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Removal of Water Turbidity by Natural Coagulants Obtained from ProsopisJuliflora and Cactus Opuntia

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ABSTRACT

Observing the need for clean water and recycling of wastewater through effective treatment to help counter the continued water scarcity facing Nagpur, the study sought to explore the possibility of using cactus and juliflora in the coagulation-flocculation process. The study employed an analytic literature review model, sourcing recent and authoritative studies to investigate the effectiveness of cactus &juliflora plants as coagulants, and the involved pH implications. Increasing urbanization, industrialization and over population are the factors mainly responsible for adding hazardous components in lake water, which mainly constitutes heavy metals and chemicals etc. Water bodies are the main targets for disposing the pollutants directly or indirectly. In this research paper illustrating the role of natural coagulants to assist the treatment of wastewater. Lakes in urban expanses are ecologically very important. Those inland water bodies play a major role in sustainable urban development. As a result of the swelling land use and effluent disposal from domestic and industrial activities, water bodies in the urban regions have been suffering in recent times. The present study aims in understanding the physical, chemical and biological conditions of the Futala Lake. This Lake is situated in Nagpur, Maharashtra. This project is based on treating Lake water using organic purification unit which consists of two natural coagulants, which are ProsopisJuliflora and Cactus Opuntia which are locally available. Studies conclusively demonstrate that natural coagulants are as efficient alum in purifying water at low cost and also have antimicrobial properties. These were locally available natural coagulants in this study to reduce turbidity and other parameters. The findings indicate that plant based coagulants such as cactus, juliflora are being considered as alternatives to conventional synthetic chemical coagulants in aspects such as costs, health effects, non-biodegradability, altered pH in post-treatment water and corrosion and transmission problems. In addition, cactus &juliflora appears to have no significant effects on the pH of treated water. However, the findings demonstrate a lack of consensus regarding the optimal pH at which cactus and juliflora is best effective in coagulation.

KEYWORDS-Natural Coagulants, Turbidity, ProsopisJuliflora, Cactus Opuntia, Wastewater, Lake

1. INTRODUCTION

1.1 Background of the Study

The rapid increase of industrialization, urbanization, and population increase in the last few decades had caused a dramatic increase in the demanded surface water, as well as significant deteriorations in water quality throughout the world. The coagulation/flocculation process offers various advantages for the treatment of both industrial

and municipal wastewaters including the lowered sensitivity to toxic loadings and to higher amounts of organics, the easy operation, the energy saving, etc. However, it had been demonstrated in various studies that chemicals (such as aluminum salts, acrylamides, etc.) used in the coagulationflocculation process remain in treated water and may induce health problems. As indicated higher than, various health effects such as neurotoxic, carcinogenic, genotoxic and cancerogenic properties were reported.Moreover, artificial polymers and undesirable substances related to them could react with others additional materials throughout the treatment and make by-products with unknown health effects. For example, alum, the most widely used coagulant, was reported to be related to Alzheimer's disease.Today's rapidly growing populations outstrip available water resources, which is especially problematic in developing countries that may be on the verge of water scarcity. In the context of limited water resources and water scarcity, water treatment and recycling procedures constitute one of the alternatives to obtain potable water in future. It is therefore necessary to develop suitable, rapid, and inexpensive water and wastewater treatment methods to remove turbidity, coloration, and heavy metals among other contaminants (Gupta et al. 2012). Such an approach to water treatment should also take into consideration contributions to environment and sustainable development. Wastewater treatment primarily entails the coagulation–flocculation process, which is a widely employed physicochemical treatment approach. Traditionally, synthetic inorganic chemicals such as alum and ferric chloride have found wide used as coagulants and flocculants (Nilsen et al., 2005). However, the use of such conventional synthetic chemical coagulants raises environmental, safety, and sustainability concerns, surrounding aspects such as high procurement costs, possible human health risk concerns, their effects on the final pH of the treated water, and non-biodegradability which have detrimental environmental concerns (Yin 2010). These issues have led to the pursuit of alternative coagulants in wastewater treatment, with plant-based coagulants emerging as potential replacements. Such natural coagulants bear much promise in delivering effective wastewater treatment while responding to environmental and sustainability considerations.The possibility of using plant-based coagulants in treating wastewater would prove useful for the country in terms of such environmental, health, and sustainable development objectives, as these coagulants are generally considered to be safe to human health, inexpensive and locally available therefore affordable, biodegradable and result in lowlevel sludge production (Vijayaraghavan et al., 2011). One such plant-based coagulant under research entails the use of cactus species, with multiple studies seeking to establish the plant's effectiveness as a coagulant. Cactus and Juliflora is native to Nagpur making it readily available, which indicates that it bears significant promise as a natural coagulant to address the problem faced in potable water supply and sustainable wastewater treatment in the city. However, its use as a coagulant first requires an overview of its effectiveness levels and optimum conditions especially in relation to pH, which would then guide further research and use in local contexts in Nagpur.

