the most common crops grown in almost all tropical countries, including India. It is an abundant and cheap agriculture product. Banana chip and banana fig are the main products from banana flesh produced by a number of small and medium factories located nationwide. As industrial by-products, peels represent about 35-50 g/ 100 g of fruit weight. This resulted in 250 tons of waste from banana peels in India generated each day and these amounts tend to increase annually. The banana peels waste is normally disposed in municipal landfills, which contribute to the existing environmental problems. However, the problem can be recovered by utilizing its high-added value compounds, including the dietary fiber fraction that has a great potential in the preparation of functional foods. Kokum has multiple health and medicinal benefits. The fruits of kokum are an excellent source of antioxidants that prevent to free radicals thereby helps from different diseases. It is also known as cool king of India fruits. Dietary fiber has shown beneficial effects in the prevention of several diseases, such as cardiovascular diseases, diverticulosis, constipation, irritable colon colon cancer, and diabetes. The fruit fiber has a better quality than other fiber sources due to its high total and soluble fiber content, water and oil holding capacities, and colonic ferment ability as well as a lower phytic acid and caloric value content. A high dietary fiber content of banana peel (about 50g/ 100 g) is indicative of a good source of dietary fiber. Cellulose, lignin, and hemicelluloses contents of bananapeels, the components of the insoluble dietary fiber fractions, varied from 8 to 10 g/ 100 g ,7.4 to 9.6 g/ 100 g and 6.4 to 8.4 g/100 g respectively falling within the safety limits. These results indicated that banana peels were safe and valuable functional ingredients for human consumption. Several technological treatment applied to the fruit residue may affect dietary fiber compositions and functional properties. At present there are no published studies on the suitable processes to produce dietary fiber from banana peel. Therefore, the overall objective of this study was to investigate the influence of different preparation methods of banana peels powder and nutrient composition of banana peel juice and its drying characteristic which used as a medicinal purpose on the chemical compositions and properties of dietary fiber concentrate used as a raw material for functional food.

Advances in food industry have opened up numerous possibilities for the large scale production. Nowadays we gave an artificial beverage which is not safe for human health. The banana peel powder is prepared naturally consisting the nutritive value which are method were investigated on their effects on the chemical composition and properties of the banana peel dietary fiber concentrate (BDFC). Banana is common crop grown in almost all tropical countries including India. There are various nutrient content can be used in various ways in India. In the present study used banana peel which is good source of dietary fiber where dietary fiber can be extracted from banana peel powder can be obtained by using sun drying method and peel powder can be used as nutritional juice which is used for medicinal purpose also.

2.6 Antibacterial and phytochemical analysis of Banana peel

The invitro antibacterial activity of ethanolic and aqueous extract of banana (Musasapientum) peels was investigated on both gram-positive and gramnegative bacteria using agar well diffusion technique. Phytochemical result showed ethanol to be a better solvent for the extraction of the bioactive agents in banana peels which include: glycosides, alkaloids, saponins, tannins, flavonoids and volatile oil. The presence of glycosides and alkaloids in Musa sapientum peels may be attributed to their use by traditional medicine practitioners in healthcare systems in the treatment of some bacterial infections such as cough, fever, cold and venereal diseases. Thus extracts from the peel can be used to control infections caused by Salmonella typhi, Escherichia coli, Klebsiella pneumoniae and Staphylococcus aureus. Infections such as bronchopneumonia, bacterial endocarditis and meningitis caused by Micrococcus Spp. and Pseudomonas aeruginosa will also find treatment with the extracts of this medicinal peel. Thus the use of banana peel by traditional medical practitioners is justified.

2.7 Nutrient and Heavy Metal Composition of Banana (Musa paradisiaca) Peels

The higher amounts of K than Na in the peel samples investigated are considered of comparative advantage. This is because intake of diets with higher Na to K ratio has been related to the incidence of hypertension. Phosphorus is involved in several biological processes such as: bone mineralization, energy production, ell signaling and regulation of acid-base homeostasis. Findings from this study indicate that unripe plantain peel contains higher quantities of Zn than ripe plantain peel, unripe and ripe banana peels respectively. The considerable amount of Fe in unripe plantain peel is an important finding in this study. Iron is an essential component of hemoglobin and it is critical to the proper function of the immune system and the production of energy. Mineral content in a banana peel is primarily consistent of potassium (78.10mg/g) and manganese (76.20mg/g). Other minerals present are sodium, calcium and iron at 24.30, 19.20 and 0.61 mg/g respectively. The peel's high potassium content, if taken orally, aids in maintaining normal blood pressure. About 91.50 percent of a banana peel is organic nutrient matter consisting of lipids, proteins, crude fiber and carbohydrates. About 31.70 percent of total mass is fiber with carbohydrates accounting for 59 percent and protein and lipids accounting for 0.9 and 1.7 percents respectively. The high fiber content is useful as a natural laxative.

2.7.1 Phytate

Phytate (myo-inositol hexaphosphate) content of a banana peel is 0.28mg/g, lower than in most whole grains. The only risk associated with phytate and dietary consumption comes from a lack of it. Low phytate consumption increases risk for osteoporosis and adding it to the diet increases bone density.

2.7.2 Saponins

Saponins are known for their foaming property and are another potentially dangerous constituent of a banana peel. The levels are high in banana at 24 percent, greatly exceeding the 3.00 percent level marked safe for consumption by animals. Saponins consumption at high levels can paralyze the sensory system and are known to increase cholesterol production in the body.

