Plantago Psyllium Mucilage For Sewage and Tannery Effluent Treatment

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ABSTRACT

The ability of low cost flocculating material, plantago psyllium mucilage, for removal of suspended solid (SS) from sewage and tannery has been successfully investigated. Jar test method has been used for flocculation studies. The effects of polymer dose, pH and contact time on percent removal of solid wastes are reported. Increase in solid wastes removal was observed with increasing polymer dose to a certain level, beyond which further increase in dosage shows a decreasing trend in solid removal. The maximum solid removal (94.69 %) was seen only after 1 h and the suitable pH range was acidic to neutral in case of sewage treatment, whereas, the time required for maximum solid removal (87.03 %) was 1 h and suitable pH range was neutral to alkaline in case of tannery effluent treatment. X-Ray analysis of pure plantago psyllium mucilage and flocs obtained after treatment shows the interaction between the suspended solid with the mucilage.

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Key Words:

plantago psyllium mucilage;
flocculant;
biodegradable;
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sewage;
tannery effluent.

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INTRODUCTION

Solid liquid separation is often an integral part of any effluent treatment unit. It is required for the retention of solid fines from effluent prior to recycling of water discharging into rivers to prevent water pollution. The retained solid fines may have high reuse value. Flocculants are used for this purpose. Natural polymer based flocculants have started gaining importance for their eco-friendly nature and their natural inertness to pH changes.

Natural water-soluble polysaccharides have capability of flocculating small particles [1] and of causing turbulent drag reduction. These properties have been ushered in their novel applications in agriculture, in effluent treatment and mineral beneficiation. Natural polymers such as starch, sodium alginate, amylopectin, guar gum, xanthan gum [1-3], kendu gum [4], chitosan [5], okra mucilage [6] and psyllium mucilage[7] find extensive application as flocculants. Many starch based products have been used for removal of toxic wastes like hexavalent chromium [8], cadmium [9] and gallium [10] which are usually present in many industrial wastewater such as those from textiles, leather tanning, electroplating and metal finishing industries.

Plantago psyllium seed husk is known as Isabgol husk in India and widely used as laxative. Psylliun is an anionic polysaccharide of *L*-arabinose, *D*-xylose and *D*-galactoronic acid. It is easily available and its use is very economical. In the present study, flocculation efficiency of this polysaccharide was tested with sewage and tannery effluent for the very first time. The flocculation efficiency was studied by varying the polysaccharide dose, pH and contact time. X-Ray diffractograms of pure mucilage, solid waste from effluents and flocs were obtained to support the proposed mechanism of flocculation.

EXPERIMENTAL

The raw material plantago psyllium mucilage was obtained from its husk (The Sidhpur Sat-Isabgol Factory, Gujurat, India) and it was used after purification. Its purification was carried out by precipitation from aqueous solution with alcohol and it was finally washed with acetone and dried. The FTIR spectrum of purified mucilage was recorded on Brucker-vector-22 spectrophotometer. The viscosity of the polymer solution was measured by Ostwald viscometer. The intrinsic viscosity was obtained (from the point of intersection) after extrapolation of two plots, i.e. η_{sp}/C vs. C and ln η_{rel}/C vs. C to zero concentration. Here, C is the concentration of polymer in g/dL and $\eta_{sp}/C= \eta_{rel}-1/C$, where $\eta_{rel} = \eta/\eta_0 = t/t_0$; t, being time of flow of polymer solution (of viscosity η), t_0, the time of flow of solvents (of viscosity η_0) at the time of measurements.

Sewage samples (domestic) were collected from its source (main sewage collection point). The tannery wastewater samples were collected from a tannery situated at Jajmau, Kanpur (India) where vegetable and chrome tanning processes are used. The pH of the wastewater samples and of mucilage solution in water was measured by Microprocessor pH meter CP 931. The conductivity of the wastewater samples were measured by the Century Microprocessor conductivity meter CC 631 and chemical oxygen demand (COD) was measured by usual standard method [11].

Flocculation studies of plantago psyllium were conducted by standard jar test [11] described in our earlier publications [6,12]. The solid contents were calculated by the standard equations for its evaluation [11].

A measured volume of 20 mL of samples was taken to determine the solid content of the effluents before and after treatment with the polysaccharide. The suspended solid contents were calculated by the equation:

where:

$$\text{Solids (mg/L)} = \frac{(A - B) \times 1000}{\text{volume of the sample (mL)}}$$

A - weight of the dried residue + crucible
B - weight of the crucible

To determine the total dissolved solids, known volume of samples were filtered and the solids obtained were dried and weighed and they were taken as for total solids unfiltered samples. Suspended Solids in wastewater were determined by subtracting total dissolved solids from total solids.

