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Ground water nitrate removal by using 'Chitosan' as an adsorbent

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ABSTRACT: *Environmental pollution is the most terrible ecological crisis to which we are subjected today. Today the environment has become foul, contaminated, undesirable, and therefore harmful for the health of living organisms, including man. The most common contaminant identified in ground water is dissolved nitrogen in the form of Nitrate (NO_3).Decomposition of organic matter present in soils leaching, of soluble fertilizers, human and animal excreta are the source of nitrate in subsurface waters. This research work is for to find preventive measures to avoid the nitrate pollution. This paper explains suitability of naturally available adsorbent i.e. 'Chitosan' for removal of nitrates from water is studied. The work is for the use of Chitosan in the different forms and concentrations to achieve the task.*

Keywords: *Adsorption, Chitosan, Ground water, Nitrates, pH*

I. INTRODUCTION

Water is a common chemical substance that is essential for the survival of all known forms of life. About 97% of earth's water is saline and is contained in oceans. Reaming 3% is fresh water. About 68.7% of fresh water is trapped in the ice caps and glaciers, while 30.1 % of fresh water exists in the form of groundwater, 0.3 %in surface water and 0.9% in other form.

Nitrate is a chemical, like salt. We get nitrate in food and in water. Usually, water is a fairly minor source of nitrate. However, sometimes water has high levels of nitrate - then it is a significant source. Nitrates are naturally present in many foods like carrots and spinach. Nitrate (NO_3^-) is a water-soluble molecule made up of nitrogen and oxygen. It is formed when nitrogen from ammonia or other sources combines with oxygenated water. Nitrate is a natural constituent of plants and is found in vegetables at varying levels depending on the amount of fertilizer applied and on other growing conditions. According to the World Health Organization, most adults ingest 20-70 milligrams of nitrate- nitrogen per day with most of this coming from foods like lettuce, celery, beets, and spinach. When foods containing nitrate are eaten as part of a balanced diet the nitrate exposure is not thought to be harmful.

Nitrate is formed when nitrogen from ammonia or other sources combines with oxygenated water. Nitrate is a natural constituent of plants and is found in vegetables at varying levels depending on the amount of fertilizer applied and on other growing conditions.

1.1 Sources of Nitrates Pollution in Groundwater:

Cultivation in areas where the soil layer is relatively thin, or has poor nutrient buffering capacity, or where there are changes in land use;

- Over fertilization of crop for intensification of agricultural activity;
- Spread cultivation of crops which require high fertilizes doses and which leave the soil bare over long periods (maize, tobacco and vegetables);
- Drainage systems which lead to drainage of fertilizers;
- Intensive agricultural rotation cycles involving frequent plugging and extensive areas of bare soils during winters;
- Organic fertilizers form animal husbandry;
- Increased urbanization.

1.2 Problems Associated With High Nitrate Levels:

If the level is 10 mg/l or higher do not use the water to feed your baby. Infants who are fed water that is high in nitrate can develop a condition that doctors call methamoglobinemia. The condition is also called "blue baby syndrome" because the skin appears blue-gray or lavender in color. Although many studies have been performed attempting to link stomach and gastrointestinal cancer due to nitrate intake

II. OBJECTIVE OF THE STUDY

1) To investigate the groundwater pollution status in the study area.
2) To study the suitability of water for domestic use.
3) To study the suitability of different forms chitosan as an adsorbent for removal of nitrates.

III. METHODOLOGY

3.1 Sample Collection:

The region we selected is having mixed cultures of irrigation and cropping pattern. Also the area is having industries and the fields around the disposing area are irrigated by the wells which are being contaminated. Also some areas are irrigated by the river water was also selected for the nitrate concentration.

About 130 water samples of groundwater from areas over the agricultural belt in Sangamner taluka region of Ahmednagar District, Maharashtra were randomly collected over the period of six months. All samples were collected in 1 lit polythene bottles and carried to the laboratory for analysis.

3.2 Methods of Nitrate Determination:

1) Spectrophotometer
2) IS code method
3) Nitrates kit

In this experimental work Spectrophotometer method was used for determination of nitrate concentration in groundwater samples collected.

3.3 Methods for Nitrate Removal from Water:

There are various methods and materials with the help of with nitrate can be removed from water. There are two options for achieving safe nitrate levels. First of all there are non-treatment techniques that consist of blending drinking waters, or changing water sources. The second alternative is the use of treatment processes, such as ion exchange, reverse osmosis, biological de-nitrification and chemical reduction to actually remove portions of the pollutant.

These are following various treatment processes for removal of nitrate:

- Nitrate removal from water using conifer tissues.
- Removal of nitrates and ammonium ions from water using natural sorbent as zeolite (clinoptilolite).
- The removal of nitrate from water by chitosan.(proposed)

However, among the treatment process listed above we have used chitosan as an adsorbent in powder and liquid form for removal of nitrate from source water.