2.7.3 Oxalates

Oxalates are organic acids associated with kidney disease and are known to decrease the absorption of minerals, such as calcium, in the body by binding with them decreasing their availability. Eighty percent of all kidney stones occurring in adults in the United States are calcium oxalate stones. The oxalate level in a banana peel is 0.51mg/g, which is low and relatively nonthreatening.

2.7.4 Hydrogen Cyanides

Hydrogen Cyanides Of the anti-nutritive constituents the most poisonous is hydrogen cyanide. It is present in the peel at 1.33mg/g. The chemical can cause immediate death if taken in high dosages and in small dosages may cause stiffening of the throat and chest, heart palpitations and weak muscles. Amounts in a peel fall into the 0.5 to 3.5mg/g safe range.

2.8 Chemical Properties Of Banana Peel

Musa sapientum (banana) peels have been used in conjunction with other substances to remedy the achy and painful symptoms of arthritis. They are composed of nutritive chemicals, minerals, and nonnutritive chemicals. Banana peels have both highly beneficial and highly dangerous constituents and can be manipulated to serve both as a remedy and a poison. According to 5 banana peel has been discovered to have nutrients and compounds including protein, dietary fiber, potassium, polyunsaturated fatty acids and essential amino acids as well as antioxidant compounds such as carotenoids, catecholamines and polyphenols. Mineral content in a banana peel is primarily consistent of potassium (78.10mg/g) and manganese (76.20mg/g). Other minerals present are sodium, calcium and iron at 24.30, 19.20 and 0.61 mg/g respectively.

2.9 Waste water

Rapid industrialization has posed many threats to the environment due to the wastewater generation through various industrial processes. Indiscriminate disposal of this wastewater (with or without an appropriate level of treatment) can cause water pollution and land pollution. This has a profound effect on the health of living beings apart from the impacts on the abiotic components such as soil and water (Some key sources of industrial wastewater are palm oil mills, paper and pulp industry, brewery and winery, cosmetic industry, tannery industry , slaughterhouses , paint industry , dairy industry, etc. A huge quantity of industrial wastewater is generated worldwide daily. claimed that a single unit of Indian distillery uses 1133.5 KLD of water, and, after processing, around 668 KLD of wastewater is generated. In another attempt to quantufy the wastewater generation in India, Majumder et al. (2014) estimated that every day around 13,468 MLD of wastewater is generated, out of which, more than 50% is discharged into the environment untreated. The quantity and quality of industrial effuent are functions of the ongoing industrial process, raw material utilized, and products manufactured in each industrial unit, and therefore the composition and constutution of wastewater generated are different for different industries. For instance, the textile dyeing processes in the textile industry generate colored wastewater rich in chemical dyes. On the other hand, the effuent from paper and pulp industry contains large quantites of sodium salts of organic acids, lignin, etc.. Wastewater from the cosmetic industry has significant concentrations of COD, oils, detergents, fats, and suspended solids. Muralimohan et al. (2014) studied the various processes contributing to the wastewater generation in the textile industry.The study revealed that processes like cleaning, de-sizing, etc. are responsible for toxic wastewater generation. The main high-risk constituents of this wastewater are chemicals, dyes, bleaching agents, oils, acids, bases, etc. Sometimes, wastewater contain heavy metals which are a potential cause of concern for the environment and human health . Prasad and Rao 2016 studied the impact of the cadmium pollution, caused due to the discharges from the mining activities. Elevated levels of cadmium can cause diseases like ItaiItai; whereas, at low 17 levels, it may cause problems like kidney damage, sterility among males, u disorders, and high blood pressure. The characteristics of wastewater have been studied in terms of key parameters like BOD, TDS, COD, and color. These parameters help in gauging the level of potential hazard the effuent can pose to the environment and human health. Due to the potential toxicity, industrial effuents may require prior treatment before their release into the environment. Improper disposal of the wastewater can cost liability in addition to their environmental impacts . Sahu and Chaudhari 2013 suggested that industrial wastewater management is necessary to eliminate the health and socio-economic concerns. Wastewater treatment technologies can be physical, chemical, or biological. Among the physicochemical processes, coagulationflocculation has been frequently used. In this process, the charge of the colloidal particles is destabilized with the help of coagulants (typically aluminium or iron salts) which results in floc formation due to collision of destabilized particles and their aggregation, which ultimately gets separated from the liquid phase. An alternative to the conventional coagulationflocculation is the electrocoagulation process. Here, coagulants are formed due to electro-dissolution of the anode which causes hydrolysis products that result in the destabilization of the particles . Wastewater streams obtained from industries like tannery, hospital paper and pulp mill etc. have been treated by coagulation using synthetic chemicals. The use of chemical coagulants for coagulation of wastewater has various implications such as their potential to cause diseases, the possibility of groundwater contamination or surface runo of treated water containing high residual aluminium concentration and therefore their use for the wastewater treatment is not an eco-friendly option. On the other hand, the use of natural substances for coagulation in place of chemicals is a promising alternative for the treatment of industrial wastewater. Natural coagulants are safe for consumption (owing to their plant-origins) and are biodegradable in the environment. Natural coagulation has been used for treating wastewater from various industries like texile, dairy, etc. A compilation of the various chemical and natural coagulants used for the treatment of industrial wastewate. In comparison, some of the synthetic coagulants used for the treatment of domestic sewage include alum , ferric chloride, poly-aluminium chloride and aluminium sulphate. Several research studies have shown the potential of natural coagulants in treating the wastewaters originating from different industries and have shown them to be equivalent to chemical coagulants in terms of treatment efficiencies for various parameters of interest. Coagulation using natural coagulants has also been effectively used for the water treatment.