Flocculation studies were carried out at three pH values 4.0, 7.0 and 9.2. A large amount of buffer (450 mL buffer in 50 mL waste water) was used to control the pH. X-Ray diffraction patterns of powder sample of grafted copolymer, solid waste and flocs were obtained at ambient conditions on an Iso-Debyflux-2002 X-ray diffractometer (Rich and Scifert) with a CuK_γ radiation source.

RESULTS AND DISCUSSION

Characterization

The IR spectrum of the purified sample shows characteristic peaks of-OH between 3609-3288 cm^{-1}, COOH between 1635-1617 cm^{-1} and ether linkage at 1419 cm^{-1}. The intrinsic viscosity of plantgopsyllium mucilage was found to be 1.29 dL/g. The pH values of 100 mL aqueous solution having different concentrations of plantago psyllium mucilage were found to be in the

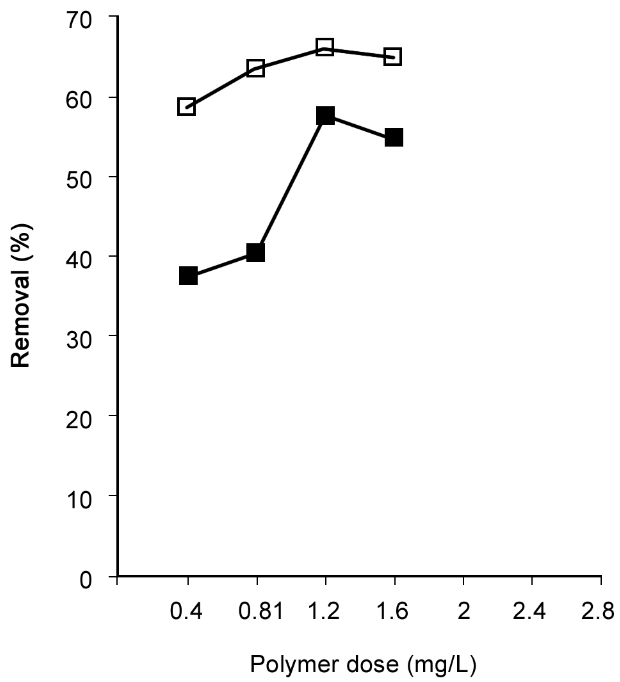

Figure 1. Plots of percentage removal of suspended solid sewage (□) and Tannery (■) vs. polymer dose at temperature = 32°C.

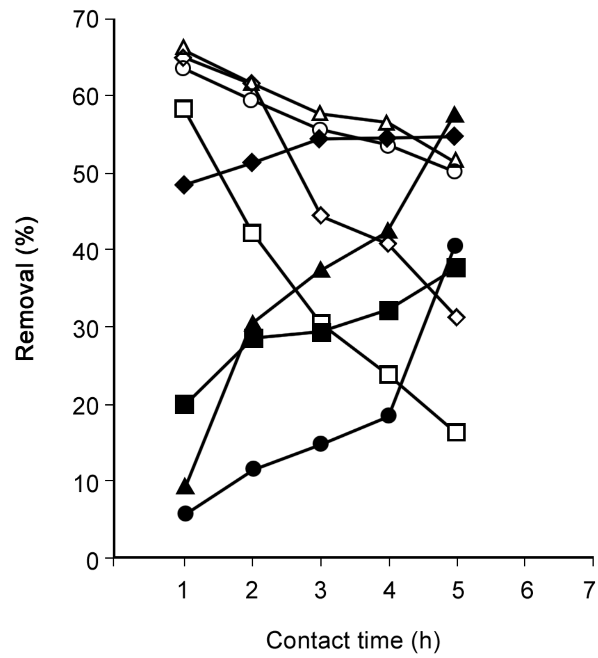

Figure 2. Plots of percentage removal of suspended solid of sewage vs. contact time with polymer dose. (□) 0.4 mg/L; (○) 0.8mg/L; (△) 1.2 mg/L; (◇) 1.6mg/L.
Plots of percentage removal of suspended solid of tannery effluent vs. contact time with polymer dose. (■) 0.4 mg/L; (●) 0.8 mg/L; (▲) 1.2 mg/L; (◆) 1.6 mg/L.

range of 7.11 to 7.26.

