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WHITE POPINAC AS POTENTIAL PHYTO-COAGULANT TO REDUCE TURBIDITY OF RIVER WATER

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ABSTRACT

One of the main problems in many rivers is high turbidity. People lose attraction to rivers if the water is turbid. Reduction of turbidity is also one of the main objectives to achieve acceptable water quality for municipal water supply. Turbidity is generally removed by adding chemical coagulants, which show good result, but less environment friendly. Therefore, a significant amount of research is needed to discover efficient biodegradable coagulant to reduce turbidity of water. This study investigated the potential use of phyto-coagulants for turbidity reduction in synthetic and river water. Among the four phyto-ingredients tested, white popinac was found to be efficient in reducing the turbidity of river water by 76% at 50 mg/L with initial turbidity of 319 NTU. The efficiency of white popinac in reducing synthetic turbid water was not as profuse as seen in river water. Thus, white popinac being a non-toxic element and posing no threat to human health could be used as a potential coagulant to reduce turbidity of water. However, further experimentations are needed to ascertain the toxicological and antiseptic aspects of white popinac for wider applications, which is reported to be consumed occasionally by local people for several health benefits.

Keywords: coagulant, river water, turbidity, white popinac.

1. INTRODUCTION

Fresh water is one of the most important resources in the world, needed by all living beings. However, this resource in different parts of the world is becoming scarce due to ecological degradation, threatening to human health and international conflicts (Postel *et al.* 1996). Access to clean and safe water affects many developing countries, and millions of people and animals die due to diseases associated with contaminated water (Asrafuzzaman *et al.* 2011). On top of that, the rivers (mainly the urban rivers) are losing attraction due to high turbidity of water. Water turbidity can be reduced by coagulation/flocculation, sedimentation, filtration, etc. Coagulation tends to be the rate-determining step of the treatment process due to its efficient removal of particles and turbidity. Synthetic organic polymers, inorganic and natural coagulants are widely used in this stage (Antov *et al.* 2010). However, residual monomers are formed after the application of synthetic polymers as coagulant which pose a threat to human health as they are characterized by neurotoxic and carcinogenic properties (Mallevialle *et al.* 1984) and maximum permissible level was set at 0.1µg/L. In case of inorganic coagulants, alum is effective and used globally in water treatment, but its major disadvantages include generation of large volumes of sludge, reduced coagulation efficiency in cold water and the potential threat that link its ingestion with Alzheimer's disease (de Souza *et al.* 2014; Yin, 2010). However, reduction of turbidity in river water to improve the aesthetics of water will require huge amount of chemical coagulants, which will cause damage to the aquatic environment. Utilization of natural coagulants garnered a lot of interests as described by Narasiah et al. (2002) based on their characteristics, including biodegradability, safety to human health and minimum sludge generation which is 20 – 30% less than that of alum. In addition, development of coagulants requires the use of renewable resources that are relatively cheap for sustainability of the treatment technologies. The uses of natural coagulants of vegetable and mineral origin are being used in various parts of the world where modernization has not reached (Sook *et al.* 2014; Asrafuzzaman *et al.* 2011). For instance, seeds of Strychnos potato rum (Nirmali), a tree found in India, Sri Lanka and Burma contain anionic polyelectrolytes that destabilize particles through inter-particle bridging. Sanskrit writings imply that Strychnos potato rum has been used to clarify turbid surface waters for over 4000 years (Yin, 2010). Moringa oleifera (Drumstick) is a tropical plant found in Asia, Sub Saharan Africa, and Latin America. Moringa oleifera seed has coagulant properties related to cationic proteins. The main mechanism for coagulation is adsorption and charge neutralization (Miller *et al.* 2008). Vigna unguiculata and Parkinsonia aculeata are plants containing cationic proteins, which are active in coagulation of turbid waters. Thus, several natural coagulants have been reported to be effective in water clarification and treatment ranging from seeds of various plant species to extracts from bone shells and exoskeleton of shellfish and mineral soils (Miller *et al.* 2008). Some of the coagulants include seeds of Moringa oleifera (Narasiah *et al.* 2002), chestnut, acorn (Šciban *et al.* 2009), Phaseolus vulgaris (Antov *et al.* 2010), Strychnos potato rum (Babu and Chaudhuri, 2005), Opuntia sp. (Miller *et al.* 2008), Dolichos lablab, Cicer arietinum (Asrafuzzaman *et al.* 2011) and tannins from Acacia, Castanea and Schinopsis (Beltran-Heredia *et al.* 2009).

This study was aimed at screening some of the indigenous and abundantly available plants in Malaysia for possible use as natural coagulants in water treatment. Such technology for water treatment in rural and peri-urban

areas would provide easy access to safe water if the process were less capital intensive, effective, renewable, benign, and achievable.

