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Research Article

AN EXPERIMENTAL STUDY ON CHITOSAN FOR WATER TREATMENT

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A B S T R A C T

As environmental protection is becoming an important global attention and focused on getting a value added by product from waste which does not cause environmental pollution or eco-friendly. Chitosan is a natural biopolymer obtained as by-product from sea food industry waste, has versatile application in various fields.

The objective of present work, to study suitability of chitosan for water Treatment. Chitosan is used as a coagulant to remove turbidity and compared with other commonly used coagulant, alum (Aluminium sulphate). In present work, we also focused on ability of chitosan in reducing removing other quality parameters such as hardness, chloride and nitrate. also studied the various characteristics of chitosan. The chitosan solution is prepared by dissolving 1gm of chitosan in 1 % of acetic acid with constant stirring.

The chitosan solution is added to jar test apparatus at different concentration varying PH to determine optimum concentration and ph. The treated water is analysed for other as per standard procedure.

The maximum removal of turbidity is observed at concentration 80mg/l and PH 9. Where turbidity is reduced to 3 NTU from 88 NTU. Results also show itis effective in reducing parameters like chloride, hardness, etc.

The chitosan can be used as a coagulant in water treatment plant.

INTRODUCTION

Water is absolutely essential for the survival of life on the earth. Hence it is necessary that the water required for their needs must be good and it should not contain unwanted impurities or harmful chemical compounds or bacteria's in it. Due to heavy environmental pollution the quality of water is deteriorated. Therefore, to supply good quality of water for domestic, industrial and other purposes has to be treated. Solid waste management has become major concern. So it is necessity to reduce solid waste from food processing industry which is the greatest challenge in front of the world. Sea food industries are major industries in coastal areas. Major problem in sea food industry is disposal of exoskeleton of shrimp, crab etc., So efforts are made to recover value added by-product so as to make by-product as economical, efficient and eco-friendly purpose. Chitosan is a by-product material recovered from sea food industry.

Objectives

Chitosan is a natural cellulose-like copolymer of glucosamine and N-acetyl-glucosamine. Because of their biodegradability chitosan-based materials have been suggested as a more eco-friendly coagulant for water and wastewater treatment.

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Chitosan was an effective coagulant in several prior laboratory studies. Practical application of chitosan as a drinking water treatment coagulant is evaluated here through a series of jar tests. Chitosan has received limited study as a drinking water coagulant. The chemical modification methods used to prepare chitosan-based flocculants and the influence of structural elements on flocculation properties and mechanisms have been recently reviewed. The practical application of chitosan as a water treatment coagulant is examined in the study presented here

- To study the suitability of chitosan in removing turbidity.
- To study the ability of chitosan in reducing other water parameters such as hardness, chloride and nitrate.

To study the various characteristics of chitosan.

Aboutchitosan

Chitosan is a natural linear biopolymer extracted from the exoskeleton of the sea crustaceans (crabs, prawns, lobsters, shrimps etc.). It is a sea food waste which is produced in abundance at coastal areas. However, this humble looking material possesses outstanding combination of properties required for water purification, food industries, cosmetics, biomedical applications. In addition to this, chitosan is inexpensive, biodegradable and nontoxic for mammals. Chitosan is natural water coagulant/flocculent and is able to reduce turbidity, colour, clay particles etc. from water. Additionally, considerable savings in chemicals and sludge handling is achieved by using a natural coagulant like chitosan. Chitosan is also effective in removal of organic pollutants, heavy metals, bacteria etc.

