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Removal of nitrate from water by using activated coconut shell charcoal

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ABSTRACT
Groundwater is one of the major resource for drinking and agricultural usage. Excessive use of nitrogen fertilizers in agricultural activities have increased the nitrate level in groundwater, which severely affects the health of human beings and this cause methemoglobinemia (MetHb), commonly called as "blue baby syndrome". The main aim of this experiment is to develop a cost effective process, efficient removal of nitrate and eco-friendly. In this strategy, sodium hydroxide (NaOH) activated coconut shell charcoal was used as an adsorbent to evaluate the removal efficiency of nitrate in groundwater. This experiment was carried out by changing the pH value, adsorbent dosage, temperature, initial nitrate concentration and contact time. Within the studied observation from the mentioned parameters, it is noticed that the optimum removal of nitrate takes place with the change in initial nitrate concentration.

1. INTRODUCTION

Water is the major resource used by humans and every living being in the earth. Due to population increase, deficiency in water occurs. This caused the increase in the usage of ground water.

For all the living matter, nitrogen is an essential element. Nitrogen with various oxidation levels are easily soluble in water which is highly toxic to human health. Ground water contamination by nitrate content increased due to the usage of high level nitrate contained fertilizers for agricultural purpose. The other sources of nitrate contaminated water include landfill leachate, leakage of septic tank and municipal storm water runoff. Increased level of nitrate in drinking water affects the haemoglobin which mainly cause blue baby syndrome for infants. It also provokes eutrophication and algal growth in water bodies. To reduce the nitrate level in water miscellaneous methods such as adsorption, ion-exchange, biological denitrification, chemical reduction and reverse osmosis are used. From this adsorption is one of the lucrative and productive method which is manipulated to reduce the nitrate content in contaminated water.

The activated carbon can be prepared from neem leaves, coconut coir, rice husk, etc., to treat the nitrate contaminated water. In this project coconut shell is adopted to make activated coconut shell charcoal. coconut shell is a carbonaceous material. The specific properties of this adsorbent used to reduce the nitrate level in water.

1.1 OBJECTIVE

- The prime objective of this project is to adopt uncomplicated, safe and lucrative method to treat the nitrate contaminated water.
- The chosen adsorbent must be accessible naturally.
- To achieve high range of productivity with the chosen adsorbent.

1.2 SCOPE

- The minimum resources such as coconut shell, sodium hydroxide and potassium nitrate are utilized in this method are easily available.
- The adsorbent adopted in this process is highly carbonaceous.
- The adsorption method which is chosen for nitrate removal is the effective one.

2. METHODOLOGY

2.1 Activation of raw coconut shell

Activated coconut shell charcoal with increased surface area performs better. Adsorption method for liquids, activated carbon of smaller size are used as adsorbent to get high removal efficiency of nitrate.

The raw coconut shell was collected from erode district. It is cleaned with distilled water and then dried. The clean dried coconut shell was burned in the drum at 300° C for 2 hours. It is then soaked at sodium hydroxide solution for 18 hours to convert it into chemically activated charcoal. After washing it with distilled water, it is allowed to dry in oven for 3 hours at 110° C temperature. Finally, by using the crusher iron, the dried activated coconut shell charcoal was made into 100 mesh. The prepared sample was stored in the air tight container.

2.2 Preparation of nitrate solution

A stock solution is the one which is diluted from higher concentration to lower for the actual use. It will improve the accuracy of the results, can be preserved for a period and saves time.

Potassium nitrate of 3.6g was taken and dried at 105° C for 24 hours. It is then dissolved in 1000mL of distilled water to get nitrate stock solution of concentration 500mg/L. For experiment, 50mL of solution was used from the prepared concentration level.

2.3 Adsorption experiment

Adsorption of nitrate with activated coconut shell charcoal by batch experiment was studied. Nitrate solution of 50mL was taken in a flask and the pH of the solutions was adjusted by adding buffer solutions into it. The experimental

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study was taken after shaken the solution at 200 rpm with a constant temperature. The test procedure was repeated for three times to get the stable result. The parameters such as pH, temperature, contact time, adsorption dosage and initial nitrate concentration were tested and the optimum result was taken.

