TREATMENT OF HIGH STRENGTH INDUSTRIAL WASTEWATER BY USING NATURAL COAGULANT – A REVIEW

Abstract

The contamination present in the high strength wastewater discharged from various Industries release toxic compound to the environment and creates major threats to both human and environment. Different technologies were adopted for the treatment of high strength wastewater. However it has some drawbacks such as toxicity, sludge production and high production cost. This review paper present the recent technologies adopted in the treatment of high strength wastewater discharged from various industries like Textiles, Tannery, Pharmaceutical, Dye and Dairy industries by using natural coagulants. The main mechanism of Natural coagulant for high strength wastewater treatment is by the process of flocculation and charge neutralization. The Natural coagulant extracted from leaf, stem, root, bark and seed of a plant and tree are used as a natural coagulant, which is easily available at low cost and affordability. The application of natural coagulants helps to reduce the strength of wastewater and can be discharged within the prescribed limits and thereby implementing greener wastewater treatment technology.

Keywords: High strength wastewater, coagulation, Natural coagulants, Flocculation, Green Technology.

Authors

A. Sathiya Priya
Research Scholar,
Department of Civil Engineering
Sri Manakula Vinayagar Engineering College
Puducherry, India.

S. Sundararaman
Professor,
Department of Civil Engineering
Sri Manakula Vinayagar Engineering College
Puducherry, India.

Dr. Pannirselvam
Associate Professor
Department of Civil Engineering
College of Engineering and Technology
SRM Institute of Science and Technology
Kattankulathur, Chennai, Tamilnadu, India.
pannirsn@srmist.edu.in

J. Vanjinathan
Assistant Professor
Department of Civil Engineering,
Sathyabama Institute of Sciences and Technology,
Chennai, Tamil Nadu, India.

S. Kandasamy
Professor,
Department of Civil Engineering
Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology
Chennai, Tamil Nadu, India.

S. Azhagarsamy
Research Scholar
Department of Civil Engineering,
College of Engineering and Technology
SRM Institute of Science and Technology
Kattankulathur, Tamil Nadu, India.

I. INTRODUCTION

High strength wastewater includes wastewater from Industries like Textiles, Tannery, Paper, Pharmaceutical, Chemical, Dye, Distillery, Dairy, and Paint and Pesticide these types of waste need some special treatment which has to degrade the complex compound into simple compound, and to reduce the toxicity. High strength wastewater is a liquid that has high concentration of BOD, TSS, COD and other complex compound higher than the discharge limits, which is discharged from factories and finding way to local water bodies to create threats to Human and Environment. The conventional method has some drawback due to its high cost, duration and availability. The treatment of wastewater carried in three ways Physical method, Chemical method and Biological method [3].Physical methods involves Sedimentation, filtration process whereas chemical methods involve chemical reactions and the biological methods involves aerobic and anaerobic processes. But each process has some disadvantages like chemical requirement, cost and sludge production. Therefore to treat the high strength wastewater, we need new technologies to be adopted by using some natural materials which are easily and at low cost. To treat the high strength concentration wastewater, natural coagulants like Grape seed extract, Banana peel powder, Neem seed powder, Papaya seed, Peanut seed, and Moringa oleifera (drumstick) seed powder are utilized.

II. COAGULANTS

Coagulants can be divided into two categories: natural and chemical. Natural coagulants are coagulants made from plants and animals found in the natural environment. Aluminum sulfate, ferric sulfate, ferric chloride, and poly aluminum chloride are some of the compounds used to make chemical coagulants. Natural coagulants come in three different varieties: those based on plants, animals, and microorganisms. The flower, seed, leaves, stem, bark, roots, and resin gums of plants and trees are used to make plant-based coagulants. The Chitosan found in the shells of crabs, lobsters, shrimp, diatoms, fungi, insects, freshwater and marine sponges, and mollusks is used to make animal-based coagulants [19]. The microorganism category consists of bacteria with extracellular polymeric substance can acts as a Bio coagulation /Bio flocculants.

1. **Coagulation Process:** Coagulation is a process of disintegrating the solids into small particles there by increasing the surface area of the particles so the coagulant can be more easily adsorbed by the particles and as result flocs are formed, due to gravity and the particles settles down. Usually coagulation process is carried out in Jar Test apparatus. To assess the ideal dosage of coagulant required for wastewater treatment, a jar test has been utilized. It has six jars with steel paddles which helps for rapid mixing for first 2 to 3 minutes, and then at slow speed for 15 minutes after these process the jars are kept idle for 30 minutes. And noted the settling of sediments is considered to be the optimum dosage of coagulant taken into the study.