2.10 Coagulant Mean

According to corrosionpedia, This is an inorganic or organic substance that initiates or aids a congealing process during water treatment. A coagulant, together with other chemicals, are added in water to aggregate dissolved contaminants and tiny particles into larger particles so that filtration, clarification, or any other solid removal process may be used to remove them. Inorganic coagulants, except the sodium aluminate (which is basic), decrease alkalinity levels in water. This helps to reduce risks of corrosion attack in pipes transporting wastewater. To further explain Coagulants; A coagulant is used in colored, low pH or alkaline and low turbidity water. The optimum pH it generates helps in water purification. The coagulate dose used in purification produces a hydrolysis process that generates a pH suitable for coagulation. The metal hydroxide formed is what adsorbs the impurities (humus) to form compounds that become flocs. These flocs can later be filtered out since they are suspended solid bodies and when heavy they settle at the base. The importance of a coagulant is to destabilize the acidity of the fluid and cause flocs formation and also to Purify the fluid by removing unwanted active metallic or non-metallic elements. An inappropriate coagulant dose might lead to corrosion due to acidity, hence one must follow guidelines by the governing authority.

Coagulation flocculation involves the addition of compounds that promote the clumping of fines into larger floc so that they can be more easily separated from the water. Coagulation is a chemical process that involves neutralization of charge. (Jiang and Jia-Qian 2015; Chekli et al., 2017). Coagulation is an effective, simple and widely practiced water treatment method. However, the usage of chemical coagulant pose detrimental effect on living organism and human health as well as producing large amount of toxic sludge. This study describes the utilization of banana peel as a natural coagulant for the treatment of household wastewater. The natural coagulant extracted from banana peel was prepared by using simple extraction method. The effectiveness of the natural coagulant was evaluated based on the reduction of turbidity during the treatment process

2.11 Essence Of Coagulation

Untreated surface water contains several constituents nsuch as clay, inert solids, bacteria and others. Most of these constituents may cause several problems such as inhabiting disinfections, leaving the untreated water cloudy and causing problem in the distribution system. It is also known that these suspended solids in aqueous solution exhibit Brownian movement, which keeps them in constant motion, inhabiting settling. By coagulating or flocculating, the suspended aqueous solution is neutralized so that those like charges in the suspension are flocked together into large particles, since the larger the size, the faster the settlimg (WTAS Worldwide Water). Morso, it can be noticed that the ability of particles to remain msuspended in water is a function of both the particle sizes and specific gravity. Large sized particles may generallys not require any coagulant and may settle in a matter of seconds, but colloidal particles ranges in sizes from 0.001 to 1umm in diameter may take days to months for complete settling and since detention time in water treatment processes are generally less that twelve hours, the rate of settling must be increased in the treatment process. This is accomplished in the coagulation process when tiny particles are brought closer into denser particles which will settle more quickly, thus the high surface area to mass ratio in the colloidal suspension is reduced or destabilized (Shaw, 1989). For effective coagulation, an ion that has opposite charge to that of the colloidal particle is usually added. Since colloidal particles are usually negatively charged the ions added as coagulants must be cations. The coagulating power of an ion is dependent on its valence and magnitude of charge. When a coagulant is added to water, this results into a series of complicated reactions, firstly, the ions of the coagulant are hydrated, also anions present in the water such as hydroxide and sulphate ions attach themselves to the aluminum ions, leading to a large positively charged molecule with aluminium ions centered. As this continues, elation reaction takes place and this involves bridging of two or more of these larger molecukes to produce large, positively charged ions. As this process proceeds with hydroxylation and elation, the masses become larger so that they are able to trap turbidity particles and settle under normal condition. It is also noted that the zeta potential at the surface of the colloid reduces to approximately 5 mill volts depending on the specific set of characteristics of the water but this potential cannot be zero for coagulation to be effective. This is so because, for coagulation to occur, forces of attraction must exercise some predominance.

2.12 Factors affecting Coagulation

Coagulation is affected by the type of coagulant used, its dose and mass; pH and initial turbidity of the water that is being treated; and properties of the pollutants present. (Ramavandi and Bahman 2014). The effectiveness of the coagulation process is also affected by pretreatments like oxidation. (Ayekoe et al., 2017).

2.13 Mechanism of coagulant function

In a colloidal suspension, particles will settle very slowly or not at all because the colloidal particles carry surface electrical charges that mutually repel each other. This surface charge is most commonly evaluated in terms of zeta potential, the + potential at the slipping plane. To induce coagulation, a coagulant (typically a metallic salt) with the opposite charge is added to the water to overcome the repulsive charge and "destabilize" the suspension. For example, the colloidal particles are negatively charged and alum is added as a coagulant to create positively charged ions. Once the repulsive charges have been neutralized (since opposite charges attract), van der Waals force will cause the particles to cling together (agglomerate) and form micro floc. (Wikipedia.net).

2.14 Flocculants

Flocculants are chemical that are used to promote flocculating by causing colloids and other suspended particles in liquids to aggregate, forming flocs. Flocculants are used in water treatment process to improve the sedimentation of small particles. For this reason, flocculants are sometimes called coagulants aid at water treatment operation (Tillman, 1996; Faust and Aly, 1999). Many flocculants are multivalent cations such as aluminum, iron, calcium or magnesium. These positively charge molecules interact with negatively charged particles and molecules to reduce the barriers to aggregation. In addition, many of these chemicals under appropriate Ph react with water to form insoluble hydroxides. These on precipitation link together to form long chains or mesh which traps small particles into larger proportion.

