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Evaluating the Efficiency of Plantago Ovata and Starch in Water turbidity removal

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ABSTRACT: In the current study, the efficiency of starch and Plantago ovata extract as coagulant aids is compared in water turbidity removal. The coagulant is ferric chloride and the experiments are run in two ranges of pH 7 and 8. The achieved results of turbidity removal in different turbidity levels of 100, 50 and 20 NTU caused by different concentrations of starch and P.ovata as coagulant aids besides ferric chloride as the main coagulant are compared. According to the achieved results, the use of P.ovata or starch as the coagulant aid may play a key role in reducing the amount of $FeCl_3$ as the main coagulant and consequently decreasing the generated sludge. Furthermore, the remarkable turbidity removal efficiency gained when these coagulant aids are used in comparison with the case when no coagulant aid is introduced is also of interest. Generally, the both coagulant aids seem to be more efficient in pH value of 7 rather than 8. Although both coagulant aids used in this study manifested acceptable turbidity removal efficiencies, P.ovata showed higher capabilities of removal in different turbidity levels and pH values in comparison with starch.

Key words: Coagulant, Coagulant aid, Plantago ovata, Starch, Turbidity

INTRODUCTION

Water pollution results from human activities such as: domestic, agricultural and industrial, caused by wastewater treatment sludge, minerals and petroleum or persistent organic pollutants from incinerating of wastes, chemical synthetic substances (dyes, pesticides and so on) (Crini and Badot, 2007; Mishra *et al.,* 2009; Sengupta *et al.,* 2009; Ahmed and Al-Hajri, 2009; Gong *et al.,* 2010; Kulluru *et al.,* 2010; Nakane and Haidary, 2010; Nouri *et al.,* 2010; Shegefti *et al.,* 2010; Rehman *et al.,* 2009; Dabhade *et al.,* 2009). A vast variety of processes have been considered for water treatment focusing on particular contaminants (Salim and Munekage, 2009; Boadi *et al.,* 2009; Bhatnagar and Sangwan, 2009; Ataei *et al.,* 2009; Praveena *et al.,* 2010; Tashauoei *et al.,* 2010; Rahmani *et al.,* 2010; Naim *et al.,* 2010; Rajesh Kannan *et al.,* 2010). Coagulation and flocculation are physicochemical process which is used for colloidal suspensions destabilization and remove them (Zouboulis and Traskas, 2005). Particulates responsible for water turbidity include suspended particles, clay and silt, bacteria and algae (Montogomery, 1985; Salvato, 1992; Twort *et al.,*1994). Coagulation is mainly done by metal salts, e.g., ferric and aluminium sulphates and chlorides. The most common coagulants are ferric chloride, ferric sulphate and aluminium sulphate (Stechemesser and Dobias, 2005; Bratby, 2007).

Regarding adverse hygienic effects of synthetic polyelectrolytes, the substitution of a series of natural polyelectrolyte is developed (Fu *et al.,* 2001; Ozacar and Sengil, 2002; Bell and Buckley, 2003). Moringa oleifera, starch, tannins, mucilages are natural coagulant. There are interesting studies about turbidity removal ability of them (Bratskaya *et al.,* 2005; Pal *et al.,* 2005; Beltran–Heredia and Sanchez–Martin, 2009). As a reliable substitution of metal salts and synthetic polyelectrolytes, chitosan biopolymer has also manifested considerable efficiencies in coagulation and flocculation processes (Szygula *et al.,* 2008; Renault *et al.,* 2009). P.ovata extract as a coagulant aid is efficient in water turbidity removal (Basudehradun *et al.,*1989; Raychaudhuri and Ahmad, 1993; Chadho and Rajender, 1995; Nabi Bidhendi *et al.,* 2009).

One of the most important polysaccharides is starch. Starch consists of two fractions: amylose and amylopectin (Biliaderis, 1998).

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In the current study, the efficiency of starch and P.ovata extract as coagulant aid is compared in water turbidity removal. The coagulant is ferric chloride and the experiments are run in two practical pHs of 7 and 8.

MATERIALS & METHODS

Three different turbidity levels of high (100 NTU), medium (50 NTU) and low (20 NTU) was made synthetically by adding sufficient clay to water samples. The MERCK ferric chloride ($FeCl_3$, $6H_2O$), starch and P.ovata extract are used as the coagulant and coagulant aids, respectively. Normal sulfuric acid is used for pH adjustment. The experiments were performed in the water and wastewater lab of the faculty of environment, University of Tehran.

