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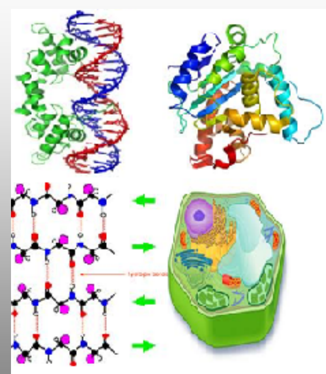

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RESEARCH PAPER

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Bioremediation- Natural Way for Water Treatment

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ABSTRACT

The primary objective of this study is to identify the most appropriate herbal plants for the removal of contaminants from water. Nearly three herbs namely Strychnos potatorum, Prosopis juliflora, Vicia faba were chosen for this study. The results obtained from this study satisfy the drinking water standards prescribed by World Health Organization (WHO).

Keywords: Herbs, dosage, turbidity, total dissolved solids, water treatment.

INTRODUCTION

Just as there are many sources of water contamination, there are many ways to clean it up. New developments in environmental engineering are providing promising solutions to many water pollution problems. Chemicals can be added to toxic waste water to precipitate, immobilize, or solidify contaminants. Natural water is usually turbid to some extent. Coagulation and flocculation are commonly used methods for water turbidity removal, and are usually conducted by adding chemicals such as salts of aluminum and iron and poly electrolytes.

The first investigations about harmful influence of these chemicals on human health were published in the 60's of the 20th century. Those and later publications showed that the residues of aluminum salts in the water can cause Alzheimer's disease (Menkiti 2011, WHO 2004, Ghebremichael 2004). Also, some studies indicate that some of synthetic organic polymers, such as acrylamide, have strong neurotoxic and carcinogenic effect.

Often, living organisms can clean contaminated water effectively and inexpensively. We call this bioremediation. (Sharma, Katayon 2006, Santos 2005, Muyibi 2002, Zhang et al 2006) Restored wetlands, for instance, along stream banks or lake margins can effectively filter out sediment and remove pollutants. They generally cost far less than mechanical water treatment facilities and provide wildlife habitat as well.

At the same time, on the household level, coagulation by means of natural coagulants of plant and soil origin and simple devices has been practiced traditionally by many peoples in developing countries.

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.

Model 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).

Coagulants: Natural coagulants were extracted from four types of seed.

- Sample 1 – *Strychnos potatorum*
- Sample 2 – *Prosopis juliflora*
- Sample 3 – *Vicia faba*

Natural coagulants were obtained in the following way: seeds were ground and sieved through the sieve with pore size of 0.4 mm. An amount of a 10 g/L of the smaller fraction was suspended in distilled water. This suspension was stirred 10 minutes on a magnetic stirrer in order to extract active coagulants. After that, the suspension was filtered through filter paper Macherey-Nagel MN 651/120. Obtained filtrates, called crude extracts, were stored in a refrigerator at 5ºC. The equipment used for jar test experiments was a Cintex flocculator jar test apparatus with 4 beakers of 1.0 L capacity each (Figure 1). Each beaker was filled with 500ml of test water with identical turbidity. Different volumes of coagulant reagent were added to 4 beakers. The content of the jars left to settle for approximately 30 minutes. After sedimentation, samples were taken for water quality determination. For each coagulant and turbidity level, three identical jar tests were performed in order to obtain statistically reliable results.

RESULTS AND DISCUSSION

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 *Strychnos potatorum*(Diaz 1999, Ozacar 2002, Roussy 2005) *Prosopis juliflora*, and *Vicia faba* made them used as natural coagulants for the clarification of water Turbidity (NTU)

