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FULL LENGTH ARTICLE

Extraction of chitosan, characterisation and its use for water purification

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Abstract This study was carried out in the Food Science Department, Agriculture College, Basrah University to investigate the effect of different chitosan concentrations on drinking water quality. The studied parameters were turbidity, TDS, electrical conductivity and pH. The results showed that the turbidity, TDS, electrical conductivity and pH have been decreased with the increase of chitosan concentration. When chitosan concentration increased from 0 to 1 g 100 ml^{-1}, the turbidity, TDS, electrical conductivity and pH were decreased from 1.98 to 0.98 NTU, 5.67 to 4.13 g L^{-1}, 10.18 to 5.27 mS cm^{-1}, 6.1 to 5.71 respectively. The linear equations have represented the relationship between all parameters and chitosan concentration. However, the total bacteria count, total coliform bacteria, *Staphylococci*, Fecal coliform bacteria and *Vibrio* spp. have been eliminated completely by using Chitosan concentration of 0.8, 0.4, 0.8, 0.2 and 0.2 g 100 ml^{-1} respectively.

1. Introduction

World Health Organization (WHO) (2007) announced that 1.1 billion people lack access to an improved drinking water supply, 88% of the 4 billion annual cases of diarrheal disease are attributed to unsafe water and inadequate sanitation and hygiene, and 1.8 million people die from diarrhoeal diseases each year (Piyali, 2013). The adsorption process has also received much attention and has become one of the more popular methods for the removal of heavy metal ions and microbial contaminants from water, because of its competitive and effective process. Numerous adsorbents have been reported for the removal of toxic metal ions, such as chitin, Chitosan, cellulose and Guarana, which are not only eco-friendly and cost effective but are also effective in the remediation of common effluents present in wastewater (Chooaksorn and Nitisoravut, 2015). Water purification plants throughout the world use chitosan to remove oils, grease, heavy metals and the fine particulate matter that cause turbidity in waste water streams (Hennen, 1996).

Chitosan is a biomaterial, primarily produced from the alkaline deacetylation (40–50% NaOH) of chitin where this N-deacetylation is almost never complete. The chitosan is considered as a partially N-deacetylated derivative of chitin. It is an abundant natural biopolymer obtained from the exoskeletons of crustaceans and arthropods which is a non toxic copolymer consisting of β-(1,4)-2-acetamido-2-deoxy-D-glucose and β-(1,4)-2-anaino-2-deoxy-D-glucose units. Each

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glucosamine unit contains a free amino group, and these groups can take on a positive charge which gives amazing properties of chitosan, its useful in a wide application in various industries such as pharmaceuticals, biochemistry, biotechnology, cosmetic, biomedical, paper industry, food and textile industries and others (Muzzarelli, 1985). These biopolymers offer a wide range of unique applications including bioconversion for the production of value-added food products, preservation of foods from microbial deterioration, formation of biodegradable films, recovery of waste material from food processing discards, purification of water and clarification and de-acidification of fruit juices (Shahidi et al., 1999; Abd and Niamah, 2012; Luo and Wang, 2013).

Access to safe drinking water is important as a health and development issue at national, regional and local levels; therefore, the present investigation was carried out to study the effectiveness of Chitosan for improving the quality of drinking water by the removal of metal contents and microbial contaminants.

2. Material and method

2.1. Samples collection

The raw water was obtained from the Shatt al-Arab River at Basrah city in Iraq. The shrimp (*Penaeus semisulcatus*) shells were purchased from local markets and used for the isolation of Chitosan.

2.2. Preparation of Chitosan solution

At the preconditioning stage, shrimp shells were washed thoroughly with water and dried to remove excess water. Then dried shells were demineralized using 1N HCL (1:15 w/v) at ambient temperature (approximately 30 °C) for 6 h. The residue was washed with distilled water until pH reached to 6.5–7 then the residue was dried.

