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Plant Based Coagulant For Waste Water Treatment

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Abstract: ***Water is one of the essential things for human survival. In rural areas those people who were living in extreme poverty, they are drinking contaminated water because of high procurement cost of chemical coagulants and high cost of water treatment process. Usage of plant based coagulant instead of chemical coagulant is the best solution for above mentioned problems Usage of plant based coagulants like "Mung bean, Peanut seeds, Cactus, has many like low procurement cost, and biodegradable sludge production. After several months of studies and investigations we come up with the solutions for waste water treatment, our project gives a new way to treatment of waste water by plant based coagulants.***

Keywords: Plant, Based Coagulant, Waste Water, Treatment

1. INTRODUCTION

Water is a vital resource, but presents a worrisome depletion in recent times. Adequate water supply for human consumption is a concern, since most of this resource is found in oceans where the high salt content makes it unsuitable for drinking. Features such as growing population, increased economic activities and industrialization have resulted in high demand for drinking water and the subsequent misuse of this natural resource, which is severe. This hinders the treatability process and increases water treatment costs. For these reasons, coagulation-flocculation procedures associated with other processes are of great importance in order to separate contaminating component sand achieving high degrees of drinking water quality.

Aloe Vera specifically refers to the Aloe barbadensis Miller plant. Aloe Verais the oldest medicinal plant ever known and the most applied medicinal plant Worldwide. This is a perennial tropical plant that can be cultivated in drought prone areas. In India, it is scattered in the wild, along the coast of southern India. It is a stem less or very short-stemmed succulent plant growing to 60–100 cm (24–39 in) tall, spreading by offsets. The leaves are thick and fleshy, green to grey-green, with some varieties showing white flecks on their upper and lower stem surfaces. AloeVera plant requires very less water for its growth as it contains 98% of water in its leaves. It contains around 75 nutrients and 200 active compounds including minerals, amino acids, enzymes and vitamins.

1.1 General

Coagulants are chemicals that water needs to help the process of precipitation of small particles that can't settle by themselves. Commonly, industrial treatment used inorganic coagulants such as alum, PAC, ferric chloride, ferric sulphate and cation polymer in their waste water treatment. Inorganic coagulants are more effective than organic coagulants, but in high doses, they may cause precipitates that are difficult to treat. This reason make organic coagulant as an alternative to replace inorganic one. Plant seeds are commonly used as organic coagulants raw material.

Tamarind seeds can be used as coagulant because the seeds protein content that acts as a polyelectrolyte. According to Dobrynin& Michael (2005), polyelectrolytes are polymers that carry positive or negative charges of ionized groups. In a polar solvent such as water, the group may dissociate, leaving the charge on its polymer chain and releasing the opposing ion in solution. The addition of a polyelectrolyte concentration will result in reduced colloidal stability and will reduce the rejecting force between particles to support the precipitation process.

Coagulation is the growing of fine particles that occurs as a result of its collisions. Chemical reactions are often incomplete. They have numerous side reactions with other substances in the wastewater. Coagulation varies with various factors like pH, temperature and dosage. The four basic mechanisms involved in this process are double layer compression, charge neutralization, sweep flocculation and adsorption. This method is not feasible in many developing countries due to high fixed capital and unavailability of chemical coagulants. There are a lot of problems arising due to the use of synthetic or chemical coagulants. Alum treated water contain residual aluminum that leads to serious health issues such as the development of Alzheimer's disease (AD) and senile dementia. In addition, using of inorganic coagulants complicates the handling and disposal operations. Due to these downsides of chemical coagulants, natural coagulants are taking uplift from environment's point of view. Furthermore, natural coagulants produces biodegradable and minimum volume sludge 20-30% that of chemical coagulant. Natural coagulants have been used for domestic household for centuries in traditional water treatment in tropical rural areas.

