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The efficacy of chitosan obtained from Nigerian snail shell for the treatment of waste water effluent

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Abstract

The search for a better alternative for conventional coagulants has become an important challenge in water treatment processes, with the aim of reducing health effects associated with the use of inorganic coagulants. The aim of the study was to evaluate the effectiveness of snail shell chitosan as a coagulant in waste water treatment.

Chitin was prepared from snail shell after grinding by demineralization, deproteinization and decolorization. Chitosan was obtained by alkaline deacetylation of chitin. The results showed a reduction in turbidity, conductivity, total suspended solids, total dissolved solids and total solids, respectively. The snail shell chitosan decreased the biological oxygen demand and chemical oxygen demand while increasing the dissolved oxygen. The nitrate and sulphate were also reduced while phosphate was almost completely removed. It can be concluded from the results obtained that the snail shell chitosan is an effective coagulant in the treatment of waste coloured water effluent.

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Introduction

The importance of good quality water for both domestic and industrial use cannot be over emphasized (Ani *et al.*, 2011). In recent times, increased industrialization in many countries implied that there will be increased level of industrial pollution (Ugonabo *et al.*, 2012). The disposal of organic contaminants in the environment is becoming a matter of concern in view of the growing awareness of pollution problems (Patel and Vashi, 2013).

Coagulation and flocculation have been suggested to be relatively simple and cost effective (Kacha *et al.*,2003; Kim *et al.*, 2004; Oladoja and Aliu, 2008). Many methods of treating industrial effluent water have been reported (Amokrane *et al.*, 1997;Guibal and Roussy, 2007). It has been stated that flocculation and coagulation of suspended particles and colloids result from different mechanisms (Guibal and Roussy, 2007). Inorganic coagulants are used for the treatment of water turbidity because of their cost effectiveness and easier handling (Ani *et al.*, 2011). The sludge obtained from inorganic treatment (alum) poses environmental and public health challenges (Driscol and Lettermoon, 1995, Divakaran and Pillai, 2001). These challenges therefore require the search for a better environmental and health friendly natural coagulant in waste water treatment procedures. Hence, attention has shifted to chitosan, an environmental friendly bio-coagulant or bio-flocculant. Some reports have shown the use of flocculants and coagulants of biological origins such as tannins, extracts of *Moringa oleiferia* (Ndabisengesere and Narasiah, 1998), extract of plantain peelings ash (Oladoja and Aliu, 2008), and extracts of okra and Nirmali seeds (Al-Samawi and Shokralla, 1996).

Compared with traditional chemical flocculants chitosan has many advantages from different reports (Divakaran and Pillai, 2002; Ahmad *et al.*, 2006; Zeng *et al.*, 2008; Bina *et al.*, 2009). Natural chitosan is obtained from chitin that is widely distributed in marine invertebrates, insects, outer shells of crustaceans (crabs and shrimps) (Ching *et al.*,1994; Divakaran and Pillar, 2004; Renault *et al.*,2009; Bina *et al*,2009; Hesami *et al.*,2014) and snail shell which is the subject of this study.

The family of Snell that is common in Nigeria belongs to the *Achatinadae*. They are used as source of protein by many families in the Eastern part of Nigeria and the shell thrown away. The aim of the study was to determine the efficiency of chitosan obtained from snail as a flocculant/coagulant in the treatment of domestic waste coloured effluent.

Materials and methods

Snail shell preparation

The snails were bought from a local market in Markurdi Benue State, Nigeria. The snail shell was prepared as described by Oladoja and Aliu, 2008. Accordingly, the snail shells were washed in clean water and thoroughly rinsed with deionized water. It was dried in an oven at 100^{O}C and left overnight. It was ground in a wooden mortar and pestle and made into powder using a laboratory grinding machine and sieved with a laboratory sieve with known mesh size and was properly packed.

Chitin isolation

15g of the crushed shells were mixed with 2M NaOH at a solid to liquid ratio of 1:20 and heated at 100^{o}C for 6 hours with constant stirring. The mixture was then filtered and washed to neutral pH using distilled water followed by ethanol and left to dry at room temperature. The deproteinised shells were placed in 0.2M HCL overnight at a solid to liquid ratio of 1:20 with constant stirring. The obtained chitin was then decolorized overnight with 1:1 acetone/ethanol at a solid to liquid ratio 1:10. The mixture was finally filtered and dried at room temperature.

Chitosan preparation

The obtained chitin was deacetylated with 50%w/w of NaOH at a solid to liquid ratio of 1:20 at 100^{o}C for four hours. The chitosan was filtered and washed several times in distilled water and finally in ethanol to neutral pH and dried at room temperature.