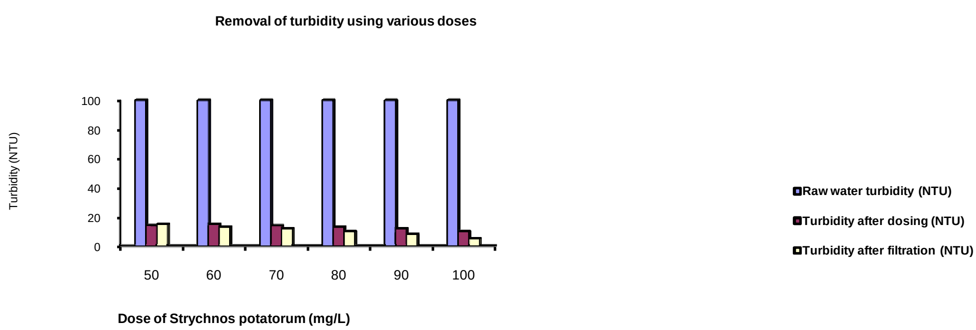

Figure 1. Removal of turbidity using various doses of *Strychnos potatorum* (for highly turbid water).

Doses started from 50 mg/L to 100 mg/L for corresponding six beakers. Turbidity was measured before and after treatment. Figures 1–3 show the results of different doses of coagulant treatment in jar test. From Figure 3, 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 *Strychnos potatorum* 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. *Strychnos potatorum* work well in higher-turbidity water than lower- and medium-turbidity water. Turbidity reduction increases with increasing doses.

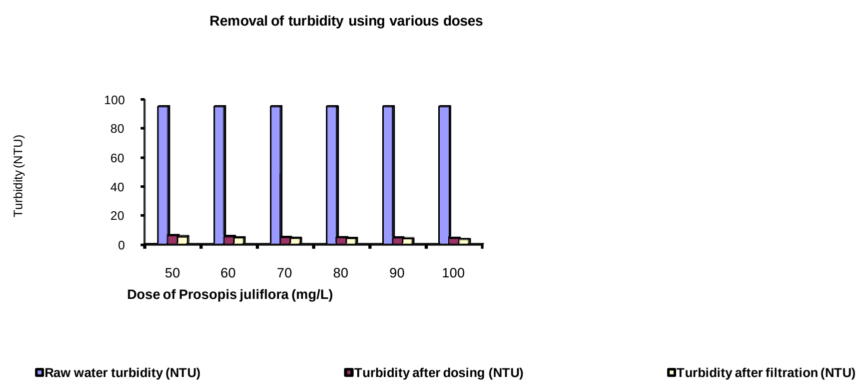

Figure 2. Removal of turbidity using various doses of *Prosopis juliflora* (for highly turbid water).

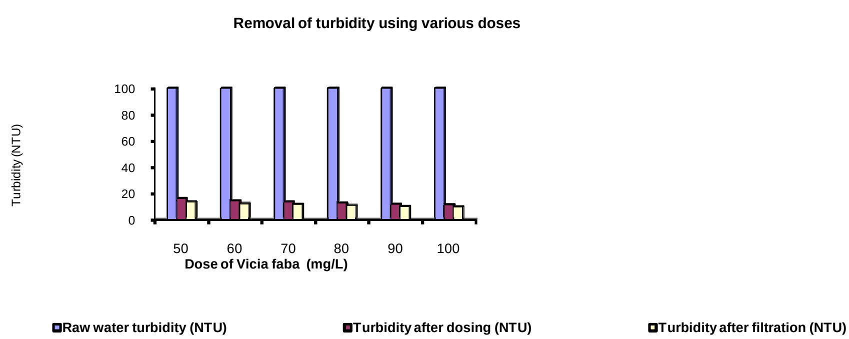

Figure 3. Removal of turbidity using various doses of *Vicia faba* (for highly turbid water).

A similar study conducted by (E. A. Ali et al 2009) showed that the processed *Strychnos potatorum* 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. (Kebr. G. Ghebremichael 2005) found that the *Strychnos potatorum* 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 (Ndabigengesere 2009).

Results for the removal of turbidity using various doses of *Prosopis juliflora* are shown in Figure 4. 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 *Prosopis juliflora* 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 *Prosopis juliflora* for higher-, medium-, and lower-turbidity-range comply with the Indian drinking standard and the WHO guidelines 2006. *Prosopis juliflora* 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. *Prosopis juliflora* is cheap, easily cultivable, and available in Chhattisgarh (India). On the other hand naturally occurring coagulants are biodegradable and presumed safe for human health.