After that the demineralized shrimp shells were deproteinized using 3.5% NaOH solution (1:10 w/v) at 65 °C for 2 h and Decoloration was done with NaOCl (0.315%). Then residue was washed thoroughly with water, followed by distilled water until the pH reached in the range of 6.5–7.5. The chitin was dried and ground and screened. The chitin obtained from the above process was deacetylated in 50% NaOH (1:10 w/v) for 5 h at 100 °C. After deacetylation, the chitosan was washed thoroughly with water, followed by distilled water even the pH reached between at 6.5 and 7.5 (Ocloo et al., 2011).

Chitosan powder (0–1 g) was accurately weighed into a glass beaker, mixed with 5 ml of 1% acetic acid solution (in the same of water sample), and kept aside for about 30 min to dissolve. It was then diluted to 100 ml with distilled water and stirred for 1 h at 25 °C. Six samples of 100 ml raw water were placed into six beakers (250 ml), and different concentrations of chitosan (0, 0.2, 0.4, 0.6, 0.8 and 1 g 100 ml^{-1} water) were added under stirring (100 rpm).

2.3. Chemical analysis of chitosan

The different chemical and functional properties were measured as per the standard methods, Moisture content was determined by the standard method, and Moisture of samples was determined by drying the samples at 60 °C for 24 h or until the weights were constant. It was then calculated by percentage of weight loss compared to the initial weight of the samples. Yield was determined by comparing weight measurements of the raw material and of the chitosan obtained after treatment. Ash content determination was performed by transferring the samples into a muffle furnace at 550 °C until it turned white and free of carbon. The sample was then removed from the furnace, cooled in a desiccator to a room temperature and reweighed immediately. The weight of the residual ash was then calculated by nitrogen contents (micro Kjeldahl method) and fat (Accurately weighed moisture free sample was taken in a thimble plugged with cotton and extracted with petroleum ether in a Soxhlet apparatus for about 10 h at a condensation rate of 5–6 drops per second.) of chitosan were measured according to a previously described procedure (AOAC, 1990).

2.4. Water quality parameters

2.4.1. Chemical tests

- pH was measured by using pH meter (Sartorius/Germany) with combined glass electrode after calibrated by using buffer solutions of pH 4.0 and pH 7.0 (AOAC, 1990).
- Electrical Conductivity (EC) and Total dissolved solids (TDS) were determined using 4510 conductivity meter (Jenway) (Hp Technical Assistance, 1999).
- Turbidity was measured using Turbidimeter (a Lovibond, TurbiDirect) the sample of which was filled into a sample cell and put into the cell holder for measurement (APHA, 2005).

2.4.2. Microbial tests

- Peptone water: 1 g peptone dissolved in 1000 ml distilled water and used to dilute the water samples (APHA, 2005).
- Alkaline Peptone Water: Alkaline peptone water was used as an enrichment medium in the isolation of *Vibrio* spp. isolation weighing 15 g peptone, 10 g sodium chloride and 20 g sodium citrate dissolved in 1000 ml distilled water, final pH: 8.6 (Lesmana et al., 1985).
- Culture media: Nutrient agar (Hi-media, India) for total aerobic bacteria count. MacConkey agar (Hi-media, India) for total coliform bacteria count. Eosin methylene blue agar (Oxoid, England) for fecal coliform bacteria count, Thiosulfate citrate bile salt agar (LAB, UK) for *Vibrio* spp. count, and Mannitol salt agar (Hi-media, India) for Staphylococci count (Barrow and Feltham, 2003).
- Numbers of bacteria count: Pour plate method was used to number the bacteria count. 1 ml of last dilutions transferred into a Petri dish and culture media poured after that incubation at 35 °C for 24–48 h (Harley and Prescott, 2002).

3. Results and discussion

The chemical composition of prepared chitosan from shrimp shells with yield reached 12.93% which, was lower than that reported by Hossain and Iqbal (2014) who reported 15.40% yield from shrimp waste. This reduction might be due to

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