2.15 Particle Settling Theory

The settling of discrete, non-flocculating particles can be analysed by means of the classic law of sedimentation formed by Newton and Stoke. Newton's law yields the terminal particle velocity by equating the gravitational force of the particle to the frictional resistance or drag.

The gravitational force is given by

FG = (Pp – Pw)g Vp

Where,

FG = gravitational force Kg M / S2

Pw = density of water Kg/M3

Pp = Density of particle Kg/m3

G = acceleration dur to gravity (9.8 m/s)

Vp = Volume of particle (m3)

The frictional drag force depends on the particle velocity, fluid density, fluid viscosity and drag coefficient Cd (dimensionless) and is given by Fd = CdApPwV2p

Where,

Fd = frictional drag force (Kgm/s2)

Ap = cross sectional or project area of particle in the direction of flow (m2)

Vp = particle settling velocity (M/S)

The coefficient of drag Cd takes on different values depending on whether the flow regime surrounding the particles is laminar or turbulent. Although particle shape affects the value of the drag coefficient, for particles that are approximately spherical, the Cd is approximated by the equation;

$Cd = 24/NR + 3/\{NR + 0.34$

The Reynolds number for settling particle is defined as ;

$NR = VpdpPw/N = Vpdp/v$

Where

N = dynamic viscocity (n-s/m^2)

V = kinetic viscocity (m^2 /s)

Vp = particle velocity (m/s)

Dp = particle diameter (m)

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2.16 Chemical coagulation

Chemical coagulation is the process of destabilizing the colloidal impurities in water or wastewater by using chemically produced substances. The process of formation of flocs on charge neutralization is known as flocculation (Hamawand, 2015). Aluminum sulfate (Quintero-Jaramillo et al., 2016), potassium aluminum sulfate, Iron (III) chloride hexahydrate, ferric sulfate (Karamany, 2010), etc. can be used as coagulants for water and wastewater treatment. Alum is the most commonly used chemical coagulant. Alum contains potassium and aluminum, and is chemically represented as $KAl(SO_4)_2.12H_2O$. Alum or potassium aluminium sulfate is very frequently used for water and wastewater treatment. Alum is easily available and is an inexpensive alternative for the wastewater treatment. Madhavi et al. 2014 used alum for treating wastewater from the metal fabrication industry. Alum, at a concentration of 450mg/L, removed 99% of color from the wastewater at a pH of 8.0 (Madhavi et al., 2014). The effectiveness of alum can be increased by using it with other coagulants. In a study, alum, when used with polyacrylamide (PAA) and poly ferric sulfate (PFS), resulted in an increase in the efficiency of COD removal to 82% from 68% (Loloei et al., 2014). Jiang and Llyod 2002 reviewed the potential of ferrate salts for the treatment of wastewater and reported their potential application for wastewater treatment. Iron (III) chloride, also called as ferric chloride (represented as FeCl3), can also be used as a coagulant for wastewater treatment. Bogacki et al. 2011 used ferric chloride for the treatment of cosmetic industry wastewater with the aim of COD reduction. Using ferric chloride, up to 63.9% reduction of COD was achieved at a pH of 6.0. Poly aluminum ferric chloride can also be used as a coagulant (Ebrahimi et al., 2014). Liang et al. 2009 used ferric chloride for treating the molasses wastewater. At optimum conditions, 96% color and 86% COD could be removed from the wastewater (Liang et al., 2009).

2.16.1 Disadvantages of chemical coagulants:

Health and environmental impacts Chemical coagulation is carried out using synthetic chemical coagulants. This practice has the potential of leaving a bad impact on the environment and the public health. Chemical coagulants are non- biodegradable and remain in the water even after the coagulation process is completed. There is a possibility that the treated supernatant contains the traces of metals present in the chemical coagulants due to the presence of residual aluminum in the supernatant (Zouboulis and Tzoupanos, 2009). Use of chemical coagulants can cause neurological diseases like Alzheimer's disease (WHO Guidelines, 2010; Nique e et al., 2004), Encephalopathy (Srinivasan et al., 1999) leading to dementia, Down's syndrome and staining of Hippocampal neurons (Walton, 2006). Parmar et al. 2012 in his study suggested that supernatant obtained from dairy industry using alum and ferrous sulfate was not suitable for discharge into the municipal drains due to the high values of various parameters like BOD and COD in the supernatant. Major issues with the use of aluminiumbased coagulants are that they lead to increased concentration of residual aluminium in the supernatant (WHO Guidelines, 2010). This aluminum may either seep into the groundwater or may have a surface runo (WHO Guidelines, 2010). Conventional, water and wastewater treatment plants do not remove aluminium and water with elevated aluminium content (Walton, 2006) is supplied to the end consumers (Srinivasan et al., 1999). If aluminium entered the public distribution system, it could lead to precipitation of hydrous aluminium in the water, which is to be supplied to the consumers (Srinivasan et al., 1999). Residual aluminium in the treated water is found to negatively impact the health of consumers. Exposure to aluminium is linked to Alzheimer's disease (WHO Guidelines, 2010; Nique e et al., 2004) as it stains the Hippocampal neurons (Watson, 2006). Aluminium is neurotoxic and is responsible for disorders like Parkinson's disease and Down's syndrome (Watson, 2006). Its accumulation in the bloodstream for the long term can result in severe Encephalopathy (Srinivasan et al., 1999), and consequently contributing to dementia (Oaks et al., 2004).