Results for the removal of turbidity using various doses of *Vicia faba are* shown in Figure 3. Different doses were used for different turbidity ranges, and turbidity was measured after dosing. From Figure 3, it is found that the raw water turbidity was 100 NTU. Turbidity reduced to 15.8, 14.3, 13.7, 12.6, 11.9, and 11.4 NTU corresponding to 50, 60, 70, 80, 90, and 100 mg/L *Vicia faba* (Néstor GM 2012) doses. After filtration, turbidity reduced to 13.7, 12.3, 11.8, 10.8, 10.2, and 9.8 NTU, respectively. For medium-turbidity water (turbidity 49 NTU), same doses reduce turbidity to 17.4, 17.0, 16.6, 16.2, 16.1, and 15.9 NTU, respectively after, dosing. After filtration it was 15.1, 14.6, 14.3, 13.9, 13.8, and 13.7 NTU, respectively.

A study was conducted using *Vicia faba as* natural coagulant for reduction of turbidity by Unnisa et al.2010, 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 *Vicia faba* 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.

Higher turbidity is a great problem of peripheral rivers of the Raipur City Rivers especially in rainy season (Hossain *et al*. 2006). 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)

Turbidity Reduction Efficiency of Different Coagulants in Different Turbidity Ranges

A comparative study of turbidity reduction efficiency of different coagulants in different turbidity ranges are presented in Table 1. In every case 50 to 100 mg/L doses were used. It was found that *Prosopis juliflora* reduced maximum turbidity among all coagulants used. It reduced up to 95.89% for highly turbid water which is almost as same as the reduction capacity of alum. So, it was found most efficient among the studied natural coagulants. Second highest among the natural coagulants used for the study was for *Strychnos potatorum.* It reduced up to 94.1% for highly turbid water. All of studied natural coagulants were efficient in higher-turbidity ranges than lower- and medium-turbidity waters.

The study also showed that higher dosages did not significantly increase pollutant removal and were not economically viable. Another study using Chitosan, a natural linear biopolyaminosaccharide, was obtained by alkaline deacetylation of chitin and showed turbidity reduction efficiency 74.3–98.2% at a pH 7.0–7.5, Mehdinejad et al. 2009, and 94.9%, Hassan 2003. Previous study (Published: 2011) showed that the processed *Strychnos potatorum* was improved by isolation of bioactive constituents from the seeds as a coagulant/flocculants which gave turbidity removal up to 99.3%.

Another study regarding *Strychnos potatorum* showed the effectiveness of *Strychnos potatorum* (Published: june 1, 2012, *Journal of Medicinal Plants Research,* Volume: 3, 2012)

Table 1. Reduction efficiency of turbidity using different coagulants in different turbidity ranges.

Coagulants	Dose used (mg/L)	% of turbidity reduction (High-*turbidity water)	% of turbidity reduction (Medium-*turbidity water)	% of turbidity reduction (Low-*turbidity water)
Strychnos potatorum	50	86.3	65.2	56.2
	60	88.4	65.9	57.3
	70	89.3	66.7	58.5
	80	91.9	67.8	58.9
	90	93.4	68.7	59.5
	100	95.2	69.2	60.2
Prosopis juliflora	50	92.8	74.2	62.4
	60	93.3	75.8	64.2
	70	93.9	76.4	66.5
	80	94.5	78.8	67.4
	90	94.9	80.5	69.5
	100	95.5	81.5	71.5
Vicia faba	50	84.5	65.4	49.2
	60	86.8	65.8	51.5
	70	87.9	67.3	56.3
	80	88.3	67.8	57.2
	90	88.9	68.5	59.4
	100	89.3	68.9	60.9

***** For *Strychnos potatorum* (high turbidity = 100 NTU, medium turbidity = 48 NTU, low turbidity = 25 NTU); *Prosopis juliflora* (high turbidity = 95 NTU, medium turbidity = 49 NTU, low turbidity = 31 NTU); *Vicia faba* (high turbidity = 100 NTU, medium turbidity = 49 NTU, low turbidity = 35 NTU), and for alum high turbidity was 100 NTU.

for turbidity removals of up to 97% for high, turbid water and lower removals of 86% for low-turbidity waters (Abaliwano *et al.* 2008) So, these natural coagulants (*Prosopis juliflora*, *Strychnos potatorum*, and *Vicia faba*) might be considered as excellent alternative of traditional chemicals like alum and very efficient coagulants for high-turbidity ranges.