1.2 Problems Statement

Coagulation is the most commonly used method for purifying water. Coagulants can be used in wastewater to reduce suspended solids and other pollutants. Many synthetic coagulants like aluminium sulphate (alum) and ferric chloride are widely used in conventional water treatment processes for turbidity will removal. On the other hand effect in the functioning of living cells but presents some toxic effects in elevated concentrations. Natural coagulants work better with high turbid. And the use of natural coagulant suitable, easier, and environmental friendly option for water treatment. Natural coagulant is a naturally occurred; plants based coagulant that can be used in coagulation-flocculation process of wastewater treatment for reducing turbidity. Natural coagulants have been used for domestic household for centuries in traditional water treatment in rural areas. Now a day, some reports describe natural coagulants from plants are used for natural water purification. The use of plant seed materials is receiving attention for their effectiveness in wastewater treatment. The technologies involved are economical, traditional and easy to implement and ideal for rural areas. The process being biological in nature does not generate any non-treatable wastes. These processes are easy to operate and require little or no maintenance. For the future development of the use of plant materials for wastewater treatment, other native plants and plant materials should

be investigated as coagulants for color and turbidity removal.The natural coagulants prevent the wear of the establishment and the machinery, achieving lower maintenance costs.Produce lower volumes of sludge, less toxic, and therefore cheaper to manage.

Disadvantages of using chemical coagulants:

- Existence of Aluminium zest in treated water may provoke Neurological and Pathological diseases.
- With Aluminium salts, there is always a concern about residuals in treated water. It has strong carcinogenic properties.
- Consumption of water treated with chemical coagulants on a long run may also lead to Dementia and Alzheimer's disease.
- Cost of imported chemicals can be a serious financial burden for developing countries.
- Alum, when reacts with natural alkalinity present in water, leads to reduction of pH and a low efficiency in coagulation of particles in cold water.
- Sludge produced while using chemical coagulants is voluminous and non-biodegradable after treatment.
- Poor disposal of sludge after clarification leads to increase in cost of treatment.
- Inorganic Coagulants add dissolved solids (salts) to water.
- Aluminium sulfate is effective only over a limited pH range. 10. Sodium Aluminate is ineffective in soft waters.

In India, majority of the population still lives in villages and small towns. These rural/tribal communities do not have access to public water supplies. People living in these regions obtain their water supply from unprotected sources such as open dug wells or small streams and ponds which are polluted. The treatment of water in these areas has a unique problem. Therefore, there is an urgent need for development and widespread promotion of simple treatment techniques for rural/tribal areas. The proteins in natural coagulants are considered to act similar to synthetic, positively charged polymer coagulants of non-plant origin. When added to raw water, proteins which carry a positive charge bind to the negatively charged particulates that make raw water turbid. Under proper agitation, these bound particulates grow in size due to agglomeration thereby forming flocs, which may be left to settle by gravity or be removed by Filtration.

1.3 Natural Coagulants

The history of the use of natural coagulants is long. Natural organic polymers have been used for more than 2000 years in India, Africa, and China as effective coagulants and coagulant aids at high water turbidities. They may be manufactured from plant seeds, leaves, and roots. These natural organic polymers are interesting because, comparative to the use of synthetic organic polymers containing acrylamide monomers, there is no human health danger and the cost of these natural coagulants would be less expensive than the conventional chemicals alike since it is locally available in most rural communities of Bangladesh. A number of effective coagulants from plant origin have been identified: *Nirmali*, *Okra*, red bean, sugar and red maize , *Moringaoleifera* , *Cactus latifera*, and seed powder of *Prosopis juliflora* . Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification.According to Yin (2010), lack of proper and effective water treatment systems in rural areas of underdeveloped regions of the world necessitates the use of cost-effective point-of-use approaches. The study demonstrates how the opportunity for use of natural plant-based coagulants arises. Among the various point-of-use approaches, coagulation has found wide use in treating both surface water and industrial wastewater. Such wide application in the removal of dissolved chemicals and turbidity from water entails the use of conventional chemical-based coagulants, including alum (Al2 (SO4)3, poly-aluminium chloride (PAC) and ferric chloride (FeCl3). However, Yin (2010) notes that these conventional coagulants are associated with demerits such as ineffectiveness in lowtemperature water, high procurement costs, deleterious impacts on human health, production of large sludge volumes and significant effect on the pH of the treated water. Meanwhile, the study establishes that natural plantbased alternatives avert these shortcomings of conventional coagulants through their low cost as they are locally available, the unlikely effect on extreme pH changes and high biodegradability. This study demonstrates that cactus may be advantageous because it is not only effective, but also

helps avoid the environmental impacts of synthetic coagulants, besides also providing a sustainable option towards wastewater treatment.

