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Evaluation of Chitosan Adsorbent Efficiency in Nitrate Removal from Aqueous Solutions and the Effect of Parameters on Adsorption Process

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Abstract
Human societies to the acceleration of urbanization, industrialization and development of agricultural activities have led to the release of environmental pollutants. Due to the high solubility of nitrate, this compound easily penetrates into the soil and then underground aquifers. Surface waters such as lakes, reservoirs and rivers are also exposed to nitrate pollution resulting from these sources.
This applied experimental study was conducted to evaluate the nitrate removal using chitosan as the adsorbent in the same operating conditions and ambient temperature. The study variables included pH (2,4,6,8,10), adsorbent dosage(0.5,2,4,6,8,10 g/l), initial nitrate concentration(25,50,100,200,300,400,500 mg/l) and contact time 5,10,20,40,60,80,100,120 min**.** The results of the test showed that the time had the highest removal percentage. The present study shows that increasing the amount of adsorbent is one of the effective parameters in increasing the absorption efficiency, because by increasing the amount of adsorbent, the exchangeable surface available for absorbing the equilibrium available to the absorbent substance increases.
Keywords: *Chitosan, Adsorbent, Nitrate, Aqueous Solutions*

1. Introduction

Human societies to the acceleration of urbanization, industrialization and development of agricultural activities have led to the release of environmental pollutants. Nitrate and nitrite ions are an important part of the natural nitrogen cycle [1]. Although nitrates are naturally present in drinking water, large amounts of them are introduced into groundwater resources usually resulting from human activities, such as urban and industrial waste discharges, unprogrammed waste landfills, onsite wastewater treatment systems, runoff or groundwater related to agricultural land that uses fertilizers or animal manure to increase fertility, flood drainage and pastures [2]. Due to the high solubility of nitrate, this compound easily penetrates into the soil and then underground aquifers. Surface waters such as lakes, reservoirs and rivers are also exposed to nitrate pollution resulting from these sources. In the regions with low rainfall and poor vegetation, the water pollution with nitrates is exacerbated [3]. Nitrogen compounds are among the pollutants that enter the environment due to environmental contamination and cause problems such as eutrophication of lakes, water quality degradation and adverse effects on the health of humans and animals [4]. The first health concern about nitrates can be observed for infants under the age of 6 months. The nitrate in drinking water results in developing methemoglobinemia among the infants [5]. In addition to the health problems associated with methemoglobinemia, excess nitrate concentrations in drinking water should be removed due to their role in blood pressure, increased child mortality, gastric cancer, thyroid disorders, cytogenetic defects, birth defects and goiter [6]. The maximum allowable concentration for nitrate in drinking water is 45 mg/l while 10 mg/l in many developed countries such as the USA, 10 mg/l in Canada and 11/3 mg/l in the European Union [7].

It is difficult to remove the nitrate ions from the water using conventional chemical coagulation and absorption processes because of its high stability and solubility. Due to the adverse effects of this pollutant, various methods are used to remove, including chemical denitrification, biological denitrification, adsorption, membrane processes such as reverse osmosis, Nano filtration, electro dialysis, ion exchange and electrochemical methods [8]. There are several disadvantages for some of these processes to remove nitrate from water. For example, the reverse osmosis and ion exchange processes do not selectively eliminate nitrate and require the continuous regeneration of the environment. These two processes do not change the chemical form in nitrate and eventually pollutant waste is produced [9]. The process of biological denitrification occurs often on sewage and is undesirable in the process of water treatment due to the need for organic substrate and also the high maintenance of the system. In addition, the resulting biological sludge needs to be treated and removed [10].

In general, the aforementioned methods are costly economically, while also having side effects on the water. At the present, the adsorption process has attracted further attention as the best approach to remove nitrate due to its low cost, simplicity and easy handling (1, 9). In this regard, many studies have been done in the world to replace the inexpensive adsorbents that have been useful in some cases and can compete with resins. Chitosan is one of the polymeric absorbents obtained from marine crustacean shells. Chitin and chitosan polymers are natural amino-polysaccharides that have a unique structure, complex functions and extensive applications in biotechnology and industrial areas [10]. Its positive features, such as excellent biocompatibility, biodegradability, environmental safety, low toxicity and antimicrobial properties have led to increasing attention to these compounds for environmental application. On the other hand, the chitosan has a low solubility due to the presence of hydrogen bonds with a quasi-crystalline structure, which is considered as its other advantages [11]. Therefore, the purpose of this study was to investigate the efficiency of adsorption method using the chitosan as an adsorbent in removing nitrate from aqueous solutions and determining the effect of different parameters.