Sewage sample was faint gray in colour and had a pH of 7.65, conductivity 8.80 mS, turbidity 30 NTU, COD value 398 mg/L, total solids 1760 mg/L and suspended solids 350 mg/L. The pH of the sewage after addition of mucilage (1.2 mg/L) was found to be 7.63 (after 1 h), 7.60 (after 3 h) and 7.21 (after 5 h). Tannery effluent sample was bluish-green in colour and had a pH of 8.56, conductivity 10.91 mS, turbidity 50 NTU, COD value 2025 mg/L, total solids 6985 mg/L and suspended solids 1280 mg/L. The pH of the tannery effluent after addition of mucilage (1.2 mg/L) was found to be 8.56 (after 1 h), 8.60 (after 3 h) and 8.53 (after 5 h).

Effect of Polymer dose

The solid removal efficiency of plantago psyllium mucilage with sewage and tannery effluent is shown in Figure 1. It shows the plots of percent removal of SS vs. polysaccharide dose. It is apparent from the plots that with increase in polymer dose, percent removal of SS increases and the optimal dose (at which maximum removal is seen) is 1.2 mg/L in both cases. After a certain polymer dose, decreasing trend in solid removal is seen with further increase in polymer dose. This trend suggests that increase in polymer concentration beyond the optimal dose in suspension causes the aggregated particles to redisperse in the suspension and also disturbs the particle settling [13].

Effect of Contact Time

The solid removal efficiency of the mucilage is shown with varying contact time in Figure 2. Figure 2 shows percentage removal of the solid waste from sewage and tannery with contact time at different polymer doses. Maximum solid removal was 66.29% in case of sewage, whereas it was 57.89% in case of tannery effluent samples. The optimal time for the maximum removal was 1 and 5 h for sewage and tannery, respectively. Further increase in contact time also shows a reverse trend in solid removal. The most plausible reason for this trend may be the change in the surface chemistry of effluent with time and due to the destabilization of the aggregated particles after optimal contact duration [14].

The maximum solid removal was seen after one hour of the contact time in case of sewage wastewater

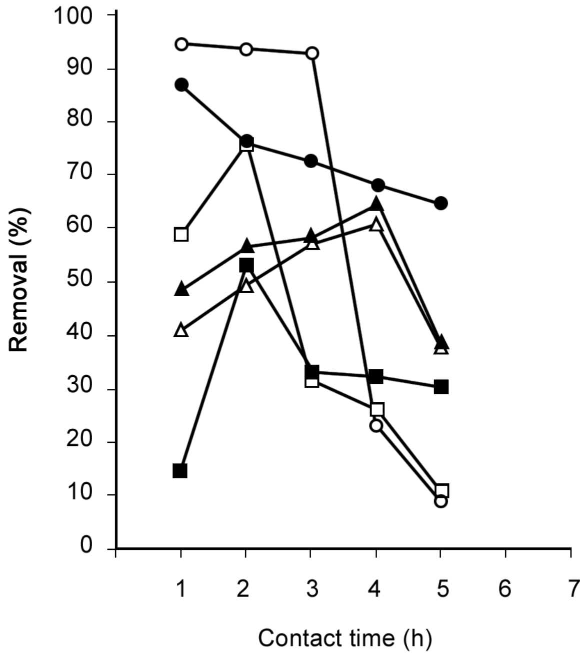

Figure 3. Plots of percentage removal of suspended solid of sewage vs. contact time. Polymer dose = 1.2 mg/L; pH (□)4.0; (○) 7.0; (△)9.2.
Plots of percentage removal of suspended solid of tannery effluent vs contact time. Polymer dose = 1.2 mg/L; pH (■)4.0; (●)7.0; (△)9.2.

and five hours in case of tannery effluent. The time taken for solid removal from tannery effluent was much more than that taken by sewage. This difference in treatment time is due to the higher values of zeta potential and COD of the tannery effluent than those of sewage waste. In addition to this reason, there is proteinaceous matter in tannery effluent, which surrounds the colloidal particles thus slowing down the neutralization process of zeta potential.