2. MATERIALS AND METHODS

Phyto-materials used in this study (Palm seed kernel, cucumber peels, watermelon peels and white popinac seed) were obtained from the IIUM campus. The experiments were carried out using synthetic turbid water prepared from bentonite solution and natural turbid water obtained from Pusu River, which flows through the campus.

a) Preparation of coagulants

The palm seed kernel, cucumber peels, watermelon peels, and white popinac seeds (Figure-1) were washed thoroughly to remove adhering dirt before being dried at stages varying temperature from 60°C to 100ºC for 48 hrs. The samples were ground and sieved through 300µm screen for uniformity of their particle sizes. The samples were kept under laboratory conditions at room temperature.

b) Preparation of coagulant solution

The coagulant solution was prepared by dissolving the powdered samples (Palm seed kernel, cucumber peels, watermelon peels, and white popinac seed) in distilled water and 1 M NaCl at different concentrations ranging from 1–5 mg/l.

Figure-1. White popinac (*Leucaena leucocephala*) dry fruit and seed.

c) Preparation of synthetic turbid water

Synthetic turbid water was prepared by adding 0.5 g of bentonite into 1 liter of distilled water. The bentonite suspension was stirred for 15 minutes for uniform dispersion. The suspension was left undisturbed for 1 hr and the supernatant was transferred into an Erlenmeyer flask as a stock solution. Synthetic turbid water of different turbidity (NTU) was then prepared prior to coagulation experiments.

d) Conventional jar test

Jar test apparatus consisting of six beakers with spindle steel paddles (Figure-2) was used to monitor the effect of coagulants in synthetic turbid water. Each beaker contained different concentrations of coagulant (1–5 mg/l) in order to find the optimum dosage for the coagulation process. The beakers were vigorously agitated at a fast mixing rate of 200–250 rpm for 3–5 minutes and a slow mixing rate of 30–40 rpm for 15–20 min.

Figure-2. Jar test experiment using the coagulants for treatment of turbid water.

The beakers were allowed to settle for 30 minutes and samples from each setup were withdrawn to determine the turbidity difference before and after the experiment. Turbidity was measured using turbid meter (Model-2100P, HACH, USA) and the pH meter was used for measuring the pH of both the natural and synthetic water.

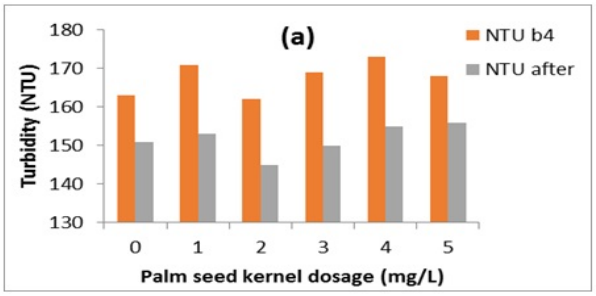
3. RESULTS AND DISCUSSION

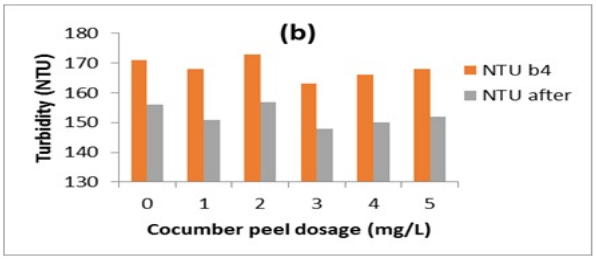
In order to determine the efficiency of four ingredients (Palm seed kernel, cucumber peels, watermelon peels, and white popinac seed) as coagulants, Jar test was carried out. Figure-3(a) shows the reduction of turbidity of synthetic water by palm seed kernel where the highest percentage of reduction was 11% for 1 mg/L coagulant dose. A further increase in dosage of palm kernel seed up to 5 mg/L could not improve the reduction efficiency. In case of cucumber peel (Figure-3b), turbidity reduction was found to be 9–10% and it is independent on dosage. Similarly, 5 mg/L of watermelon peel dosage led to maximum turbidity reduction of 15% (Figure-3c).