Processing of Chitosan

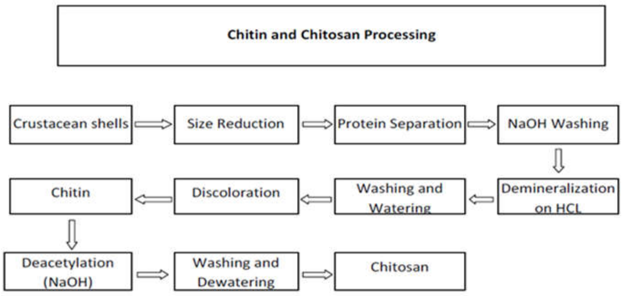


Fig 2 processing of chitosan

The process of the present invention comprises a process to manufacture chitosan comprising the steps of: pre-treatment (not needed in all cases), demineralization, deproteination, deacetylation and drying, with water washes after each step except, of course, the drying and dewatering steps. The steps of the process are preferably carried out in the order listed. The starting material may be any naturally occurring source of chitin, such as shells of crustaceans, for example, waste shrimp shells resulting from processing of shrimp. The process of the invention provides a white medical-grade quality chitosan without need for any of the prior art chitosan decolorizing steps.

Structure of Chitosan

Chitosan is a linear biopolymer (Fig. 4.3), having beta 1→4 linked units of poly (D glucosamine) (80%) and poly (*N*-acetyl-d-glucosamine) (20%). Chitosan is extracted from chitin by removal of acetate moiety through hydrolysis (deacetylation) under strong alkaline conditions (Fig. 4.4).

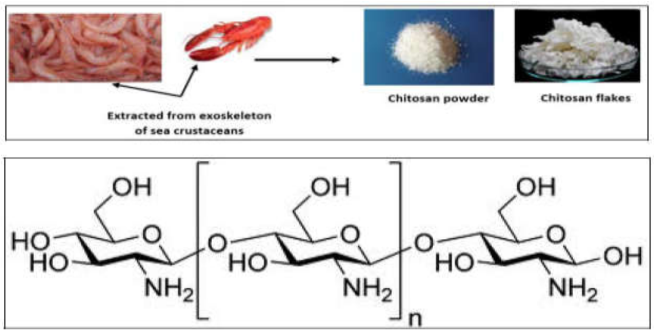
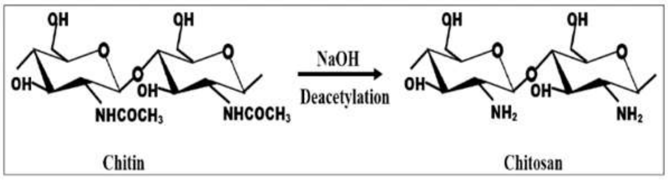


Fig 2 Chitosan, a polysaccharide with β-(1-4) linked glucosamine units

The available glucosamine and acetyl glucosamine units in the chitosan depend upon the degree of deacetylation of chitin. The degree of deacetylation (number of –NH2 and-CH3CONH2 groups) controls properties such as solubility, acid base behaviour etc.

Fig 4 Deacetylation process by which chitosan is obtained from chitin.



MATERIALS AND METHOD

Source of Chitosan

Crude chitosan obtained from local industry, were characterized for molecular weight of 1500lakhs Da and degree of deacetylation is 85% (DD). The Chitosan were ground followed by sieving to get fine powder.

Sources of Turbid Material

The different turbid material used are

River Silt

River silt is collected from a dried pond near BMCE College. The collected sample is processed and passing through 75 microns IS sieve, is used as a turbid material.

Shedi Soil

Shedi soil is collected from Bharanikave which is near BMCE college.

Bentonite

Fig 5.2.3 Bentonite Soil

Bentonite is collected from local industry. The collected sample is processed and passing through 300micron IS sieve, is used as a turbid material.

Sources of Water Samples

The sample of water is collected from different source

- Sasthamcotta lake
- Tap water from college
- River water near college
- Public tap water
- Home well water
- Public well water

Preparation of Chitosan Solution

The Chitosan solutions were prepared by dissolving 1gram of chitosan in 1 % of acetic acid solution under agitation

Preparation of Turbid Solution

River silt

Turbid solution is prepared by dissolving 8.5 g of river silt in litre of distilled water for Chitosan and pH standardization. The turbidity was maintained at 80 NTU.

Shedi Soil

Turbid solution is prepared by dissolving 22 g of shedi soil in litre of distilled water for Chitosan and pH standardization. The turbidity was maintained at 80 NTU.