Fig.1: (a) Burned coconut shell, (b) Burned coconut shell was soaked in NaOH

Fig.2: Powdered activated coconut shell charcoal

3 RESULTS AND DISCUSSION

3.1 Effect of adsorbent dosage

Activated coconut shell charcoal of different grams (0.5 to 3g) was added into conical flask with 50mL of nitrate solution of concentration 500mg/L. The solution was maintained with constant temperature 30°C, pH 4 and contact time of 90 minutes. Increase in adsorbent dosage increases the adsorbent potential and the surface area. Hence it is observed from the test result that the removal efficiency of nitrate increases with increase in adsorbent dosage.

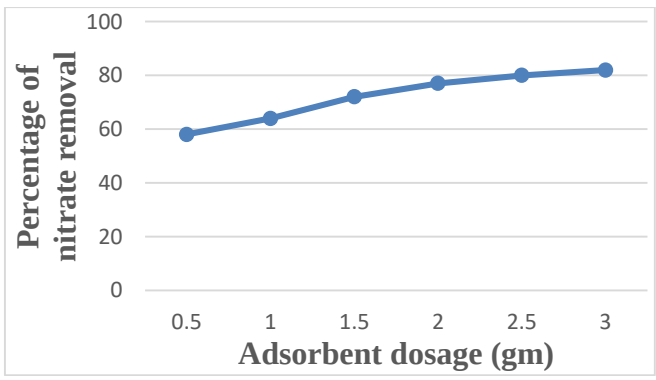

Fig.3: Effect of adsorbent dosage on efficiency of nitrate removal

3.2 Effect of pH

The nitrate solution samples were adjusted to pH of range varying from acidic medium to alkalinity (i.e. pH 4 to pH 8). The adjustment takes place by adding buffer solution into it. Other parameters such as nitrate concentration (500mg/L), adsorbent dosage (2g), temperature (30°C), and contact time (90 minutes) were maintained constant. It is observed from the test result that the decrease in the efficiency of nitrate removal occurs due to the presence of excessive OH^- in the sample taken. Hence the high range of adsorption of nitrate takes place inthe acidic medium of pH adjusted sample.

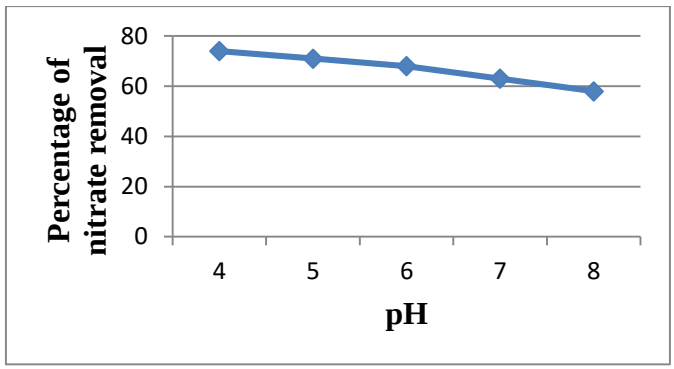

Fig.4: Effect of pH on efficiency of nitrate removal

3.3 Effect of temperature

Nitrate solution was undergone absorption process with varying temperatures from 20°C to 40°C and maintaining other parameters constant throughout the test process. Increase in temperature increases the solubility of nitrate ions due to exothermic reactions and alter the interactions between molecules. From the absorption process carried out with varying temperatures, it is observed that the removal of nitrate efficiency decreases with fall in temperature.

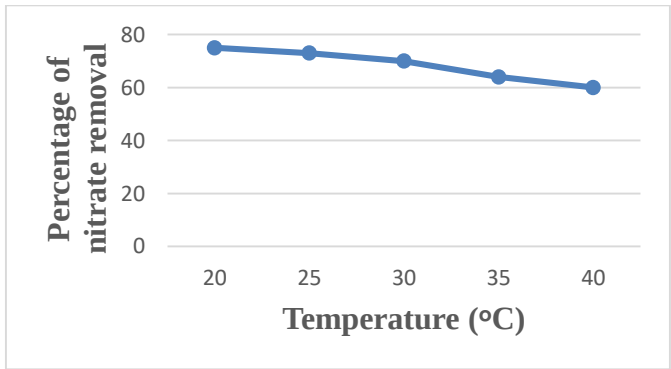

Fig.5: Effect of temperature on efficiency of nitrate removal

3.4 Effect of contact time

The equilibrium time of adsorption process was determined by contact time of adsorbent with nitrate solution.