1.4 Objecrive of the Study

- To reduce the level of turbidity and bacteriological contaminants from water using locally available natural coagulants like Cactus Opuntia, Prosopisjuliflora.
- To make the water treatment process easier and environmental friendly for household applications.

1.5 Scope of the Study

- Water is undoubtedly the most vital element among the natural resources.
- In many developing countries, access to clean and safe water is a crucial issue.
- Developing countries pay a high cost to import chemicals for water treatment.
- In most of the cases, these are expensive since they are required in higher dose.
- Many of the chemicals are also associated with human health and environmental problems.
- So natural coagulants can be used for water treatment as they do not causes any problems which occur due to the use of chemical coagulants.

2. LITERATURE REVIEW

Research Article 1 (Summary)

Moringaoleifera, Cicer arietinum, and Dolichos lablab were used as locally available natural coagulants in this study to reduce turbidity of synthetic water. The tests were carried out, using artificial turbid water with conventional jar test apparatus. Optimum mixing intensity and duration were determined. After dosing water-soluble extracts of Moringaoleifera, Cicer arietinum, and Dolichos lablab reduced turbidity to 5.9, 3.9, and 11.1 nephelometric turbidity unit (NTU), respectively, from 100 NTU and 5, 3.3, and 9.5, NTU, respectively, after dosing and filtration. Natural coagulants worked better with high, turbid, water compared to medium, or low, turbid, water. Highest turbidity reduction efficiency (95.89%) was found with Cicer arietinum. The jar test operations using different coagulants were carried out in different turbidity ranges namely higher- (90–120) NTU, medium- (40–50) NTU, and lower- (25–35) NTU of synthetic turbid water. The efficiency of the extracts of Moringaoleifera, Cicer arietinum, and Dolichos lablab made them used as natural coagulants for the clarification of water. Doses started from 50 mg/L to 100 mg/L for corresponding six beakers. Turbidity was measured before and after treatment. It was found that the raw water turbidity was 100 NTU. Turbidity reduced to 13.1, 12.7, 10.6, 10, 9.2, and 5.9 NTU corresponding to 50, 60, 70, 80, 90, and 100 mg/L Moringaoleifera doses respectively. After filtration, turbidity reduced to 11.2, 10.9, 9.1, 8.6, 7.9, and 5 NTU, respectively. For medium-turbidity water (turbidity 48 NTU), same doses reduce turbidity to 16.5, 16.1, 15.7, 15.1, 14.9, and 14.7 NTU, respectively, after dosing. And, after filtration, it was 14.1, 13.8, 13.5, 12.9, 12.8, and 12.6 NTU, respectively. Moringaoleifera worked well in higher-turbidity water than lower and medium-turbidity water. Turbidity reduction increases with increasing doses. A similar study conducted showed that the processed Moringaoleifera was improved by isolation of bioactive constituents from the seeds as coagulant/flocculants which gave turbidity removal from 43.9, 91, and 333 NTU to 1.99, 1.40, and 2.20 NTU, respectively, corresponding to the of 0.05, 0.15, 0.30 mg/L. They found that the Moringaoleifera seed is nontoxic and good coagulant in water treatment. It is recommended to be used as a coagulant in developing countries. Encouraged by results of these studies, many developing countries have turned to use this plant as a viable coagulant in water and wastewater treatment on a small scale.It was found that the raw water turbidity was 95 NTU. Turbidity reduced to 5.9, 5.1, 4.6, 4.5, 4.3, and 3.9 NTU corresponding to 50, 60, 70, 80, 90, and 100 mg/L Cicer arietinum doses. After filtration, turbidity reduced to 5, 4.3, 3.9, 3.8, 3.6, and 3.3 NTU, respectively. For medium-turbidity water (turbidity 49 NTU) same doses reduce turbidity to 12.6, 12.4, 10.2, 9.3, 9.1, and 9 NTU, respectively, after dosing. And, after filtration, it was 10.8, 10.6, 8.7, 7.9, 7.8, and 7.7 NTU, respectively. Most of the results using Cicer arietinum for higher- , medium-, and lower-turbidity-range comply with the Bangladesh drinking standard and the WHO guidelines. Cicer arietinum was found most effective for coagulation when the dose were 100 mg/L for high-, medium-, and lowturbidity water at a 3-min slow mixing time, 12 min slow mixing, and 30 min settling time. Cicer arietinum is cheap, easily cultivable, and available in Bangladesh. On the other hand naturally occurring coagulants are