2.17 Natural coagulants for wastewater treatment

The potential environmental and human health hazards associated with the use of chemical coagulants has necessitated the need for the use of natural coagulants for industrial wastewater treatment. Natural coagulants are gaining a lot of attention these days as they are an effective alternative to the chemical coagulants (Yin, 2010). Natural coagulants are a sustainable approach Folkard et al., 1995). Plant-based materials have been investigated for treating industrial effuents from different industries. Plant-based substances like Moringa Oleifera (Chonde and Raut, 2017; Sivakumar, 2013), chitosan and chitin, Abelmoschus esculentus, Opun a cus-indica, Synchorous Potatorum, Prosopis laevigata Seed Gum, Hibiscus rosa-sinensis (Awang and Aziz, 2012), Acacia mearnsii (Beltrán-Heredia et al., 2011), etc. can be used as coagulants. Generally, the natural coagulants are directly used as a powder or a stock solution. In some cases, the deoiled powder is also used, a er extraction of oil from the coagulant. The plant-based products (such as seeds, etc.) are first extracted from the plant, cleaned to remove any impurities that may interfere with coagulation, and then dried. The powder is then formed (with or without the oil extraction, as per need) by grinding (Miller et al., 2008). This powder may be directly used, or a stock solution can be prepared from it. In some cases, proteins may be extracted from the specific plant parts and used as a coagulant. This may require extensive extraction and purification steps (Kansal and Kumari, 2014). Kumar et al. 2017 and Tariq et al., 2015 reported that the microbial polysaccharides, starches, gelatin galactomannans, cellulose derivatives, chitosan, glues, and alginate can be used for wastewater treatment. Mohamed et al. 2014 used Moringa oleifera and Strychnos potatorum seeds as a natural coagulant for car wash wastewater. The turbidity and COD reduction efficiency of coagulants was studied. Using Moringa oleifera, 94% turbidity, 60% COD, 81% phosphorus removal were obtained, whereas using Strychnos potatorum, 97% turbidity, 54% COD, and 82% phosphorus removal were obtained. These results were compared with synthetic coagulants, and natural coagulants were suggested for coagulation process as they provide better treatment, are cost-effective and are safe for environment. Kani et al. 2016 used banana pith juice for textile wastewater treatment. At pH 4, 97.5% turbidity and 50.1% total solids were removed from the wastewater. There was a significant improvement in the electrical conductivity. The results confirmed that banana stem juice has an enormous potential for turbidity removal from the textile wastewater.

2.17.1 Advantages of natural coagulants

Wastewater treatment using natural coagulants is an eco-friendly option. Natural coagulants are non-toxic, biodegradable, and environment friendly (Verma et al., 2012; Muralimohan et al., 2014). Unlike synthetic coagulants, treated water contains no residual aluminium. Prodanović et al. 2013 used common bean extract for the treatment of dis llery wastewater treatment. The study claimed that anaerobic sludge contained no aluminium salt. Need for natural coagulants Chemical coagulant used has raised controversial issues due to its toxic nature for living organisms and can be categorized into three types: hydrolyzing metallic salts, pre-hydrolyzing metallic salts, and synthetic cationic polymers(Freitas et al., 2018; Verma et al., 2012). Due to the low cost, easy handling, storage, and high availability, chemical coagulants are more prevalent in wastewater treatment processes. $Al2(SO4)3$, $Fe2(SO4)3$, $AlCl3$, and $FeCl3$ are the most commonly used coagulant salts (Freitas et al., 2018; Matilainen et al., 2010; Sher et al., 2013). Despite the availability, low cost etc.; chemical coagulants are far behind in green chemistry due to high residual concentrations of aluminum found in treated wastewater(Freitas et al., 2018; Matilainen et al., 2010). According to Freitas et al., 2018; McLachlan 1995; Polizzi et al. 2002, Alzheimer's disease is linked with the neurotoxicity of aluminum. Synthetic polymer coagulants form hazardous secondary products such as acrylamide which is carcinogenic and neurotoxic, and also synthetic polymers have low biodegradability (Freitas et al., 2018;Kurniawan et al., 2020). Excessive concentrations of chemical coagulants such as aluminum reduce the pH of water tends and also, they can be accumulated to food chains (Kurniawan et al., 2020). Improper disposal of toxic sludge pollutes the groundwater and soil. Accumulation of toxic sludge, such as aluminum, iron etc., in natural water bodies causes adverse effects on aquatic organisms and plant species (Kurniawan et al., 2020). Hence there is a need for the efficient utilization of natural coagulants for water and wastewater treatment.

2.18 Applications, Advantages and disadvantages of banana peel as a coagulant.

Applications of banana peel as a coagulant

• To identify a sustainable, simple, locally available.

• Ecofriendly water treatment technology which is more suitable for the earth to protect it from pollution caused by

• chemical coagulant.

• Evaluate the optimum dosages of banana powder for a different level to remove turbidity.

• Removal efficiency is very high in banana powder.

2.18.1 Advantages of banana peel as a coagulant.

• It is non-toxic and safe for consumption

• It is biodegradable

• Safe for consumption.

• Banana peel is rich in organic compounds

• Banana peel has high nutrients.

