THE EFFECTIVENESS OF LOCAL PLANTS AS NATURAL COAGULANTS IN TREATING TURBID WATER IN SRI LANKA

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INTRODUCTION

The removal of turbidity is essential in producing potable drinking water. In a conventional water treatment process, the coagulation/flocculation stage removes or reduces turbidity in the form of suspended and colloidal material. As many of our water supply sources depend on rivers, streams and lakes, this is an important process to remove turbidity, bacteria, algae, color, organic compounds and clay particles (Babu and Chaudhuri, 2005).

The coagulants can be categorized broadly into three classes as inorganic (eg.. aluminum sulfate, polyaluminium chloride and ferric chloride), synthetic organic polymers (eg., polyacrylamide derivatives and polyethylene imine) or natural coagulants (eg., chitosan and plant extracts) (Sutherland et al, 1999). It has been stated by many researchers in the past that the residuals of some synthetic organic polymers, such as acrylamide, have neurotoxicity and strong carcinogenic properties (Folkard et al, 1999). Besides, many developing countries can hardly afford the costs of imported chemicals for water and wastewater treatment. On the other hand, natural coagulants are biodegradable and are presumed to be safe for human health (Fugate et al, 2008). Many studies on natural coagulants have already been carried out and various natural coagulants have been produced or extracted from microorganisms, animals or plants (Marobhe, 2008).

The use of natural materials of plant origin to clarify turbid raw waters is not a new idea (Šćiban, *et al*, 2005). Natural coagulants have been used in domestic households for centuries in traditional water treatment in rural areas in many different countries. In the recent past, more interesting studies have been carried out on the subject of natural coagulants, especially to reduce problems of water and wastewater treatment in developing countries and to avoid health risks. Studies have been conducted to evaluate the coagulation efficiency of many plant materials, including the extract of Moringa seeds (*Moringa oleifera*) (Ndabigengesere *et al*., 1995), tamarind seeds (*Tamarindus indica*) (Bhole, 1995) and vegetable tannins (Özacar & Şengil, 2003). Huang and Chen (1996) studied the coagulation potential of chitosan, one of the most effective natural coagulants extracted from the organic skeletal substance in the shells of crustaceans. The preliminary study of the coagulation efficiency of the Moringa seed was carried out by Jahn (1984) in Sudan.

Sri Lanka is a country that is blessed with weather that supports the growth of various types of trees. From traditional knowledge, it has been identified that Kumburu (*Caesalpinia*) and Igini (*Srtyshnos potatorum*) seeds and the Kumbuk root (*Terminalia arjuna*) have abilities to purify water. The Water Board of Sri Lanka spends about Rs. 0.28, for the cost of alum only, to remove turbidity per $1m^3$ of water. However, it was discovered that although such plant seeds seem to be effective water clarifiers, good coagulation results were not always obtained due to a lack of understanding on how the seed powder coagulates turbid waters. The aim of our study is to investigate the suitability of locally available plants as natural coagulants.

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METHODOLOGY

Preparation of seed extracts

As stated above, seeds of three locally grown plants were identified to be used as natural coagulants. Moringa (*Moringa olefeira*) is a highly valued plant, distributed in many countries of the tropics and subtropics. It has an impressive range of medicinal uses with a high nutritional value (Jahn *et al*, 2006). People in Sri Lanka have been using it as an item of their daily diet. In addition to that, it has compelling water purifying properties.

Moringa pods were collected from surrounding areas and dried for several days. Then the pods were chopped and their seed kernels were separated. Thereafter, the separated seeds were dried for several days. Approximately 10kg of moringa pods were needed to make 100g of seed powder. Kumburu and igini seed powders were also prepared in the same manner. Kumbuk roots were collected and washed, and the roots were dried for several days. The above seed kernels were ground into fine powder using a blender. Seed powder with different grain sizes were obtained by sieving through mesh sizes of 0.3, 0.6 and 1.18 mm.

Preparation of synthetic turbid water

Turbid raw water samples were collected from the intake chamber of the treatment plant at Malimbada, Matara. As soon as the samples were collected, they were brought to the laboratory of the treatment plant. Immediately before coagulation experiments were conducted, suspensions were prepared with initial turbidity which was High, Medium and Low. These samples were made by adding clay particles into the above raw water samples and stirring well. Then the resultant mixture was filtered through No. 1 Whatman filter paper.

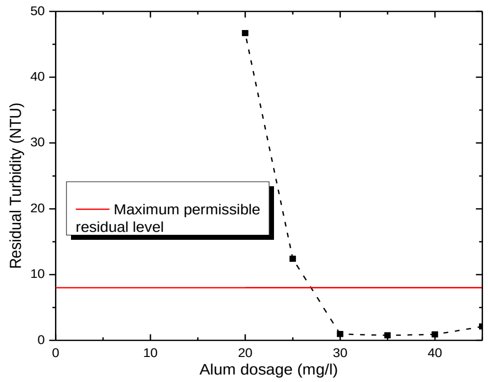
Coagulation test

Preparation of alum solution

An Alum solution was prepared by dissolving 1g alum, $Al_2(SO_4)_3 .18H_2O$ in 100ml of distilled water. A Jar test was used for the evaluation of the coagulation processes. Coagulation activity of each seed extract was verified by the jar test. The synthetic turbid water of High initial turbidity was added into six 1000ml beakers into which individually and separately 1, 1.5, 2, 2.5, 3 and 3.5ml of the alum solution were added (Water Board Report, 1989). 1ml of lime water ($Ca(OH)_2$) was also added to each beaker at the same time for pH adjustment. The mixtures were mixed thoroughly at 180rpm for 3 min and continued at 30rpm for 30 min. Finally, the samples were allowed to settle 30 minutes. After sedimentation of 30 minutes, residual turbidity (RTS) was measured, and the pH was measured at six beakers. The same coagulation test was conducted with natural coagulants using the same procedure with 2% alum solution. The residual turbidity (RTB) and pH were measured.