Preparation of chitosan solution

0.2g of Chitosan (deacetylated chitin) was weighted into a glass beaker and mixed with 0.1M Hcl and allowed to stand for 15 minutes to dissolve. The dissolution was carried out fresh before each set of experiment using 0.4g, 0.6g, 0.8g, 1.0g, 1.2g, 1.4g, 1.6g, and 1.8g respectively.

Experimental procedure

The coloured waste water was fractionated into several beakers containing 100ml of effluents. A sample of the effluent was collected to measure the initial turbidity. Fixed volume of chitosan was added to each beaker and shaked for about 10 minutes. At the end of the shaking, the sample was kept aside for 15 minutes for sedimentation. After this period of time, a sample was collected from each of the beakers for analysis of turbidity. This was done in a UV visible spectrophotometer at wavelength of 528nm and the final turbidity of the sample was used for the comparison of coagulation//flocculation effectiveness of snail chitosan at different doses.

Physico-chemical determination

The samples were examined in the laboratory to determine some physical, chemical and biological parameter. The analysis was carried out for different water quality parameters including pH, turbidity, conductivity, temperature, total dissolved solid(TDS), total suspended solid(TSS), total solid(TS), nitrate(NO2), nitrogen (ammonium-nitrogen), phosphate, biological oxygen demand(BOD), chemical oxygen demand(COD), and dissolved oxygen (DO) using standard methods (Jayalakshmi *et al.,* 2011). The reagents used were of analytical grade and double distilled water used for preparation of solutions.

Results and discussion

The results of the effectiveness of snail chitosan aid in colour removal is represented in Fig.1. It is seen from the Figure that chitosan can efficiently remove colour. The efficiency of the removal increased from 0.2 to 1.0g/100ml dose of chitosan and subsequently decreased from 1.2 to 1.8g/100ml. The best result was obtained at 1.0g/100ml dose of chitosan which gives 78.6% removal efficiency which suggests the optimum level of chitosan to be used at such volume of the coloured effluent. It is interesting to note that the efficiency of the process was very sensitive to the amount of chitosan especially at low dose, while an excess or higher dose of chitosan had a lower impact on coagulation performance of the coloured waste water.

Table 1. Result of waste water analysis before and after treatment with chitosan solution.

Parameters	Before treatment	After treatment.
Ph	7.98	11.12
Colour	Dark brown.	Colourless
Turbidity. (NTU)	170	36.8
Temperature (^oC)	20	20
Conductivity ($Mscm^{-1}$)	2.677	0.836
Total suspended solid (Mg/l)	0.98	0.184
Total dissolved solids (Mg/l)	730.45	5.099
Total solids (Mg/l)	741.2	717.32
Nitrogen (ammonium-nitrogen)(Mg/l)	0.066	0.023
Nitrate. (Mg/l)	35.81	11.55
Sulphate. (Mg/l)	49.71	14.85
Phosphate. (Mg/l)	0.159	0.011
Biological oxygen demand. (Mg/l)	21.101	17.48
Chemical oxygen demand. (Mg/l)	695.2	187.5
Dissolved oxygen. (Mg/l)	1.08	1.49

The results in Table 1 show the physicochemical parameters of the coloured waste water effluent (CWWE) before and after treatment with snail chitosan. The results indicate that the pH of the CWWE increased from 7.98 to 11.12 after treatment. This could be because snail shell contains calcium carbonate (Oladoja and Aliu, 2009). The pH is used to measure the acidity and alkalinity in aquatic bodies. It is an important operational water quality parameters and when the value is greater than 7 will indicate that the water sample is probably hard and containing magnesium and calcium (David, 2004).

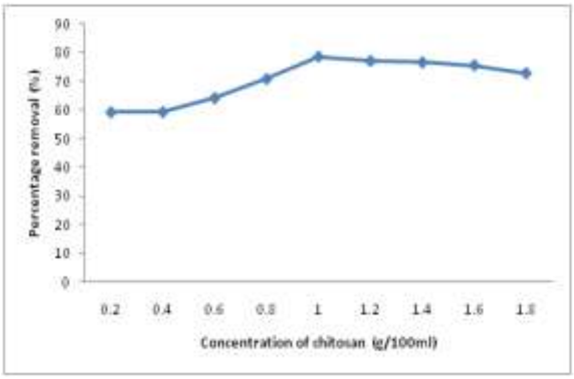

Fig. 1. Effectiveness of chitosan as a coagulant aid in colour removal.

Based on the results, the temperature was 20 °C. The temperature of water effects the chemistry and biochemical reactions in the organism (Jayalakshmi *et al.*, 2011). Waste water and waters are subject to ambient temperature and the temperature of water influences the efficiency of treatment units. It is known that during cold weather, the viscosity increases which reduces the effectiveness of settling of the solids that the water may have because of the resistance that the high viscosity offers to the downward motion of the particles as they settle (Jayalakshmi *et al.*, 2011).