Reductions of Total Coliforms in Raw Water Using Natural Coagulants

Total coliform counts were determined for the turbid raw water and clarified treated water; the results are shown in Table 2. Very significant removal of total coliforms was found after treatment with natural coagulants. In the synthetic turbid water, total coliform count was recorded 1.35×10^3 cfu/100 mL in an experiment, and, after treatment with water soluble extract of *Strychnos potatorum,* it was 5.4×10^1. *Prosopis juliflora* and *Vicia faba* reduced turbidity from 1.05×10^3 cfu/100 mL to 1.0×10^2 cfu/100 mL and 1.1×10^2 cfu/100 mL, respectively. In this experiment, the reduction of total coliform counts were about 96%, 90.47%, and 89.52% using *Strychnos potatorum*, *Prosopis juliflora*, and *Vicia faba* , respectively (Table 2). Initial reduction of the bacteria count, followed by a secondary rise after only 24 hours, reaching or even surpassing the initial concentration;

Previous study by Suarez et al 2003 demonstrated the ability of a recombinant plant protein to decrease the viability of Gram-negative or Gram-positive bacterial cells and to mediate the aggregation of negatively charged particles in suspension, such as bacterial cells, clay, or silicate micro spheres. A study conducted by Michael 2009 showed

Table 2. Reduction of total coliform after treatment using natural coagulants

Coagulants	**Total coliform counts (cfu/100 mL)**		**% reduction**
	Before treatment	**After treatment**	
Strychnos potatorum	1.35×10^3	5.4 × 101	96
Prosopis juliflora	1.05×10^3	1.0 × 102	90.47
Vicia faba	1.05×10^3	1.1 × 102	89.52

efficient reduction (80% to 99.5%) for high-turbidity pathogenic surface water and produces an aesthetically clear supernatant, concurrently accompanied by 90.00% to 99.99% (1 to 4 log) bacterial reduction. This may be an indication bactericidal activity of these natural coagulants.

CONCLUSION

Using some locally available natural coagulants, for example, *Strychnos potatorum*, *Prosopis juliflora*, *Vicia faba* , 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, water-soluble extract of *Strychnos potatorum*, *Prosopis juliflora*, and *Vicia faba 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, *Prosopis juliflora* was found most effective. It reduced up to 95.89% turbidity from the raw turbid water.

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. In ancient Indian literatures, it is clearly mentioned that every plant on this earth is useful for human beings, animals and also for other plants. Many medicinal, industrial and allele pathic uses of common weeds have been reported. The natives of Chhattisgarh use many common weeds to treat their health problems.

The use of seed materials and aquatic plants are 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. Algae derived substances, chitosan produced from shells of shrimps and lobsters and dough from millet bread are some of the potential natural coagulants.

Future studies should focus upon the dosage of these materials to be used in water treatment. Efforts should be made to make these traditional technologies, which are already being used in rural areas, recognized and accepted globally.

Wet land waste treatment systems are now operating in many developing countries. Effluent from these operations can be used to irrigate crops or raise fish for human consumption if care is taken to first destroy pathogens. Usually 20 to 30 days of exposer to sun, air, and aquatic plants is enough to make the water safe. A 2,500-ha (6000-acre) waste fed aquaculture facility in Calcutta, for example, supplies about 7,000 metric tons of fish annually to local markets.

Artificial wetlands (David Krantz and Brad Kifferstein, Kannabiran and Pragasam, 1993, V. Rangel, Folkard *et al*., 1993, Folkard *et al*., 1995) gel, can be created by using phytoremediation and can be mainly used for municipal and residential wastewater, storm water runoff, agriculture wastewater, landfill leachates, acid mine drainage and decontamination of polluted groundwater. Constructed wetlands can also provide excellent wildlife habitat, recreational opportunities, and an aesthetically pleasing treatment facility. Water hyacinth based and other wetland systems produce plant biomass that can be used as a fertilizer, animal feed supplement, or even as a source of methane.

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