2. **Natural Coagulants for High Strength Wastewater Treatment:** Natural coagulants play a significant part in the treatment of high strength wastewater. They are composed of polymers of polysaccharides and amino acids as well as carbohydrates, protein, and lipids. According to research, charge neutralization and polymer bridging are the primary mechanisms underlying coagulation action. Polymer absorption creates polymer bridging

[41]. The goal of polymer adsorption is to alter the way surfaces interact, which enhances flocculation procedures, surface characteristics, and particle dispersion. Most frequently, it is determined by how quickly a solution loses concentration after coming into contact with a surface [41].

III. DYE INDUSTRY

Synthetic dye colors are created using dyes such as dispersed dyes 218 and dispersed navy 35, basic orange 37, and basic red 1. During this procedure, the dye colors are dissolved in water and used for coloring purposes, with the leftover wastewater being released as effluent. [3]. The application of natural coagulant derived from various plants and animals has more advantages than other in the treatment of wastewater. The pH of the treated water is not changed by the natural coagulant. The majority of all-natural coagulants, such as banana peel powder, neem seed powder, papaya seed powder, and peanut powder, are used to treat wastewater from the dairy industry. Neem seed powder has been found to be effective for treating wastewater from the dye industry, with a 90% reduction in COD from the initial level of 1486 mg/l to 563 mg/l. sewage with a pH of 7.32 [1].

The roots of Alcearosea (hollyhocks) were naturally dried, and 2.5 g of the powdered root was put to 100 ml of 0.5 M sodium chloride that had been produced with distilled water and filtered through a mesh made of cloth. The resulting milky mucilage was then removed and utilized as a coagent. The most effective way to remove disperse dyes from aqueous solutions and sewage is with alcearosea coagulant [2].

Moringa oleifera seed is allowed to dry in the broiler for 24 hours at a temperature of 50°C, then it grinded into a medium fine powder by using residential blender , the seed of Tamarina indica were collected from the kitchen as waste material is dried for one hour at 110 oC in an air broiler, then crushed in a four mill, strychonospotatorum (Nirmali) seed was gathered and soaked in water along with 2 ml of conc HCL due to their hard structure and followed for 7 days, then blended to make into soup like arrangement and filter through nylon fabric ,these material is dried in 24h at 103 to 105 ^{o}C, among the three seeds, M. oliefera has a better capacity for the reduction of TDS and TSS, BOD and COD, and Tamarind has the capacity to lower fluoride concentration. These three seeds are utilized as natural coagulants for the treatment of wastewater. [3].

Canna Indica commonly known as Kalvazhai is used for the industrial wastewater treatment [4] when the industrial effluent is made to pass through Canna Indica which proves to be efficient in removing the increased organic load, colour, and nitrogen compound from the wastewater. The rhizobium of this plant is believed to be responsible for the removal of pollutant [4].Tamarind powder can reduce the turbidity and COD of 97.78% and 43.50%, and the colour removal of 100 %. It also noted that tamarind power has the capacity to reduce fluoride content, tamarind contain phenolic groups that can remove proton from any atom, ion or molecule to produce phenoxide which enhance the effect of coagulation.[4].

The application of Hibiscus seeds as Natural coagulant used to reduce the concentration of turbidity, the natural polyelectrolyte present in the seed in the form of polysaccharide and protein usually exhibit higher molecular weight, the greater increase of surface area increases the adsorption processes and coagulation. Additionally, hibiscus

sabdariffa seeds include cationic peptides such glutamic, aspartic, and leucine as well as coagulation protein [5]. Hibiscus sabdariffa flowers are picked, the seeds are removed, and they are cleaned with distilled water. After drying for two hours at 600 C while utilizing this powdered as a natural coagulant, color removal can reach up to 96.67% under ideal conditions. [5].

At pH 4.0 and a coagulant concentration of 25 mg/l, it was discovered that the maximum percentage of Congo red (CR) elimination could be achieved with SSP (Surjana seed powder), Chitosan, and MSP (Maize seed powder), respectively [6]. The seeds of the Plantago major (great plantain) plant were harvested, dried at 1000°C for 2 hours, ground in a grinder, and sieved to a mesh size of 35 (500 m) [7]. The powdered material was then soaked in boiling water containing a 0.9% NaCl solution and stirred for 2 hours before being thoroughly mixed for 10 minutes at 20 rpm. The ideal circumstances of 49.6 minutes, pH 6.5, and 297.6 mg/L coagulant dose were employed to generate this mixed solution, which was used as a natural coagulant to achieve a high color 92.4% and COD 81.6% reduction efficiency [7].