The results on the electrical conductivity and turbidity show that the conductivity reduced from 2.68 to 0.84Mscm^{-1} while the turbidity reduced from 170 to 36.8 NTU after the treatment of CWWE with snail shell chitosan. The electrical conductivity of water is another important factor used in the assessment of water quality. It determines the water's ability for carrying electrical current and is directly related to the concentrations of ionized substances in the water. The total dissolved solids, organic compounds and temperature affects the electrical conductivity of water (Jayalakshmi *et al.*, 2011).

The turbidity value indicates the measure of suspended matter in water sample which include clay, silt and mud etc. The results showed that the turbidity reduced from 170 to 36.8 NTU after treatment with snail shell chitosan. The conductivity and turbidity values before treatment was an indication that the CWWE contained high amounts of dissolved and suspended particles and ions (Hanson, 1973). Although, there was a substantial reduction in turbidity, it was still above maximum permissible levels for turbidity, which vary from 0-10 NTU (WRC, 2003). Excessively turbid water could cause problems during water purification process such as filtration and flocculation. The high turbidity and conductivity values obtained from the study show that the CWWE contains high amount of dissolved and suspended particles and ions (Hanson, 1973). High turbidity in water can be associated with the possibility of microbial contamination since high turbidity makes it hard to properly disinfect water (Jayalakshmi *et al.*, 2011).

The Dissolved oxygen (DO) increased from 1.08 to 1.49 mg/l after treatment with snail shell chitosan (Table 1). The dissolved oxygen is a critical factor in assessing water quality. Dissolved oxygen helps to maintain biological life and keep proper balance of various populations, thereby making the water body healthy. An increase in the DO after treatment with snail shell chitosan is an indication of effectiveness of the snail shell chitosan in improving waste water quality. The Biological oxygen demand (BOD) decreased from 21.1 to 17.48 mg/l after treatment with snail shell chitosan. Increased organic matter results in the excess oxidation of organic matter to carbon (IV)oxide and water creates an atmosphere of oxygen depletion that will result in high BOD levels (Jayalakshmi *et al.*, 2011). Higher contents of organic load as well as proliferation of microorganisms are causative factors for maximum BOD levels (Shukla *et al.*, 1989).

The Chemical Oxygen demand (COD) also decreased from 695.2 to 187.5 mg/l after treatment with snail shell chitosan. The COD determines the oxygen needed for chemical oxidation of organic matters and the value conveys the amount of dissolved oxidisable organic matters present in it (Mahananda *et al.,* 2010). High levels of BOD and COD show the depletion of the dissolved oxygen in water system. The increase in the values of DO and decrease in the BOD and COD from this study is an indication of the improved quality of the CWWE after treatment with snail shell chitosan. The results showed that there were substantial reductions in the total dissolved solids (TDS), total suspended solids (TSS), and total solids (TS) of the CWWE after treatment with snail shell chitosan in comparison to values before treatment. Water with high suspended solid may be aesthetically unsatisfactory for bathing (APHA, 1998). In water the TSS and TDS are made up of carbonates, bicarbonates, chlorides, phosphate and nitrates of calcium, manganese, organic matter, salt and other particles. The effect of the presence of TSS is the turbidity due to silt and organic matter (Mahananda *et al.*, 2010).

The treatment of CWWE with snail shell chitosan resulted in the reduction of the nitrate, sulphate and phosphate ions levels. Nitrates represent the final product of the oxidation of ammonia and its monitoring in drinking water supply is very important because of health effects on humans and animals. Phosphate has been shown to occur in natural water in low quantity as many aquatic plants absorb and store phosphorus many times their actual immediate needs (Mahananda *et al.*, 2010). High levels of both phosphate and nitrates can lead to eutrophication which increases algal growth and ultimately reduces dissolved oxygen in the water (Murdoch *et al.*, 2001). The level of sulphates can be increased through industrial contamination and aluminum sulphates used in water purification processes. Higher sulphate levels present in drainage water causes laxative effects and diarrhea (Guru, 2003).

Conclusion

The results from the study is an indication that snail shell chitosan is an effective coagulant in the treatment of waste coloured water effuluent.

References

Ahmad AL, Sumathi S, Hameed BH. 2006. Coagulation of residue oil and suspended solid in polar oil mill effuluent by chitosan, alum and PAC. Chemical Engineering Journal **118**, 99-105.

Al-Samawi AA, Shokralla EM. 1996. An investigation into an indigenous natural coagulant. Journal of Environmental Science and Health **A31,** 1881-1897.

American Public Health Association (ALPH). 1989. Standard method for examination of water and waste water. 20th edition, Washington DC.