Bentonite

Turbid solution is prepared by adding 8 .5 gms of bentonite in litre of distilled water for Chitosan and pH standardization. The turbidity was maintained at 54 NTU approximately

RESULTS AND DISCUSSIONS

Optimum Amount of Chitosan Concentration

Bentonite is collected from local industry. The collected sample is processed and passing through 300micron IS sieve, is used as a turbid material.

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RESULTS AND DISCUSSIONS

Optimum Amount of Chitosan Concentration

The jar tests were conducted to determine the concentration of chitosan in reducing the turbidity at varying pH using different turbid materials

Jar Test in River Silt Soil

Jar tests experiment were conducted by varying chitosan concentration and PH. The initial turbidity of river silt was maintained at 80 NTU. At pH-5 the removal efficiency is not effective compared to PH-7 and PH-9. at PH -5 the removal efficiency was found to be 78%. Whereas at pH-7 it was 95 % and at PH-9 it was 100%. At optimum PH-9 with 80mg/L of chitosan concentration the turbidity was reduced to 0 NTU

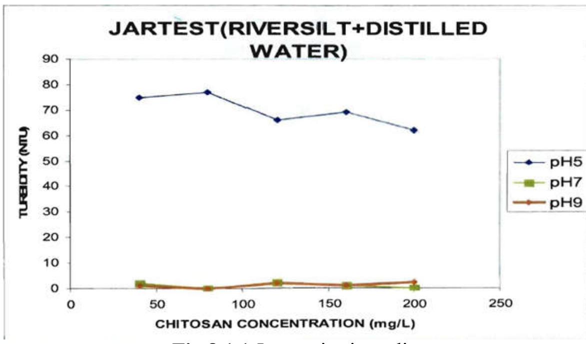

Fig 8.1.1 Jar test in river slit

Jar Test in Shedi Soil

Similarly Jar tests were conducted on shedi material by varying PH and chitosan concentration. The initial turbidity was maintained at 80NTU. At PH-5 the result shows an increase in turbidity value. Whereas at PH-7 and PH-9 the removal efficiency was found to be 95% and 100% respectively. At optimum PH-9 for 40mg/L of chitosan concentration the turbidity is reduced to ONTU

Jar Test in Bentonite

Similarly Jar tests were conducted on bentonite material by varying PH and chitosan concentration. The initial turbidity was maintained at 54NTU. At PH-5 the result shows an increase in turbidity value. Whereas at PH-7 and PH-9 the removal efficiency was found to be 95% and 100% respectively. At optimum PH-9 for 40mgIL of chitosan concentration the turbidity is reduced to ONTU.

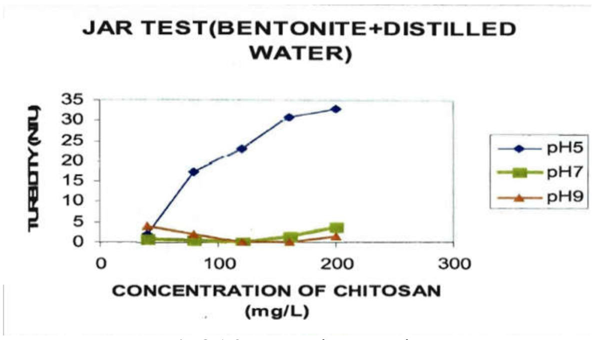

Fig 8.1.3 Jar Test in Bentonite

Effect of Chitosan in Chemical Test

Samples: chemical test conducted on chitosan solution prepared by dissolving 1gram chitosan in 1% acetic acid solution under agitation

Table 1 Effect of Chitosan in Chemical Test

Sl.no	Test	Concentration	Character
1	PH	4.4	Acidic nature
2	Hardness	96 mg/l	Moderately soft
3	Chloride	220 mg/l	No taste
4	Alkalinity	328 mg/l	Domestic purposes
5	Total dissolved solids	729 mg/l	normal
6	BOD	212 mg/l	normal
7	COD	2656 mg/l	normal

Effect of Chitosan in Water Parameters

Samples: Jar tests were conducted on different water samples collected from different sources at varying concentration of chitosan solution at pH-9 using river silt as a turbid material. Turbid solutions were prepared by dissolving8.5glL of soil. The initial turbidity of water samples is in the range of 36 to80 NTU. The concentration of optimum dosage of chitosan for different water samples is in the range of 40-120mglL.