Grape seed were purchased from a nearby store, and grape seed extract was made by first washing the seeds with water, drying them, and then powdering them. 20 cc of a 70% ethanol solution were used to extract 1g of grape seeds overnight in a shaking incubator at 106 rpm and 280C. The extract was again incubated for 10 minutes at 95 0C after being filtered and stored at 40 0C before being added to dye-contaminated water [8]. It is proved that the treatment by using GSE as natural coagulant, toxicity of MG and CV (Malachite green and crystal violet) contamination decreased. Table 1 lists the numerous natural coagulants used to remediate effluent from the dye industry.

Table 1: Treatment of Dye Industries Wastewater by using Various Natural Coagulants

Method	Material used	Parameter Studied	Remark	Reference
Coagulation (Jar test)	Banana Peel Powder Neem seed powder Papaya seed Peanut seed powder	pH, Turbidity BOD,COD and Chloride	Among the all, Neem seed powder is more efficient in treating dye wastewater at pH 7.32 and reduces C.O.D. values by 90%.	[1]
Coagulation	Alcearosea root mucilage	Red 60 dye and reactive blue 19 dye are dispersed	The best method for removing dyes from aqueous solutions and sewage is alcearosea coagulant, especially for disperse colours.	[2]
Coagulation	Moringa oleifera, TamarinaIndica and Strychonomouspotatorum	pH, Turbidity, TSS, TDS,BOD,COD	Between the two characteristics, M. oliefera has a stronger ability for the	[3]

			expulsion of TDS and TSS, BOD and COD, and it has a more effective method for treating coloring manating. Tamarin have the capacity of reduce fluoride.	
Coagulation	Canna Indica (KalVazhai) and Tamarind	Turbidity, COD	Turbidity and COD are removed with 97.78%, 97.01%, 43.50%, and 24.86%, respectively.	[4]
Coagulation	Hibiscus sabdariffa seeds	Dye Concentration	A 96.67% dye clearance rate is possible with the best conditions.	[5]
Coagulation	Maize seed powder (MSP), Chitosan, and Surjana seed powder (SSP)	Sludge Volume Index (SVI), pH, coagulant dose, flocculation period, and turbidity	At pH 4.0 and a coagulant dose of 25 mg/l, the highest percentage (congo Red) elimination was determined to be 98.0, 94.5 and 89.4% for SSP, Chitosan, and MSP respectively.	[6]
Coagulation	Plantago major	pH , coagulant dose , colour and COD reduction	P. majorL. was used to achieve high color 92.4% and COD 81.6% reduction efficiency at the ideal circumstances of 49.6 min, pH 6.5, and 297.6 mg/L coagulant dosage.	[7]
Coagulation	Grape seed extract	Malachite green and crystal violet	The toxicity of MG and CV contamination was lessened by treatment with natural polyphenols and GSE.	[8]

IV. DAIRY INDUSTRY

Massive amount of water is required for the production of dairy industries need, for the production of 1 litre of processed milk 3 litre waste water will be produced [9]. Due to the presence of organic components, the dairy industry's effluent has a high concentration of organic elements such fats, carbohydrates, grease, and proteins as well as a high concentration of TDS, COD, BOD, and turbidity. Orange peels, Neem leaves, Cactus were collected from the local market and surrounding then it is washed in water, dried in sunlight for 4 to 8 days, the grinded power is used as a natural coagulant for the treatment of Dairy wastewater. Among this cactus has the good reduction in 64.65% of Turbidity and 72.60% of COD [9].

Yellow passion fruit and ripe okra (lady's finger) is collected form a agro-industrial processing waste. The seed of the passion fruit and ripe okra fruit is dried in an oven at a 150^0C for 4 hrs and 110^0C for 8 hrs respectively. Then it is crushed and sieved through the size of 0.35mm to 0.85mm. Okra dosage of 2.0 g L-1 at pH 9.00 and passion fruit seed dosage of 1.3 g L-1 at pH 5.00 were determined to be the best conditions for eliminating turbidity and COD. Okra as a coagulant reduced turbidity by 91.1% and COD by 48.3%, whilst passion fruit seeds reduced turbidity by 91.5% and COD by 50.3% [10].

Fenugreek and Moringa oleifere seeds were purchased from local markets and farms, then stored for 24 hours in sunlight or an oven before being ground and sieved through a 600 m sieve.Moringa oleifera delivers doses of 0.2gm/l, 0.4gm/l, 0.6gm/l, 0.8gm/l, and 1gm/l. The doses delivered by fenugreek are 1 gm/l, 1.5 gm/l, 2 gm/l, 2.5 gm/l, and 3 gm/l from the optimum dose chosen, which is 0.6 gm/l. From this, 2.5gm/l is the chosen optimal dose. Numerous metrics, including BOD, COD, and turbidity, have been decreased to low levels. Because it contains protein, Moringa oleifera is a more effective coagulant than other coagulants. [11].