• Banana peel has lignin

• Banana peels are a good source of galacturonic acid

• Banana peel is consumer approachable and eco-friendly, a substitute for minor size water treatment.

• Banana peel is a renewable source that can be grown on a huge scale.

• Using Banana peel as an alternate coagulant that meets up water quality factors. • Banana peel is simple to use, effortlessly available, easy to maintain and can be used as a domestic coagulant.

• The banana peel can remove Hardness, Chlorides, and Residual chlorine

• It is eco-friendly proficiency which has additional benefits more than other treatment alternatives.

2.18.2 Disadvantages of banana peel as a coagulant.

• Availability of dried peel is a bit difficult.

• It requires a large quantity of growing.

• The smell it may cause after using in water treatment.

2.19 Mechanism of coagulation by natural coagulants

Coagulation occurs between the coagulant added, the impurities, and the alkalinity of the water, resulting in the formation of insoluble flocs. Flocs are the agglomerations of particulate suspended matter in the raw water, reaction products of the added chemicals, colloidal and dissolved matter from the water adsorbed by these reaction products. Unprocessed water from the reservoir contains organic and inorganic impurities, such as silt, rotten substance, alga, bacterium, etc. Hence coagulation is the essential step in water purification. In addition, coagulants make suspensions in water to gather and reduce the turbidity of water. The successful coagulation of natural coagulants stands on these three pillars: characteristics of coagulant used, characteristics of water to be treated, characteristics of mixing process. Coagulants' molecular weight, types of equipment and reagents used, chemical and physical properties of the pollutants such as zeta potential, color, the concentration of the colloidal particles, the presence or absence of impurities (trace elements and dissolved salts (ions and chemicals) also affect the coagulation process. If the natural coagulant contain positive surface charge, its coagulation activity against negatively charged suspended particles will be higher and vice versa for negatively charged natural coagulants with positively charged suspended particles. Functional groups also contribute to surface charge. Molecular weight of natural coagulant is very important in particle bridging. If the molecular weight of natural coagulant is higher, it can form strong bridges with the particles and it leads to the formation of strong flocs and improve settling. Mixing is another critical step in the coagulation process. Fast mixing increases the interactions between coagulants and suspended particles and forms micro flocs. Slow mixing leads to the aggregation of micro flocs into large flocs. Coagulation also affects the other steps of the treatment process. An efficient and effective coagulation process favors the microbiological quality of the end product and increases the lifetime of filters, reducing the total cost of treated water. Natural coagulants are composed of carbohydrates, protein, and lipids. The primary building blocks are the polymer of polysaccharides and amino acids. According to the previous research, the main mechanisms governing coagulation activity are charge neutralization and polymer bridging. Polymer bridging is preceded by polymer adsorption. Because of the affinity between long-chain polymers and colloidal particles, long-chained polymers can attach to the colloidal particle's surface. A part of the polymer is attached to the particle while the other parts form loops and tails. These loops and tails are the main structure of polymer bridging loops, and tails allow attaching to other colloidal particles and form larger flocs. The basis of charge neutralization is known as the electrostatic patch mechanism. The patches of positive and negative regions on the particle's surface cause the additional attraction between particles. Ionizable polymer (polyelectrolytes) is used as a coagulant in the charge neutralization mechanism. It stabilizes the negatively charged colloidal particles. Polycation is used to stabilize the particles, gaining near to zero zeta potential. The optimum dosage of polyelectrolyte needed will be determined by the charge density of the polyelectrolyte. Natural coagulants have varied mechanisms of action. Let us consider some of the coagulation mechanisms of natural coagulants.

2.20 Potential coagulants presents in banana peel powder and possible mechanism of coagulation

Banana peel powder was found to be a better coagulant than others in terms of coagulant activity (turbidity removal). Banana peel is composed of polymeric substances such as fiber (11.04%) and protein (10.14%). The FTIR analysis of banana peels revealed various peaks of different functional groups such as carboxylic acid (C=O), hydroxyl (-OH) and aliphatic amines (N–H) indicating the presence of both positively and negatively charged species in the polymeric substances. These functional groups of banana peel powder might be responsible for promoting the coagulation– flocculation by neutralizing both positively and negatively charged impurities in water.

CHAPTER 3

METHODOLOGY

This chapter highlights the methods as well as the procedures used in the Evaluation of banana peel powder as natural coagulant for treatment of Pond wastewater.

3.1 Sample Collection and Preparation

About 10 litres of the wastewater were collected from a pond on Anthikad village, Thrissur District and used throughout the experiment as the testing sample. The sample was taken to the laboratory immediately and initial analysis done so as to get the initial Turbidity without allowing the sample to settle. A total sum of five experiments were conducted.

3.2. Methods & Materials

Five Beakers, Volumetric pipette, 1 Litre measuring cylinder, Electronic weighing balance, Turbidity Meter, Electro-magnetic stirrer, Stop watch, Voltage regulator, Standby power generator.

Banana (Musa Acuminata species) peels were bought from market.The banana peels were cut into small pieces and washed thoroughly with tap water to remove any external dirt. The washed pieces of banana peels were air-dried under sunlight for 2 weeks and oven-dried for 24 h at 105 °C, and were finely powdered using electric grinder and then sieved through 2.36 mm IS sieves.

Fig3.1: Banana Peels

Fig 3.2 :Banana peel powder

3.3 Precautions

The following precaution were taken so as to obtain accurate results 1. The sample was collected on the very day of the experiments so as not to allow it settle before the commencement of the tests.

