Effect of Operational Parameters on Nitrate Removal from the Simulated Groundwater Using Electrochemical Method

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Abstract: Industrialization has increased significant pollution of water resources and has caused many harmful effects. In India, the ground water contamination with respect to nitrate has been observed in states like Andhra Pradesh, Bihar, Haryana, Himachal Pradesh, Karnataka, Rajasthan, Tamil nadu, Punjab, Kerala, Orissa, and Gujarat. In this work, adsorption experiments were carried out using electrochemical method for the removal of nitrate from groundwater. Synthetically prepared water with initial nitrate concentrations ranging between 60 to 80 mg/L were used for the experiments. The electrochemical (EC) experiments were conducted in a glass beaker of working volume of 1.0 L. A DC power supply, ammeter, voltmeter and magnetic stirrer were provided for the completion of EC cell set up. The studies were carried out for different electrodes like iron, mild steel and aluminum. Synthetic water containing 70-80 mg/L nitrate nitrogen was treated in the reactor for an electrolysis duration of 30, 60 and 120 minutes respectively.

Keywords: Nitrate, Electrochemical Setup, Adsorption, Ground Water, Iron, Aluminum.

I. INTRODUCTION

Water, the best of all things is the nature’s gift for living organisms. Water has been used for drinking, domestic purposes, industry, agriculture and recreation. It shows the extent to which it is an integral part of our life. Water is essential for not only for human beings, but also for animals, plants and all other living beings. The basic condition for life on earth is that water should be available in the form of liquid. In Ground water major contributors of nitrate are chemical fertilizers from cultivated land and drainage, from livestock feedlots, as well as domestic waste and some industrial waters in the course of leakage. Unpolluted natural waters contain only miniature amounts of nitrate. In surface water, nitrate is a nutrient which is taken up by plants and assimilated into nucleic acid (Jagessar and Sooknund, 2011). Nitrogen is one of the basic elements present in organic compounds which form living matter. In nature, nitrogen and its compounds are subject to changes; mainly synthesis process which results in creation of organic nitrogen compounds from nitrates and gaseous nitrogen, and decomposition of organic dead matter in which initially released ammonia changes subsequently into nitrates and free nitrogen. The most common nitrogen compounds in water environment are ammonium, nitrate and nitrite nitrogen. The schematic representation of nitrogen cycle is shown in below Figure.

![Figure 1: Schematic Representation of Nitrogen Cycle](image)

Four processes participate in the cycling of nitrogen through the biosphere and microorganisms play major roles in all 4 processes, they are Nitrogen fixation, Decay, Nitrification and Denitrification.

When nitrate concentrations reach excessive levels it can cause harmful biological consequences for the organisms, which depend on groundwater. The United States environmental protection agency (USEPA) established the drinking water standard and health advisory level of 10 mg/L nitrate nitrogen based on the human health risks due to nitrate consumption. Metheamoglobinemia (also called blue baby syndrome or cyanosis) has been to proven to result from ingestion of water containing high nitrate concentrations, above 10 ppm. While nitrate is considered to be relatively nontoxic to adults, as it is quickly excreted by kidneys, concentrations greater than 10 ppm can be fatal to infants under six months of age. In infants NO₃⁻ is reduced to NO₂⁻, which combines with haemoglobin in the blood to form metheamoglobin, and leads to a condition commonly known as “blue baby syndrome” (Kapoor and Viraraghavan, 1997). Toxicity test carried out in recent years proved that nitrate and nitrite are the precursors of nitrosamines, a chemical compound of strong toxic, mutagenous and carcinogenic effect.

The main objective of the present study is to find the optimal conditions for removal of nitrate nitrogen from
simulated groundwater by electrochemical method. The specific objectives include:

- To conduct batch electrochemical experiments using different electrode materials for nitrate nitrogen removal from simulated groundwater.
- To optimize the various operating conditions for selected electrodes for achieving maximum nitrate nitrogen removal from groundwater.
- To perform kinetics for the data obtained during experiments.

