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Application of Moringa Oleifer Seed Extract and Polyaluminum Chloride in Water Treatment

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Abstract: The use of synthetic coagulants is not regarded as suitable due to health and economic considerations. Studies were carried out in laboratory scale on deionised water containing synthetic turbidity of kaolinite. Experiments were carried out in four turbidity ranges: 10, 50, 500, 1000 (NTU) and the pH range 5-8. The efficiency of moringa oleifera seed extract and polyaluminum chloride was examined with jar test. Extract of moringa oleifera seed could respectively remove turbidities of 98, 97, 89 and 55 percent in optimum concentration 10-30 (mg/l) and the optimum pH of 6-8. Poly aluminum chloride could remove 99, 98, 95 and 89 percent of the above mentioned turbidity ranges in optimum concentration of 20-30 (mg/l) with the optimum pH of 8. The aim of this study was to compare the efficiency of two coagulants polyaluminum chloride and "moringa oleifera", which is a natural coagulant. The results of this study showed that the extract of moringa oleifera seed had a minimal effect on pH and a higher efficiency in removing high turbidities in comparison with low turbidities. Reduction of pH decreased the efficiency of polyaluminum chloride in turbidity removal. Studies showed that the dominant mechanism turbidity removal by moringa oleifera seed extract was adsorption and charge neutralization and intera particular bridging.

Key words: Moringa oleifera · Polyaluminum chloride · Water treatment · Coagulation · Natural coagulant

INTRODUCTION

About one billion people do not have healthy drinking water. More than six million people (about two million children) die because of diarrhea which is caused by polluted water. Developing countries pay a high cost to import chemicals including polyaluminium chloride and alum [1, 2]. This is the reason why these countries need low cost methods requiring low maintenance and skill. Nowadays, polyaluminum Chloride is widely used in water treatment plants all over the world. Polyaluminium chloride and alum add impurities such as epichlodine are carcinogenic [3, 4]. Aluminum is regarded as an important poisoning factor in dialysis encephalopathy. Aluminum is one of the factors which might contribute to Alzimer disease [5, 6]. Alum reaction with water alkalinity reduces water pH and its efficiency in cold water [7, 8]. However some synthetic organic polymers such as acrylamide have neourotoxicity and strong carcinogenic effect [3, 5]. Natural macromolecular coagulants are promising and have attracted the attention of many researchers because of their abundant source, low price, multi-purposeness and biodegradation [7, 9, 10]. Okra, rice and chitosan are natural compounds which have been used in turbidity removal [11-13]. Moringa oleifera is a tree of Moringaceae family with 14 species. The seeds of moringa oleifera tree are used to reduce water turbidity in the countries all round the Nile River, especially Sudan [14, 15].

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Moringa oleifera tree is known as clarifier tree around the Nile river. This is the species belonging to the north of India which is the most famous one among all species. This tree is resistant to dryness and grows in arid and semiarid areas, so it is called miracle tree [1, 2, 16]. one type of this tree, i.e. Moringa Pergenia, belongs to Iran and grows in the deserts of Sistan-and-Balochestan [17].

The advantages of moringa oleifera usage in water treatment will be mentioned later in the paper. Antimicrobial factor (rhamnosyloxy benzyl-Iso thiocyanate) has been found in this tree seed which can remove 4 log coliforms from water [1, 18, 19]. The extracted part of moringa seeds prevents the growth of coliforms, sodomonas aeroginosen which reducesthe requirement for disinfection [20, 21]. The extract of oleiferaa seed removes 60% to 70% of hardness as well as 99% of turbidity [19]. Coagulating active element in extracts is a cationic dimeric protein with molecular weight of 13 kilo Dalton and isoelectric point 10-11 [14, 22]. Extract efficiency of moringa oleifera seed for turbidity removal equals that of alum [4]. Proteinouse active element extracted from moringa oleifera seeds by dialysis and Ion exchange is 34 times more effective than that extracted by distilled water. This active proteinouse material has a molecular weight of 3000 Daltons and removes 99.9% of 10 NTU turbidity with a dosage of 0.6 mg/l. The use of this protein doesn't increase dissolved organic carbon in water [15, 23, 24].