Chick pea (Chana) seed were collected and grinded to fine powder, sieved through 600µm, 10 g of this powered is dissolved in 1 litre of distilled water stirred well for 10 minutes and stored in refrigerator at 5^0C. After 15 days of drying, tamarind seeds are ground into a fine powder that passes through a 600-mesh filter. 2g of this powder is then added to 100 ml of distilled water, and the resulting solution can be used as a natural coagulant in 30 minutes. Tamarind seed and cerarietinum reduce COD by 81.81% and 63.63%, respectively, from the original value of pH, and remove turbidity with respective removal efficiencies of 39.53% and 30.23%. There are 7.42,3 NTU of turbidity, 1826 mg/l of COD, and 400 mg/l of BOD5 correspondingly [12].

Moringa oleifera and Phaseolus Vulgaris (green beans) collected and dried in an oven at 70^0C, then it is grounded to fine powered by grinder, the powdered is sieved through 600µm. When this powder is employed as a natural coagulant, turbidity is reduced by 78.49%, BOD3 is decreased by 79.64%, COD is decreased by 85.81%, total dissolved solids are decreased by 8.59%, and total suspended solids are increased by 95.45% [13].

Moringa oleifera, Cicer arietinum (chickpea), Dolicus lablab (hyacinth bean), and Trigonella foenum-graecum (fenugreek) all the seed is collected from local market and dried naturally in sunlight, blender used to grind the ingredients through a 600-m, when this powder used as natural coagulant, M.oleifera, Azadirachtaindica T.foenumgraecum,

c.arietinum can able to reduce the turbidity by 61.60%, 71.74%, 58.20% and 78.33% respectively[14,16,17]. Acacia mearnsiide (green wattle) is a flowering plant which has high concentration of tannins can be used as a natural coagulant (Tanfloc SG and Tanfloc SH) prepared in concentrations of 1,000 mg.L-1. Tanfloc SG and Tanfloc SH while using as coagulant for the treatment of dairy wastewater can reduce COD 77.28% and 44.14% respectively [15]. M. oleifera, Dolichos lablab, T. foenum-graecum, and Cicerarietinum each have turbidity and COD values of 61.60%, 71.74%, 58.20%, and 78.33%, and 65.0%, 75%, 62.5%, and 83%, respectively. Initial pH, COD, and turbidity values are 7.41, 289.5 NTU, and 10,000 mg/l [17]. Moringa seed is more effective in reducing the % of turbidity at 77% efficiency [18]. In table 2 lists the treatment procedures and natural coagulants used in the treatment of dairy wastewater.

Table 2: Natural Coagulants Used in the Treatment of Dairy Wastewater

Method	Material used	Parameter	Remark	Reference
Coagulation (Jar test)	Cactus, Orange peels and Neem leaves	pH, COD, Turbidity and TDS	Among these three natural coagulants Cactus was found most effective. Coagulating with Cactus attained removal of 64.65% Turbidity and 72.60% COD.	[9]
Coagulation /dissolved air flotation	Ripe okra (Abelmoschuse sculentus) and passion fruit (Passifloraeduli s) seeds	pH, Turbidity and COD	Okra as a coagulant reduced turbidity by 91.1% and COD by 48.3%, whilst passion fruit seeds reduced turbidity by 91.5% and COD by 50.3% from the SDW.	[10]
Coagulation	Moringa oleifera and Fenugreek	BOD,COD, Turbidity, Total solids	Because it contains protein, moringa oleifera is a more effective coagulant than other coagulants.	[11]
Coagulation	Tamarind seed and Cicerarietinum (Chick Pea)	BOD,COD, Turbidity, TS,TSS	Tamarind seed and cicerarietinum had turbidity removal efficiencies of 39.53% and 30.23%, respectively, and COD reduction efficiencies of 81.81% and 63.63%, respectively.	[12]
Coagulation	Moringa Oleifera	BOD, COD, turbidity, pH	The decrease in turbidity, BOD3, COD, TDS and	[13]