The removal of nitrate can be accomplished by using physical, chemical, and biological methods. For example, ion exchange is commonly used in producing drinking water from groundwater, in which the cations in groundwater are exchanged with sodium ions and the anions are replaced by chloride ions when flowing through the packed ion exchange resin. Reverse osmosis has not been particularly applied to remove nitrate, but its non-selective, semi-permeable membrane can stop many contaminants that may include nitrate. Biological nitrate removal is attractive because of its cost-effectiveness. Denitrification is commonly used to remove nitrate from sewage and natural water bodies including groundwater and can be carried out by both heterotrophic and autotrophic bacteria. Nitrate removal from groundwater is conducted by either ex situ or in situ approaches, and in situ treatment is preferred because it avoids the use of the energy-intensive pump-and-treat approach (Lampe and Zhang, 1996).

Electrochemical reduction of nitrate is receiving more and more attention due to its convenience, acceptability and low cost in use. Ion exchange and reverse osmosis processes (Samatya et al., 2006) cannot transfer nitrate into harmless compounds but only concentrate nitrate from water to brine, requiring further treatment. Nitrate electro-reduction is an extremely complex process (Plieth and Bard, 1978). At the cathode, the nitrates are mainly reduced to nitrites, ammonia and nitrogen, which is electrochemically inactive. Ammonia and nitrite, in general, are the main unfavorable reduction products and their generation limits applications of the electrochemical process for de-nitrification. However, if possible, the nitrite and ammonia products may be oxidized to nitrate and nitrogen at the anode, respectively, before their diffusion to the bulk. Electro dialysis and electrocoagulation is applicable for the removal of nitrate.

The current technologies for the treatment of nitrate are ion exchange, biological treatment, reverse osmosis and electrochemical processes. The nitrate ion can be destroyed by electrochemical processes through oxidative and reductive reactions into harmless constituents such as water, nitrogen and oxygen. High installation maintenance costs and brine generation and sensitivity of membranes are some of the limitations of membrane processes. Electro dialysis and electrocoagulation is also applicable for the removal of nitrate.

II. MATERIALS AND METHODOLOGY

A. Preparation of Simulated Water

Simulated groundwater with varying nitrate concentration with KNO₃ is prepared using tap water. All the chemicals used for the experiments were analytical reagent grade.

B. Electrochemical Reactor Set-up

Electrochemical set up is designed using an ammeter, voltmeter, and the electrochemical cell. Plexiglass container of 1000 ml is used as electrochemical cell. The reactor was operated under completely mixed conditions, facilitated by a magnetic stirrer at the bottom of the reactor to avoid concentration gradients. The anode and cathode were positioned vertically and parallel to each other. Current and voltage are monitored with ammeter and voltmeter.

C. Electrodes

In the present study mild steel, iron and aluminum electrodes were used as it is cheap and readily available. Two electrode plates of dimension 5 x 5 cm and 7 x 7 cm were used as anode and cathode.

Figure 2: Schematic Representation of Electrochemical Set Up

D. Power Supply

DC power supply unit was used as power source to supply and maintain current and voltage across the electrode system by means of copper wires.

E. Batch Studies

The EC experiments were done using different electrodes in a glass beaker of constant working volume of 1 L. The anode and cathode were placed at a fixed distance of 0.5 cm and 2.5 cm apart. The DC power supply was varied for the voltages of 5, 10, 12, 14 and 16. The studies were conducted for a period of 30, 60 and 120 minutes for electrode size of 7 x 7 cm. For 5 x 5 cm
electrode size, the studies were conducted for the voltages of 14 and 16 for a period of 120 minutes.

**Figure 3:** Setup of Electrochemical reactor

These polymeric materials may get adsorbed on the electrode anode surface and may decrease the efficiency of the electrode. Instantaneous current efficiency is defined as the ratio of the current stoichiometrically required for the oxidation of organics to that of total consumption. It can be calculated using the relation:

\[ ICE = \frac{N_t - N_{t+\Delta t}}{8I\Delta t} \times FV100 \]

Where, \( N_t \) and \( N_{t+\Delta t} \) are nitrate concentrations at times \( t \) and \( t+\Delta t \), \( I \) is current, \( F \) is Faraday’s constant and \( V \) is Volume of electrolyte in liters.

Considering the initial and final concentrations of nitrate in water at different times, electrical energy (EE) consumed in kilo Watt hour per kg removal of nitrate was calculated with the following equation (Ugurlu et al., 2006).