2. A minimum of five readings were taken and the average obtained for a particular reading.

3. Other rules and principles in the use of various metres used were strictly followed

3.4 Methods

The objective of the test is to determine the effectiveness of banana peel powder as a natural coagulant for treatment of wastewater. Coagulation is not yet an extract science, although recent advances have been made in understanding the mechanics of the process. Therefore, selection and optimum dosage of coagulants are determined experimentally by the jar test. The jar test must be performed on any water that is to be coagulation and must be repeated with each significant change in the quality of the water. The jar test was performed using a series of glass beakers of uniformed sizes and shapes. Five jar beakers were used with a stirring device that mixes the contents of the jar simultaneously with uniform power point.

Fig 3.3: Magnetic stirrer with a beaker containing the sample and a magnetic stirrer.

Each of the five beakers was properly washed and cleaned to ensure zero impurities in them, and afterwards filled to the 1000ml mark with the wastewater. Different dosages of banana peel powder were added ranging from 0.1mg – 0.7mg. One of the beakes were left untreated with no reagent to serve as control and the remaining four were treated with the banana peel powder. The aim of this is to determine the efficiency of these coagulants by comparing the turbidity of the treated ones at different time intervals with the turbidity of the untreated one (the one that settled naturally) after the same time interval. After chemical addition, each of the beaker containing the wastewater, coagulant and a magnetic stirrer was placed on the electro-magnetic stirrer with hot plate and was connected to a power supply. The mixture was rapidly mixed using the electro-magnetic stirred for three (3) minutes and followed by 25minutes of slow mixing. This is to keep flocs particles to suspend uniformly. The mixture was left for one hour to allow settling and some portions of the settling water were pipette out at 2cm depth at different time intervals to determine the Turbidity by using the Turbidity meter measured in Nephelometric

Turbidity Unit (NTU).

The turbidity reduction was calculated for each sample by using the Formula as in Eq. 1..

Reduction of turbidity (NTU) = initial turbidity (NTU) – final turbidity (NTU).…(1)

3.5 Data Analysis

Initial turbidity = f1

Final turbidity = f2

Calculate for turbidity removal Turbidity Removal = Initial turbidity – Final turbidity TR = f1 - f2

Calculating for 10 minutes;

For 0.1ml dosage, TR =60 – 54 = 6

0.3ml dosage, TR = 60 – 47= 13

0.5ml dosage, TR = 60 – 52= 8

0.7ml dosage, TR = 60 – 57= 3

Calculating for 20 minutes;

For 0.1ml dosage, TR = 60 - 52 = 12

0.3ml dosage, TR = 60 – 44 = 16

0.5ml dosage, TR = 60 – 51 = 9

0.7ml dosage, TR = 60 – 54= 6

Calculating for 30 minutes;

For 0.1ml dosage, TR = 60 – 47 = 9

0.3ml dosage, TR = 60 – 37 = 23

0.5ml dosage, TR = 60 – 48 = 12

0.7ml dosage, TR = 60 – 51= 9

Calculating for 40 minutes;

For 0.1ml dosage, TR =60 – 47 = 13

0.3ml dosage, TR = 60 – 34 = 26

0.5ml dosage, TR = 60 – 43 = 16

0.7ml dosage, TR = 60 – 47 = 13

Calculating for 50 minutes;

For 0.1ml dosage, TR = 60 – 45 = 15

0.3ml dosage, TR = 60 – 37 = 23

0.5ml dosage, TR = 60 – 42 = 18

0.7ml dosage, TR = 60 – 44 = 16

Calculating for 60 minutes;

For 0.1ml dosage, TR = 60 – 44 = 15

0.3ml dosage, TR = 60 – 36= 24

0.5ml dosage, TR = 60 – 43 = 17

0.7ml dosage, TR = 60 – 42 = 18

Turbidity Removal Efficiency Calculation.

T. R.E = F1 – F2/F1 x 100 = Turbidity Removal/F1 x 100

Calculating for 10minutes;

For 0.1ml dosage =6/60 X 100 = 10 %

0.3ml dosage =13/60 X 100 = 21.67 %

0.5ml dosage = 8/60 X 100 = 13.3 %

0.7ml dosage = 3/60 X 100 = 5 %

Calculating for 20 minutes;

For 0.1ml dosage = 10/60 X 100 = 16.67 %

0.3ml dosage =16/60 X 100 = 26.67 %

0.5ml dosage = 9/60 X 100 = 15 %

0.7ml dosage = 6/60 X 100 = 10 %

Calculating for 30 minutes;

For 0.1ml dosage = 9/60 X 100 = 15 %

0.3ml dosage =23/60 X 100 = 38.33%

0.5ml dosage = 12/60 X 100 = 20 %

0.7ml dosage = 9/60 X 100 = 15 %

Calculating for 40 minutes;

For 0.1ml dosage = 13/60 X 100 = 21.6 %

0.3ml dosage = 26/60 X 100 = 43.33%

0.5ml dosage = 16/60 X 100 = 26.67 %

0.7m dosage = 13/60 X 100 =21.67 %

Calculating for 50 minutes

For 0.1ml dosage = 15/60 X 100 = 25 %

0.3ml dosage = 23/60 X 100 = 38.33%

0.5ml dosage = 18/60 X 100 = 30 %

0.7ml dosage = 16/60 X 100 = 26.67 %

Calculating for 60 minutes;