Experimental conditions of all experiments are as follow:

1) Regarding the highlighted influence of temperature on density, viscosity and amount of coagulants in keeping conditions, all the experiments were done in 25±2°C.

2) The volume of samples containing different levels of turbidity was adjusted to 500 cc.

3) Chemical oxygen demand (COD), TOC, pH and turbidity of the samples were measured by HACH DR/2000, HACH-LANGE DR/5000 uv/vis, Metrohm 691 Model digital pH meter and HANNA turbidity meter, respectively.

4) Digital scale METTLER AE200 was used for weighing.

All the experiments were performed by using jar experiment method. The jar set used in this study was PHIPPS &BIRD STIRRER 7790-402 Model.

At first, the samples of water which their turbidity and pH have been measured, were poured in special jar vessels, one time with known amount of ferric chloride as coagulant and another time ferric chloride with in accompany P.ovata as coagulant aid, then ferric chloride with starch coagulant aid were added to another samples of water in compare between P.ovata and starch as coagulant aid. 10mg/L concentration of ferric chloride as blank sample was considered in jar test for all turbidity levels. Furthermore, 10mg/L concentration of ferric chloride combined with 0.2 mg/L, 0.1 mg/L and 0.04 mg/L of starch as well as the same concentrations of P.ovata was also tested in two practical pH levels of 7 and 8 to achieve the optimum combination. All experiments were tested in 100, 50, 20 NTU turbidity ranges.

The jar test setup was adjusted as 1 minute of 100 rpm, 25 minutes of 30 rpm to make floc and 30 minutes of sedimentation. The turbidity and pH were measured and compared before and after the jar test runs to evaluate the efficiencies.

RESULTS & DISCUSSION

The final turbidity versus pH values for three different cases of 10 mg/L $FeCl_3$, 10 mg/L $FeCl_3$ & 0.2 mg/L of P.ovata and 10 mg/L $FeCl_3$ & 0.2 mg/L of starch within the sample containing primary turbidity of 100 NTU and pH values of 7 and 8 are shown in Figs 1 and 2.

Similarly, the final turbidity versus pH values for three different cases of 10 mg/ L $FeCl_3$, 10 mg/L $FeCl_3$ & 0.1 mg/L of P.ovata and 10 mg/L $FeCl_3$ & 0.1 mg/L of starch within the sample containing primary turbidity of 50 NTU and pH values of 7 and 8 are shown in Figs 3 and 4.

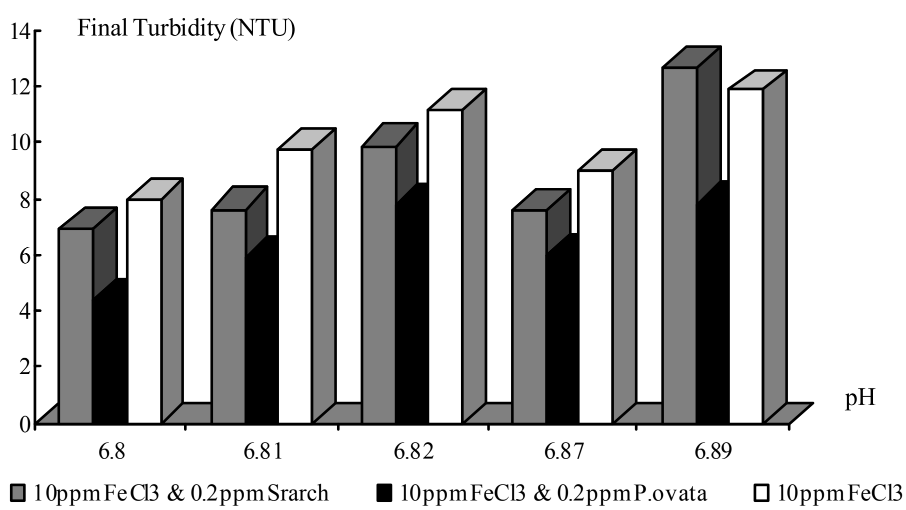

Fig. 1. Comparison of final turbidities at initial pH 7 and 100 NTU turbidity in three stages. Stage 1: ferric chloride coagulant, Stage 2: ferric chloride coagulant in accompany with P.ovata as coagulant aid, Stage 3: ferric chloride with starch coagulant aid

