Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2013, 2 (1): 73-80

(International Peer Reviewed Journal)

Coagulation-Clarification of Turbid Colored Water by Natural Coagulant (*Strychnos potatoram*) Seed Extract

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Received on 13th December and finalized on 24th December 2012

ABSTRACT

Performance of Strychnos potatoram seed extract as primary coagulant and compared with the performance of alum. S. potatoram seed extract is effective as prime coagulant. Compared with alum (residual filtrate turbidity 2 NTU and residual color 3 TCU), it produces water with slightly higher residual filtrate turbidity (4 and 3 NTU) and residual color (15 and 13 TCU), but the residual turbidity and residual color are within the WHO drinking water guideline values for turbidity (5 NTU) and color (15 TCU). The effectiveness of Strychnos potatoram in the removal of turbidity, total hardness, pH, COD, BOD and total dissolved solids (TDS) has been investigated. The results obtained from this study satisfy the drinking water standards prescribed by World Health Organization (WHO).

Keywords: Coagulation-clarification, Turbid colored water, Natural coagulant, *Strychnos potatoram*, Seed extract

INTRODUCTION

Growing population, increased economic activity and industrialization has not only created an increased demand for fresh water but also resulted in severe misuse of this natural resource. Water resources all over the world are threatened not only by over exploitation and poor management but also by ecological degradation. According to a survey conducted by UNEP, 20% of world's population lacks access to safe drinking water and 50% of the world's population lacks access to safe sanitation. Further studies [1,2]show that about 830 million people in South Asia lack access to safe drinking water and more than two billion lack proper sanitation. Polluted water is estimated to affect the health of about 1200 million people and contribute to the death of 15 million children under the age of five every year.

With increased industrial growth and urbanization, the volume of domestic and industrial effluent, agricultural waste and urban runoffs is steadily growing. Water bodies have an inherent capability to dilute the pollutants, which enter the system. However, indiscriminate dumping of untreated sewage and chemical wastes directly into rivers, lakes, and drains have made these water bodies unable to cope up with the pollutant load. The steady increase in the amount of water used and wastewater produced by urban communities and industries throughout the world also poses potential health and environmental problems. The contaminated waters disrupt the aquatic life and reduce their reproductive capability.

Natural polyelectrolytes of plant origin have been used for many centuries in developing countries for clarifying turbid water [3]. For home water treatment, the materials have to be used in the form of powder or paste, 90% of which consists of substances other than the polyelectrolytes. Even under such conditions, a few plant seeds make effective coagulants [4]. In laboratory and field studies, *Strychnos potatoram* seed extract has shown promise as coagulant in the clarification of turbid water [4-6]. A method for home water treatment comprising coagulation by *S.potatoram* seed extract and filtration through a meshed sand filter or a sand-charcoal filter was suggested [7-9]. In laboratory tests, direct filtration of turbid surface water with *S. potatoram* seed extract as coagulant, produced substantial improvements in its aesthetic and microbiological quality [10]. However, examination into the performance of *S.potatoram* seed extract in colored waters is warranted [11] because, when used as primary coagulant, polyelectrolytes may not be as effective as metallic salts to treat water with significant amounts of color-causing organics [12].
In the present study, performance of *Strychnos potatoram* seed extract as primary coagulant in clarification of turbid colored water was examined and compared with the performance of alum.

MATERIALS AND METHODS

The process for treatment will be as per following steps:

The seed contain significant quantities of a series of low molecular weight, water-soluble proteins which, in solution, carry an overall positive charge. The proteins are considered to act similarly to synthetic, positively charged polymer coagulants. When added to raw water the proteins bind to the predominantly negatively charged particulates that make raw waters turbid (silt, clay, bacteria etc.).
Under proper agitation these bound particulates then grow in size to form the flocks, which may be left to settle by gravity or be removed by filtration.

Preparation of natural coagulant from *S.potatoram* seeds: Water can be treated with this coagulant in two ways, i.e. without oil extraction and after oil extraction from the seeds. In the first method the seeds were taken and were crushed, grounded and directly used for treatment of turbid water. After preparing crude extract the presence of oil along many other organic compounds in crude extract increases the content in organic matter of the treated water and prevents its storage and consumption for more than 24 hours. This fact represents a disadvantage for its application at full-scale water treatment and highly recommends purification of crude extract.