Amokrane A, Comel C, Veron J. 1997. Landfill leachates pre-treatment by coagulation flocculation. Water Research **31,** 2775-2782.

Ani JU, menkiti MC, Onukwuli OD. 2011. Coagulation-flocculation performance of snail shell biomass for waste water purification. New York Science Journal **4(2),** 81-89.

Bina B, Mehdinajad MH, Nikaeen M, Attar, HM. 2009. Effectiveness of chitosan as natural coagulant aid in treatinf turbid waters. Iran Environmental Health Science and Engineering **6,** 247-252.

Ching H, Tanaka TS, Elimelec M. 1994. Dynamics of coagulation of kaolin particles with ferric chloride. Water Research **28,** 559-569.

David C. 2004. Snail water supplies. Cromwell

Press. Trowbridge, Wiltshire. India.

Divakaran R, Pillai VNS. 2001. Flocculation of kaolinite suspension water by chitosan. Water Research **35,** 3904-3908.

Divakaran R Pillai VN. 2004. Mechanism of kaolinite and titanium dioxide flocculation using chitosan-assistance by fulvic acid? Water Research **38,** 2135-2143.

Divakaran R, Pillai VN. 2002. Flocculation of river silt using chitosan. Water Research **36,** 2414-2418.

Driscol CT, Lettermon RD. 1995. Factors regulating residual aluminium concentrations in treated waters. Environmetrics **6,** 287-309.

Guibal, E, Roussy J. 2007. Coagulation and flocculation of dye-containing solutions using a biopolymer (chitosn). Reactive and Functional Polymers **67,** 33-42.

Guru Prasa B. 2003. Physic-chemical and bacteriological quality of ground water at Tadepalli Mandal of Guntur District, Andhra Pradesh. Nature Environment and Pollution Technology **2,** 173-178.

Hanson NW. 1973. Official standardized and recommended methods of analysis: The Society of Analytical Chemistry London. 80-82.

Hesami F, Bina B, Ebrahimi A. 2014. The effectiveness of chitosan as coagulant aid in turbidity removal from water. International Journal of Environmental Health Engineering **3(8),** 46-51.

Jayalakshmi V, lakshmi N, Singgara Charya MA. 2011. Assessment of physic-chemical parameters of water and waste water in and around Vijayawada. International Journal of Research in Pharmaceutical and Biomedical Sciences **2(3),** 1041-1045.

Kacha S, Derriche Z, Elmaleh S. 2003. Equilibrium and kinetics of colour removal from dye solution with bentonite and polyaluminium hydroxide. Water Environment Research **75(1),** 15-20.

Kim TH, Park E., Shin EB, Kim S. 2004. Decolorisation of disperse and reactive dye solutions using ferric chloride, Desalination **161(1),** 49-58.

Mahananda MR, Mohanty BP, Behera NR. 2010. Physic-chemical characteristics of surface and ground water of Bargarh district, Orissa, india. International Journal of Research and Reviews in Applied Sciences **2(3),** 284-295.

Murdoch T, Cheo M, Laughlin OK. 2001. Stream keeper's Field guide: Watershed Iventory and Stream monitoring methods. Adopt-A-Stream foundation W.A.

Ndabingesere A, Narasiah KS. 1998. Quality of water treated by coagulation using *Moringa oleifera* seeds. Water Research **32**, 781-791.

Oladoja NA, Aliu YD. 2008. Evaluation of plantain peeling ash extract as coagulant of colloidal particle in low pH aqua system. Water Quality Research Journal, Canada **43(2/3),** 231-238.

Ozacar MS, Sengil IA. 2000. Effectiveness of tannins obtained from Valona as a coagulant aid for dewatering of sludge. Water Research **34(4),** 1407-1412.

Patel H, Vashi RT. 2013. Comparison of naturally prepared coagulants for removal of COD and color from textile waste water. Global NEST Journal **4,** 522-528.

Renault F, Sancey B, Badot PM, Crini G. 2009. Chitosan for coagulation/flocculation processes-An eco-friendly approach. European Polymer Journal **45,** 1337-1348.

Shukla GS, kant R, Tripathi BD. 1989. Ecological investigation of physic-chemical characteristics of phytoplankton productivity of river Ganga at Varanasi. Geobios **16,** 20-27.

Ugonabo VI, Menkiti MC, Onukwuli OD. 2012. Kinetics and coagulation performance of snail shell biomass in pharmaceutical effluent. IOSR Journal of Engineering **2(7),** 38-49.

Water Resource Commission (WRC). 2003. Water Resources management problems. Identification, analysis and prioritization study. CSIR-Water Research Institute, Accra Ghana.

Zeng D, Wu J, Kennedy JF. 2008. Application of a chitosan flocculant to water treatment. Carbohydrate Polymer **71,** 135-139.