The volume of sludge produced by extract of moringa oleifera seed is 5 times less than that produced by alum [1, 7, 15]. Moringa oleifera extract has no effect on pH, electrical conductivity and alkalinity after treatment [1, 4, 15, 23]. Studies show that the sodium chloride increases the solubility of coagulating active elements in moringa oleifera seed [15, 24] and that the most effective salt for the extraction of coagulating active element in sodium chloride for turbidity remove is 7.4 times more than that extracted by distilled water [23]. Polyaluminum chloride (PAC) coagulant has been developed and used in water and wastewater treatment since 1980s throughout the world [25]. PAC is made by partial hydrolysis of acid aluminum chloride solution using a specific reactor. PAC has shown the following advantages in the clarification of water and wastewater: rapid aggregation velocity, bigger and heavier flocs and less dosage required. Therefore, PAC has been used extensively in place of aluminum sulphate at water purification plants and at wastewater treatment plants all over the world [26, 27].

This compound forms aquatic complexes in aquatic forms aquatics complex in aquatic environments which in turn leads to unique ability of this coagulant in coagulation process [28]. In chloride polyaluminum molecules, aluminum is in the from of a polymer including hydroxide and chloride and in some of them it includes mineral salts such as sodium, potassium, calcium, magnesium and chloride [29, 30]. Polyaluminum chloride is produced in solid and liquid forms with a purity of 18-30 percent [29].

Previous studies have been mainly focusing on effectiveness of MOC for the coagulation of high turbidity waters. This study investigated the use of MOC-SC for the coagulation of low turbidity waters. The main objectives of this study were to assess the effectiveness of MOC-SC and PAC on turbidity water and estimate the optimum dose for removal turbidity. This experiment aimed at determining the effect of pH on the efficiency of these two coagulants as well.

MATERIALS AND METHODS

Experiments were carried out in the laboratory of faculty of Health in Isfahan. The seeds used in this survey were obtained from agricultural research center of Boushehr and after being approved by a master of drug making college. The pictures of their seeds have been shown in Figs. l and 2.

In all coagulation experiments, samples of turbid water were prepared by adding kaolin into distilled water. 10 grams of measured kaolin powder (Fluka company) was dried in an oven with the temperature 105°C for three hours. After that it was removed from the oven and was embedded in desiccators for half an hour. Then, 50 mL of distilled water was added to the kaolin powder. Suspension was kept in room temperature for 24 hours and then was completely mixed for 20 minutes by an electrical blender. After that, the suspension was kept in stable conditions for 4 hours in order to settle coarser particles. One liter of supernatant was transferred to erlyne and was kept as stock solution [31].

To obtain moringa oleifera seed extract (MOC-SC), the seed was first skinned and then its core was crushed. 5 gr of the powder of moringa oleifera seed was mixed with 500 ml of solvent 1M sodium chloride. Suspension was mixed by a magnetic stirer for 10 minutes. Then, the suspension was passed through a paper filter with 8μm pores. After that the filtered extract was used in these experiments [23].

Fig. 1: Moringa oleiafera pods

Fig. 2: Moringa oleiafera seeds

To determine the optimum concentration of extract moringa oleifera seed and polyalumininium chloride, 1000 ml of the water sample made with a given turbidity was poured in beakers and experiments were carried out in the following order:

- The pH and the primary turbidity of the samples were determined.
- Jar test was carried out by using a jar test (Philips and Brid) on raw water samples with two extracts of moringa oleifera and polyauminum chloride. The optimum concentrations for turbidity removal were obtained.

The concentratinos 50, 45, 40, 35, 25, 20, 15, 10 and 5 mg/l were used to determine the concentration of the oleifera seed extract and polyaluminium chloride.

- The pH of water samples with the given turbidity was calibrated in four ranges 5, 6, 7 and 8 by sodium hydroxide and chloridric acid (Merk).
- The pH changes and final turbidity of the samples after jar test was surveyed in two stages.
- One sample of the extracted material was kept in refrigerator for 2, 15, 30 and 60 days. The efficiency of these extracts was tested in turbidity removal of water samples with the primary turbidity of 50 NTU and pH 7. The results are shown in Fig. 6. Jar tests were done by 6 box devices of Philips company. The speed of fast and slow mix was respectively 120 rpm and 40 rpm for 20 min and the settling time was considered to be 30 min. After sedimentation for 30 min, 5 ml of the sample was collected from the middle of the beaker and residual turbidity of each coagulated water sample was measured by turbidity meter (Hach 2100A) and pH with pH meter (Corning M-120).

RESULTS

Three turbidity ranges - high (1000NTU), medium (50NTU) and low (10NTU)- were developed in water. The efficiency of the extract of moringa oleifera seed and chloride polyaluminium in turbidity removal was compared. The results are shown in Fig (3- 4).

According to Fig. 3, the optimum dose of the moringa oleifera seed extract is 10 mg/L in the removal of the turbidity 1000 NTU and the optimum pH is 8.