So in order to increase the stability and storage time of the treated water the seeds are purified and deoiled with soxhalet apparatus and the oil was extracted from the seeds. The solvent used for oil extraction was hexane. The seeds of *Strychnos potatoram* are expected to contain as much as 40% oil by weight having high quality fatty substances and can be used for many medicinal purposes because of its high nutritious values.

The purified *Strychnos potatoram* extract is now mixed with water and stock solution is prepared which can be used for different coagulant dosing and for future usage purpose.

Preparation of Stock Solution: Approximately 2.5 g of stored, finely crushed white SP powder (the equivalent of 48 seeds) is taken into a clean plastic bottle. To this a small amount of clean or clarified water (100 ml) is added and by vigorous shaking of it paste is formed. The paste can now be diluted to the required dosing strength to form the stock solution. This can be used after further dilution. Different volume dosages of stock solution are individually added to each of the three 250-ml raw surface water–filled water bottles. The content in water is stirred rapidly for 60 sec and stirred gently at a speed of 15 to 20 rpm for 5 min. The slow mixing allows flocculation to take place. As the particles are attracted to each

other, larger particles (flocs) are formed, which will be allowed to settle (sedimentation) or be filtered out. Then these are allowed to sit undisturbed for 1 hr for the settlement of larger flocks.

Measurements and analysis: The filtered water was subjected to pH, turbidity, total dissolved solids, total hardness, pH, COD and BOD measurements. All analysis was carried out according to standard methods (APHA-AWA-WPCF, 1992).

RESULTS AND DISCUSSION

The performances of the herbal were studied on removal of water contaminants. In the first phase of the study, the herbal was used in raw form and their effectiveness was studied. The result of this study showed poor performance. In the second phase, the raw herbal is processed properly as per procedure. The outcome of this study was elaborately presented and discussed in detail. The characteristics of raw sample used in this study are given in Table 1.

Table 1: Characteristics of Raw water sample

Sl. No	**Parameter**	**Raw water**
1	Turbidity	80
2	pH	3.94-4.5
3	TDS	**1.15**
4	Total Hardness	116.035
6	Chloride	74.97
7	BOD_5, 20^0C, (mg/L)	22.044
8	COD_T mg/L	**80000-120000**
9	Conductivity(mho/cm)	1.15
10	DO	**0.23-0.45**

All are expressed in mg/L except pH

Table 2 : Characteristics of Raw water sample

Sl. No	Parameter	Raw water	Using alum	S.potatoram	WHO Standards
1	Turbidity	80	04	02	<10
2	pH	3.94-4.5	5.20	8.33	6.5-9.2
3	TDS	1.15			
4	Total Hardness	480	260	160	<600
6	Chloride	74.97	59.98	74.97	200
7	BOD_5, 20^0C, (mg/L)	60000	156	120	<200
8	COD_T mg/L	80000-120000	80	40	<100
9		1.15	3.85	1.29	1
10	DO	0.23-0.45	2	3	8.72

All are expressed in mg/l except pH

Effectiveness of *S. potatoram* on Turbidity: *S. potatoram* seed extract is effective as prime coagulant and as coagulant aid with alum in clarification of turbid colored water. Compared with alum (residual filtrate

turbidity of 2 NTU and residual color of 3 TCU), it produces water with slightly higher residual filtrate turbidity (4 and 3 NTU) and residual color (15 and 13 TCU), but the residual turbidity and residual color are within the WHO (2006) drinking water guideline values for turbidity (5 NTU) and color (15 TCU).The effectiveness of herbs on reduction of turbidity is presented in figure 1. This figure shows that the *Strychnos potatoram* reduced the turbidity up to 90% with an optimum dosage of 4g/L. Using alum is likely to lead to cost reduction in the conventional water treatment and no threat to human life in the case of overdose as stated in the another finding [13-15].

Effectiveness of Herbals on Hardness: The effectiveness of herbs on reduction of hardness is presented in figure 2. This figure shows that S.potatoram reduced the hardness more than 78% with an optimum dosage of 4gm/lit. The result from this study is clearly indicated that the moderate dose of S.potatoram is more effective in softening raw water. A comparison with previous study [16-18] the softening property of S.potatoram which was discovered in that study is the only one documented to date. The present study was therefore carried out to explore the potential use of S.potatoram for the removal of hardness from raw water.