2. Methods and material

This applied experimental study was conducted to evaluate the nitrate removal using chitosan as the adsorbent in the same operating conditions and ambient temperature. The study variables included pH, adsorbent dosage, initial nitrate concentration and contact time. The constant variables were temperature and shaker rate. The optimal conditions for all three adsorbents were determined by keeping the variable constant and altering other variables. After detecting the optimal conditions for each variable, the tests were continued based on the optimal variable conditions. To evaluate the chitosan efficiency using urban drinking water, the nitrates with different concentrations were added to the samples. The pH was adjusted y 1-0.1M HCl or NaOH. At first, pH was considered to be variable and adsorbent dosage, initial nitrate concentration and contact time were constant. Using this method, the PH was in the range of 2-10 and the adsorbent dosage in the range of 0.5-10 g/l, the contact time in the range of 5-120 minutes and the initial nitrate concentration in the range of 25-500 mg/l. All experiments were carried out using a DR 5000 apparatus at a wavelength of 220 nm. The tests were performed with at least two replicates to reduce errors and increase accuracy. Finally, the data was averaged. Excel software was applied to examine the relationship between the data obtained. The range of variables is as follows. The variables are as follows:

Range of variations of pH is: 2, 4, 6, 8, 10

Range of variations of Absorbent dose (g/L) = 0.5, 2, 4, 6, 8, 10

Range of variations of Contact time (min) = 5, 10, 20, 40, 60, 8, 100, 120

Range of variations of Concentration of nitrate (mg/l) = 25, 50, 100, 200, 300, 400, 500

The optimal conditions are as follows:

(A) The nitrate removal efficiency was determined in the pH range of 2 to 10, the constant adsorbent dosage of 2 g/l, and the contact time of 10 minutes and the initial nitrate concentration of 50 mg/l. At this stage, the optimal pH was measured for each absorbent.

B) The nitrate removal efficiency at the optimal pH value determined from the previous step was obtained in the variable contact time range of 5 to 120 minutes, the constant adsorbent dosage of 2 g/l, and the initial nitrate concentration of 50 mg/l. At this stage, the optimal contact time was measured for each absorbent.

C) The nitrate removal efficiency at the optimal pH and contact time determined from the previous steps was achieved in the variable adsorbent dosage of 0.5 to 10 g/l and the initial nitrate concentration of 50 mg/l. At this stage, the optimal adsorbent dosage was measured for each absorbent.

D) Under optimal conditions of pH, contact time and adsorbent dosage, the nitrate removal efficiency was determined at the initial nitrate concentrations of 25 to 500 mg/l.

Initially, the pH was varied and the adsorbent dosage, the contact time and initial nitrate concentration were kept constant and 50 mg of sodium nitrate reach the final volume.