Table 2 Effect of Chitosan In Water Samples

Water samples	Initial turbidity water	After adding turbid material	Optimum dosage of chitosan(mg/L)	Turbidity at that dosage value (NTU)
Sample 1	4	80	80	1
Sample 2	5.5	44	120	0
Sample 3	0	66	120	1
Sample 4	1	80	80	0
Sample 5	0	58	120	0
Sample 6	4.5	63	40	0

Effect of Chitosan in Reducing Dichlorination

Chloride tests were conducted on different water samples collected from different sources at different concentration of chitosan using river silt as a turbid material at pH-9.

Table 3 Effect of Chitosan In Dichlorination Content

Water Samples	Initial hardness (mg/L)	After adding turbid material (mg/L)	Chloride after adding chitosan solutions (mg/L)					
			2ml	4ml	6ml	8ml	10ml	12ml
1	23.485	23.485	18.4	15.2	18.66	17.28	13.134	14.125
2	15485	15485	15692	15415	14724	14447	14032	13687
3	2.765	5.5302	2.765	2.765	2.765	1.38	2.765	1.38
4	24.89	26.27	19.36	22.12	23.5	22.12	24.89	24.89
5	15484.6	15484.6	14309	14724	14586	13410	14724	14379
6	58.06	58.06	69.12	74.65	80.18	80.18	71.89	74.65

Effect of Chitosan in Reducing Hardness Content

Hardness tests were conducted on different water samples collected from different sources at different concentration of chitosan using river silt as a turbid material at pH-9.

Table 4 Effect of Chitosan In Hardness Content

Water Samples	Initial hardness (mg/L)	After adding turbid material (mg/L)	Hardness after adding chitosan solutions (mg/L)					
			2ml	4ml	6ml	8ml	10ml	12ml
1	25205	23785			24140			
2	170.4	241.4			85.2			
3	355	326.6	198.8	184.6	184.6	198.8	198.8	170.4
4	255.6	284	126.1	127.8	156.2	113.6	127.8	152
5	979.8	965.6	269.8	255.6	284	269.8	227.2	341
6	24220	24850	23785	22365	21300	20590	22365	20945

Effect of Chitosan in Reducing Nitrate Content

Nitrate tests were conducted on different water samples collected from different sources at different concentration of chitosan using river silt as a turbid material at pH-9

Table 5 Effect of Chitosan in Nitrate Content

Water Samples	Initial hardness (mg/L)	After adding turbid material (mg/L)	Nitrate after adding chitosan solutions (mg/L)					
			2ml	4ml	6ml	8ml	10ml	12ml
1	3.841	3.841	3.854	2.22	1.152	3.012	1.152	2.215
2	2.04	2.04	4.164	5.892	0.532	3.323	2.75	0.1772
3	1.0632	1.0632	5.848	5.848	5.848	4.962	6.025	6.7336
4	8.026	8.026	1.639	1.905	2.569	1.152	3.588	2.215
5	2.791	2.791	2.5	4.784	4.784	4.784	4.159	5.670
6	3.8541	3.8541	3.854	2.22	1.152	3.012	1.152	2.215

The result of Table 1 shows the effect of chitosan in chemical test. Here the PH value of chitosan is 4 therefore it is acidic in nature. Also it involves various test like alkalinity, hardness, chloride, Tds, bod and cod also. alkalinity shows the sample is suitable for domestic purposes. It is moderately soft in hardness. According to chloride there is no taste. Tds, Bod and Cod are normal.

The result of TABLE 2 shows the optimum concentration of chitosan to remove the turbidity varies for different water samples collected from different sources having different water parameters. For sample 1 and 4 the optimum concentration of chitosan is 80mglL, for sample 2, 3 and 5 it is 120mgIL where as for other samples the concentration of chitosan is only40mglL. This shows that the removal efficiency of chitosan in removing turbidity depends upon the various water characteristics.The result of TABLE 3 shows the effect of chitosan on chloride content of different water samples. In water sample 1, 5 and 6the chloride content got reduced after adding chitosan but in sample 2 initially it got increased but later it showed reduction. In sample 4 the chitosan did not show much effect in reducing chloride content. In rest of the water samples chloride content got increased after adding chitosan. These all variation may be due to various internal water characteristics.