A dose of 10 mg/l of moringa oleifera seed extract could remove 99.4% of primary turbidity 1000 NTU. Turbidity was reduced to 4 NTU in the optimum concentration of 10 mg/L. The optimum dose of polyaluminium chloride to remove the turbidity 1000 NTU is 30 mg/l and the optimum pH was 8. 30 mg/l of polyalumium chloride could remove 99.6% of the primary turbidity 1000 NTU and reduce the final turbidity to 4 NTU.

According to Fig. 4, the optimum dose of extract of moringa oleifera seed to remove turbidity 500 NTU is 10 mg/l and the optimum pH is 6. The moringa oleifera seed extraction can remove 98.7% of the turbidity and the turbidity 500 NTU is reduced to 6.2 NTU in optimum dose of 10 mg/l and optimum pH 6. Polyalumium chloride dose of 10 mg/l and optimum pH 8 can remove 98.9% of turbidity 500 NTU. It reduces final turbidity to 5.5 NTU.

According to Fig. 5, extract of moringa oleifera seed can remove 91% of turbidity 50 NTU. Extract of moringa oleifera seed reduces turbidity of 50 NTU to 6 NTU in an optimum dose of 20 mg/l and pH 7. 20 mg/l of polyaluminium chloride dose and optimum pH 8 can remove 89% of turbidity 50 NTU and reduce final turbidity to 4.5 NTU. According to Fig. 6, Optimum dose and pH

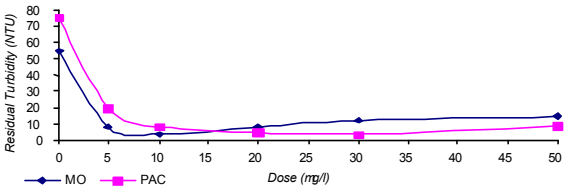

Fig. 3: Comparison of turbidity reduction after using different concentrations of moringa oleifera seed extract and polyaluminium chloride in water samples with the primary turbidity 1000 NTU.

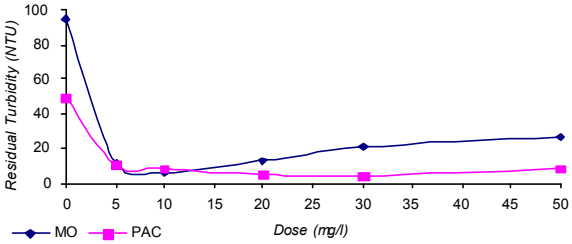

Fig. 4: Comparison of turbidity reduction after using different concentrations of moringa oleifera seed extract and polyaluminium chloride in water samples with primary turbidity 500 NTU

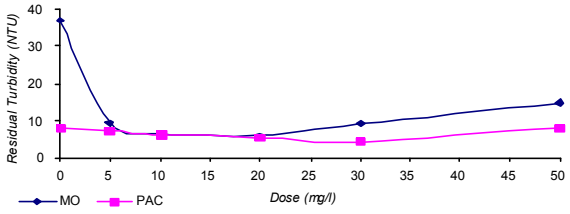

Fig. 5: Comparison of turbidity reduction after using different concentrations of moringa oleifera seed extract and polyaluminium chloride in water samples with primary turbidity 50 NTU

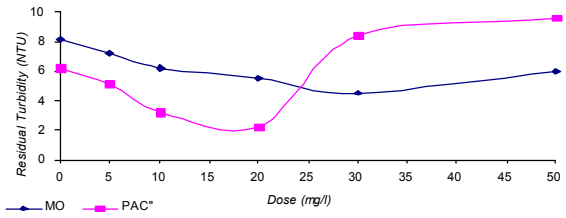

Fig. 6: Comparison of turbidity reduction after using different concentrations of moringa oleifera seed extract and polyaluminium chloride in water samples with primary turbidity 10 NTU

the extract of moringa oleifera seed to remove the turbidity 10NTU are 30 mg/l and 8 respectively, which reduce this turbidity to 4.5 NTU. Extract of moringa oleifera seed can

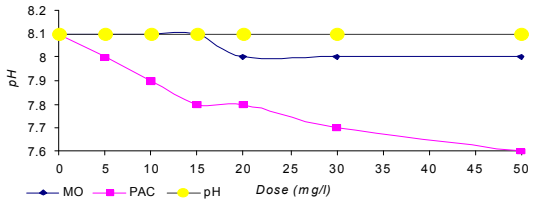

Fig. 7: The effect of coagulant concentration of moringa oleifera seed extract and polyaluminium chloride on the water sample with primary with pH 8.1

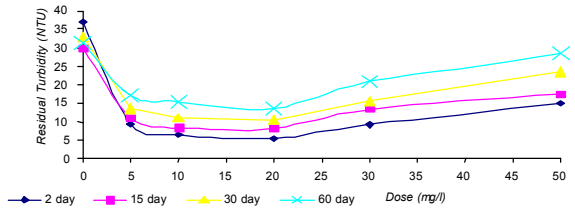

Fig. 8: The effect of keeping time on the efficiency of moringa oleifera seed extract in removal of primary turbidity 50 NTU with primary pH 7.

reduce 55% of turbidity 10 NTU. The optimum dose and pH of polyaluminum chloride to remove the turbidity 10 NTU are respectively 20 mg/l and 8. polyaluninium chloride can remove 89% of turbidity 10 NTU.