3.3.1 Chitosan:

Chitin and chitosan are nitrogenous polysaccharides that are made up of acetyl glucosamine and glucosamine units. In fact, these two polymers have exactly the same basic chemical structure: (1→4)-2-acetamido-2-deoxy-β-D-glucan and(1→4)-2-amino-2-deoxy-β-D-glucan, respectively. The chemical structure of chitosan is shown in fig. no.1. The difference between them is the deacetylation degree (DD) and their respective solubility in dilute acidic media. Sorlier et al., (2001) considered that chitosan is the only derivative to be soluble at a DD above 40%. Chitosan is a biodegradable, nontoxic extract from shellfish shells used in a variety of water purification applications. Chitosan is derived from chitin (pronounced ky-tin), nature's second most abundant biopolymer and primary constituent of shellfish shells, insect exoskeletons, and fungi cell walls. Chitosan is so safe that it is used in commercial aquariums to clarify the water in the aquarium exhibits and it is also used to clarify public pools and spas. In addition to its safety record, the secret of its success is the way in which it interacts with sediment particles. Chitosan creates a fibrous web linking sediment particles together in a three-dimensional matrix. When this matrix enters a sand filter it is caught in the sand but allows the water through, but other polymers and coagulants form a gelatinous flock that rapidly clogs filters. Chitosan allows extremely long filtration cycles at sediment loading rates that are well above industry standards. Characteristics of Chitosan are shown in table no.1.

IV. EXPERIMENTAL WORK & ANALYSIS

This experimental research work is within two phase by using chitosan in powder and liquid form for removal of nitrate.

Phase 1: Removal of nitrates using chitosan in the powder form:

The feasibility of removal of nitrates by chitosan was tested by using chitosan in the powder form. 0.5, 1 and 1.5 g of chitosan powder was added separately to 250 ml sample of groundwater. Graph No.1 shows change in nitrate level with varying dosage of chitosan in powder form.

This suggests that chitosan is an efficient disinfectant in its native form (powder). There was no change in the fluoride concentration after treating the groundwater sample with chitosan in powder form. The other observation was that, the use of chitosan in powder form imparted turbidity to the treated water.

Phase 2: Removal of nitrates using chitosan in solution form:

In phase-2, chitosan was used in solution form. 3% acetic acid solution was prepared by diluting 3ml of acetic acid to 100 ml with distilled water. Desired quantity of Chitosan powder was then weighed and dissolved in this acetic acid solution to obtain chitosan solution. Two sets of chitosan solution were prepared. One set was prepared by dissolving 0.01g of chitosan and the other, by dissolving 0.05g of chitosan powder. Chitosan dissolved completely to give a colourless solution. The chitosan solutions were then used in different volumes. 1ml, 5ml and 10ml of the two chitosan solutions were added separately to every 250ml of the groundwater sample. Graph No.2 shows change in nitrate level with varying dosage of chitosan solution.

A significant reduction in the nitrate nitrogen concentration was observed. The use of chitosan in solution showed better results in comparison to the use of the same in powder form. Another important observation was that there was no significant increase in turbidity. The treated solution was rather clear. But there was a reduction in pH of the treated water with an increase in the chitosan solution dosage. A pH of 5.27 was obtained the least, obtained with 10ml of chitosan solution.

The chitosan solution containing 0.05g of chitosan was also found to give good results. There were significant reductions in the concentration of nitrates. The pH dropped to 5.31 in the water sample treated with 10ml of chitosan solution.

V. CONCLUSIONS

1. The use of chitosan in powder form, to treat water, showed positive results. Nitrate removal was significant. But, chitosan powder rendered the water turbid which may be aesthetically objectionable. It showed better results in the lowest concentration used i.e. 0.5g/250ml sample.
2. Use of chitosan in solution form showed better results in comparison with the performance of the same in powder form. The quantity of chitosan powder consumed was meager and therefore economically more feasible.
3. Chitosan in solution was found to remove hardness and chlorides and there were significant reductions in nitrate and fluoride concentrations. Disinfection efficiency was 99.5%.
4. Unlike in the powder form, the solution form did not impart turbidity to the treated water but there was a steep decrease in the pH with an increase in the chitosan solution dosage.

