

Modeling and Optimization of Natural Coagulant for Surface Water Treatment



Environment

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ABSTRACT

The objective of this study was to develop a treatment system that can effectively reduce the concentration of colloidal particles in raw water. Among the various techniques, coagulation and flocculation is the conventional method used to remove colloidal substances. Sago starch is used as a coagulant. The influence of pH, temperature, coagulant dosages on the coagulation process was studied and conditions were optimized corresponding to the best removal of colloids, color, total solids, chlorides, hardness and decrease in turbidity. 100% reduction of colour from raw water was achieved by using the optimum coagulant dosage (0.1 and 0.2g/l) in the optimum pH range (6 and 7). 70 - 100% reduction of turbidity was also achieved in the same optimized conditions. Higher dosages did not significantly increase pollutant removal and were not economical. The results provide useful information for raw water treatment with sago.

Introduction

In over 50 years of political independence and economic development, India has not been able to ensure the most basic of human needs – safe drinking water – for all its citizens. Rural areas contain the largest number of people without access to safe water (Urban Water Supply in India).

Clarity of water is important towards products meant for human consumption. Turbidity in water is caused by suspended and colloidal matters such as clay, silts, finely divided organic and inorganic matter, plankton and other microorganisms (Nnaji, 2012). The efficiency of suspended solid (colloid) separation from water has been achieved by the application of coagulants like alum, ferric chloride, polyelectrolyte, etc. The factors that influence coag-flocculation are, among others, temperature, pH, effluent quality, dosage and coagulant type (Nnaji, 2012; Jin, 2005; Ma et.al. 2001).

Coagulants and polymers obtained from many natural sources, when applied as coagulants primary or auxiliary in coagulation/ flocculation present as viable and inexpensive alternatives for the replacement or reduction of the dosage of the coagulant metal employed in the process of treating water, and respective drawbacks associated with these salts (Joseane et.al. 2013).

In present work, sago starch provides the focus of the study. Sago starch is a natural, non-toxic and biodegradable polymer. Chemically, starch is a homopolymer made up of basically two molecular species— amylopectin and amylose. While the amylose constitutes the inner part without any phosphorus, the amylopectin makes up the outer skin and contains combined species of phosphorus (Xie et.al. 2005; Nanji, 2014).

Methodology

Coagulant and its preparation

Sago in terms of pearls were procured from the local market and were ground using a food processor, dried in an oven at 105°C for 24 h and then screened through a 14 mesh sieve.

Collection of water samples

The water samples for were collected from the surface reservoir – Mudasarlova and a lake at pothinamallayyapalem located at a radius distance of 5 km from the Environmental Monitoring Laboratory, GITAM University, where the experiments were carried out.

Coagulation-flocculation Tests

Jar tests: The best approach for determining the treat ability of a water source and determining the optimum parameters (more

effective coagulant, required dose rates, pH, flocculation times, most effective coagulant aids) is by use of a jar tester (Cintex Make).

The coagulant was evaluated for its efficiency at the above pH ranges with varied mixing speeds. Two mixing speeds were nominated

1. Rapid mixing at 80rpm and slow mixing at 30rpm
2. Rapid mixing at 70rpm and slow mixing at 20rpm

Results

Colour reduction was peak with 99.93% in both the mixing speeds (Figure -1). At 80-30 mixing speed turbidity reduction was maximum (53.85 to 100%) at pH 6 for all doses comparatively with 70-20 mixing speed which showed maximum reduction (53.85 to 100%) at pH 7 (Figure - 2).

The best reduction of total solids was noted at a lower mixing speed of 70-20 at pH 7 (42.86%) Figure - 3. pH 8 has also showed the similar results at the same mixing speed. Dissolved solids also showed the noble reduction at the mixing speed of 70-20 at pH 6 (Figure - 4).

Both pH and conductivity have shown negative trends implying increase in both parameters after coagulation irrespective of the conditions tested. The removal of chloride was perceived to be noble at pH 7 with mixing speed of 70-20 (78.57%), Figure - 7.

Alkalinity was also removed well at the same mixing speed at pH 6 (80%). In fact hardness removal was also good at the same mixing speed with pH 8 (87.5%). Over all it can be concluded that 70 – 20 mixing speed resulted in removal of maximum physico-chemical impurities from the water.

Discussion

With aluminum salts, there is a concern about residuals in the treated water and Alzheimer disease and, whilst iron salts are cheaper options, the cost of any imported chemicals can be a serious problem for developing countries. Thus, in recent years, there has been considerable interest in the development of natural coagulants. By using natural coagulants, considerable savings in chemicals and sludge handling cost may be achieved (Diaz et. al. 1999).

From the results it is implicit that the reduction of colour was nearly 100% by the sago starch. A study by Di Frollini and Bernard (2000) using corn starch and cationic waxy cassava (es-

essentially 100% amylopectin), and cationic synthetic polymer, demonstrated that cationic waxy cassava starch was more efficient than the other two polymers in removing turbidity and apparent color, the settling velocities studied.

