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Research Article

CATIONIC MODIFIED RICE STARCH FOR DRINKING WATER PURIFICATION

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ABSTRACT

Drinking water treatment is of paramount importance for all people all over the world. Traditional water coagulant, aluminum sulfate poses a great risk for human health as it adds residual aluminum metal to drinking water. A cationic rice starch polymer prepared from waste product (broken rice) was evaluated to be used in water treatment. The suggested polymer is a biodegradable product and environment friendly. Application of cationic rice starch in the treatment of Nile river water showed that the turbidity caused by organic matter, colloidal silica were decreased to the lowest levels by using 6 ppm of cationic rice starch. Also, better results of water treatment were observed than that obtained when using 40 ppm of aluminum sulfate. Maximum treatment results were obtained on using a mixture of (4 and 23) ppm of cationic rice starch and aluminum sulfate, respectively for the treatment of raw water.

1. INTRODUCTION

Removal of water turbidity resulting from suspended mater is a problem facing water treatment plants for producing potable water. Turbidity forming materials are natural organic matter and siliceous materials. Inorganic coagulants such as aluminum sulfate and ferric sulfate have been used for the removal of raw water suspended mater [1-3]. Finished water contains appreciable amounts from such metals and the sludge as well. These residuals (in drinking water and sludge) pose disposal problems and tend to accumulate in the environment. The residual aluminum which may be present in water as a result of aluminum treatment, is being expressed by the public in connection with Alzheimer's disease [4. 5]

Thus, it becomes necessary to develop more efficient and environment friendly coagulants for the removal of suspended mater in surface waters, by using biodegradable materials. These can be natural or modified natural products such as cationic starch [6-8].

Removal of the above mentioned substances by clarification is generally accompanied by coagulation, flocculation, and sedimentation [2]. The combination of the three processes is referred to as conventional clarification. In most clarification processes, the coagulation involves neutralizing charged particles to destabilize suspended solids then flocculation starts when neutralized or entrapped particles begin to collide to form large particles. These processes is enhanced by the addition of polymeric flocculants, which increase floc by charged sites binding and molecular bridging. The effectiveness of polymeric flocculants strongly depends on charge density, molecular weight and other chain structural properties [9, 3].

The charges of most polymeric flocculants such as cationic rice starch are distributed along chain backbones providing stronger attaching points to anionic particle surfaces. Rice starches contain tertiary amino and/or phosphate groups that are considered the most important cationic derivatives and were produced by various di alkyl amino alkyl chloride reagents [7, 10].

The present work deals with the evaluation of newly synthesized cationic rice starch polymer to be used in the clarification of water.

2. MATERIAL AND METHODS

2.1. Chemicals

Egyptian broken rice as a natural waste product was obtained from local market, Egypt. Phosphorus pentachloride was supplied by Loba/Chemi India. Triethanolamine was supplied by Nice Chemicals PVT, LTD India. Sodium hydroxide was supplied by Spectrum, Hong Kong. Ethyl Alcohol was supplied by Adwic, German. Commercial aluminum sulfate ($A1_2(SO_4)_3.18H_2O$) was used as an inorganic coagulant. The other chemicals used for analysis of water were of analytical grade.

2.2. Raw water

Raw water samples were obtained from Nile River at west Cairo, Egypt.

2.3. Material preparation

The cationic rice starch was prepared by a technique based on the dry state process [11] as follows: sodium hydroxide solution (2 g) in 100ml water was prepared and stirred while the adding of 5g finely powdered broken rice (starch). The stirring was continued to ensure the formation of alkali rice starch via rising the temperature of the mixture to (70°C), then 1ml of triethanolamine and phosphorus pentachloride (1.5g) were added. The mixture was subjected to appropriate temperature (70°C) for 20 min. The reaction product was then precipitated in ethyl alcohol and washed thoroughly by ethyl alcohol/water (80/20) till alkai free, then dried in electric oven at 60°C.