1.2 Coagulation

Due to the lack of proper water treatment systems in these rural or underdeveloped communities, the best immediate option is to use simple and relatively cost effective point-of-use (POU) technologies such as coagulation. Coagulation is an essential process in the treatment of both surface water and industrial wastewater. Its application includes removal of dissolved chemical species and turbidity from water via addition of conventional chemical-based coagulants, namely, alum ($AlCl_3$), ferric chloride ($FeCl_3$) and polyaluminum chloride (PAC). While the effectiveness of these chemicals as coagulants is well-recognized, there are, nonetheless, disadvantages associated with usage of these coagulants such as ineffectiveness in low-temperature water, relatively high procurement costs, detrimental effects on human health, production of large sludge volumes and the fact that they significantly affect pH of treated water. There is also strong evidence linking aluminum-based coagulants to the development of Alzheimer's disease in human beings. It is therefore desirable to replace these chemical coagulants with plant-based coagulants to counteract the aforementioned drawbacks.

1.3 Merits of Plant-Based Coagulants

The main advantages of using natural plant-based coagulants as POU water treatment material are apparent; they are cost-effective, unlikely to produce treated water with extreme pH and highly biodegradable. These advantages are especially augmented if the plant from which his coagulant is extracted is indigenous to a rural community. In the age of climate change, depletion of earth's natural resources and widespread environmental degradation, application of these coagulants is a vital effort in line with the global sustainable development initiatives. Usage of plant-based coagulants for turbid water treatment dates back to over several millennia ago and thus far, environmental scientists have been able to identify several plant types for this purpose. While it is understandable that the coagulants are meant as simple domestic POU technology, there have also been numerous studies focused on their usage for treatment of industrial wastewaters. The mechanisms associated with different natural coagulants are varied as well. It is imperative for relevant take holders to fully comprehend the technicalities involved when considering the coagulants for rural, domestic or industrial water treatment. To address this, this paper provides an overview of the natural coagulant sources, processes and mechanisms involved so that environmental specialists can tailor its usage for a myriad of water contaminants. To provide a more focused discussion, natural coagulants derived from non-plant sources such as chitosan (widely produced from exoskeleton of crustaceans) and isinglass (produced from fish swim bladders) are excluded from this review. This exclusion is based on practicability, since non-plant sources are less likely to have the potential for mass production compared to plant sources. It is surprising to note that a comprehensive critical analysis of available plant-based coagulants is still non-existent given the importance of sustainable environmental technology in the 21st century and hopefully this review can provide an immediate platform for environmental scientists to intensify their research on these natural materials.

1.4 Natural Plant-Based Coagulants and Coagulation Mechanisms

Polymeric coagulants can be cationic, anionic or non-ionic, in which the former two are collectively termed as polyelectrolytes. Many studies concerning natural coagulants referred to them as 'polyelectrolytes' even though many of these studies did not actually conduct in-depth chemical characterization to determine their ionic activity . As such, this term should be used carefully, and be applied only after ionic activity is determined to be present in the coagulant.

Natural coagulants are mostly either polysaccharides or proteins. In many cases, even though polymers labelled as non-ionic are not necessarily absent of charged interactions, as there may be interactions between the polymer and a solvent within a solution environment as the polymer may contain partially charged groups including ^{-}OH along its chain. It is imperative to fully grasp the underlying coagulation mechanisms associated with these natural coagulants so that complete discussion in the following sections. The existence of background electrolytes in aqueous medium can facilitate the coagulating effect of polymeric coagulants since there is lesser electrostatic repulsion between particles. Although many plant-based coagulants have been reported, only four types are generally well known within the scientific community, namely, Nirmali seeds (Strychnospotatorum), Moringaoleifera, Tannin and Cactus. Understanding of their usage can be realized. Aggregation of Particulates in a solution can occur via four classic coagulation mechanisms: (a) double layer compression; (b) sweep flocculation; (c) adsorption and charge neutralization; and (d) adsorption and inter particle bridging. The presence of salts [or suitable coagulants] can cause compression of the double layer which destabilizes the particulates. Sweep flocculation occurs when a coagulant encapsulates suspended particulates in a soft colloidal floc. Adsorption and charge neutralization refer to the sorption of two particulates with oppositely charged ions while inter particle bridging occurs when a coagulant provides a polymeric chain which sorbs particulates. Polymeric coagulants are generally associated with mechanisms (c) and (d) as their long-chained structures (especially polymers with high molecular weights) greatly increase the number of unoccupied adsorption sites. It appears that these two mechanisms provide underlying principles to the inner workings of plant based coagulants as well and they are the focus of discussion in the following sections.