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3. Figures

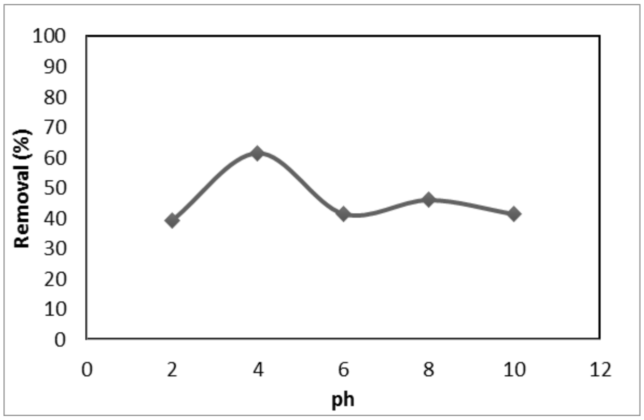

Fig1- Effect of pH on chitosan adsorption capacity in nitrate pollutant removal

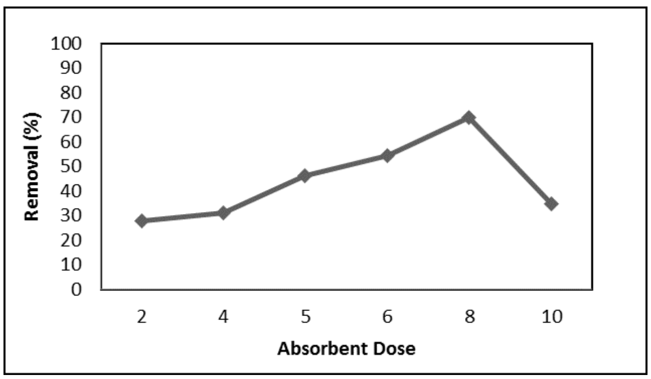

Fig 2- Effect of Adsorbent on Chitosan Absorption Capacity in Removal of Nitrate

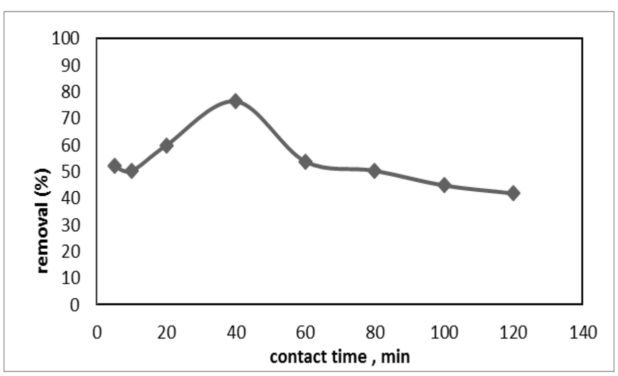

Fig3- The effect of contact time on chitosan absorption capacity in nitrate contaminant removal

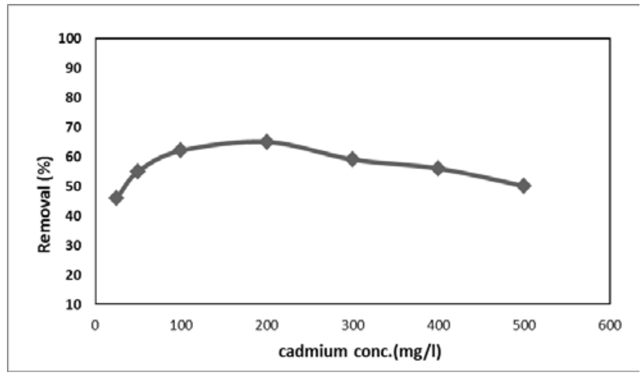

Fig4- Effect of Nitrate Concentration on Chitosan Absorption Capacity in Removal of Nitrate Pollutants