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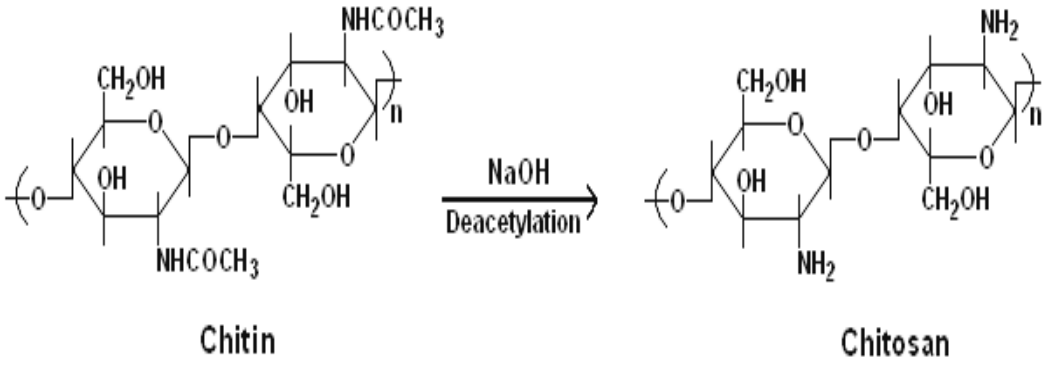
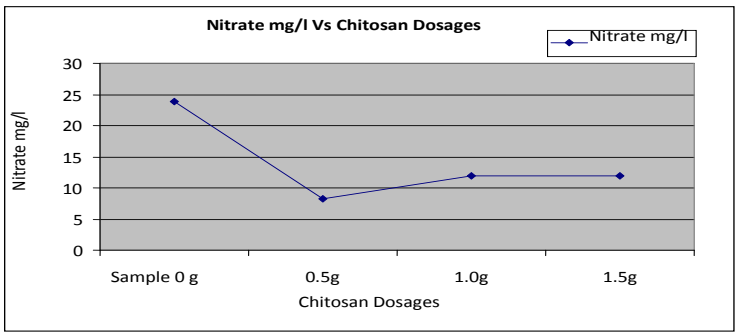


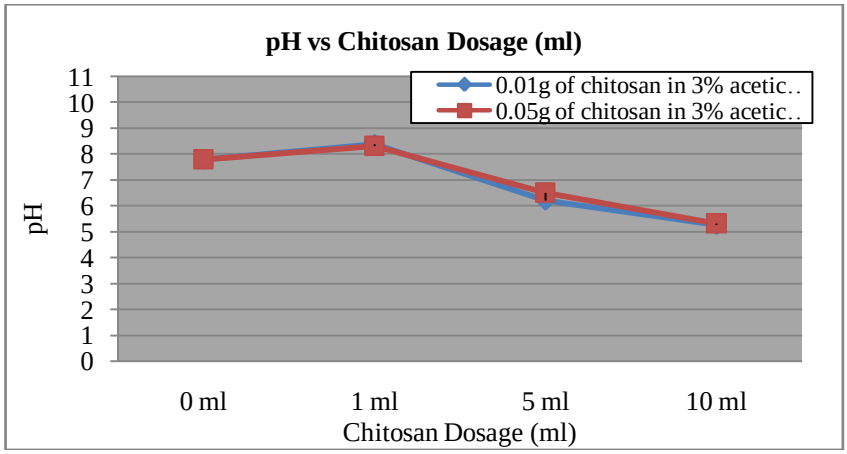
Fig No.1 Scheme of Chemical Deactivation of Chitin to Produce Chitosan

Table No.1-Characteristics of Chitosan

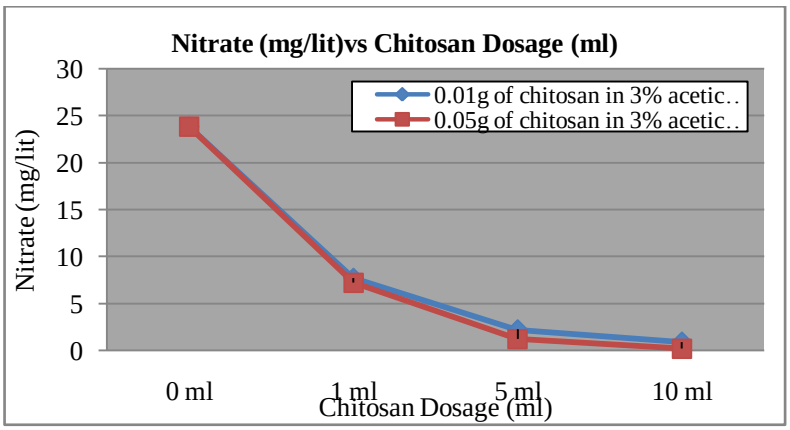
Item	Characteristic
1. Appearance	Yellowish
2. particle size	Mesh no.60
3. ash content	0.83%
4. moisture content	8.5%
5. deacetylation degree(%DAC)	86%
6. Solution(1% in 1% acetic acid)	
Insoluble	0.59%
Viscosity	152 cps
7. Heavy metals	0 ppm
Total Plate count	50
Yeast and Mould	20
E.coli	Nil
Salmonelia	Nil



Graph 1 Profile of nitrate Vs Chitosan dosage



Graph 2 Profile of pH versus Chitosan Dosage in solution form (Phase- 2).



Graph 3 Profile of Nitrate versus Chitosan Dosage in solution form (Phase- 2).