2.4. Water samples preparation

Jar test method is the best way to simulate clarification and permit the comparison of various chemicals combination for determining the optimum chemical program to establish the correct order of addition. The most critical measurements in jar test are coagulation and/or flocculant dosages, floc size, settling characteristics, floc forming time, and finished water clarity. The flocculator in the forementioned jar test method contains six (1 liter) beakers in conjugation with multiple stirrers. Each beaker was filled with one liter of raw water and stirred at 100 rpm. The different doses of coagulant were added rapidly and stirred for 3 minutes. The stirring rate was then reduced to 50 and 20 rpm for a period of 5 and 10 minutes respectively to allow complete floc formation, then stirring was stopped. The relative settling rate, floc size and supernatant clarity were recorded**.** After a settling period of 15 minutes, 250 ml of supernatant water were siphoned-off for further analysis**.**

2.4.1. Tested aluminum sulfate dose

Aluminum sulfate dose was added in different concentrations in the range of (15- 50 ppm) of raw water at intervals of concentration (5 ppm) aluminum sulfate/liter of raw water. Turbidity, organic matter, colloidal silica and sulfate ions were tested to obtain the optimum dose of aluminum sulfate that gave best result of water clarity**.**

2.4.2. Tested cationic rice dose

Cationic rice starch was added (in a dose of 2-8 ppm) of raw water at intervals of concentration (2 ppm) cationic rice starch /liter of raw water, the examined parameters were tested to observe cationic rice starch used as coagulant aid.

2.4.3. Combined coagulant dose

A combination of aluminum sulfate and cationic rice starch was made and the same parameters were tested. Thus three different concentrations namely (18, 23 and 28 ppm) of aluminum sulfate were selected, for each one of them, four different concentrations of cationic rice starch namely (2,4,6 and 8 ppm), were added successively and used for clarification of raw water representing the best condition chosen from several series of examination.

2.5. Testing and analysis:

All series of water examination and chemical analysis were carried out according to the standard method of ASTM [12].

3. RESULTS AND DISCUSSION

Removal of turbidity, organic matter, colloidal silica, and sulfate ions were studied in case of both coagulants individually and in combination. Better result was obtained when using cationic rice starch alone or in combination with aluminum sulfate.

3.1. Effect of aluminum sulfate concentration on water treatment

The above finding result tested in Figure (1) showed that aluminum sulfate in concentration (40 ppm) of aluminum sulfate/liter improved removal both turbidity and organic matter from raw water better than that reported in previous work [13] and that a concentration of (40 ppm) is considered to be the optimum dose of aluminum sulfate alone that gave best clarity of water. Also, Figure (2) represents the results obtained, when concerning the variation of colloidal silica and sulfate with aluminum sulfate concentration. Aluminum sulfate is able to remove colloidal silica occurred at (40 ppm) aluminum sulfate/liter by coagulation process of raw water. This is in conformity with previous studies [9]. Figure (2) showed that increasing aluminum sulfate concentration led to increase sulfate ions in water. Increasing sulfate ions cause some problems to human health [14].

3.2. Effect of cationic rice starch concentration:

Using cationic rice starch (in a dose of 2-8 ppm), the examined parameters revealed that cationic rice starch is able to remove turbidity, organic matter, colloidal silica, give better water clarity, more than using aluminum sulfate alone. Figures 3 and 4 show that the optimum dose that gave best result was (6 ppm). It can be noticed that it have coagulation properties as those mentioned by other authors [7, 8]. Also, it is clearly seen form figure (4) that increasing cationic rice starch concentration resulted in a decrease sulfate ions concentration in water.

3.3. Effect of combined aluminum sulfate and cationic rice starch:

Figures (5&6) represent the obtained results. It is evident that maximum removal of turbidity was obtained when using a mixer of (23 and 4 ppm) of aluminum sulfate and cationic rice starch respectively. Also, figure (6) illustrates that maximum removal of organic matter was obtained at the same combined dose.

Figure 1: Effect of aluminum sulfate dose on turbidity and organic matter

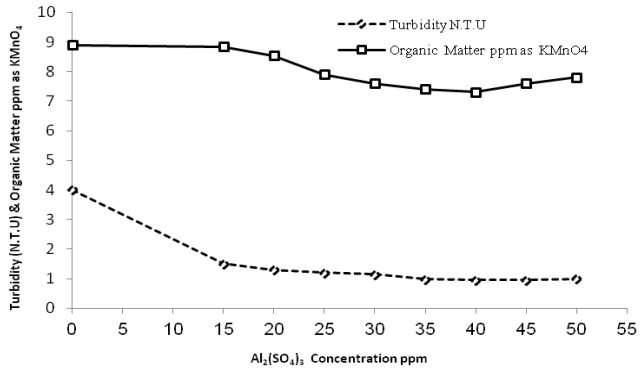


Figure 2: Effect of aluminum sulphate dose on colloidal silica and sulphate.