**Figure 4:** Flow information after EC treatment

### Table 1: Methodology Adopted For Measuring Various Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Tap Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.1</td>
</tr>
<tr>
<td>Nitrate, mg/L</td>
<td>22.3</td>
</tr>
<tr>
<td>Turbidity, NTU</td>
<td>3.9</td>
</tr>
<tr>
<td>COD, mg/L</td>
<td>12.8</td>
</tr>
<tr>
<td>Chlorides, mg/L</td>
<td>96.90</td>
</tr>
<tr>
<td>Total hardness, mg/L</td>
<td>264</td>
</tr>
<tr>
<td>Calcium hardness, mg/L</td>
<td>200</td>
</tr>
</tbody>
</table>

These polymeric materials may get adsorbed on the electrode anode surface and may decrease the efficiency of the electrode.

**III. RESULTS AND DISCUSSIONS**

The tap water of microbiology lab was characterized for various physical and chemical parameters. The tap water has been used for preparing synthetic water. The characterization results for various parameters are shown in Table 2.

![Electrical Energy consumption](image)

**Electrical Energy consumption**

\[ V \times I \times t \times 1000 = \frac{60(N_0 - N_t)S_v}{N_0 - N_t + \Delta t} \]

Where, \( V \) is Voltage, \( I \) is Current, \( t \) is electrolysis time, \( S_v \) is Sample volume, \( N_0, N_t \) initial & concentration of Nitrate at time \( t \).

**A. Performance of Nitrate Removal for Tap Water Using Different Electrode Material**

The electrochemical (EC) experiments using iron, mild steel and aluminum electrodes of size 7x 7cm were conducted in a glass beaker of constant working volume of 1 L. The anode and cathode were placed at a fixed distance of 2.5 cm apart. 10V, 12V and 14V power supply was maintained using DC power supply to optimize the power consumption. Initially to study the feasibility of electrochemical treatment processes, synthetic water containing 70-80 mg/L nitrate nitrogen was treated in the reactor for 30 and 60 minutes.

![Figure 5 (a)](image)

![Figure 5 (b)](image)
Figure 5(a)

Figure 5: Variation of nitrate nitrogen versus time for mild steel electrode [(10 V, 7 x 7), (12 V, 7 x 7 cm) & (14 V, 7 x 7 cm) electrode size and 2.5 cm electrodes distance)

Figure-5 a, b & c graphs are plotted taking nitrate nitrogen in mg/L along y-axis and time in minutes along x-axis respectively. The above graphs show the removal of nitrate nitrogen from synthetic water using EC treatment for mild steel electrode. Samples were collected at regular time intervals and analysed for nitrate nitrogen. For 10V power supply at 60th minute, nitrate nitrogen was reduced to 48.90 mg/L from an initial concentration of 61.48 mg/L which accounted for about 27% nitrate nitrogen removal. For 12V power supply at 30th minute, nitrate nitrogen was reduced to 62.18 mg/L from an initial concentration of 82.15 mg/L which accounted for about 24% nitrate nitrogen removal.

For 14V power supply at 30th minute, nitrate nitrogen was reduced to 58.42 mg/L from an initial concentration of 82.15 mg/L which accounted for about 28% nitrate nitrogen removal.

From the experiments done for mild steel electrode with different operating conditions it was found that at 14 V and electrode size of 7 x 7 cm with distance between electrodes as 2.5 cm maximum of 28% removal is been observed.

Figure 6 (a)

Figure 6: Variation of nitrate nitrogen versus time for Iron electrode [(10 V, 7 x 7) & (12 V, 7 x 7 cm) electrode size and 2.5 cm electrodes distance]

The results of experiments done with iron electrode are shown above. Samples were collected at regular time intervals and analyzed for nitrate nitrogen. At 10V power supply at 60th minute of electrolysis period, the nitrate nitrogen was reduced to 79.08 mg/L from an initial concentration of 89.4 mg/L which accounted for about 12% nitrate nitrogen removal. At higher voltage of 12 V at 60th minute, nitrate nitrogen was reduced 69.89 mg/L from an initial concentration of 89.9 mg/L which accounted for about 22% nitrate nitrogen removal.

The optimum conditions obtained for EC treatment with iron electrode was at 12 V power supply with 7 x 7 cm electrode size and at 2.5 cm electrode distance a maximum of 22% removal was observed. Since the nitrate removal efficiency with iron electrodes was very less, further batch EC experiments were continued with aluminum electrodes.

With electrodes experiments were done with electrode size of 5 cm x 5 cm and 7 cm x 7 cm at 10 V, 14 V and 16 V power supply. The distance between the electrodes was maintained at 2.5 cm and 0.5 cm. The results of experiments with above operating conditions are shown in below.