The existence of background electrolytes in aqueous medium can facilitate the coagulating effect of polymeric coagulants since there is lesser electrostatic repulsion between particles. Although many plant-based coagulants have been reported, only four types are generally well-known within the scientific community, namely, Nirmali seeds (Strychnospotatorum), Moringaoleifera, Tannin and Cactus,Peanuts,aloe Vera,mung Bean.

2. METHODOLOGY

Figure 1 shows the methodology of the study

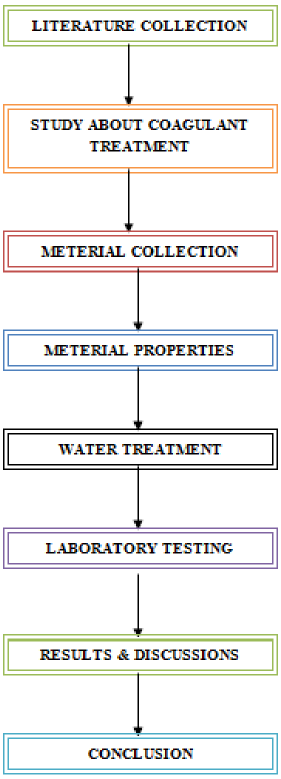

Figure 1 Methodology

3. TREATMENT OF COAGULATION

3.1 Treatment of Industrial Waste Waters

Many natural coagulants may be inappropriate for treatment of industrial wastewaters due to their low availability for large-scale treatment and the extreme conditions (pH and concentration) of the wastewaters but usage of natural polymeric coagulants may afford benefits that can somewhat offset its disadvantages. Other than the evident sustainable and environmental-friendly aspects, natural polymeric coagulants also form stronger flocs via bridging effect with higher resistance to shear forces in a turbulent flow compared to non-polymeric coagulants such as alum. This implies that natural coagulants can be utilized within a batch stirred tank setup to treat contaminated industrial wastewaters, at least in a mechanical sense, since bridging linkages are more resistant to breakage at high shear levels. So far, identified usage of natural coagulants for industrial wastewater has been limited to academic research. Many findings from these academic studies, however, indicate their good potential for industrial wastewater treatment. In many cases, the natural coagulants can perform at their best when used for treatment of wastewaters with less variety of contaminants. Early studies suggest that plant-based coagulants can be effectively used for treating selected dyeing effluent. There are several studies conducted to evaluate the technical viability of using plant-based coagulants for other types of industrial wastewater, though their research aims are rather divergent. It appears that many of these coagulants are quite uncommon and represent new varieties of plant-based active coagulant extract besides the afforested established plant coagulants. Hence, further studies should be conducted by other research groups to verify the veracity of such results. It should be noted that there is scarcity of comprehensive studies that compare the effectiveness of these natural coagulants with that of chemical coagulants and this may be one of the factors that inhibit their potential for industrial wastewater application.

Figure 2 shows the treatment process of the study.

