Nitrate Removal from Drinking Water by Sodium Thiosulfate and its impact on health.

Adel Alsalaymeh
Medical & Environmental Scientist
Water Quality Laboratory, Hebron Municipality, Hebron – Palestine.
Introduction

• Nitrate is seldom present in geological formations and therefore contamination due to nitrate is mainly attributed to anthropogenic sources such as sewages and fertilizers.

• Microbial nitrification is the natural origin of nitrate. Through this process, ammonia is converted into nitrite and then nitrite to nitrate by the nitrosomonas genus and nitrobacter genus bacteria, respectively (Sajil Kumar et al.2014).

• Since nitrate has more stable oxidation state than nitrite, it is less absorbed by the aquifer matrix.

• Due to its mobility, it can travel long distances and pollute the groundwater easily (Assaf and Saadeh 2009, Sajil Kumar et al.2014).
Sources of nitrate

• Groundwater concentrations exceeding an arbitrary threshold of 3 mg/l may be indicative of contamination of natural groundwater as a result of human activities (Burkart and Kolpin, 1993, E. Pastén-Zapata et al. 2014).
Sources of nitrate

- Industrial wastewater containing nitrate.
- Domestic wastewater.
- Fertilizers in agricultural.
- Discharges from animal operations.
- Wastewater treatment facilities.
- Septic systems and commercial activities.
- Other sources include, atmospheric deposition and spreading of sewage sludge to land and seepage from landfills (Wakida and Lerner, 2005, E. Pastén-Zapata et al. 2014).
Health Effects of Nitrate

• Studies on animals in the laboratory have not indicated that nitrate or nitrite is directly carcinogenic, but it may react in the stomach with food containing secondary amines to produce N-nitroso compounds (NOC) which are known to be carcinogenic in animals (LWRDRC 1999, Ward et al. 2005, and Sajil Kumar et al. 2014).
Health Effects of Nitrate

• Both nitrate and nitrite are significant public health concerns since they can cause methemoglobinemia or “blue-baby syndrome.

• Excess levels of nitrate effects on health by forming hypertension, thyroid disability and carcinogenicity hazard of nitrosamine (Majlesi et al.2016).

• Can cause gastric cancer (Mason, 2002), meningitis, Parkinson’s disease etc. (Moorcroft, Davis, Compton, 2001 &Kumar Gaurav et al.2015).
Effect of Nitrate on Environment

- Increased level of nutrients (eutrophication) affecting adversely biodiversity, mammals, birds, and fish population by producing toxins and reducing oxygen levels (Environmental Agency, EA, 2005).
- Can cause poisoning in animals (Stadler, 2012).
- Denitrification processes contribute to the emission of greenhouse gases due to production of N2O (Haag and Kaupenjohann, 2001, E. Pastén-Zapata et al. 2014).
Nitrate Treatment

- Ion exchange.
- Reverse osmosis.
- Electrodialysis.
- Biological denitrification.
- Catalytic (chemical) denitrification.
- Hybrid systems based on fly ash adsorption.
- Membrane filtration.
- Electrocoagulation.
Sodium thiosulphate

• Sodium thiosulphate (Na2S2O3, STS) is an industrial compound which is typically available as the pentahydrate, Na2S2O3 • 5H2O.

• It has medical uses in the treatment of some rare medical conditions. These include calciphylaxis in hemodialysis patients with end-stage kidney disease as well as cyanide poisoning.

• It also has functions as a preservative in table salt (less than 0.1 %) and alcoholic beverages (less than 0.0005 %)( Lee et al 2016).
Medical Uses of Sodium Thiosulfate

- Intravenous medication for metal poisoning
- Treatment of certain rare medical conditions. (cyanide poisoning, calciphylaxis, and cisplatin toxicity).
- In vitro assays have demonstrated that it is an anti-inflammatory and neuroprotective agent.
- It therefore has potential for treating neurodegenerative diseases such as Alzheimer disease and Parkinson disease.
Aim of this Study

• The aim of this research is to investigate the potential of removing nitrate from drinking water using sodium thiosulfate and its impact on human health.
Methodology