RESULTS AND DISCUSSION

Jar tests were conducted to determine optimum pH values and the dosage of alum. In the Jar test, the pH level should be controlled in order get the optimum result. The traditional way of controlling the pH is adding lime ($Ca(OH)_2$) as the final solution tends to have lower pH value due to the alum.



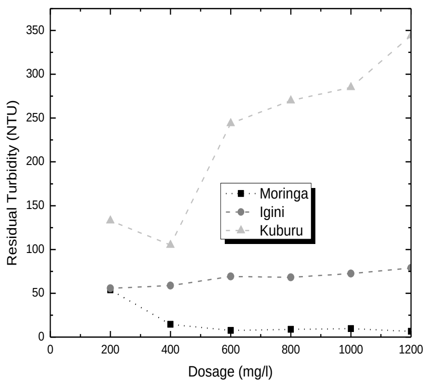


Figure 1a: Turbidity removal using alum

Figure 1b: Turbidity removal using natural coagulants for initial high turbidity

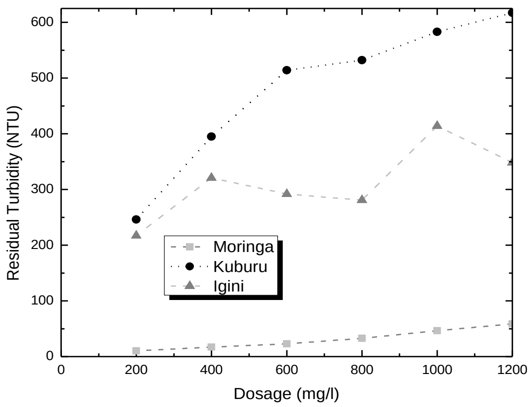
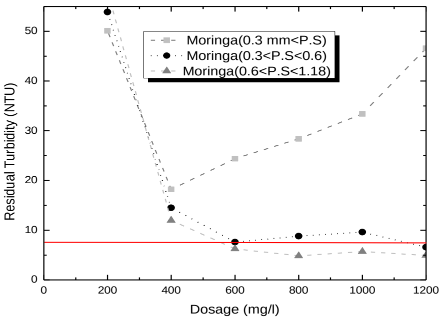


Figure 1c: Turbidity removal using natural coagulants for initial low turbidity

Figure 1a shows the test results of the variation of residual turbidity against the alum dosage. A minimum turbidity of 0.77 NTU was obtained when the alum dosage was 35 mg/l and the pH value was 6.9. In the same manner, tests were conducted for the natural coagulants, but with high and low intial tubidity levels. The variation of turbidity against the different natural coagulants dosages is illustrated for low turbidity samples in Figure 1b, and for high turbidity samples in Figure 1c.

According to the above figures, Kuburu, Igini and Kumbuk show low performances in removing turbidity, while Moringa is the only one coagulant that has a higher ability to remove turbidity. Therefore, a further study was carried out to investigate into the ability of Moringa to remove turbidity. A number of tests were performed for High turbidity and Low turbidity water for different particle sizes. Figures 2a and 2b show tests results with Moringa.



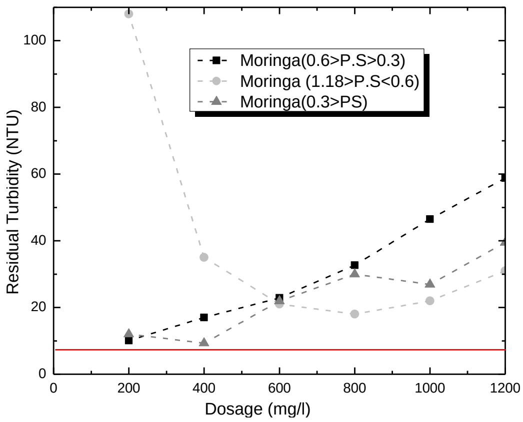


Figure 2a: Effects of particle size for high initial turbidity

Figure 2b: Effects of particle size for low initial turbidity

The line going though 8 NTU represents the maximum permisible turbidity level (8 NTU, Design Manual D3 1989 there was a Water Board report in page 2; is it the same? If so stick to that, be consistent). The residual turbidity value below the above line satisfy the standard for drinking water in relation to turbidity. Figure 2a shows that the use of coagulants with particle sizes in the range 0.6 - 1.18 mm OR μm? and dosages between 550 mg/L and 1200mg/L achieves the required level of turbidity removal. The required dosage for the particle size (0.3 < PS < 0.6) is 600 mg/l. Figure 2b shows the variation of residual turbidity for high turbidity water. A particle size that is less than 0.3 mm gives results close to the drinking water standard.

CONCLUSIONS

In this study, we have investigated the effectiveness of locally available plant parts to reduce turbidity of surface water. The three plants that were identified for the study are Moringa, Kumbuk and Kuburu. In the conventional treatment process, 35mg/L of alum is necessary to bring down turbidity to an acceptable level. The turbidity removal capacity of Kumbuk and Kuburu were not as effective as Moringa, which grows well in the dry zone of Sri Lanka. Therefore, powder prepared from these seeds can be used domestically to clarify water free of charge.

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