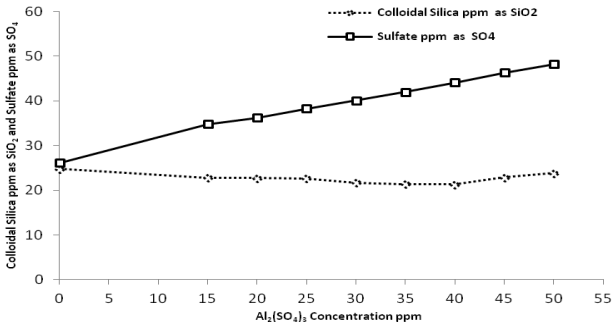


Figure 3: Effect of cationic rice starch dose on turbidity and organic matter

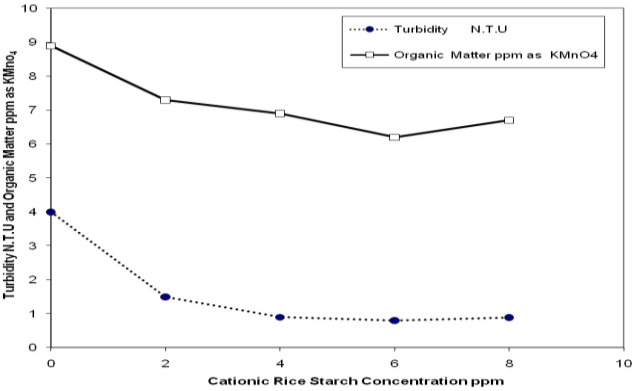


Figure 4: Effect of cationic rice starch dose on colloidal silica and sulphate

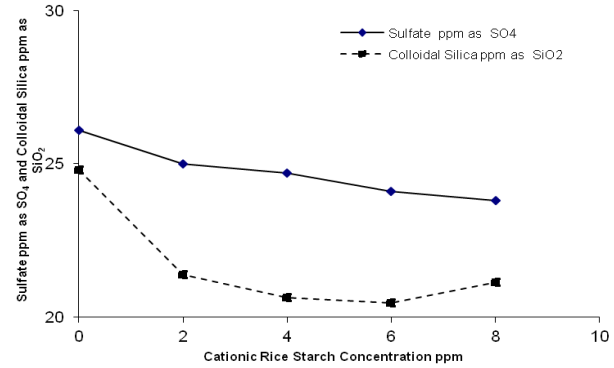


Figure 5: Effect of cationic rice starch dose on turbidity at (18, 23 and 28) ppm aluminum sulfate.

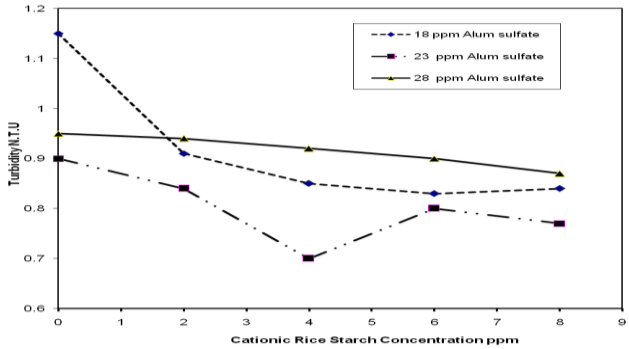
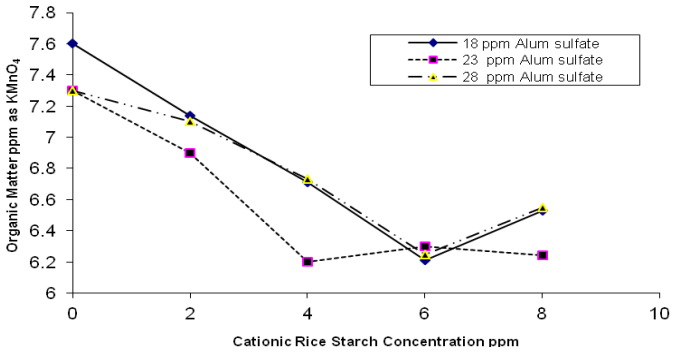


Figure 6: Effect of combined cationic rice starch/aluminum sulfate doses on organic matter removal



4. CONCLUSION

Treatment of raw water with cationic rice starch is achieved with an improvement of the water quality without addition of aluminum sulfate ions that result from aluminum sulfate when used in the treatment of water. Also, when using cationic rice starch in combination with aluminum sulfate, a small amount of cationic rice starch (4 ppm), reduced the consumption of aluminum sulfate about 42%.

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