biodegradable and presumed safe for human health.Different doses were used for different turbidity ranges, and turbidity was measured after dosing. It is found that the raw water turbidity was 100 NTU. Turbidity reduced to 15.5, 14, 13.4, 12.3, 11.6, and 11.1 NTU corresponding to 50, 60, 70, 80, 90, and 100 mg/L Dolichos lablab doses. After filtration, turbidity reduced to 13.3, 12, 11.5, 10.5, 9.9, and 9.5 NTU, respectively. For medium-turbidity water (turbidity 49 NTU), same doses reduce turbidity to 17.1, 16.7, 16.3, 15.9, 15.8, and 15.6 NTU, respectively after, dosing. After filtration it was 14.7, 14.3, 14, 13.6, 13.5, and 13.4 NTU, respectively. A study was conducted using Dolichos lablab as natural coagulant for reduction of turbidity by Unnisa et al, and the study showed that initial turbidities of 20 (low), 40 (medium), and 80 (high) NTUs mainly considerably decreased when the coagulant doses increased. Coagulation was the most effective at a dose of 200 mg/500 mL, when the coagulation activity of the Dolichos lablab seed extract was 65, 62, and 68% at a 60 min settling time. So the use of locally available materials like beans provides a better option for clean, safe water accessible to rural people.Using some locally available natural coagulants, for example, Moringaoleifera, Cicer arietinum, Dolichos lablab, significant improvement in removing turbidity and total coliforms from synthetic raw water was found. Maximum turbidity reduction was found for highly turbid waters. After dosing, watersoluble extract of Moringaoleifera, Cicer arietinum, and Dolichos lablab reduced turbidity to 5.9, 3.9, and 11.1 NTU, respectively, from 100 NTU and 5, 3.3, and 9.5 NTU, respectively after dosing and filtration. It was also found that these natural coagulants reduced about 89–96% of total coliforms. Among the natural coagulants used in this study for turbidity reduction, Cicer arietinum was found most effective. It reduced up to 95.89% turbidity from the raw turbid water.

Research Article 2 (Summary)

In the present study experiments were conducted in the lab to investigate the efficiency of stock solutions obtained from the herbs of MoringaOleifera (Drum sticks) , Okra gum , and the mucilage isolated from the dry flowers of C.Procera as flocculent for the treatment of turbid water samples containing synthetic turbidity caused by clay materials. Jar test experiments were carried out for high (250NTU and 500NTU), low levels (15NTU, 30NTU and 50 NTU) and medium level(100NTU) of turbidity with the flocculent dosages of 0mg/l 2.5mg/l ,5.0mg/l ,7.5mg/l ,10.0mg/l ,12.5mg/l ,15.0mg/l for MoringaOleifera , Okra and C.Procera. The results have been compared with the results of alum. The supernatant turbidities obtained from this phase of the study were > 5 NTU. In the next phase again jar tests results were obtained from adding nearly 50% optimum dose of the natural coagulant was kept as constant and dosage of alum was varied. The supernatant turbidities obtained from this study were nearly equal to 5 NTU. (Guide line value recommended by WHO). From the first phase (Batch Coagulation Test) of the study , it was found that the optimum dosages of Alum, MoringaOliefera, Okra and C.procera were 10 mg/l , 7.5 mg/l , 10 mg/l and 15 mg/l with the maximum turbidity removal efficiencies of 96% , 76% , 54 % and 64 % for low turbid waters and 92% , 87% , 68% and 73% for medium turbid waters and 98% , 92% , 74% and 86.8% for high turbid water respectively. The supernatant turbidities obtained at the end of this phase for medium turbid water were 8NTU, 13 NTU, 32 NTU and 27 NTU when Alum, S.Potatorum, Cactus and C.Indica were applied as a coagulant respectively. These values are greater than 5 NTU (value recommended by WHO). From the second phase of the study, it was found that when nearly and equal to 50% optimum dose of each coagulants (5 mg/l in the case of MoringaOliefera, 5 mg/l in the case of Okra and 7.5 mg/l in the case of C.Procera) were applied with varying dosages of alum (2.5 mg/l , 5 mg/l , 7.5 mg/l , 10 mg/l , 12.5 mg/l , 15 mg/l 17.5 mg/l and 20mg/l) it was found that alum of 5 mg/l gave the maximum turbidity removal efficiencies. The supernatant turbidities obtained at the end of this test were 5 NTU, 2 NTU and 3 NTU for MoringaOliefera, Okra and C.Procera respectively which are equal to and less than 5NTU. From the observations taken it was also concluded that when natural coagulants were used as a coagulant aid, the dosage of alum can be reduced to almost 50% which can help to reduce the detrimental effects caused by chemical based coagulants. Natural coagulant is sustainable and economical way of water treatment process. In this research the conventional coagulant alum has been mixed with nearly 50% of optimal dosages of each coagulant.