			TSS is 78.49%, 79.64%, 85.81% 8.59% and 95.45% respectively	
Coagulation-flocculation	Moringaoliefera, Azadirachtaindica, Trigonella foenum graecum (fenugreek) and cicer arietinum	BOD, COD, turbidity, pH	The effectiveness of M. oleifera, Azadirachta indica, T. foenum graecum, and C. arietinum in lowering turbidity is 61.60%, 71.74%, 58.20%, and 78.33%, respectively.	[14]
Coagulation -flocculation	Tanfloc SG and SH	Turbidity COD Total solids Sludge volume Total coliform Thermotolerant coliform	COD elimination with Tanfloc SG coagulant was 77.28%, whereas with Tanfloc SH it was 44.14%.	[15]
Coagulation	Cicer Arietinum (Chick Pea)	BOD, COD TSS and turbidity	The highest percentages of COD and turbidity reduction were discovered to be 58.9% and 86.29%, respectively.	[16]
Coagulation	Moringa Oleifera seeds, Fenugreek Dolichos lablab (hyacinth bean) and Cicer arietinum.	BOD, COD, pH and turbidity	M. oleifera, Dolichos lablab, T. foenum-graecum, and Cicerarietinum each have a turbidity reduction efficiency of 61.60%, 71.74%, 58.20%, and 78.33%, respectively. M. oleifera, Dolichos lablab, T. foenum-graecum, and Cicerarietinum all reduce COD with efficiencies of 65.0%, 75%, 62.5%, and 83%, respectively.	[17]
Coagulation	Moringa olifera	pH , conductivity, DO ,turbidity and hardness metals such as copper, chromium,	Moringa seed is more effective than alum with the highest purity in turbidity at 77% efficiency.	[18]

		lead, calcium, magnesium, cobalt and zinc		

V. PHARMACEUTICAL INDUSTRY

Pharmaceutical effluent are wastewater is discharged from the pharm industry which contain hazardous waste in nature due to the presence of toxic metals and active pharmaceutical complex compound which does not undergo any degradation processes in nature [21]. Pharmaceutical contamination threatens both human and environmental. One option for treating pharmaceutical wastewater is the coagulation-flocculation process, which uses a natural coagulant. Plant based coagulant is more effective than animal based [19].

The peeled Moringa seeds and Tapioca starch are mashed dried at temperature of 60^0C and sieved by using 24 mesh size, this sieved moringa powder and tapioca starch was used has natural coagulant by the method of coagulation and flocculation in jar test at 100 rpm for 10 minute. BOD and COD are removed with moringa seed as a coagulant at a rate of 90.12% and 71.23%, respectively. Using tapioca starch as coagulants, 95.25% and 94.63% of BOD and COD were removed. The elimination of BOD and COD was 32% and 31%, respectively, when tiny crab chitosan was used as a coagulant [20].

When paired with either another natural coagulant or an inorganic coagulant in the proper ratios, natural coagulants derived from plants and animals are more successful at treating effluents [21]. Using a composite coagulant made of polyaluminum chloride, M. oleifera seed protein was extracted and described. Fourier Transform Infrared (FTIR) spectroscopy can be used to determine this. Scanning Electron Microscopy (SEM) can be used to compare the morphology of M. oleifera before and after treatment. [22]. Hospital wastewater could be cleaned up by using MOP and MOP-PAC, a composite coagulant made of M. oleifera protein and polyaluminum chloride [22].

Phoenix dactylifera (dates) were collected form farm and dried in sunlight for two weeks after that it is ground using grinder to a particle size of 1.18µm sieve. It has been demonstrated that using this power as a natural coagulant to remove color from wastewater has a maximum color removal effectiveness of 99.86% at a dosage of 100 mg/L [23].

Hibiscus Sabdariffa (Roselle) seed used as a natural coagulant, due to its coagulant properties and Jatropha Curcas contain protein which is used as natural coagulant, Good quality of both seed is collected washed dried in an oven at 60^0C for 3 hrs then it is crushed into fine powder for using as coagulantIt was discovered that H. Sabdariffa performs best at pH 4 and 190 mg/L of coagulant, removing the largest percentage of turbidity (35.6%) and reducing COD by 29%. [24].

M.oleifera seed were collected from local market dried and converted to fine powdered of size of 600µm.Moringa oleifera seeds removed around 80.0% to 99.5% turbidity

and color respectively. BOD and COD reduce to the value of 373 and 5135 mg/lit from 3776 and 13728 mg/lit[25].

Table 3: Treatment of Pharmaceutical Industry Wastewater using Various Natural Coagulants

Method	Material used	Parameter	Remark	Reference
Coagulation -flocculation	Moringaoleifera, Chitosan, Rice starch, Jatrophacurcas, Watermelon seeds, Banana pith, Ocimumbasilicum(tulsi)	pH, COD ,colour, TSS, Turbidity, TOC	Natural coagulants made of plants are less expensive than those made of animals.	[19]
Coagulation - flocculation	Moringa seed, tapioca starch coagulants, crab chitosan coagulant	BOD,COD	BOD removal of 90.12% and COD removal of 71.23% are achieved utilizing moringa seed coagulant. BOD and COD removal from tapioca starch was 95.25% and 94.63%, respectively. The elimination of BOD and CODs was 32% and 31%, respectively, when tiny crab chitosan coagulant was used.	[20]
Coagulation	Moringaoleifer, Citrulluslanatus (Seed of watermelon), Treculiaafricana (African bread fruit) Phoenix dactylifera (Date), Zea mays (Corn or maize), Banana peels, Sesamumindicum (Beniseed)	COD, TSS and turbidity, pH	When paired with either another natural coagulant or an inorganic coagulant in the proper ratios, natural coagulants derived from plants and animals are more successful at treating effluents.	[21]
Coagulation	Protein-polyaluminum chloride composite	Turbidity,pH,COD, E-	Hospital wastewater	[22]