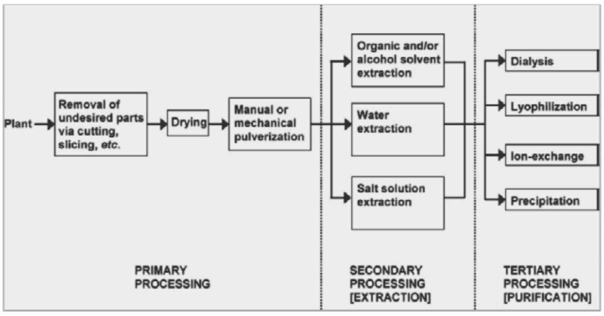

Figure 2 Treatment process

3.2 Cost of Plant-Based Coagulants

It has been explained in previous sections that usage of plant based coagulants provides environmental benefits and numerous lab-scale studies have proven that they are technically feasible for small-scale POU utilization. Nevertheless, in terms of commercialization, the bottom line is that it will always be based primarily on whether the scale-up system can sustain similar treatment performance at comparable (or reduced) cost with the natural coagulants when compared with established chemical coagulants. There are a few anecdotal reports that provide the costs of raw materials of the coagulants but direct comparisons in terms of coagulant types, Processing stages and prices in different geographical regions are a very complicated task given the different exchange rates, inflation factor and varying accuracies of the costing values. Thus, the costs stated here should be treated as an indication rather than absolute values. A comprehensive survey conducted reveals that costing analysis of Peanut Seeds, Peanut Seeds powder has been given priority over other natural coagulants and this is unsurprising given the well-publicized advantages of the plant.

4.1 *3.3 Coagulation and Flocculation in Water and Wastewater Treatment*

In water treatment, coagulation flocculation involves the addition of polymers that clump the small, destabilized particles together into larger aggregates so that they can be more easily separated from the water. Coagulation is a chemical process that involves neutralization of charge whereas flocculation is a physical process and does not involve neutralization of charge. The coagulation-flocculation process can be used as a preliminary or intermediary step between other water or wastewater treatment processes like filtration and sedimentation. Iron and aluminum salts are the most widely used coagulants but salts of other metals such as titanium and zirconium have been found to be highly effective as well.

Coagulation and flocculation are an essential part of drinking water treatment as well as wastewater treatment. This article provides an overview of the processes and looks at the latest thinking. Material for this article was largely taken from reference.

Coagulation and flocculation are essential processes in various disciplines. In potable water treatment, clarification of water using coagulating agents has been practiced from ancient times. As early as 2000 BC the Egyptians used almonds smeared around vessels to clarify river water. The use of alum as a coagulant by the Romans was mentioned in around 77 AD. By 1757, alum was being used for coagulation in municipal water treatment in England.

In modern water treatment, coagulation and flocculation are still essential components of the overall suite of treatment processes – understandably, because since 1989 the regulatory limit in the US for treated water turbidity has progressively reduced from 1.0 NTU in 1989 to 0.3 NTU today. Many water utilities are committed to consistently producing treated water turbidity's of less than 0.1 NTU to guard against pathogen contamination. Coagulation is also important in several wastewater treatment operations. A common example is chemical phosphorus removal and another, in overloaded waste water treatment plants, is the practice of chemically enhancing primary treatment to reduce suspended solids and organic loads from primary clarifiers.

3.4 Plant-Based Coagulants (PBC)

The PBC are broadly utilized for the purification of contaminated water that is in less urbanized, because they seems to be less carrying cost treated coagulates as compared to artificial. PBC coagulants are assumed to treat water showing low-to-medium turbidity range (50–500) NTU. It is unforeseen that a complete decisive analysis of existing PBC is still imaginary in this 21st century. The significance of PBC to ecosystem in the end yield to an instant area for researcher in strengthening the investigation to find inherent resources. Among PCB described namely, Peanut Seeds, Peanut Seeds powder and Cactus. Anionic polyelectrolytes are polymers of aloe Vera whose particles get faded in water by through inter particle bridging. The seed extracts contains –COOH and –OH groups that are able increase the coagulation competency because lipids, carbohydrates and alkaloids. Galactomannani and galactanii are mixture of polysaccharide division that are extracted from Strychnospotatorum seeds which is capable in reducing turbidity up to 80%. In all aspects, the galactomannans are prepared up 1,4-linked β-d-mannopyranosyli residuum mien end α-d-galactopyranosyl units associated with 0–6 point of some mannerresidue. Peanut Seeds , Peanut Seeds powder and its associated coagulation process yet not been studied, the presence of abundant amount of –OH groups along chains of galactomannan and galactan provides weakly but profuse adsorption that eventually lead to the preceding coagulant interparticle bridging effect more research can be carried out in this aspects.