Research Article 3 (Summary)

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 the 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 stakeholders 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.The usage of natural coagulants derived from plant based sources represents a vital development in 'grassroots' sustainable environmental technology since it focuses on the improvement of quality of life for underdeveloped communities. Fortunately, it is surprised that usage of these coagulants is far more receptive by environmentalists worldwide since it avoids the common problem faced by biofuels usage where skeptics feel that their benefits are outweighed by global food shortage and deforestation caused by mass plantation of biofuel plants. Nonetheless, there are many pressing issues that are hindering process development of these coagulants, namely, absence of mass plantation of the plants that affords bulk processing, perceived low-volume market and virtually non-existent supportive regulation that stipulates the quality of the processed coagulant extracts. The cost-effectiveness of using the natural coagulant as simple POU technology. The last factor is especially vital since it is normally difficult for regulatory authorities to endorse a product for sale to the general public. In view of this, it is felt that application is currently restricted to smallscale usage and academic research but it can benefit from fervent promotion and endorsement from relevant stakeholders, particularly the from the authorities. In technical terms, these natural coagulants are highly effectual for treatment of waters with low turbidity but may not be feasible in the case of wastewaters with extreme pH. As such, it is always prudent for water treatment practitioners to circumspectly select the most suitable natural coagulants and tailor them for specific proposes. Quite clearly, M. oleifera is the most researched plantbased coagulants but it is felt that further research can be conducted by using the information described in this review as a platform to discover other plant species which are non-toxic and can be mass produced. As a starting point, researchers should pay close attention to other plants with parts that have high active coagulation extract yields which contain recognized active coagulant agents including galacturonic acid.Researchers have identified the coagulant component from M. oleifera seed extract as a cationic protein. It is thought to consist of dimeric proteins with a molecular weight in the range of 6.5–14 kDa. Using the crude extract as coagulant presented problems of residual dissolved organic carbon (DOC) which makes its use in drinking water not feasible. It is therefore necessary to purify the coagulant. However, the direct application of this isolated agent is not possible under the hypothesis of sustainable and appropriate technology. Consequently, the search for simple and low cost purifications procedures as well as the use of the coagulant in combination with other coagulants and

treatment processes needs to be adopted. Moringaoleifera (horseradish or drumstick tree), a nontoxic (at low concentrations) tropical plant found throughout India, Asia, sub Saharan Africa and Latin America whose seeds contain an edible oil and water soluble substance , is arguably the most studied natural coagulant within the environmental scientific community. It is widely acknowledged as a plant with numerous uses with almost every part of its plant system can be utilized for beneficial purposes. Moringa is most frequently used as food and medicinal sources within less-developed communities. It has been reported that rural communities in African countries utilize its crude seed extracts to clear turbid river water. Moringaoleifera is a tropical multipurpose tree that is commonly known as the miracle tree. Among many other properties, M. oleifera seeds contain a coagulant protein that can be used either in drinking water clarification or wastewater treatment.Hence an analysis and review of available literature reveals that biocoagulant activity of studied plants has been little explored. Review of literature indicate that there are lot of work done on effect of plant based coagulants on water quality.

Research Article 4 (Summary)

Feria-Díazet al (2016) make similar observations regarding the use of conventional chemical coagulants in treating surface water and wastewater. The scholars noted that such coagulants are based on inorganic salts or synthetic organic polymers, which do have various disadvantages including risk to human health, high cost, high sludge volume production, water temperature dependent and significant alteration of the treated water. Further, chemical coagulants lead to high aluminum concentration in water after treatment, which interferes with water disinfection, which poses some distribution problems, decreases transmission capacity, and generates corrosion problems. Meanwhile, the scholars noted that alternative coagulants from natural sources have advantages in their safety for human health, biodegradability, low acquisition costs, low toxicity, and low-level sludge production. These merits underscore the environmental and sustainability gains that would be made upon embracing natural coagulants in treating wastewater. The study concludes that natural coagulants are equally effective in treating water and are also unlikely to alter the pH of treated water.

Research Article 5 (Summary)

Vijayaraghavan et al. (2011) reviewed the use of plant-based coagulants in the treatment of water and wastewater. Among the factors contributing to the interest in the use of plant-based coagulants, the scholars highlight the presence of residual monomers during the use of synthetic polymers, which are undesirable owing to their neurotoxicity and carcinogenic properties. This led to researchers getting interested in plant-based coagulants, which could solve the problem of residual monomers. The plant-based coagulants are designed as point-of-use technologies in less-developed societies, as they are relatively cost-effective when compared to their chemical counterparts. In addition, the scholars note that plant-based coagulants are also advantageous owing to the ease of processing to useable form alongside their biodegradability, translating to sustainable wastewater treatment. These bio-coagulants achieve comparable treatment efficiency to chemical coagulants when employed in treating waters that have a low-to-medium turbidity range of 50 –500 NTU. Although the scholars observed that application of the natural coagulants in industrial wastewater treatment is still in infancy, they noted that such coagulants hold much technical promise in water treatment. Cactus, Nirmali seeds (Strychnospotatorum), tannin, and Moringaoleifera are among the most studied plant-based coagulants, representing important progress in sustainable water treatment technologies.