• 1.09% solution of sodium thiosulfate was prepared by dissolving pills (taken from Hach vials) in 100 ml of deionized water.
• Different doses of sodium thiosulfate solution (0.1, 0.3, 0.5, 1, 2, 3, and 5 ml) were added to 100 ml of water to be treated to determine the lowest dose that give high percentage of nitrate removal.
• The lowest contact time was determined by adding the lowest dose that gives high percentage of nitrate removal.
• Nitrate level was determined by cadmium reduction method (Hach method no. 8039) using nitraVer 5 high range powder pillow nitrate reagent.
• The effect of adding sodium thiosulfate on the level of TDS, alkalinity, sulphate and total hardness was studied after one hour contact time.
• TDS was determined by Hach CO 150 conductivity meter.
• Alkalinity was determined by Hach method no. 8203 (phenolphthalein and total method).
• Sulfate was determined by Hach method no. 8051.
• Total hardness was determined by Hach test kit 20-400mg/l Model 5-EPMG-L Cat. No.1454-01.
• Literature was reviewed to determine the effect of sodium thiosulfate on human health.
## Results

Table 1 The effect of adding different doses of sodium thiosulfate on different parameters of raw water.

<table>
<thead>
<tr>
<th>Sodium Thiosulfate dose</th>
<th>0</th>
<th>0.1</th>
<th>0.3</th>
<th>0.5</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate</td>
<td>41.5</td>
<td>41</td>
<td>31</td>
<td>20.5</td>
<td>11.5</td>
<td>10</td>
<td>2.2</td>
<td>1.5</td>
</tr>
<tr>
<td>pH</td>
<td>7.18</td>
<td>8.04</td>
<td>8.00</td>
<td>7.99</td>
<td>7.94</td>
<td>8.08</td>
<td>7.76</td>
<td>7.85</td>
</tr>
<tr>
<td>Turbidity</td>
<td>0.33</td>
<td>0.17</td>
<td>0.21</td>
<td>0.26</td>
<td>0.27</td>
<td>0.23</td>
<td>0.17</td>
<td>0.34</td>
</tr>
<tr>
<td>EC</td>
<td>925</td>
<td>931</td>
<td>954</td>
<td>989</td>
<td>1056</td>
<td>1209</td>
<td>1346</td>
<td>1611</td>
</tr>
<tr>
<td>TDS</td>
<td>427</td>
<td>437</td>
<td>448</td>
<td>465</td>
<td>497</td>
<td>572</td>
<td>639</td>
<td>767</td>
</tr>
</tbody>
</table>
Table 2 The percentage of reduction in nitrate level and percentage increase in EC and TDS level at different doses of 1.09% of sodium thiosulfate solution.

<table>
<thead>
<tr>
<th>Sodium Thiosulfate dose</th>
<th>0.1</th>
<th>0.3</th>
<th>0.5</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Reduction in nitrate concentration</td>
<td>1%</td>
<td>25%</td>
<td>51%</td>
<td>72% (11.5)</td>
<td>76%</td>
<td>95%</td>
<td>96%</td>
</tr>
<tr>
<td>% increase in EC</td>
<td>0.6%</td>
<td>3%</td>
<td>7%</td>
<td>14%</td>
<td>31%</td>
<td>45%</td>
<td>74%</td>
</tr>
<tr>
<td>% increase in TDS</td>
<td>2%</td>
<td>9%</td>
<td>9%</td>
<td>16% (497)</td>
<td>34%</td>
<td>50%</td>
<td>80%</td>
</tr>
</tbody>
</table>
Table 4 The effect of 1ml of 1.09% solution of sodium thiosulfate addition on different parameters of raw water.

<table>
<thead>
<tr>
<th>Test</th>
<th>Before addition</th>
<th>After addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Hardness</td>
<td>490</td>
<td>500</td>
</tr>
<tr>
<td>Sulfate</td>
<td>53</td>
<td>56</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>259</td>
<td>235</td>
</tr>
</tbody>
</table>
Conclusions

• Removal of nitrate from drinking water by adding 1.09 % of sodium thiosulfate is easy, cost effective method and remove high percentage of nitrate.
• Further research is needed to confirm that addition of sodium thiosulfate to drinking water is safe process.
• Further studies is needed to know the chemical compounds produced from reaction between sodium thiosulfate and nitrate.