3.5 Applications of Natural Coagulants to Treat Wastewater

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

3.6 Various Problems Due To Impure Water in Developing Countries

- Large seasonal variation in raw water quality e.g. turbidity.
- Water treatment chemicals are imported with scarce foreign currency.
- High cost of water treatment chemicals which constitute in between 35% to 70% of recurrent expenditure.
- Inadequate supply of chemicals for water treatment.
- Inadequate laboratory facilities to monitor process performances required to operate the plants, Inadequate funding, Low revenue base.
- Water supply considered as a social commodity rather than an economic resource inadequate skilled manpower, Poor operational and maintenance schedules, Adoption of inappropriate technology.

- Inadequate supply to meet growing demand under dosing of chemicals leading supply of poor quality water.

3.7 Problems Are Due To Use of Chemicals in Water Treatment

- Aluminum has also been indicated to be a causative agent in neurological diseases such Foreign exchange problem as pre-senile dementia.
- There is a fear that ingestion of aluminum ions may induce Alzheimer's disease.
- Sludge produced is voluminous and non - biodegradable after treatment and therefore poses disposal problems leading to increase cost of treatment.
- The costs of these chemicals have been increasing at an alarming rate in developing countries.
- Most of the water treatment companies cannot

3.8 Factors

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. The effectiveness of the coagulation process is also affected by pre-treatments like oxidation.

3.9 Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.

Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand (the settable solids), very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid. **Turbidity** (or haze) is also applied to transparent solids such as glass or plastic. In plastic production, haze is defined as the percentage of light that is deflected more than 2.5° from the incoming light direction.

3.9.1 Drinking Water Standards

Governments have set standards on the allowable turbidity in drinking water. In the United States, systems that use conventional or direct filtration methods turbidity cannot be higher than 1.0 nephelometric turbidity units (NTU) at the plant outlet and all samples for turbidity must be less than or equal to 0.3 NTU for at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU. Many drinking water utilities strive to achieve levels as low as 0.1 NTU.[11] The European standards for turbidity state that it must be no more than 4 NTU.[12] The World Health Organization, establishes that the turbidity of drinking water should not be more than 5 NTU, and should ideally be below 1 NTU.

3.9.2 Treatment

Turbidity is commonly treated using either a settling or filtration process. Depending on the application, chemical reagents, will be dosed into the wastewater stream to increase the effectiveness of the settling or filtration process. Potable water treatment and municipal wastewater plants often remove turbidity with a combination of sand filtration, settling tanks and clarifiers.

In-situ water treatment or direct dosing for the treatment of turbidity is common when the affected water bodies are dispersed (i.e. there are numerous water bodies spread out over a geographical area, such as small drinking water reservoirs), when the problem is not consistent (i.e. when there is turbidity in a water body only during and after the wet season) or when a low cost solution is required. In-situ treatment of turbidity involves the addition of a reagent, generally a flocculant, evenly dispensed over the surface of the body of water. The flocs then settle at the bottom of the water body where they remain or are removed when the water body is drained. This method is commonly used at coal mines and coal loading facilities where storm water collection ponds have seasonal issues with turbidity. A number of companies offer portable treatment systems for in-situ water treatment or direct dosing of reagents.