3. PROPOSED METHODOLOGY

3.1 Material and Methods

All coagulation experiments were carried out using synthetic artificial turbid water. A conventional jar test apparatus was used in the experiments to coagulate sample of synthetic turbid water using coagulants.

3.1.1 Modal Water

The coagulation activity was assessed by jar test using synthetic turbid water. As first, kaolin was ground in a ceramic mortar and sieved through the sieve with pore size of 0.4 mm. smaller fraction was then taken to prepare a 10 g/L suspension in tap water. The suspension was stirred for 60 minutes on a magnetic stirrer, and left for 24 hours in order to achieve complete hydration of kaolin. Model water was prepared just before performing the coagulation test, by adding this 1% kaolin suspension to

tap water in an amount of 5 ml/L to obtain the water with initial turbidity of 35 NTU (nephelometric turbidity units).

3.1.2 Coagulants

Natural coagulant is a naturally occurred; plants based coagulant that can be used in coagulation-flocculation process of wastewater treatment for reducing turbidity.

Natural coagulants were extracted from four types of seed.

- Sample 1 – Cactus Opuntia
- Sample 2 – Prosopisjuliflora

3.1.2.1 Prosopis Juliflora

Prosopisjuliflora is a thorny shrub 3-5 m or tree growing up to 15 m height. It has a thick rough grey-green bark that becomes scaly with age. The plants are often multi-stemmed and furnished with abundant large and very sharp thorns measuring up to 5 cm. The tree is deeply rooted. The stems are shaped in a "mild zigzag" way with one or two stout thorns at each turn of the stem.

[Fig.3.1: Prosopisjuliflora]

3.1.2.2 CACTUS OPUNTIA

Several studies demonstrate that cactus is potentially an effective natural coagulant that is also responsive to environmental and sustainability concerns. Betatacheet al. (2014) compared north Algerian prickly pear cactus (OpuntiaficusIndica) juice with polyelectrolytes (Chimfloc C4346, Sedipur NF 102, a cationic polymer, and Sedipu AF 400) and inorganic conditioners (FeCl3 and Al2 (SO4)3) in coagulating wastewater sludge. The study entailed a chemical characterization of the cactus juice alongside conditioning of the sludge with the juice and comparison chemicals, with analysis involving Fourier Transform Infrared spectral analysis and photometry. The findings demonstrated that the juice from the cactus promoted the coagulation of almost all of sludge, enabling liquid and solid separating and easing filtration process. Further, residual turbidity, the specific resistance of filtration and dryness obtained were comparable to those of ChimflocC4346, and significantly better than those of Sedipur AF400 and the inorganic chemicals analyzed, with the optimum dosage for the cactus being 0.4 g kg−1of dry matter. These findings led these researchers to conclude that the juice from the prickly pear cactus could find use as a natural conditioner in treating sewage sludge.

Rodiño-Arguelloet al. (2015) compared five natural coagulants, Hylocereus cf. trigonus (cactus) stems, Campano (Albiziasaman), exudate gum, the bark of Guácimo (Guazumaulmifolia), and bark and seed from Moringa (Moringaoleifera) in treating raw water samples taken from Sinú river, Colombia. The scholars measured initial turbidity levels and turbidity removal efficiencies as a percent activity function for coagulant dosages at 5 mg/L to 200 mg/L. Although the Moringa extract was found to be most effective in turbidity removal efficiency and coagulation activity, the cactus also had attractive results in removing turbidity (98% turbidity removal). The aforementioned observations underscore the turbidity removal prospects of cactus extracts, demonstrating why it may find crucial use in wastewater treatment in the third world.

[Fig.3.2: Cactus Opuntia]

3.2 JAR TEST

Jar test is the most widely used experimental methods for coagulation-flocculation. A conventional jar test apparatus was used in the experiments to coagulate sample of synthetic turbid water using some coagulants . It was carried out as a batch test, accommodating a series of six beakers together with sixspindle steel paddles. Before operating the jar test, the sample was mixed homogenously. Then, the samples ought to be measured for turbidity, coliform count for representing an initial concentration. Coagulants of varying concentrations were added in the beakers. The whole procedures in the jar test were conducted in different rotating speed.

3.2.1 JAR TEST PROCEDURE

The jar test procedures involves the following steps:

1. Fill the jar testing apparatus containers with sample water. One container will be used as a control while the other 5 containers can be adjusted depending on what conditions are being tested. For example, the pH of the jars can be adjusted or variations of coagulant dosages can be added to determine optimum operating conditions.
2. Add the coagulant to each container and stir at approximately 100 rpm for 1 minute. The rapid mix stage helps to disperse the coagulant throughout each container.
3. Turn off the mixers and allow the containers to settle for 30 to 45 minutes. Then measure the final turbidity in each container.
4. Reduce the stirring speed to 25 to 35 rpm and continue mixing for 15 to 20 minutes. This slower mixing speed helps promote floc formation by enhancing particle collisions which lead to larger flocs.
5. Residual turbidity vs. coagulant dose is then plotted and optimal conditions are determined. The values that are obtained through the experiment are correlated and adjusted in order to account for the actual treatment system.