According to Fig. 7, extract of moringa oleifera seed has a minimal effect on the pH of the water samples and lowers the pH to 0.1 while polyalumium chloride reduces the pH to 0.5.

Fig. 8, shows the effect of maintenance time on the efficiency of moringa oleifera seed extract. The efficiency of extract moringa oleifera decreases with an increase in moringa oleifera extract maintenance time. The best efficiency was obtained in turbidity 50 NTU and PH 7. In maintenance time which is 15 days and an optimum dose of 20 mg/l, the efficiency of moringa oleifera extract was 83%. Turbidity 50 NTU was reduced to 10.2 NTU in 30 days and the optimum dose was 20 mg/l. The extract of moringa oleifera seed had 79.4% efficiency level. The primary turbidity 50 NTU was reduced to 13.5 NTU in 60 days and optimum dose 20mg/l. The results showed the efficiency of moringa oleifera in turbidity removal to be 73%.

DISCUSSION

According to Figs. 3-6, the following results were obtained: Unlike polyaluminium chloride, the efficiency of the moringa oleifera extract as a coagulant is not affected

Table 1: percentage of mean diffrences in turbidity removal with poly aluminium chloride and moringa oleifera extract

Coagulant	Number	Mean	SD
PAC	96	92.4	7.8
MO	96	83.2	20.8

Table 2: The effectiveness of pH to remove turbidity by polyaluminium chloride

Final turbidity (NTU)	Initial turbidity (NTU)	Initial pH	Dose (mg/l)	Removal turbidity %
4.5	50	8.1	20	91
6	50	7.1	20	88
9.3	50	6.1	20	81
13.2	50	5.1	20	73

by pH. The pH increased its efficiency, which is one of the advantages of natural coagulants.

The extracts of moringa oleifera seed had the best efficiency in 10 mg/l as compared with polyaluninum chloride with 30 mg/l which can remove turbidity 1000 NTU. The efficiency of moringa oleifera seed extract decreases with turbidity reduction. Optimum concentration increases from 10 mg/l to 30 mg/l but polyaluminium chloride has a better efficiency in low turbidities.

The results of statistical analysis show that the average efficiency of the coagulant polyaluminium chloride in the turbidity removal (10-50-500-1000 NTU) is 92.4%, with the standard deviation of ±7.8, the average of the efficiency of moringa oleifera extract in the above-mentioned turbidities is 83.2% and its standard deviation is ±20.8 (Table 1). T-test results (Pvalue<0.001) show that seed and polyaluminium chloride in removing the above-mentioned turbidities and the efficiency of polyaluminium chloride is a significantly different between the efficiency of the extract of moringa oleifera more than that of moringa oleifera extract.

According to Fig. 7, the moringa oleifera seed exract does not reduce the final pH of water samples. However, polyaluminium chloride reduces the pH of water samples as much as 0.5. Increaseing the maintenance time reduces the efficiency of moringa oleifera seed extract. The statistical analysis ANOVA (Pvalue=0.00) shows that the efficiency of moringa oleifera seed decreases as the maintenance time increases. According to Peter's studies [29], polyaluminium chloride can maintain its efficiency for 4 to 5 months in 25°C [29].

The results of the statistical analysis ANOVA (Pvalue=0.000) show that polyaluminium chloride reduces pH(Table 2).

Studies show that the dominant mechanism in turbidity removal by moringa oleifera seed extract is adsorption and charge neutralization and intera particular bridging. The results of the above-mentioned survey show that the required doses of moringa oleifera are reduced with a reduction in kaolin concentration. This shows that adsorption and charge neutralization are dominant mechanisms. The dominant mechanism of polyaluminium chloride is intera particulate bridging. The cultivation cost of every kilograms of moringa oleifera seed is 2 dollars and a higher is needed in comparison with the production cost of alum and polyaluminium chloride. Application of moringa oleifera extract has lower damages to health but considering the growth of this tree in south of Iran, more studies are necessary to expand the cultivation of this tree.

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