3.10 Oxidation

3.10.1 Definitions

The processes of oxidation and reduction occur simultaneously and cannot happen independently of one another, similar to the acid–base reaction. The oxidation alone and the reduction alone are each called a half-reaction, because two half-reactions always occur together to form a whole reaction. When writing half-reactions, the gained or lost electrons are typically included explicitly in order that the half-reaction be balanced with respect to electric charge.

Though sufficient for many purposes, these general descriptions are not precisely correct. Although oxidation and reduction properly refer to a change in oxidation state the actual transfer of electrons may never occur. The oxidation state of an atom is the fictitious charge that an atom would have if all bonds between atoms of different elements were 100% ionic. Thus, oxidation is best defined as an increase in oxidation state, and reduction as a decrease in oxidation state. In practice, the transfer of electrons will always cause a change in oxidation state, but there are many reactions that are classed as "redox" even though no electron transfer occurs (such as those involving covalent bonds).

3.11 Flocculation

Flocculation, in the field of chemistry, is a process wherein colloids come out of suspension in the form of floc or flake, either spontaneously or due to the addition of a clarifying agent. The action differs from precipitation in that, prior to flocculation, colloids are merely suspended in a liquid and not actually dissolved in a solution. In the flocculated system, there is no formation of a cake, since all the flocs are in the suspension.

Coagulation and flocculation are important processes in water treatment with coagulation to destabilize particles through chemical reaction between coagulant and colloids, and flocculation to transport the destabilized particles that will cause collisions with floc.

3.11.1 Water Treatment Process

Flocculation and sedimentation are widely employed in the purification of drinking water as well as in sewage treatment, storm-water treatment and treatment of industrial wastewater streams. Typical treatment processes consist of grates, coagulation, flocculation, sedimentation, granular filtration and disinfection.

4. MATERIAL COLLECTION

4.1 Preparation of Aloe Veragel

Aloe Vera leaves were collected from in campus. The leaves were washed under the tap water to remove the dirt. Thick green cover or epidermis was carefully separated from the gel part. Then the gel part was blended in mixer to form liquid and preserved in glass bottles in refrigerator. 1% dilution of aloe vera was made by using 1ml aloe vera gel in 100 ml distilled water similarly different percentage of aloe vera solutions were made. Preparation of Peanut Seed Powder the peanut seeds used in this study were obtained from Sudan. The seed cover was shelled by hand just before extraction. The extraction of the active ingredients was carried out by removing the shell to collect the kernel inside the shell. In order to ensure the efficiency of Peanut seeds extraction, the kernels have been crushed and grinded to medium fine powder by using the domestic blender every time when the preparation of Peanut seeds extraction was needed.

4.2 Preparation of Peanut Seed Powder

The peanut seeds used in this study were obtained from Sudan. The seed cover wasshelled by hand just before extraction. The extraction of the active ingredients was carried out by removing the shell to collect the kernel inside the shell. In order to ensure the efficiency of Peanut seeds extraction, the kernels have been crushed and grinded to medium fine powder by using the domestic blender (Assparo, Model 900) every time when the preparation of Peanut seeds extraction was needed.

4.3 Peanut Seeds

Preparation of Peanut Seeds Extraction Peanut seeds extraction was prepared by using a salt solution of NaCl with varied concentrations, and Peanut cake in 5% (w/v) suspension mixed with a domestic blender (Assparo, Model 900) for 10 minutes and left settling for 10 minutes. The suspension was then filtered using a vacuum pump filter with filter paper of 70 μ m pore size (Whatman). The five salts used were, NaCl, KNO 3, KCl, NH4Cl and NaNO3. Different concentrations for each type were tested. This extraction was used to obtain the required dosage of coagulant. Figure 3 shows the peanut seeds which is used in this study.