Substantial reduction of residual turbidity was achieved by S. S-g-PAM. The performance of S.S-g-PAM were found to be good as compared to liquid alum with the advantages of the biodegradability of S.S-g-PAM as well as less dosage of S.S-g-PAM used as compared to liquid alum (QudsiehandsamYassin, 2006).

pH and alkalinity variations were observed to be moderate when treated with sago starch. In terms of action on the physico-chemical characteristics of the clarified water, the natural polymers and coagulants show little variation in pH, alkalinity, conductivity and concentration of cations and anions, and allow more effective removal of BOD and COD and in some cases microorganisms. Being from natural sources, these compounds can generate value-added products, presenting itself as a new source of income (Joseane et.al. 2013). In general, the natural polymers have efficiency in removal of turbidity of water, comparable or superior to that achieved by metal coagulants, spending a lower dosage. These products proved not dependent on temperature or pH correction and alkalinity of the water to work efficiently (Joseane et.al. 2013).

Reduction in calcium and magnesium metal ions in terms of hardness was observed to be good at pH 8 by the natural coagulant. The removal of metal ions from aqueous solution by adsorption is related to the pH of solution, as the latter affects the surface charge of adsorbents, the degree of ionisation and the species of adsorbate. The selection of the optimum pH must take into account the fact that, if too high a pH value is chosen, precipitation of would occur. This would defeat the purpose of employing adsorption (Quek et.al. 1998).

The removal of total solids in the present study was upto a maximum of 70% which correlates with the studies performed by Berna HASÇAKIR (2003). Total Solids, Turbidity, SS, Oil & grease, and color parameters were measured throughout the experimental studies by Berna HASÇAKIR (2003). Coagulation-flocculation-sedimentation (CFS) with starch has shown that treatment performances are poor in general except oil and grease removals for domestic wastewater. Almost 100% oil and grease removal is achieved for domestic wastewater as a result of the CFS process with starch.

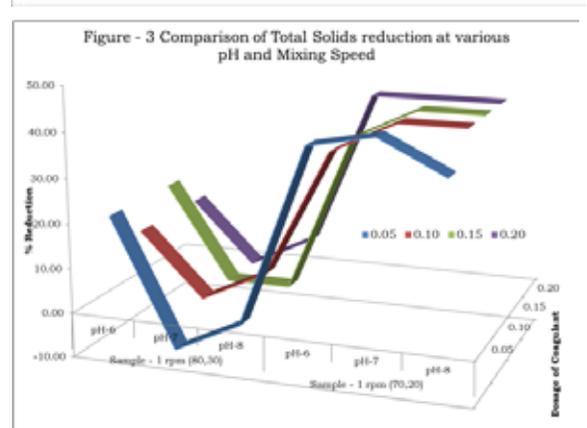
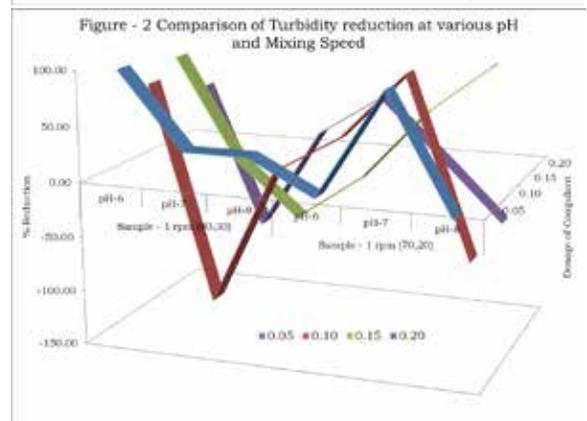
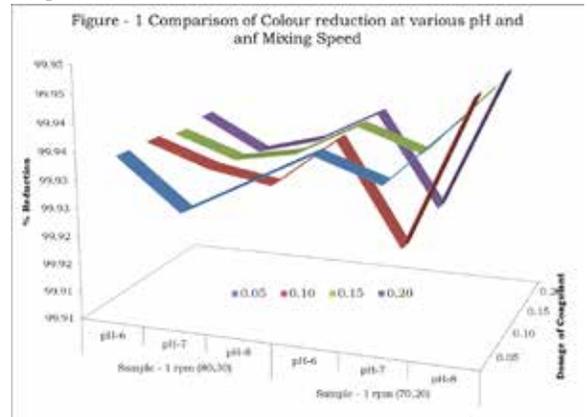
The best performance of the coagulant at pH 6 in conjunction to the results obtained by Lutfor and Mashitah (2011). Further Mohamad Zakiet.al. 2001, from the results inferred that the relative amount of metal ions taken up by the Sago Starch Based Poly (Hydroxamic Acid) resin were pH dependent and increases steadily with the increase of the pH of the medium.

Conclusion

Environmental requirements are becoming of great importance in today's society, since there is an increased interest in the industrial use of renewable resources such as starch and chitin considerable efforts are now being made in the research and development of polysaccharide derivatives as the basic materials for new applications (Blackburn, 2004; Guibal, 2004).

Experimental results conducted for starch encourage its use for water treatment purpose. Starch offers certain advantages such as availability (easy to obtain), cost, neutral pH conditions, etc. thus makes their uses reasonable. However, despite all the associated benefits, natural coagulants and polymers should be effectively applied to the process of water clarification in scale only after undergoing tests where certifying its non-toxicity, biodegradability and viability. Further efforts should be made to improve flocculation efficiency of starch as flocculant in order to take place of complexes of polyacrylamide and $Al_2(SO_4)_2$.

Graphs



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