Figure 7 (a)

Figure 7: Variation of nitrate nitrogen versus time for Aluminum electrode [(10 V, 7 x 7), (12 V, 7 x 7 cm) &
(14 V, 7 x 7 cm electrode size and 2.5 cm electrodes distance]

Figure 8 (a)

Figure 8 (b)

Figure 8: Variation of nitrate nitrogen versus time for Aluminum electrode [(14 V, 0.2 A, 7 x 7 cm electrode size and 2.5 cm electrodes distance)]

The graphs shown for above Figures are for the removal of nitrate nitrogen from synthetic water using EC treatment for aluminum electrode. Samples were collected at regular time intervals and analysed for nitrate nitrogen. For 10V power supply at 30th minute, nitrate nitrogen was reduced to 45.46 mg/L from an initial concentration of 62.62 mg/L which accounted for about 28% nitrate nitrogen removal. As observed in 12V power supply and at 0.1A with 60 minutes electrolysis period, nitrate nitrogen reduced to 45.30 mg/L from an initial concentration of 64.1 mg/L which accounted for about 30% nitrate nitrogen removal. At same voltage of 12V at higher amperes (0.2A) at the end of electrolysis period of 60 minutes, nitrate nitrogen was reduced to 44 mg/L from an initial concentration of 62.73 mg/L which accounted for about 30% nitrate nitrogen removal. Since the removal of nitrate nitrogen was as expected the power supply was increased to 14 V and as observed in Figure 8 (a), at 0.1A and at 30th minute, the nitrate nitrogen was reduced to 45.46 mg/L from an initial concentration of 62.61 mg/L which accounted for about 28% nitrate nitrogen removal. For 14V power supply, 0.2 A at 60th minute, nitrate nitrogen reduced to 43.53 mg/L from an initial concentration of 69.48 mg/L which accounted for about 38% nitrate nitrogen removal.

From the above experiments it is clear that aluminum electrodes are suitable for conducting EC experiments and can be used to find the optimal operating conditions in further experiments with different electrode size.

Below shows the comparison of nitrate nitrogen removal in EC reactor operated with different electrodes and at different operating conditions. From the table it is observed that aluminum electrode gave better performance with maximum nitrate nitrogen removal of 38% at 14 V power supply with electrolysis duration of 60 minutes.

Table 3: Effect of operating Conditions on Nitrate Nitrogen Removal with different Electrodes

<table>
<thead>
<tr>
<th>Electrodes</th>
<th>Operating Conditions</th>
<th>Distance b/w electrodes</th>
<th>Electrode size (cm)</th>
<th>Initial (mg/L)</th>
<th>Final (mg/L)</th>
<th>% removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>10</td>
<td>2.5</td>
<td>7 x 7</td>
<td>60</td>
<td>69.9</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2.5</td>
<td>7 x 7</td>
<td>60</td>
<td>69.89</td>
<td>0.22</td>
</tr>
<tr>
<td>Mild steel</td>
<td>10</td>
<td>2.5</td>
<td>7 x 7</td>
<td>60</td>
<td>61.48</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2.5</td>
<td>7 x 7</td>
<td>30</td>
<td>62.15</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>2.5</td>
<td>7 x 7</td>
<td>50</td>
<td>62.15</td>
<td>0.28</td>
</tr>
<tr>
<td>Aluminum</td>
<td>10</td>
<td>2.5</td>
<td>7 x 7</td>
<td>60</td>
<td>64.10</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2.5</td>
<td>7 x 7</td>
<td>60</td>
<td>69.48</td>
<td>0.38</td>
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<tr>
<td></td>
<td>14</td>
<td>2.5</td>
<td>7 x 7</td>
<td>60</td>
<td>69.48</td>
<td>0.38</td>
</tr>
</tbody>
</table>

B. Optimization of conditions for aluminum electrode for nitrate nitrogen removal from simulated groundwater

Based on the results obtained in the previous batch studies further electrochemical experiments using aluminum electrodes of varying size 5 x 5 cm and 7 x 7 cm were conducted in a glass beaker of constant working volume of 1L. The anode and cathode were placed at a fixed distance of 0.5 and 2.5 cm apart for different set of experiments carried out. 14V and 16V power supply was maintained using DC power supply to optimise the power consumption and the experiments were carried out for 120 minutes respectively.