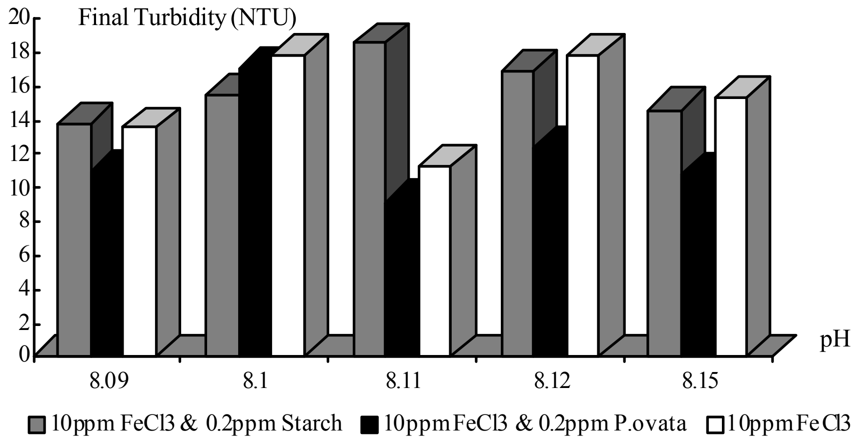

Fig. 2. Comparison of final turbidities at initial pH 8 and 100 NTU turbidity in three stages. Stage 1: ferric chloride coagulant, Stage 2: ferric chloride coagulant in accompany with P.ovata as coagulant aid, Stage 3: ferric chloride with starch coagulant aid

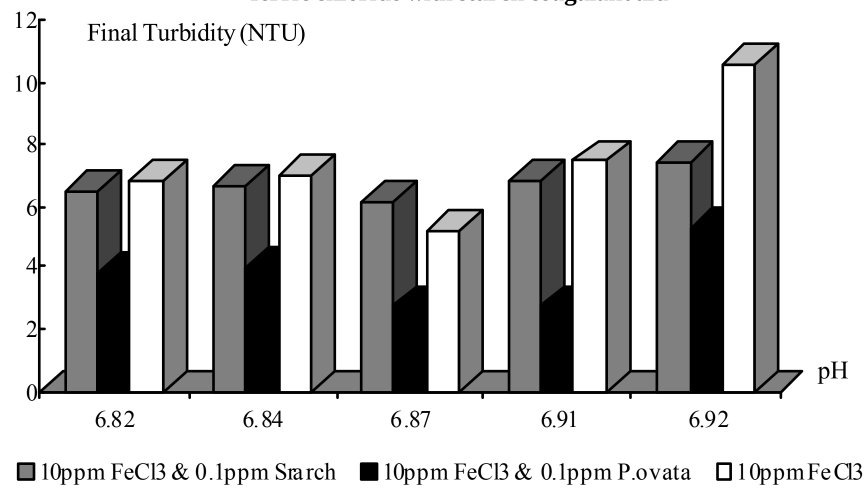

Fig. 3. Comparison of final turbidities at initial pH 7 and 50 NTU turbidity in three stages. Stage 1: ferric chloride coagulant, Stage 2: ferric chloride coagulant in accompany with P.ovata as coagulant aid, Stage 3: ferric chloride with starch coagulant aid

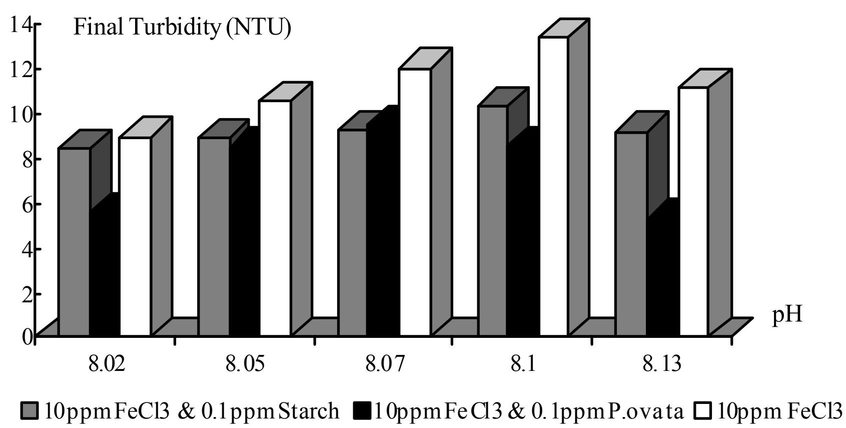

Fig. 4. Comparison of final turbidities at initial pH 8 and 50 NTU turbidity in three stages. Stage 1: ferric chloride coagulant, Stage 2: ferric chloride coagulant in accompany with P.ovata as coagulant aid, Stage 3: ferric chloride with starch coagulant aid

And in the same manner, the results of three cases of 10 mg/L $FeCl_3$, 10 mg/L $FeCl_3$ & 0.04 mg/L of P.ovata and 10 mg/L $FeCl_3$ & 0.04 mg/L of starch within the sample containing primary turbidity of 20 NTU and pH values of 7 and 8 are manifested in Figs 5 and 6.