	coagulant from Moringa oleifera seeds	Coli, UV254, V. cholera, P. aeruginosa	contaminants could be successfully removed using MOP and MOP-PAC composite coagulants.	
Coagulation -flocculation	Phoenix dactylifera (dates)	pH, settling time, and coagulant dosage, Colour	At a dosage of 100 mg/L, the highest color removal efficiency is 99.86%.	[23]
Coagulation	H. Sabdariffa and J. Curcas	pH, COD Turbidity	H. Sabdariffa performs best at pH 4 and 190 mg/L of coagulant, removing 35.8% of the greatest amount of turbidity and lowering COD by 29%.	[24]
Coagulation	Moringa Oleifera seed	Turbidity, TSS, TDS ,COD and BOD	Moringaoleifera seeds reduce around 80.0% to 99.5% turbidity and color respectively, BOD and COD reduce to the value of 373 and 5135 mg/lit from 3776 and 13728 mg/lit.	[25]

VI. TEXTILE INDUSTRY

About 200-300 m3 of wastewater are produced by the textile industry for every ton of finished textile product, and the wastewater contains significant levels of pH, BOD, COD, TSS, TDS, hazardous dyes, and other complex compounds [28]. The release of dyes into local bodies without sufficient treatment might result in serious health and environmental problems due to the presence of several dangerous chemicals [27].

Eirchorrnia crassipes (water hyacinth) and Strychnos potatorum (nirmali seeds) were gathered, and the coagulant solution may be created from the seed kernels or the solid residue by applying pressure to the caked seed. This allows the extraction to be collected and used as a natural coagulant. As just the extraction is utilized as a coagulant, it demonstrates that

Eirchorrnia crassipes minimizes the volume of sludge formed in the treatment of waste water [26].

Natural coagulant can achieve better result than the other conventional methods in Textile wastewater treatment, the seed of C.fistula were collected and dried under sunlight and then it is grounded into powder. The extraction prepared by using the fine powder with hexane as a solvent in a soxhlet system, by doing so c.fistula seed gum was produced and these can be used as natural coagulant [27].

O.stricta (Cactus) Cladodes were collected, cleaned, and cut into small pieces. It was then dried for 24 hours at 600°C in a hot air oven. The dried strip was then ground into a powder that passed through 0.42 mm. This powder was then suspended in water and filtered through Whatman filter paper of no. 42. At an ideal pH of 10.3, dose of 162.2 mg L-1, O. stricta's filtered solution, which is utilized as a natural coagulant, removes a maximum of 80.2%, 58.4%, and 77.3% of TSS, COD, and color, respectively) [28].

Azadirachta indicia (Neem leaves) were collected, cleaned, and allowed to air dry for four days at room temperature. After that, the dried leaves were crushed, and the powder was sieved using a 75 micron sieve. For the natural coagulation of textile wastewater, sieved powder is employed. Neem leaf powder significantly improves pH, Total Solids, TDS, TSS, EC, Turbidity, COD, BOD, Copper, and Chromium removal [29].

Banana trees that had reached maturity were gathered from the farm, the stem's pith was removed, and the juice was extracted by combining 100 g of the pith with 10 ml of purified water in a mixing grinder. This purified banana pith juice was employed as a natural coagulant after being removed. The amount of suspended particles decreased to 96% when banana stem extract was added to a quarter of the wastewater volume. Wastewater has a lowered hardness value of 66%.The samples' turbidity also dropped from its initial level to 78% [30][33].

Moringa oleifera seed and Tamarindus Indica were collected washed and dried at room temperature for 24 hrs .Using grinder these seed is made into powder, Tamarindus Indiaca seed is coated with HCL before grinding for peel out the skin of the seed [31] The coagulant from Moringa oleifera lowers pH by 35%, turbidity by 48%, total solids by 68%, total dissolved solids by 70%, total suspended solids by 57%, and tamandus by 68%.A coagulant called indica reduces pH by 32%, turbidity by 32%, total solids by 47%, dissolved solids by 48%, and suspended solids by 44% [31].