[Fig.3.3 : A conventional jar test apparatus for treatment of turbid water by natural coagulants]

4. RESULTS & DISCUSSIONS

Traditional alum and polyacryl amide (PAA) are used for the reduction of turbidity. Some problems are associated with the use of these chemicals. So, natural coagulants might bring a fruitful result in water treatment processes. Natural coagulants have been used to treat water for domestic household use for centuries in rural areas. Interest in the use of natural coagulants has increased over time, especially to reduce water and wastewater treatment problems in developing countries to avoid health risks. (Ghebremichael, 2005).

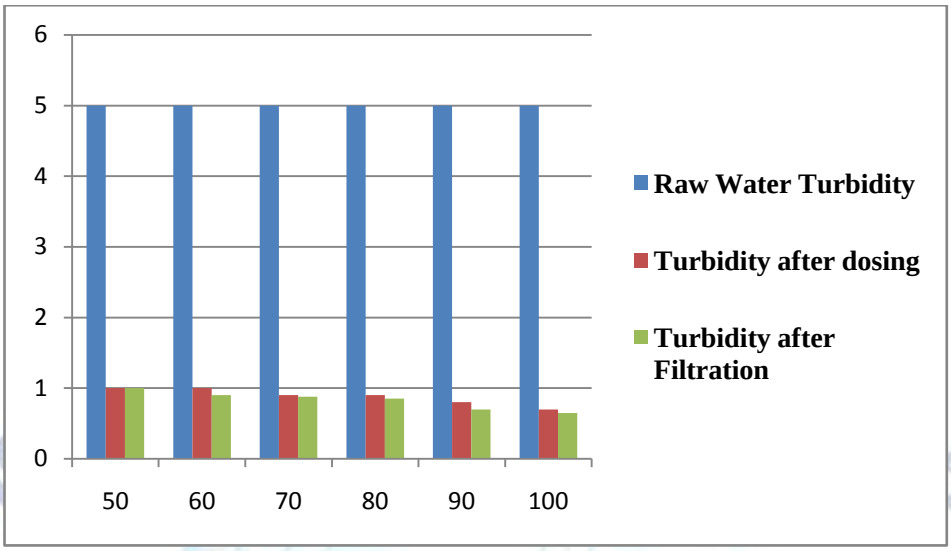
Reduction of Turbidity Using Natural Coagulants The jar test operations using different coagulants were carried out in different turbidity ranges namely higher- (90– 120) NTU, medium- (40–50) NTU, and lower- (25–35) NTU of synthetic turbid water. The efficiency of the extracts of Prosopisjuliflora, and Cactus Opuntia made them used as natural coagulants for the clarification of water Turbidity (NTU).

Doses started from 50 mg/L to 100 mg/L for corresponding six beakers. Turbidity was measured before and after treatment.

4.1 Removal of turbidity using various doses using Cactus Opuntia–

From Figure 4.1, it is found that the raw water turbidity was 100 NTU. Turbidity reduced to 14.1, 13.7, 11.6, 10, 8.9, and 6.2 NTU corresponding to 50, 60, 70, 80, 90, and 100 mg/L cactus opuntia doses respectively. After filtration, turbidity reduced to 11.8, 10.9, 9.5, 8.7, 7.6, and 5.8 NTU, respectively. For medium-turbidity water (turbidity 48 NTU), same doses reduce turbidity to 16.8, 16.5, 15.8, 15.5, 15.5, and 14.9 NTU, respectively, after dosing. And, after filtration, it was 14.3, 14.2, 13.8, 13.2,

13.2, and 12.9 NTU, respectively. Cactus Opuntiawork well in higher-turbidity water than lower- and medium-turbidity water. Turbidity reduction increases with increasing doses.