Finally, the values of primary versus final turbidity in three different levels of 100, 50 and 20 NTU in two pH values of 7 and 8 in three stages are shown in Figs 7 and 8.

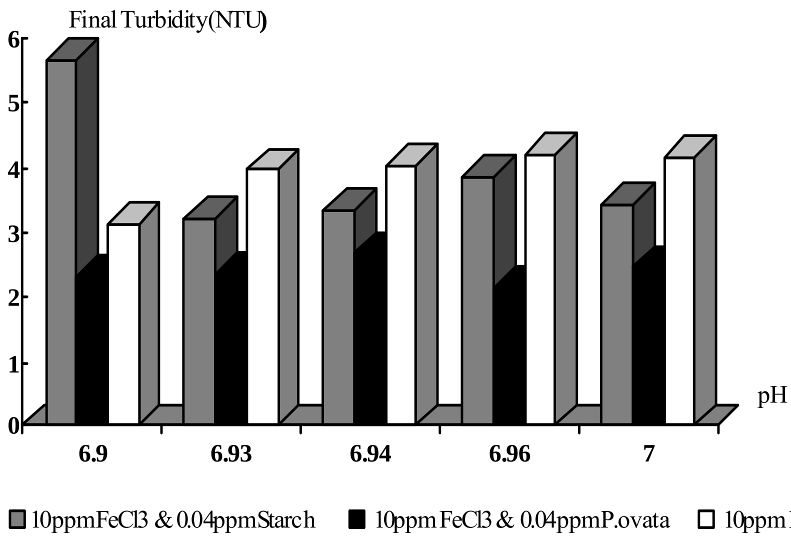

Fig. 5. Comparison of final turbidities at initial pH 7 and 20 NTU turbidity in three stages. Stage 1: ferric chloride coagulant, Stage 2: ferric chloride coagulant in accompany with P.ovata as coagulant aid, Stage 3: ferric chloride with starch coagulant aid

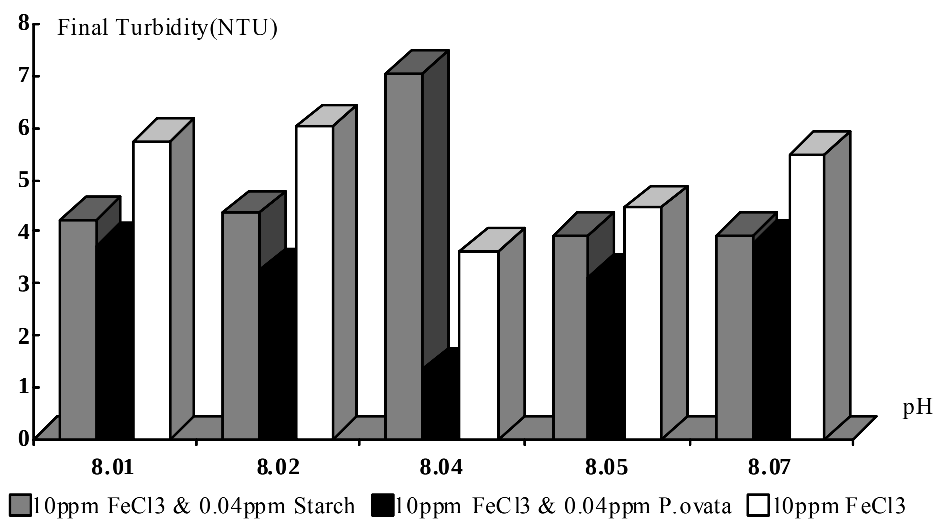

Fig. 6. Comparison of final turbidities at initial pH 8 and 20 NTU turbidity in three stages. Stage 1: ferric chloride coagulant, Stage 2: ferric chloride coagulant in accompany with P.ovata as coagulant aid, Stage 3: ferric chloride with starch coagulant aid