Effect of pH

The effect of pH on flocculation efficiency of the mucilage is shown in Figure 3. It is apparent from the plots that acidic to neutral pH is suitable for maximum SS removal from sewage samples. After 1 h, maximum solid removal was 58.79%, 94.69% and 41.37% at acidic (4.0), neutral (7.0) and at alkaline pH (9.2), respectively. In case of tannery effluent treatment, alkaline to neutral pH range is suitable for maximum SS removal. The maximum solid removal, 14.57 %, 87.03% and 48.57% was found at acidic pH (4.0), neutral pH (7.0) and alkaline pH (9.2), respectively. The increase and decrease in percent solid removal is indeed the effect of pH. It does not seem to be the effect of dilution because if it were, then, the percentage removal should be the same at all the pH values.

Usually pH changes do not affect the efficiency of natural polymers. Here, the changes in percentage solid removal with varying pH is due to the effect of the pH on constituents of sewage. At neutral pH, the hydrogen bonding between neighbouring hydroxyls and between surface adsorbed water and surface hydroxyls was disrupted by electrolyte adsorption, resulting in increase in percentage solid removal [14]. In both acidic and basic media, strong ion association occurs, but only at the sites not involved in the hydrogen bonding. The good results obtained at acidic pH in case of sewage treatment, is probably due to the oxidation of metallic ions present in the sewage, resulting in aggregation of solid waste [15]. The not so good results obtained at acidic pH in case of tannery effluent treatment, is probably due to the utilization of H^+ ions in oxidation of proteinacious matter rather than in the oxidation of metallic ions present in tannery effluent. The appreciable percentage removal of suspended solid from sewage and tannery effluent at alkaline pH may be due to the precipitation of metal ions in the form of their hydroxides, thus increasing the flocculation efficiency of the polymer [14].

On the basis of results obtained in three trials of solids removal from three samples of sewage and tannery effluent each, it may be concluded that acidic to neutral pH range for sewage treatment and alkaline to neutral pH range is suitable for tannery effluent treatment. Although no UV-vis spectrophotometric study was done to see the colour removal from the wastewater samples but the obvious change in the intensity of colour was seen after treatment with this mucilage in case of sewage samples. In case of tannery effluent, no obvious change in the intensity of colour was seen.

Figures 4 and 5 show the XRD patterns of sewage and tannery effluent before and after treatment, respectively. The Figures 4a and 5a, the XRD patterns of the waste material, show crystalline nature, whereas, pattern (b) shows complete amorphous nature of plantago psyllium mucilage. Figures 4c and5c, the XRD pattern of the flocs obtained after treatment of the effluent with the polymer, are quite different from XRD patterns (a) and (b). The 2θ and the d-values observed in (a) are changed altogether in pattern (c). This constitutes primary evidence that different crystal types were formed in wastewater during flocculation process [16]. The change in the 2θ angle and d-values indicate the change in nature of crystalline waste material after treatment.