Okra was collected from the local market, The pods were cleaned, the seeds and excessive fiber were taken out, and then the mucilage was extracted. 100 ml of each extraction were added to 1 g of gum, which was then agitated for 1 hour until the gum had completely swollen [32] and filtered using a 500 stain steel filter. The thick mucilage was gathered and utilized as a coagulant naturally to clean wastewater. Using a small amount of okra mucilage, 3.20 mg L1, it was possible to remove color 93.57%, turbidity 97.24%, and COD 85.69% [32]. The use of several natural coagulants in the treatment of textile wastewater is listed in Table 4.

Table 4: Using Different Natural Coagulants to Treat Wastewater from the Textile Industry

Method	Material used	Parameter	Remark	Reference
Coagulation	Strychnospotatorum (nirmali seeds), Eirchorrnia crassipes (water hyacinth)	pH, sulphates, chlorides, TS, TSS, TDS, acidity, alkalinity, BOD,COD.	When used to remediate waste water, Eirchorrnia crassipes produces less sludge and is environmentally benign and biodegradable.	[26]
Coagulation	Cassia fistula coagulant	pH , Colour removal	C. fistula With a percentage removal of 93.83% at a volume of 30 L and a coagulant dosage of 1.17 mg L1, coagulant is an efficient substance for treating genuine textile wastewater.	[27]
Coagulation	Opuntia stricta (O.stricta) (cactus)	TSS, COD, and color.	O. stricta gives at an ideal pH of 10.3, a dosage of 162.2 mg L-1 results in a maximum elimination of 80.2%, 58.4%, and 77.3% for TSS, COD, and color, respectively.	[28]
Coagulation	Neem leaves powder	pH, TS,TDS,TSS, EC, Turbidity, Alkanity Iron, silica, COD, BOD, copper, chromium, hardness, chloride, and sulfate	The BOD3/COD ratio of the effluent was improved as a result of the coagulation/flocculation process, according to experimental data, which showed that the wastewater could be efficiently treated.	[29]
Coagulation	banana stem extract	TSS, Turbidity and hardness	96% of the suspended solids were reduced by banana stem extract. The 66% hardness To 78%, the turbidity dropped.	[30]
Coagulation	MoringaOleifera and TamarindusIndica	PH, Turbidity, TS, TDS	35% pH, 48% Turbidity, 68% TS, 70% TDS, 57% TSS, and Tamarindus are	[31]

		and TSS	removed by MO coagulant.The contents of the indica coagulant remove 32% pH, 32% turbidity, 47% TS, 48% TDS, and 44% TSS.	
coagulation / flocculation	Abelmoschus Esculentus (okra mucilage)	Turbidity, color, and COD.	Using a small amount of okra mucilage, 3.20 mg L-1, 88.0 mg L-1, a high reduction of color (93.57%), turbidity (97.24%), and COD (85.69%) was achieved.	[32]
Coagulation	Banana pith juice	TSS, pH, and turbidity	At pH 4, the percentages of EC, TS, and turbidity removed by the banana stem juice were 50, 50.1, and 97.5%, respectively.	[33]

VII. TANNERY INDUSTRY

Tannery wastewater generate a complex mixture of both organic and inorganic components from the various manufacturing processes like preparatory stages, tanning and crusting, in which enormous of wastewater is produced, while processing the preparatory stage generate lot of hazardous waste. Nearly 1 Kg of skin while processing can produce 30-35 litres of wastewater which contain pH, High concentration of TSS, BOD, COD and complex compound [34]. High contamination of chromium salts, phenolic which can affect the both human and Environment. And also tannery waste has strong colour and foul smell due to the presence of high organic compound. Different physical-chemical techniques are employed, including active carbon adsorption, ion exchange, and reverse osmosis, but each has drawbacks that outweigh their benefits [34]. Hence a new method has to adopt which have to treat the wastewater at low cost and with high efficiency.

The seed of Moringaolifera, Sappindusemarginatus (Soup Nut) and strychnospotatorum (Nirmali seed) collected dried and made into powder, These powered can remediate tannery wastewater at concentrations of 0.05g/ml, 0.10g/ml, 0.15g/ml, and 0.20g/ml when used as natural coagulants. The turbidity is reduced to 88% at pH 7 [34].Moringa olifera seed was taken and dried in sunlight then it is made into powder which pass through 75 micron sieve, 20 gm of this powder is mixed in 250ml of distilled water, filtered using filter paper, these filtered water is used as natural coagulant, 76% of colour and odour were removed [35]. Cicer arietinum (Chickpea), Moringa oleifera and cactus obtained from the neighborhood market and the side of the road, dried at 600C for 24 hours. The highest reduction in turbidity was found to be 81.20%, 82.02%, and 78.54%, and the maximum reduction in COD was found to be 90%, 83.33%, and 75%, respectively. The dry materials were ground in a grinder and sieved through 600 m [36].