Figure 3 Peanut Seeds

Figure 4 shows the peanut seeds powder used in this study

Figure 4 Peanut Seeds powder

5. TESTING RESULT

5.1 Percentage Removal of Heavy Metals with Plant-Based Coagulants

Table 1 shows the concentration of heavy metals

Table 1: Concentration heavy metals

Natural coagulant	Cr (%)	Cd (%)	Zn (%)
Peanut Seeds powder	59.5	70.5	68.9
Mung Bean	57.3	68.2	64.8
Cactus	56.6	69.4	69.7

Figure 5 shows the percentage of heavy metals

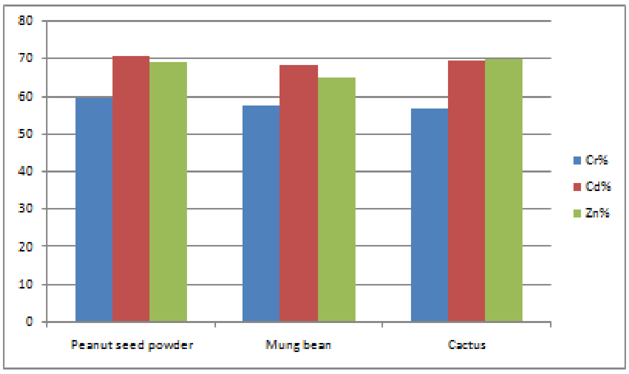

Figure 5 Percentage of heavy metals

5.2 Percentage Removal of Hardness with Plant-Based Coagulants

Table 2 shows the Hardness test results

Table 2: Hardness results

Natural coagulants	% Hardness Removal
Peanut Seeds powder	12%
Mung Bean	34%
Cactus	20%

Figure 6 shows the percentage of hardness

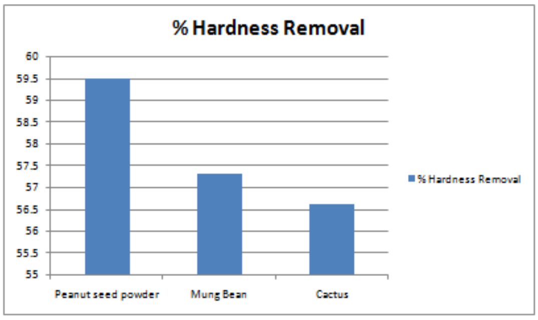

Figure 6 Percentage of hardness.

5.3 Removal of Turbidity with Plant-Based Coagulants

Table 3 shows the Turbidity results

Table 3: Turbidity Results

Natural coagulants	TURBIDITY (in NTU)	
	Before Treatment	After Treatment
Peanut Seeds powder	3.5	2.86
Mung Bean	3.5	1.32
Cactus	3.5	2.95

Figure 7 shows the turbidity graph results.

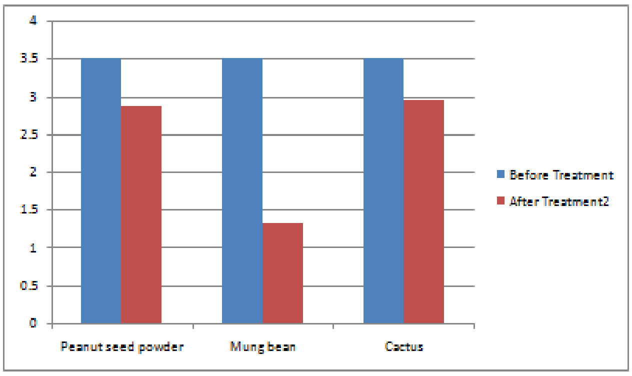

Figure 7 Graph shows the turbidity results

6 CONCLUSION

Locally available seeds such as Peanut Seeds powder, Mung Bean and Cactus were used for water purification. In our project paper evaluates Seeds powder,Mung Bean and Cactus can be used as water purifiers and it would be possible to develop an eco-friendly method of water purification. This will show the way to improve the quality of drinking water in the rural areas. We have presented natural coagulants whose availability is innate, their efficiency is also presented so that they can be considered for further study. It can be concluded that natural coagulants bring with them advantages of being, low cost, copious, native and efficient for treatment.

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