Figures 9 and 10 shows the results of EC experiments for removal of nitrate nitrogen from synthetic water using aluminum electrode. In Figure 9 (a), for 14V power supply, at 0.3A, with 0.5 cm of distance of electrodes, 5 x 5 cm electrode size at 120th minute, nitrate nitrogen reduced to 31.62 mg/L from an initial concentration of 61.07 mg/L which accounted for about 53% nitrate nitrogen removal. The initial weights of cathode and anode were 10.8956g and 11.1926g respectively and after EC treatment the electrodes weight were reduced to 10.7174g and 11.1313g respectively for cathode and anode respectively.

In Figure 9 (b), for 14V power supply at 0.3A, with electrode size of 7 x 7 cm and 0.5 cm distance apart, at the end of electrolysis period of 120 minutes, nitrate nitrogen concentration reduced to 16.57 mg/L from an initial concentration of 71.78 mg/L which accounted for...
about 76% nitrate nitrogen removal. The initial weight of cathode and anode electrodes was 18.0402g and 18.3579g respectively. After EC treatment the weights of electrodes were reduced to 17.8686g and 18.2717g respectively for cathode and anode.

Figure (c) shows the EC treatment results with operating conditions of: 14V power supply, 0.3A, 2.5 cm distance between electrodes, 5 x 5 cm electrode size, EC duration of 120 minutes. The nitrate nitrogen was reduced to 54.3 mg/L from an initial concentration of 75.14 mg/L which accounted for about 28% nitrate nitrogen removal. The initial weight of cathode and anode electrodes were 11.0445g and 11.2589g respectively. After EC treatment the weight of electrodes were reduced to 10.9920g and 11.2454g respectively for cathode and anode.

Figure 10 (b) shows the results of nitrate nitrogen removal for EC reactor operated with 16V power supply, 0.3A, electrode size of 5 x 5 cm and 0.5 cm distance between electrodes. At the end of the experiment (120 minutes), the nitrate nitrogen was reduced to 26.39 mg/L from an initial concentration of 66.36 mg/L which accounted for about 60% nitrate nitrogen removal. The initial weight of cathode and anode electrodes was 11.1227g and 11.1230g respectively. After EC treatment the weight was reduced to 10.5389g and 11.0588g respectively for the electrodes placed at cathode and anode respectively.

For the experimental conditions of previous experiment but with higher electrode size of 7 x 7 cm (16V power supply, 0.3A, 0.5 cm distance apart), at 120th minute, nitrate nitrogen was reduced to 23.99 mg/L from an initial concentration of 76.70 mg/L which accounted for about 76% nitrate nitrogen removal (Figure 10 (c)). The initial weight of cathode and anode were 17.9675g and 18.2440g respectively. After EC treatment the weight of electrodes were reduced to 17.8197g and 18.1669 g respectively for cathode and anode.
Figure 10: Variation of Nitrate nitrogen removal for EC treatment with aluminum electrodes - (14 Volts, 0.2 A, 2.5cm distance, 7 x 7 cm), (16 Volts, 0.3 A, 0.5cm distance, 7 x 7 cm) & (16 Volts, 0.3 A, 0.5cm distance, 5 x 5 cm) electrode size

Table 4.3 presents a comparison of different operating conditions with Aluminum electrode. From the table it is observed that at 14 V and with 7 x 7 cm electrode size and distance between electrodes of 0.5 cm and 2.5 cm a maximum of 76 % nitrate nitrogen removal is observed.

Table 4: Comparison of nitrate removal under different operating conditions with aluminum as electrode

<table>
<thead>
<tr>
<th>Operating conditions</th>
<th>Volts</th>
<th>Distance Between Electrodes(cm)</th>
<th>Electrode size (cm)</th>
<th>Time (minutes)</th>
<th>Initial (mg/L)</th>
<th>Final (mg/L)</th>
<th>% removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Aluminum Electrode</td>
<td>0.5</td>
<td>5X5</td>
<td>120</td>
<td>61.07</td>
<td>31.62</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>7X7</td>
<td>120</td>
<td>71.78</td>
<td>16.57</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>5X5</td>
<td>120</td>
<td>73.14</td>
<td>34.30</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>7X7</td>
<td>120</td>
<td>71.70</td>
<td>16.59</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>16 Aluminum Electrode</td>
<td>0.5</td>
<td>5X5</td>
<td>120</td>
<td>66.36</td>
<td>26.39</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>7X7</td>
<td>120</td>
<td>76.70</td>
<td>23.99</td>
<td>76</td>
<td></td>
</tr>
</tbody>
</table>

IV. KINETICS STUDY

A. Reaction Kinetics

To study the reaction kinetics for synthetic water, the samples were taken at every 15 minutes for 2 hours during EC treatment. At lower voltages, efficiency of nitrate removal was not sufficient. Hence the studies were conducted at higher voltage for reaction kinetics. It was found that the rate of reaction increases with increase in voltage.