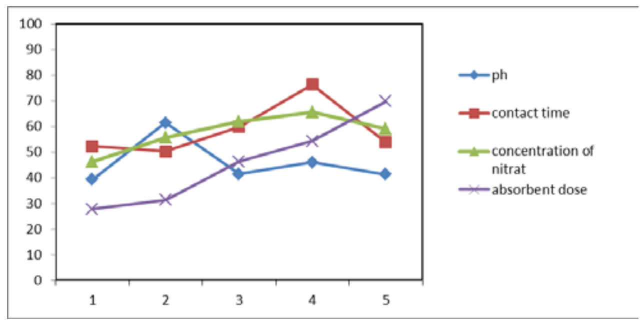

Fig5- The effect of the parameters on each other

4. Conclusions

Figure 1 shows the effect of pH on the absorption capacity of chitosan in the removal of nitrate pollutants. The results show that the nitrate removal efficiency was decreased with increasing pH and the highest nitrate removal efficiency occurred at pH value of 4, indicating the high efficiency of chitosan adsorbent in the removal of nitrate in acidic solutions compared to alkaline conditions. Figure 2 represents the effect of adsorbent dosage on chitosan absorption capacity in removing the nitrate. As shown in Figure 2, the nitrate removal efficiency increases with elevating the absorbent dosage. Figure 3 exhibits the effect of contact time on the chitosan absorption capacity in the nitrate removal. According to Figure 3, following the prolongation of the contact time, the nitrate removal efficiency increases until the contact time of 40 minutes and decreases after this time. The most effective removal occurred during the contact time of 40 minutes. Figure 4 shows the effect of initial nitrate concentration on the chitosan absorption capacity in the removal of nitrate. With regard to Figure 4, an increase in the initial nitrate concentration causes high absorption capacity. In general, the results indicate that the chitosan efficiency in synthetic aqueous solutions at optimal pH of 4, the contact time of 40 minutes and increased initial nitrate concentration causes an increase in the absorption capacity. The nitrate removal efficiency using the chitosan adsorbent is 81%. Moreover, the optimal absorbent dosage was 0.8 g/l. The comparison of the results of the present study with similar studies demonstrates that pH has a significant effect on the absorption process. In a research by Noori Sepehri [12] achieved similar results. In addition, the highest adsorption capacity at pH = 4 was 61.48%. With increasing pH, the nitrate removal efficiency using the chitosan decreased and reached 40% from 61%. The results are in line with the previous studies so that the findings have shown that the nitrate removal efficiency using the chitosan increased by decreasing pH. This is due to an increase in electrostatic collisions between negatively charged nitrate ions and positively charged amine groups [13]. Time plays an important role in advancing the reaction. The obtained experimental results revealed that the contact time prolonged to 40 minutes, caused an increase in the nitrate removal and then decreases, indicating the equilibrium time; as the nitrate removal efficiency was 76.44% in the contact time of 40 minutes and pH of 4. The changes were negligible at next contact times. The present study suggests that increasing adsorbent dosage is one of the parameters effective in improving the absorption efficiency because the increased adsorbent dosage promoted the exchange surface area available to adsorbate for equilibrium adsorption [14]. Figure 5 shows the effect of parameters on each other. This figure shows that contact time has the greatest effect on nitrite removal.

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References

[1] K Cantor. Drinking water and cancer Cancer Causes Control. 1997; 8(3): 292–308.

[2] Schick J, Caullet P, Paillaud JL, Patarin J and Mangold-Callarec C. Batch-wise nitrate removal from water on a surfactant-modified zeolite. Microporous and Mesoporous Materials. 2010; 132: 395-400.

[3] Sooknah RD and Wilkie AC. Nutrient removal by floating aquatic macrophytes cultured in anaerobically digested flushed dairy manure wastewater. Ecological Engineering. 2004; 22: 27-42.

[4] Van-Maanen JM, Van-Dijk A, Mulder K, De-Baets MH, Menheere PC, Van-Der Heide D, Mertens PL and Kleinjans JC. Consumption of drinking water with high nitrate levels causes hypertrophy of the thyroid. Toxicology letters. 1994; 72: 365-374.

[5] Li J, Li Y and Meng Q. Removal of nitrate by zero-valent iron and pillared bentonite. Journal of hazardous materials. 2010; 174: 188-193.

[6] Malberg J, Savage E and Osteryoung J. Nitrates in drinking water and the early onset of hypertension. Environmental Pollution. 1978; 15: 155-160.

[7] Kawamura S. 2000. Integrated design and operation of water treatment facilities, John Wiley & Sons.

[8] Pintar A, Batista J and Levec J. Integrated ion exchange/catalytic process for efficient removal of nitrates from drinking water. Chemical engineering science. 2001; 56: 1551-1559.

[9] Rao EP and Puttanna K. Nitrates, agriculture and environment. Current Science. 2000; 79(9):1163-1168.

[10] Dorsch MM, Scragg RK, Mcmichael AJ, Baghurst PA and Dyer KF. Congenital malformations and maternal drinking water supply in rural South Australia: a case-control study. American Journal of Epidemiology. 1984; 119: 473-486.

[11] Seffner W. Natural water contents and endemic goiter--a review. Zentralblatt fur Hygiene and Umweltmedizin= International journal of hygiene and environmental medicine. 1995; 196: 381-398.

[12]Noori Sepehr M and Jarfi S. Comparison of chitosan function as adsorbent in nitrate removal from synthetic blue solution and urban drinking water. Environmental Engineering Engineering Journal. 2013; 1:11-19.

[13] Chatterjee S and Woo SH. The removal of nitrate from aqueous solutions by chitosan hydrogel beads. Journal of hazardous materials. 2009; 164:1012-1018.

[14] Jaafarzadeh N, Amiri H and Ahmadi M. Factorial experimental design application in modification of volcanic ash as a natural adsorbent with Fenton process for arsenic removal. Environmental technology. 2012; 33: 159-165.