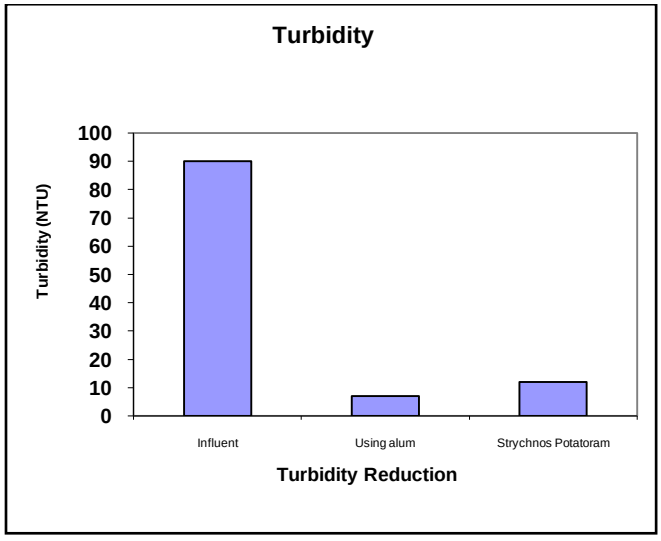


Figure 1: Turbidity reduction

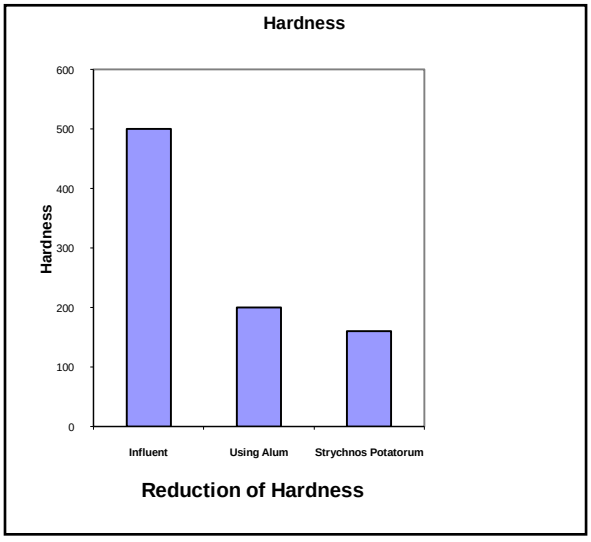


Figure 2: Change in Hardness

Effectiveness of Herbal on Chlorides: The effectiveness of herbs on reduction of chloride is presented in figure 3. This figure shows that *S. potatoram* has reduced nearly 7.6% of chloride with an optimum dosage of 8 g/L. The interaction of seeds with chlorides is not fully understood and the product of interaction is not at all known. The result of this study revealed that further studies would therefore have to be carried out to provide insight into the interaction between S.*potatoram* and the constituents of raw water which are imparting alkalinity in raw water.

Effectiveness of Herbal on pH: The result obtained shows that *S.potatoram* contain some coagulating properties. The pH values (7.29 to 7.89) obtained for the treatments were in the recommended standard set by World Health Organization (WHO).The effectiveness of herbal on adjustment of pH is presented in figure 4. This figure shows that *S.potatoram seed* has adjusted the pH of 7.63 with an optimum dosage of 1 g/L. This offers support to earlier findings of the use of powder processes from S.potatoram as a coagulant in water purification system with an optimum dosage of 12 g/L [19-22]. This work has done a same job with very minimum dosage. This proved to be a positive outcome.