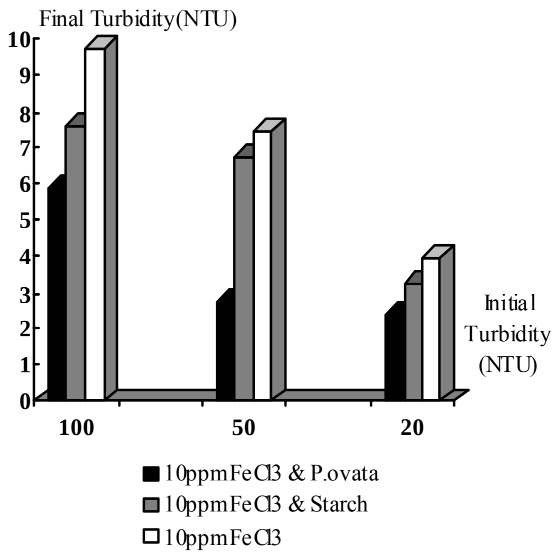

Fig. 7. The final versus primary turbidities (high, moderate and low) in water samples containing pH 7 in three stages. Stage 1: ferric chloride, Stage 2: ferric chloride and P.ovata, Stage 3: ferric chloride coagulant with starch as coagulant aid

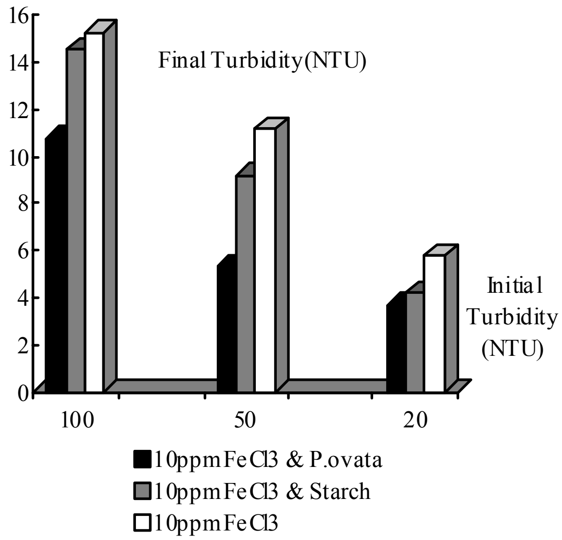

Fig. 8. Comparison of final turbidities for the applied turbidities (high, moderate and low) in three stages. Stage 1: ferric chloride coagulant, Stage 2: ferric chloride with P.ovata as coagulant aid, Stage 3: ferric chloride accompany with starch coagulant aid, pH 8

CONCLUSION

The achieved results of turbidity removal in different turbidity levels of 100, 50 and 20 NTU caused by different concentrations of starch and P.ovata as coagulant aids besides ferric chloride as the main coagulant are compared in this study. Additionally, the effect of pH in turbidity removal is also considered in each case. According to figures 1 and 2 which indicate the high turbidity water sample, the turbidity removal in the case of 10 mg/L of $FeCl_3$ and 0.2 mg/L of P.ovata is estimated to be 94.1% and 89.2% in pH values of 7 and 8, respectively. At the same time, for the combination where 10 mg/L of $FeCl_3$ and 0.2 mg/L of starch are used the removal efficiency is reported to be 92.4% and 85.44% in the two adjusted pH values. As it is shown in figures 3 and 4 (medium turbidity), the efficiency of turbidity removal in the case where P.ovata is considered as coagulant aid is estimated to be 94.5% and 89.3% for pH values of 7 and 8 respectively, while the equivalent efficiencies where the coagulant aid is introduced as starch are 86.5% for pH value of 7 and 81.6% for that of 8. The removal efficiency in low turbidity water samples (20NTU) for two pH values of 7 and 8 was 88.2% and 81.4% where P.ovata is the coagulant aid and 83.8% and 78.9% where starch is introduced as the coagulant aid.

According to the achieved results, the use of P.ovata or starch as the coagulant aid may play a key role in reducing the amount of $FeCl_3$ as the main coagulant and consequently decreasing the generated sludge. Furthermore, the remarkable turbidity removal efficiency gained when these coagulant aids are used in comparison with the case when no coagulant aid is introduced is also of interest. Generally, the both coagulant aids seem to be more efficient in pH value of 7 rather than 8. Although both coagulant aids used in this study manifested acceptable turbidity removal efficiencies, P.ovata showed higher capabilities of removal in different turbidity levels and pH values in comparison with starch.

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