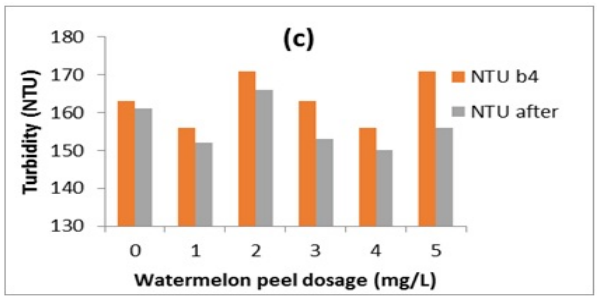
Among the four coagulants, white popinac solution of 5 mg/L showed higher efficiency for turbidity removal where the initial turbidity of 171 NTU was reduced to 131 NTU (Figure-3d) with 23% removal efficiency. Based on this, two different doses (30 mg/L and 40 mg/L) of white popinac were studied at different concentrations of synthetic turbid water. It was observed that 22% of reduction in turbidity was recorded at 40 mg/L based on reduction of initial turbidity from 187 NTU to 146 NTU. However, reduction of turbidity was found to be

less than 10% when the turbidity of synthetic water was more than 300 NTU.

On the other hand, a clear trend was observed in natural turbid water obtained from the nearby Pusu River as shown in Table-1; reduction of turbidity of river water using white popinac was effective and concentration dependent. The turbidity reduction increases with increasing doses of white popinac i.e. from 41% to 76%, which corresponded with 10 mg/L to 50 mg/L of white popinac, respectively. The fact that white popinac is non-toxic and pose no threat to human health, make it a potential coagulant for water treatment and it is consumed in different parts of the world. Similarly, the pH of natural turbid water (river) obtained in this study was 6–7. Addition of white popinac as coagulant in Jar tests did not change the pH of the solution. Thus, the findings of this study were in agreement with what was reported by Šciban et al. (2009) where extracts from chestnut and oak acorn had good coagulation properties of 80% and 70%, respectively in synthetic waters of medium turbidities. In addition, significant reduction of about 96% of raw turbid water was reported using the extract of Cicer arietinum (Asrafuzzaman *et al.* 2011). In case of M. oleifera seed coagulant, clarification of turbid water in both small and pilot scale showed excellent reduction in turbidity from 270 – 380 NTU to ≤ 4 NTU after the treatment (Sutherland *et al.* 1994).







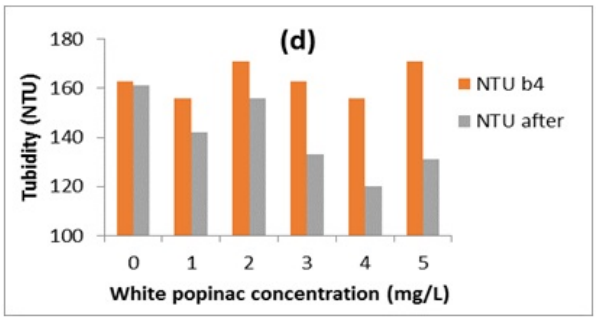


Figure-3. Reduction of turbidity by different coagulants in synthetic water.

Table-1. Reduction of river water turbidity by using white popinac.

White popinac (mg/L)	Turbidity (NTU)		Turbidity reduction (%)
	Before	After	
Control (0)	336	223	34
10	316	188	41
20	336	174	48
30	317	147	54
40	315	129	59
50	319	76.3	76

As the findings were positive, further experimentations are needed to ascertain the toxicological and antiseptic potential of white popinac. It can be concluded that the higher the dosage of white popinac, the higher the turbidity reduction in natural water.

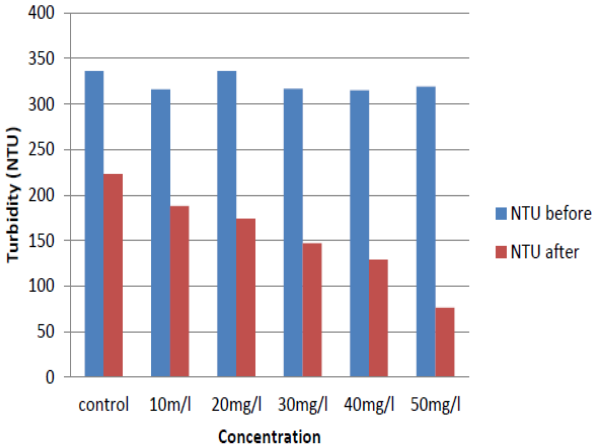


Figure-4. Performance of white popinac (Leucaena leucocephala) seed in reducing turbidity.

4. CONCLUSION

Four locally available phyto-materials were tested as potential elements to be used as natural bio-coagulant to reduce turbidity of river water. White popinac (Leucaena

leucocephala) was found to be a demanding potential candidate, which is a tropical fast growing plant and available throughout the year. The plant has been useful in firewood and timber processing, human food and manure production. The seeds of this plant are produced in large amounts (Brewbaker and Sorensson, 1990) and using them as coagulants make them more beneficial compared to their current use. However, further detailed research is necessary before having firm conclusions.

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