The TABLE 4 shows the effect of chitosan on hardness content of different water samples. The samples 3, 4, 5 and 6 showed 75%-60% reduction in hardness content whereas sample 1 and 2 which has high hardness content shows only 10% reduction after adding chitosan. This showed that chitosan is effective in reducing hardness of water samples even at lower concentration.

Comparison of Alum and Chitosan

Introduction

In conventional water treatment system, alum has been the most widely used coagulant because of its proven performance, cost-effectiveness, relative ease of handling and availability. Recently, much attention has been drawn on the extensive use of this coagulant. Besides the large amount of sludge produced, high level of aluminium remained in the treated water has raised concern on public health (Driscoll and Letterman, 1995).McLachlan in 1950 discovered that intake of large quantity of alum salt may cause Alzheimer disease. To minimize the detrimental effect accompanied with the use of alum, polymers are added either with alum or alone and have gradually gained popularity in water treatment process. Synthetic polyelectrolytes generally produce sludge of better dewatering characteristics and facilitate better filtration. However, their long term effects on human health are not well understood.

Riverslit

The comparison of chitosan with alum in removing turbidity was conducted at optimum pH-9. The initial turbidity was maintained at 80NTU. The chitosan showed 100% efficiency in removing turbidity whereas alum is found to be around 50%. But after 120 mg/L the turbidity found to be increased due to undissolved particle of alum. At optimum concentration of 80mg/L the turbidity was reduced to 2.0NTU in case of chitosan where as in alum it is only 60NTU.

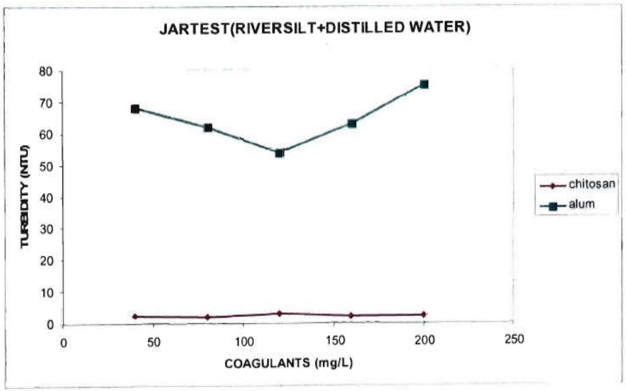

Fig 9 Comparison of alum and chitosan in river slit

Shedi Soil

The comparison of chitosan with alum in removing turbidity was conducted at optimum pH-9. The initial turbidity was maintained at 80NTU. The chitosan showed 100% efficiency in removing turbidity whereas alum is found to be around 50%. But after 200 mg/L the turbidity found to be increased due to undissolved particle of alum. At optimum concentration of 80mg/L the turbidity was reduced to 2.0NTU in case of chitosan where as in alum it is only 60NTU.

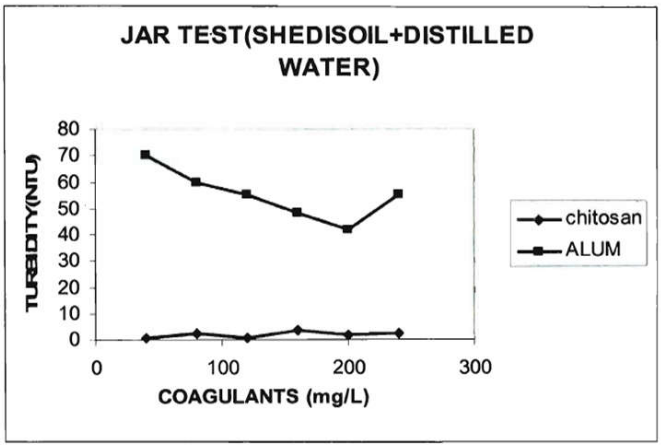

Fig 7.1.2 Comparison of alum and chitosan in shedi soil

Bentonite

The comparison of chitosan with alum in removing turbidity was conducted at optimum pH -9. The initial turbidity was maintained at 80NTU. The chitosan showed 100% efficiency in removing turbidity whereas alum is found to be around 50% But after 120 mg/L the turbidity found to be increased due to undissolved particle of alum. At optimum concentration of 40mg/L the turbidity was reduced to 0.5NTU in case of chitosan where as in alum it is only 70NTU