Various contact time such as 30, 60, 90, 120 and 150 minutes are tested. The other parameters such as pH 4, temperature (30ºC), adsorbent dosage (2g) and initial nitrate concentration (500 mg/L) were kept constant. The removal efficiency of nitrate increases with increase in contact time up to 90 minutes. After 90 minutes the fall in efficiency occurs due to the unavailability of vacant sites on the adsorbent.

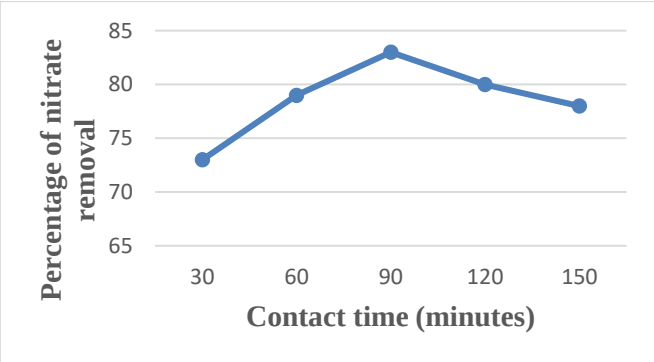

Fig.6: Effect of contact time on efficiency of nitrate removal

3.5 Effect of initial nitrate concentration

The 30ºC nitrate solution of pH 4 with varying initial nitrate concentration (50 –300 mg/L) were undergone adsorption process by adding adsorbent dosage of 2g and the contact time was taken as 90 minutes. It is observed from the test results that the efficiency of nitrate removal decreases with increase in concentration of the sample. This is due to saturation of adsorbent level was increased with increase in nitrate ion due to high range of nitrate diffusion to adsorption sites.

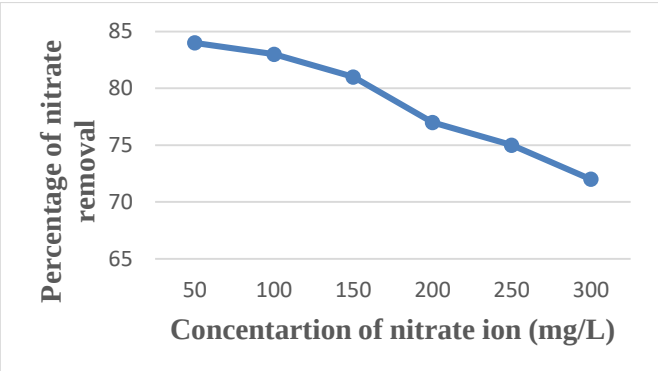

Fig.7: Effect of nitrate concentration on efficiency of nitrate removal

4 ADSORPTION STUDIES

4.1 Percentage of removal efficiency

The experimental work was carried out for varying parameters to find the percentage of nitrate removal efficiency by using activated coconut shell charcoal as adsorbent. It is assumed that the adsorbent forms a uniform monolayer onto the adsorption sites. The following formula was used to determine the nitrate removal efficiency.

$$\% \text{ Removal efficiency} = \frac{Co - Ce}{Co} * 100$$

Where C_o (mg/L) is initial level of concentration in solution and C_e (mg/L) is concentration at equilibrium time.

5 CONCLUSION

Removal of nitrate from water by adsorption process using activated coconut shell charcoal as adsorbent which was chemically activated using sodium hydroxide was carried out with various batch experiments such as adsorbent dosage, pH,
temperature, contact time and initial nitrate concentration. The high range of removal efficiency takes place during initial nitrate concentration of 50mg/L and other parameters are adsorbent dosage of 2g, pH of range 4, temperature of 30º C and contact time of 90 minutes. Thus with activated coconut shell charcoal the removal efficiency of 84% was occurs in the initial nitrate concentration of 50mg/L.

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