Azadirachtaindica (Neem Leaves) was collected from road side dried in an oven at 60^0C for 24 hrs. Then it is ground to fine power and sieved to size 600µm, The percentage of turbidity, COD, BOD, TSS, and TDS removal from this powder employed as a natural coagulant was 85.66%, 80.42%, 96.74%, 84.81%, and 87.06%, respectively [37]. Aloevera leaves were washed to get out the moisture of the leaf then it is made into slice and dried in sunlight for 48 hrs and then this dried leaves again dried at 60^0C in hot plate for 2 hrs. This aloe vera is crushed in a ball mill at 180 rpm for six hours. Aloevera coagulant's structure and shape were examined using a scanning electron microscope (SEM), which demonstrated that it functions as a natural coagulant [38].

The seed of S. potatorum (Thethankottai) and Moringa oleifera were dried and powdered for a size of 0.05 mm sieve and used as a natural coagulant for wastewater treatment to remove heavy metals, it shows S. potatorum and M. oleifera in the treatment of tannery effluent was more effective [39].AloeVera, Moringa Oleifera and Cactus were collected and dried ground into power [35][36][38] these dried power when used as coagulant M. Oleifera cactus has the best dosage at 40 mg/l with pH 7, whereas seeds provided the maximum reduction in turbidity and COD at 15 mg/L with pH 6. Aloevera's ideal dosage is 5% concentration, and its ideal pH is 5 [40].

Table 5: Treatment of Textile Industries Wastewater using Various Natural Coagulants

Method	Material used	Parameter	Remark	Reference
Coagulation and flocculation	Moringaolifera , Strychnos potatorum Sappindusemarginatus	colour, odour and turbidity	The turbidity of tannery effluent was removed by 88% at pH 7	[34]
Coagulation and flocculation	moringaolifera and lime	TDS, turbidity, odor, color	The transmittance rate rose to 76%. There was no trace of color or smell. Other original parameters were also sharply scaled back.	[35]
Coagulation and flocculation	Cicer arietinum, Moringa oleifera, and Cactus	pH,Turbidity, COD	Moringa oleifera and Cicer aretinum showed the greatest reductions in turbidity (82.02% and 90%, respectively) among the natural coagulants utilized in this study.	[36]
coagulation and flocculation	Azadirachta indica leaves powder	turbidity, TSS, TDS, COD and BOD	Azadirachta When indica leaves powder was employed as a coagulant and administered at a	[37]

			dosage of 3 mg/L, it was discovered that turbidity, COD, BOD, TSS, and TDS were removed to a percentage of 85.66%, 80.42%, 96.74%, 84.81%, and 87.06%, respectively.	
coagulation and flocculation	aloevera leaf	Turbidity, hardness, chlorides, total solids, total suspended solids, BOD, and COD.	SEM analysis of the structure and morphology of aloevera coagulant reveals an amorphous nature and rather porous matrix that permits inter-particle bridging.	[38]
Coagulation	S. potatorum and M. oleifera seeds powder	pH, TDS, TSS, Total Hardness Cr^{3-}, Mg, Fe, P, COD, BOD	S. potatorum and M. oleifera in the treatment of tannery effluent was more effective.	[39]
Coagulation	AloeVera, Moringa Oleifera and Cactus	COD and turbidity	M. Oleifera, the supplied samples, seeds removed the most turbidity and COD. The ideal pH for M. oleifera is 6, and the recommended dosage is 15 mg/l. The ideal dosage for cactus is 40mg/l, and its pH should be 7. Similar to this, aloe vera's ideal dosage at 5% concentration and pH 5 is similar.	[40]

VIII. CONCLUSION

Due to the presence of large concentrations of turbidity, TDS, TSS, COD, BOD, and other complex compounds, the removal of contaminants from different industrial wastewaters is difficult. According to several studies, employing natural coagulants to treat wastewater results in the highest levels of efficacy at the lowest possible cost, with the least amount of sludge generation. This review analyzed numerous papers on industrial wastewater treatment by using natural coagulant, like Seed, leaves, mucilage, root and flower form various plant and tree is derived as Natural coagulant, MoringaOleifera (drumstick) seed,

Azadirachtaindica (Neem) leaves, Sappindusemarginatus (SoupNut), strychnospotatorum (Nirmali) seed, AloeVera leaves okra, (Lady's Finger) seed, Eirchorrnia crassipes (water hyacinth)leaves, Phoenix dactylifera (dates) seed and H. Sabdariffa seed are used as natural coagualts in the treatment of wastewater. MoringaOleifera and Azadirachtaindica (Neem) has place major role in the reduction of high strength concentration like pH, TSS,TDS,COD,BOD, Copper and Chromium present in the in the industrial wastewater. The sludge produce from this process can be used as fertilizer for plant cultivation as it contain more organic content and it is Eco-friendly to the Environment.

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