For 0.1ml dosage = 15/60 X 100 = 25 %

0.3ml dosage = 24/60 X 100 = 40%

0.5ml dosage =17/60 X 100 = 28.33 %

0.7ml dosage = 18/60 X 100 = 30 %

Taking average of 0.1ml dosage for all time intervals

$$\frac{10\% + 16.67\% + 15\% + 21.6\% + 25\% + 25\%}{6} = 18.87\%$$

Taking average of 0.3ml dosage for all time intervals

$$\frac{21.67\% + 26.67\% + 38.33\% + 43.33\% + 38.33\% + 40\%}{6} = 34.72\%$$

Taking average of 0.5ml dosage for all time intervals

$$\frac{13.3\% + 15\% + 20\% + 26.67\% + 30\% + 28.3\%}{6} = 22.27\%$$

Taking average of 0.7ml dosage for all time intervals

$$\frac{5\,\%+10\,\%+15\,\%+21.67\,\%+26.67\,\%+30\,\%}{6}$$

$$= 18.05\,\%$$

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Jar Test Result

The tables for the results are shown below.

4.2 Determination of Optimum Dosage

The optimum dosage should correspond to the column with the least turbidity value . And also the optimum dosage has the highest settling rate, that is, more particles were removed within the stated time. Therefore, looking and comparing the values gotten by the use of different centrations of banana peel ash as shown in table 4.1

ime	oagulant Dosage NTU)	nitial Turbidity NTU)	inal Turbidity NTU)	urbidity Removal NTU)	urbidity Efficiency(%)
0 min	).1	i0	i4	i	0 %
	).3	i0	7	3	1.67 %
	).5	i0	i2		3.3 %
	).7	i0	i7		i %
0 min	).1	i0	i2	0	6.67 %
	).3	i0	4	6	6.67 %
	).5	i0	i1		5 %
	).7	i0	i4	i	0 %
0min	).1	i0	i1		5 %
	).3	i0	7	3	8.33%
	).5	i0	8	2	0 %

	).7	;0	;1	)	.5 %
]0min	).1	;0	]7	.3	]1.6 %
	).3	;0	]4	]6	]3.33%
	).5	;0	]4	.6	]6.67 %
	).7	;0	]7	.3	]1.67 %
;0 min	).1	;0	]5	.5	]5 %
	).3	;0	]7	]3	]8.33%
	).5	;0	]2	.8	]0 %
	).7	;0	]4	.6	]6.67 %
;0 min	).1	;0	]4	.5	]5 %
	).3	;0	]6	]4	]0 %
	).5	;0	]3	.7	]8.33 %
	).7	;0	]2	.8	]0 %

Table 4.1. RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE.

4.3 Efficiency

Having a control aimed at investigating the benefit of using these coagulants. And if sample is allowed to settle naturally, and at the end the turbidity value becomes low as the treated then the treated is of no use. Thus, the turbidity of the treated and untreated sample was checked at regular time intervals.

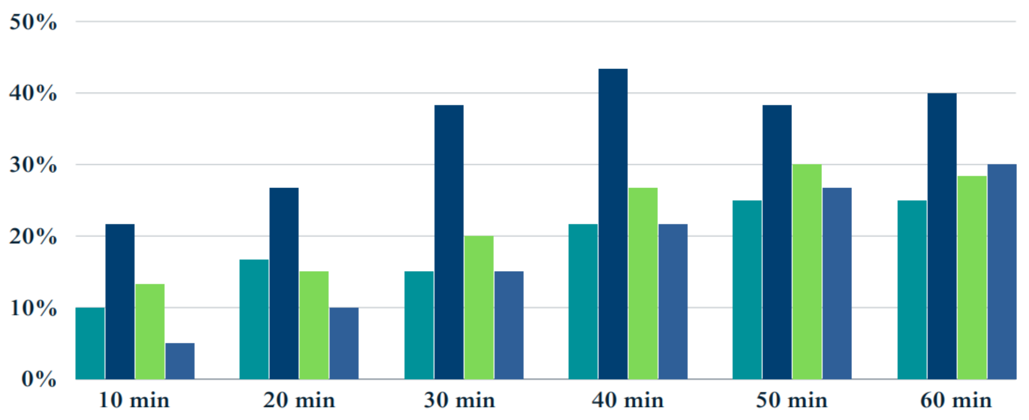
Therefore, from the table above, we calculate the efficiency of each reagent by the formula given below.

Efficiency, S = Change in turbidity/Initial turbidity X 100

4.4 Colour of End Product

After the end of the test, the end product of the treated sample gave perfect colorless water at the end of the day. Summarily, Banana peel powder has the following advantages.

1. It is effective and efficient
2. It produces a colorless end product thus no need for further treatment to remove colour.
3. Generally, it is very affordable and available



Graph 4.1 - Graph shows the turbidity efficiency with respect to time

CHAPTER 5

CONCLUSION

The efficiency of turbidity removing is more at 40 minutes of Coagulant dosage 0.3 NTU and the percentage of efficiency is 43.33%. Jar test results were used to calculate the types and quantity of coagulant to be used in the treatment of the sample. It also served to illustrate the rate order of coagulation reaction of the sample.This experimental study has produced valuable results for characterizing the rate order of settling and idea of the dosage of the coagulant (banana peel powder) needed.

Due to the quality variation of natural water from time to time and from season to season this dose cannot be fixed. Again due to unknown factors influencing coagulation of water, it is impossible to predict the type and amount of reagents necessary to achiee desired result economically for every water except through tests. Thus, trial and error experimentation via the jar test procedure must be carried out.

CHAPTER 6

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