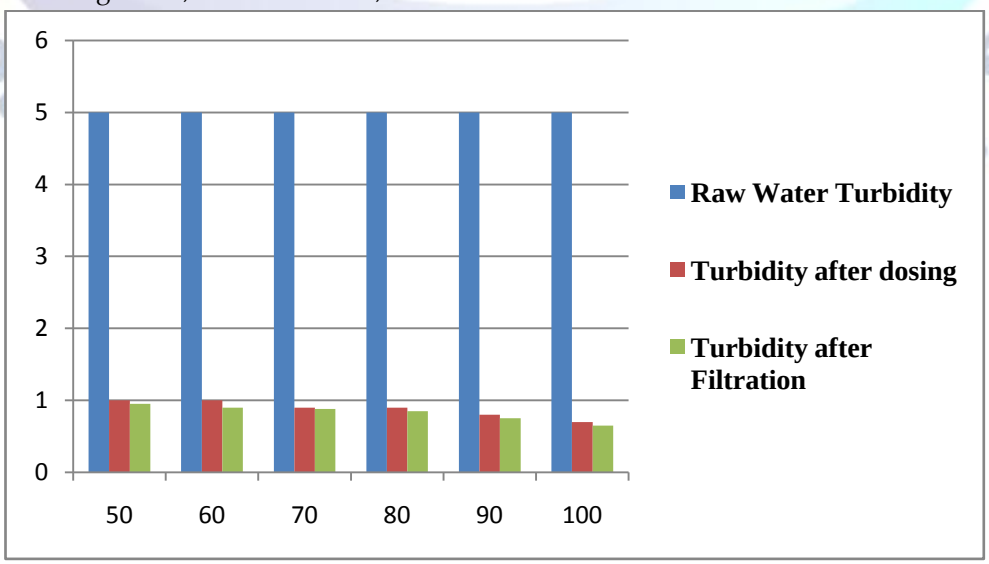


Dose of Cactus Opuntia (mg/L)

(Fig.4.1:Removal of turbidity using various doses of Cactus Opunita (for highly turbid water)

4.2 Removal of turbidity using various doses using Prosopisjuliflora

Results for the removal of turbidity using various doses of Prosopisjuliflora are shown in Figure 4.2. It was found that the raw water turbidity was 95 NTU. Turbidity reduced to 6.2, 5.4, 5.0, 4.8, 4.6, and 4.2 NTU corresponding to 50, 60, 70, 80, 90, and 100 mg/L Prosopisjuliflora doses. After filtration, turbidity reduced to 5.3, 4.6, 4.2, 4.1, 3.9, and 3.6 NTU, respectively. For medium-turbidity water (turbidity 49 NTU) same doses reduce turbidity to 12.9, 12.7, 10.5, 9.6, 9.4, and 9.3 NTU, respectively, after dosing. And, after filtration, it was 11.1, 10.9, 9.0, 8.2, 8.1, and 8.0 NTU, respectively. Most of the results using Prosopisjuliflora for higher-, medium-, and lower-turbidity-range comply with the Indian drinking standard and the WHO guidelines 2006. Prosopisjuliflora was found most effective for coagulation when the dose were 100 mg/L for high-, medium-, and low-turbidity water at a 3-min slow mixing time, 12 min slow mixing, and 30 min settling time. Prosopisjuliflora is cheap, easily cultivable, and available in India. On the other hand naturally occurring coagulants are biodegradable and presumed safe for human health.



Dose of Prosopisjuliflora (mg/L)

(Fig.4.2:Removal of turbidity using various doses of Prosopisjuliflora (for highly turbid water))

5. FUTURISTIC APPROACH

The usage of plant based natural coagulants represents a fundamental development in sustainable environmental technology for the improvement of quality of life for communities. In an era of increasing environmental concerns, water scarcity admits the draw backs of chemical coagulants and poor sanitary facilities in most low income earning countries, the need to further develop natural coagulants as alternative environmentally favorable water purifying chemicals is exigent. The usage of bio-coagulants derived from plant based sources represents a vital development in 'grassroots' sustainable environmental technology through cost effectiveness.Design natural water purification techniques using plants extracts for bioremediation of turbid water. Application of this lowcost protocol will be recommended for simplified, point-of-use, lowrisk water treatment where rural and peri-urban people living in extreme poverty are presently drinking highly turbid and microbiologically contaminated water. The ultimate purpose of proposed research study is to come up with a compendium of plant coagulants that could be used as a technology that is cost effective and ecofriendly. It is felt that further research can be conducted by using the information described in this review as a platform to discover other plant species which are non-toxic and can be mass produced.

6. CONCLUSION

The waste generated by modern society when discarded in nature can make the water unfit for human consumption. Thus to obtain drinking water is necessary to perform a physical-chemical treatment which allow the removal of the turbidity and organisms harmful to health. Various methods are used to make water safe to the consumer. The method employed depends on the character of the raw water. For the treatment of surface water some traditional chemicals are used during the treatment of surface water at its various steps. Commonly used chemicals for various treatment units are synthetic organic and inorganic substances. In most of the cases, these are expensive since they are required in higher dose and do not shows cost effectiveness. Many of the chemicals are also associated with human health and environmental problems. The use of clean up technologies without producing other harmful waste products is required as best option using vegetation to remove, detoxify or stabilize persistent pollutant is an accepted tool for cleaning of polluted soil and water. Natural coagulants have been used for domestic household for water treatment in rural areas. Now a day some reports describe natural coagulants from plants are used for natural water purification. The use of plant seed materials is receiving attention for their effectiveness in wastewater treatment. The technologies involved are economical, traditional and easy to implement. These observations motivate me to analyze the biocoagulant property of some plant species Cactus Opuntia, Prosopisjuliflora were selected for further study.Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification.

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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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