The analysis was done on bubble deck slab using both M25 and M30 grade of concrete. Total deformation, Directional deformation and Equivalent stress (Von Mises stress) were studied.The load-deflection values for various bubble deck slab using M25 and M30 grade of concrete obtained are tabulated in table 2.

8 Scope for Future Work

Effectiveness of chitosan in removing turbidity and other water quality parameters depends on internal water characteristics. The water characteristics which influence the performance of chitosan can be studied in future. Since chitosan is antimicrobial, in future it can be used as disinfectant in water treatment plants. Effectiveness of chitosan in reducing other water quality parameters like fluoride, irons etc., can be studied in future.

Chitosan is hard to obtain from the hard outer skeleton of the shellfish. Creating an efficient way to crush the shells will improve the collection of this material. Now that we have found conditions in which chitosan dissolves in, we would like to search for a safe substance or solution that will not only dissolve the chitosan but make that water safe to drink without affecting taste. An effective technique of filtration, especially for the vinegar solution, is necessary in order to obtain the dissolved chitosan to get rid of the solid particles.

Advantages

Chitosan over other polysaccharides (cellulose or starch) is their chemical structure that allows specific modifications to design polymers for selected applications. On the one hand, their reactive groups are able to develop composites with different compounds that have proven to have bejer capacity to adsorb the wastewater pollutants and to resist in acidic environment. Some examples include bentonite, kaolinite, oil palm ash, montmorillonite, polyurethane, zeolites, magnetite, etc. On the other hand, their cationic charge (chitosan is single cationic biopolymer) is able to neutralise and successfully flocculate the anionic suspended colloidal particles and reduce the levels of chemical oxygen demand, chlorides and turbidity in wastewaters.

- One of the most important advantages of chitosan is versatility and hence the material can readily be modified physically chemically.
- Chitosan biosorbent is very effective and showed extensive water treatment applications than commercial adsorbent.
- Cost-effective chitosan biosorbent has a special edge for opening up huge environmental applicability in near future.
- The use of chitosan based ecological polymeric materials could potentially contribute to the environmental friendly method for water treatment.

Social Benefits

Chitosan serves an important role in filtration. Along with sand filtration (which can remove up to 50% turbidity), chitosan can remove more unwanted particles in water than the sand filtration itself. The substance is similar to plant fibre which cannot be easily digested by the human body. Once ingested, it functions as a fat sponge. It soaks up to 6 times of its mass in fat.

- Chitosan is also used as a dietary supplement that aides in weight loss.
- Chitosan has properties within itself that allow for blood to clot quickly benefiting patients suffering from open wounds.
- Chitin and chitosan have a variety of potential applications in the areas of biotechnology, biomedicine and food ingredients

CONCLUSION

Chitosan demonstrated a much narrower pH range for acceptable turbidity removal when compared to alum and ferric. Overdosing of chitosan can result in restabilization of a dispersion Ph adjustment will be needed to avoid excess monomer if chitosan is used as a water treatment coagulant. Several practical considerations must be addressed before chitosan could be considered a viable alternative to alum or ferric for municipal water treatment. These include the quality, form and manner of product availability from the manufacturer (dry or liquid), shipping of the product, and specification of the equipment needed to feed the chemical at full-scale.

- Chitosan can be used as a coagulant in water treatment.
- Chitosan is better than alum in reducing turbidity.
- Chitosan is effective in reducing hardness, nitrate and chloride in water sample Sulphate found to be increased.
- Chitosan, a sea food industry waste shows effective in removing turbidity and other parameters.
- The value added by product from waste can be used for economical purpose instead of dumping as a waste

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