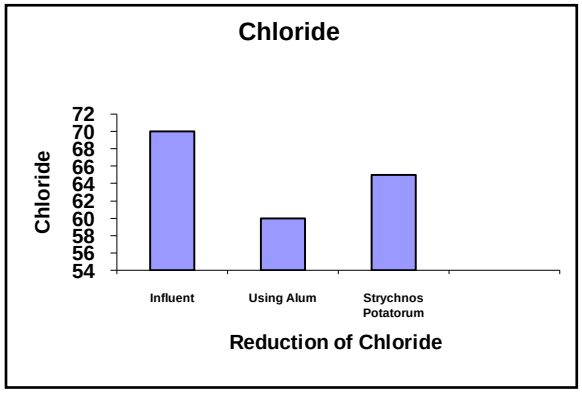


Figure 3: Change in Chloride

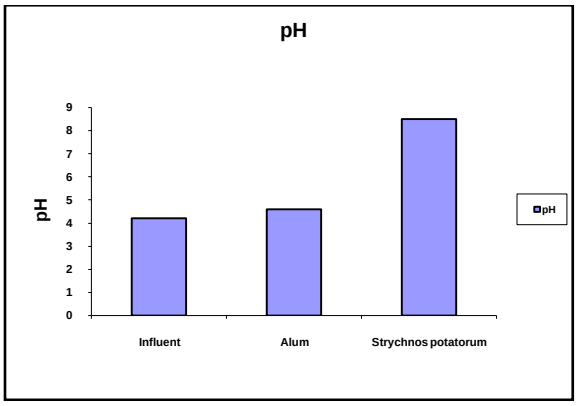


Figure 4: pH comparison

Effectiveness of S. potatoram on BOD: Biological oxygen demand (BOD) is the quantity of oxygen required to decompose the organic matter contained in the domestic waste and the sewage. Organic matter in water has a bad influence on water quality.[23-25] Its presence in water can change color and clarity, and can lead to the appearance of specific smell and taste of water. Since natural coagulants are of organic nature, in the next step we wanted to investigate how they influence the content of organic matter after performing coagulation tests. BOD was reduced by about 96 – 98 % (BOD from 60000 mg/L to 120 mg/L).

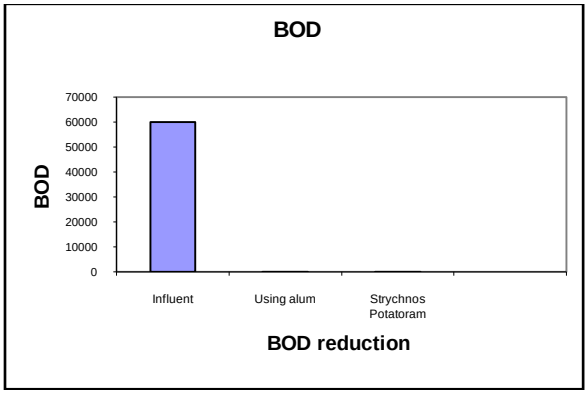


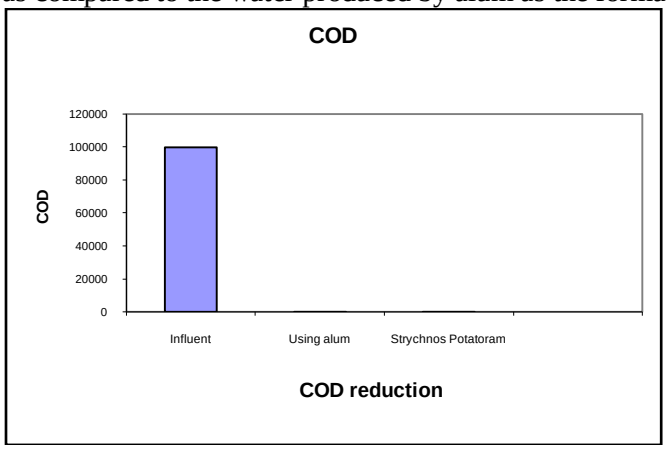
Figure 5 : BOD reduction

Effectiveness of S. potatoram on COD: Oxygen utilized in converting organic wastes to inorganic materials is referred to as chemical oxygen demand (COD). In the wastewater treatment sequence investigated *viz.* coagulation -flocculation –filtration, the maximum overall removal of 80 – 90 % of COD was obtained with this natural coagulant. These are encouraging results. When crushed into a powder, the seeds from S.potatoram act as a natural flocculent also which can eliminate very high amount of bacteria. The sludge left over from the water after treatment can also be used as a bio-fertilizer/bio-compost which has been shown to increase yields of other staple food crops. This therefore presents an excellent cycle for the seeds which can be used by rural communities. COD was reduced by about from 100000 mg/L to 40 mg/L).[26-27].