The graphs shown in Figures 11 (a), (b) & (c) are for the results obtained during the experiments conducted to know the the effect of voltage on rate of reaction. In the Figure 11 (a), for 14V power supply, 0.3A, with distance between electrodes of 0.5 cm apart, 7 X 7 cm electrode size at 120th minute, the reaction rate obtained was 0.432 minute⁻¹.

As shown in Figure11 (b), the reaction rate obtained was 0.406 minute⁻¹ for the batch experiment conducted with operating condition of 14V power supply and at 0.2A, with 2.5 cm distance between electrodes, 7 x 7 cm electrode.

In the Figure 11 (c), for 16V power supply, 0.3A, 0.5 cm distance apart, 7 X 7 cm electrode size at 120th minute, the reaction rate obtained was 0.275 minute⁻¹.

B. Instantaneous Current Efficiency and Energy Consumption

The Instantaneous current efficiency was determined for the removal of nitrate for the track study carried out when the electrochemical treatment was given at 14 V and 16 V current. The calculated ICE values were plotted with respect to time (Figure 12, 13, 14, 15). In figure 20 sudden increase has been observed among the plots during first90 minutes and dropped rapidly during further course of electrolysis. Similar trend has been
observed by many previous researches. In the figure 22 there is a sudden drop at 15th minute and again it increased at 45th minute. The probable reason for the decrease of ICE may be attributed to the growth of an adherent passivating film on anode surface that might have poisoned the electrode or by production of stable intermediates that cannot be further oxidised by direct electrolysis.

Figures 13 and 15 shows the variations of calculated power consumption with the time at 14 V and 16 V power supply respectively.

From the figure 13, it is observed that there was a gradual increase in consumption of power from 0 to 120 minutes and sudden increase of power consumption can be seen at 75th minute.

Similarly for figure 15, it is observed that there was a varying trend in consumption of power from 0 to 120 minutes.

SUMMARY

The present study aimed to remove nitrate nitrogen from synthetic water prepared using tap water. Synthetic water was prepared by adding potassium nitrate to tap water collected from Microbiology Laboratory. In this study an attempt has been made to remove nitrate nitrogen from groundwater by electrochemical method. The monopolar arrangement of the aluminum electrodes in parallel was the configuration of electrochemical cell. During the batch studies, several operating conditions such as electrolysis duration, size of electrodes, spacing between the two electrodes and applied voltage were explored to ascertain their respective effects on removal of nitrate nitrogen.

CONCLUSIONS

Preliminary experiments were carried out for identifying the suitability of electrodes for nitrate nitrogen removal. The batch EC experiments done using electrode materials such as mild steel, iron and aluminum resulted in better performance with aluminum electrodes. A set of batch studies were conducted for different electrode size, different voltages and with spacing between the electrodes varied.
results of EC batch experiments showed that performance of EC reactor varied with different operating conditions. The optimum operating conditions were determined by running a series of batch experiments by employing aluminum electrode at varied applied voltages of 5, 10, 12, 14 and 16 V. The optimum power supply was found to be 14V, with 5 x 5 cm and 7 x 7 cm electrode size for electrolysis time of 120 mins and spacing between the electrodes was 2.5 cm and 0.5 cm. The nitrate nitrogen removal was 76% by employing electrodes of 7 x 7 cm size at 14 V. Even at higher voltages removal was good but formation of sludge was more. The maximum rate constant was 0.432 minute\(^{-1}\) for 14 V power supply. The instantaneous current efficiency (ICE) was determined for the track study of removal of nitrate from simulated groundwater and it was observed that common trends was followed for different current voltages. There was a decrease in ICE during 60th minute and sudden increase in ICE was observed at 60th voltages. There was a decrease in ICE during 60th minute and sudden increase in ICE was observed at 60th voltages. The result of the study suggests that the groundwater can be effectively treated by electrochemical methods.

References