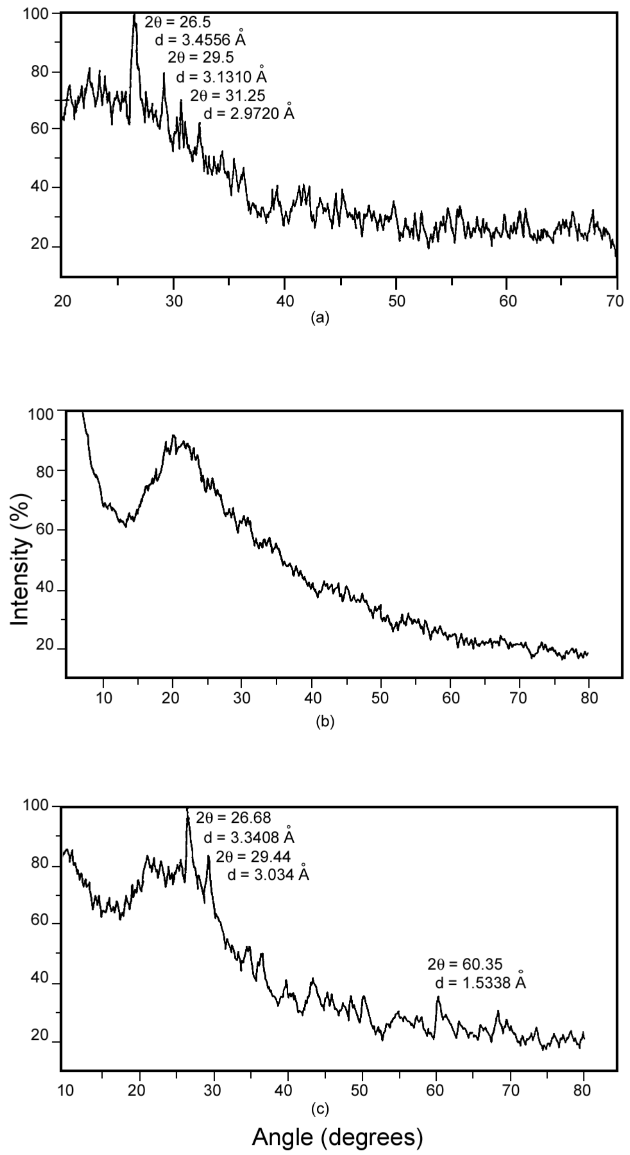

Figure 4. X-Ray diffraction patterns of solid waste (a), polymer (b), flocs obtained after treatment and (c) of sewage.

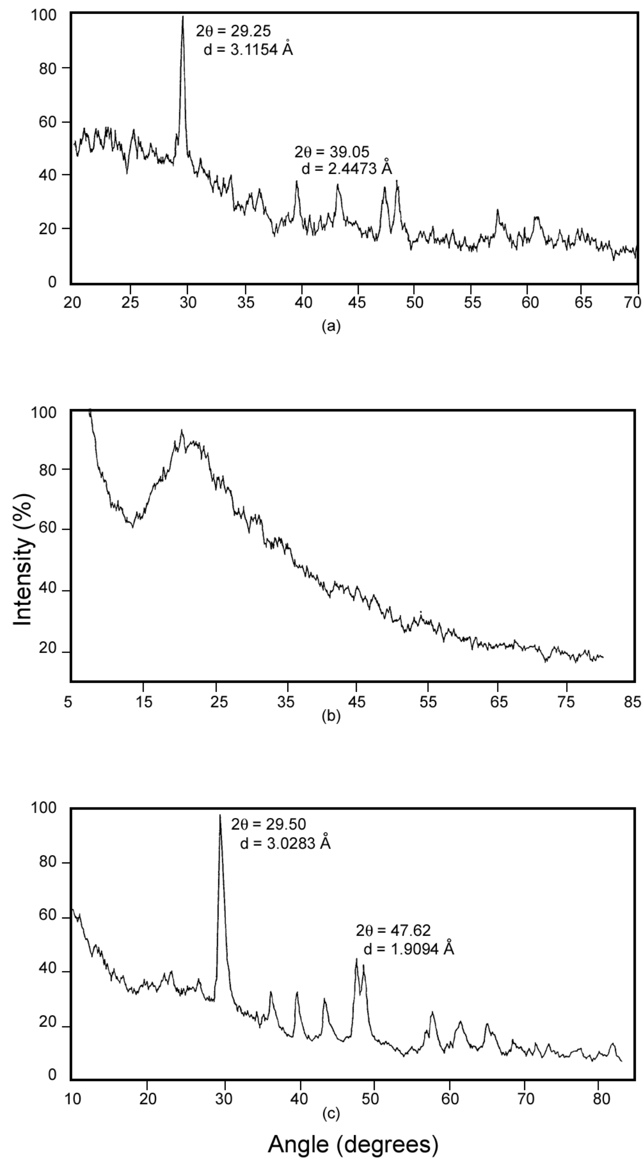

Figure 5. X-Ray diffraction patterns of solid waste (a), polymer (b), flocs obtained after treatment and (c) of tannery effluent.

This may be due to the interactions between free hydroxyls groups and carboxylic groups and contents of the sewage waste.

Anionic polymers are known to make larger flocs by bridging mechanism but in this case, extent of change observed in the patterns (a) and (c), suggest that apart from secondary bonding between flocculant and solid waste, there may also be involvement of primary bonding like chelation between crystalline matter of the waste and the polymer. Though the XRD patterns do not give any specific evidence for mechanism of flocculation but they may be used as supportive evidence.

CONCLUSION

Natural anionic polysaccharide of plantago psyllium mucilage is found to be a very effective flocculant capable of removing almost 85 and 95 percentages of suspended solid from sewage and tannery wastewater samples, respectively. A very low flocculant concentration of 1.2 mg/L was capable of removing appreciable amount of SS and the most suitable pH was found to be neutral. The optimal treatment time was found to be 1h. The XRD patterns were used as a supportive evidence for suggesting the possible mechanism of flocculation.

plantago psyllium mucilage by virtue of being cheap, easily available, biodegradable and inert to pH changes will prove to be a useful flocculant for treating waste-water in an ecological efficient manner.

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