Effectiveness of *S.potatoram* on Total Dissolved Solids: Conductivity which is a measure of total dissolved solids (TDS) in water varies considerably in different geographical regions owing to differences in the solubility of minerals [28]. As suggested by WHO (2006), there is no permissible value for it but high levels of it in drinking water may be objectionable to consume. The experimental results showed that the performance of *S.potatoram was* highly significant on reduction of TDS. This figure shows that *S.potatoram* has reduced 60% of total dissolved solids with an optimum dosage of 8g/L. The work has been done to investigate the potential existence of this herb on an antimicrobial effect [29] but no

information on reduction of TDS in raw water. This study has found that *S.potatoram* has achieved on TDS removal significantly besides its disinfecting property.

Conductivity of the water produced after treatment with natural coagulant (*S.potatoram*) was much lower as compared to the water produced by alum as the formation of ions were much less in it.



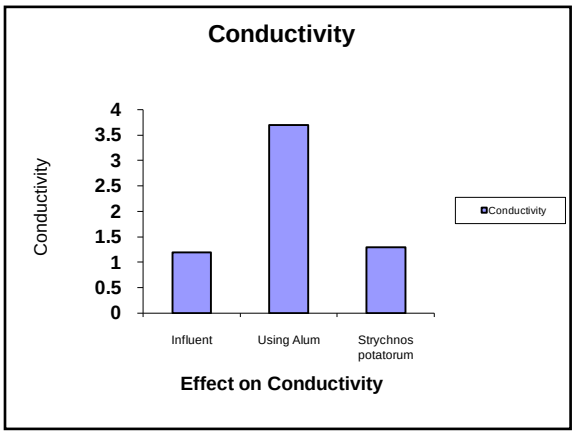


Figure6: COD reduction

Figure 7: Effect on conductivity

APPLICATIONS

In the wastewater treatment sequence investigated *viz.* coagulation, flocculation, filtration; the maximum overall removal of 80–90% of COD was obtained with this natural coagulant. We obtained encouraging results. *S.potatoram* crushed seeds powder can eliminate very high amount of bacteria act as a natural flocculent. The sludge left over from the water after treatment can also be used as a bio-fertilizer/bio-compost for other staple food crops. This therefore presents an excellent cycle for the seeds which can be used by rural communities.

Hence the coagulation of this already treated distillery effluent will leads to recycle & reuse of waste water. It may be used at large scale because of its low cost & easy availability. This coagulant may also be utilized for waste water treatment for various industries like leather, textile etc.

Further processing will add a real value and stability to the products and their markets. This represents an exciting initiative and challenge for many countries. Multidisciplinary collaboration and rigorous economic analyses are essential elements for future and continued success.

S.potatoram was found to be especially effective in reducing the parameters like turbidity, BOD, COD, hardness. Obtained sludge cakes, with high content of proteins could be used as a fodder, but additional analyses should be conducted first.

CONCLUSIONS

In the present study, the evaluation of herbal as a coagulant aid has been done to determine their efficacy in community water treatment. The following are the important findings of this work.

The *S.potatoram seed* has removed 90% of turbidity with an optimum dosage of 4 g/L.

The *S.potatoram seed* was more effective on reduction of hardness more than 78% with an optimum dosage of 4g/L.

The *S.potatoram* has removed 7.6% of Chloride with an optimum dosage of 8 g $L^{-1.}$

The *S.potatoram seed* has improved the pH level nearly 7.63 with an optimum dosage of 1 g L^{-1}.

The *S.potatoram* seed has removed BOD 96-98% (BOD from 60000 mg L^{-1} to 120 g L^{-1} mg L^{-1}).

The *S.potatoram* seed has removed COD 80-90% (COD from 100000 mg L^{-1} to 40 mg L^{-1}).

The *S.potatoram* seed has removed 60% of TDS with an optimum dosage of 8 g L^{-1}.

The herb identified in this study can be highly recommended for domestic water purification in developing countries where people are drinking contaminated water. This herb does not guarantee that the raw water ends up completely (100%) free from pathogenic microorganisms. It cleans the water and makes it drinkable but water is not completely purified.
However *S.potatoram* has ability to reduce the number of suspended and dissolved particles drastically.

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