Simultaneous heterotrophic and sulfur-oxidizing autotrophic denitrification process for drinking water treatment

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In many countries, nitrate concentration in ground water has exceeded the maximum allowable limits for the drinking water. Some wells in the Harran Plain contain nitrate as high as 180 mg/L NO_3^--N and the average concentration for whole plain is 35 mg/L NO_3^--N (Yesilnacar et al., 2008). Sulfur-based autotrophic denitrification is an effective alternative for drinking water denitrification due to low cost and availability. In this process, the elemental sulfur and nitrate behave as an electron donor and an acceptor, respectively. Hence, when nitrate is reduced to nitrogen gas, sulfur is oxidized to sulfate (Reaction 1).

$$55S^0+50NO_3^-+38H_2O+20CO_2+4NH_4^+ \rightarrow 4C_5H_7O_2N+55SO_4^{2-}+25N_2+64H^+ \qquad (1)$$

Although sulfur-based autotrophic denitrification has several advantages, its main disadvantages are sulfate and acid formation. Lime stone or bicarbonate can be used as alkalinity sources. In the process, 7.54 mg sulfate is formed for per mg NO_3^--N removal (Reaction 1). According to Turkish drinking water regulation (TS 266), the maximum sulfate concentration is 250 mg/L. When the influent nitrate concentration was above around 30 mg/L NO_3—N, sulfate concentration in the process effluent may exceed the regulations.

In our study, which is a part of TUBITAK project (110Y256), autotrophic and heterotrophic denitrification was combined in one reactor for the first time to denitrify drinking water. For this purpose, a long-term performance of a packed-bed bioreactor containing sulfur and limestone was evaluated for the denitrification of drinking water. Sulfate concentration in the treated water was below drinking water guidelines due to stimulation of simultaneous heterotrophic and autotrophic denitrification with methanol supplementation. Complete removal of 75 mg/L NO_3-N with effluent sulfate concentration of around 225 mg/L was achieved when methanol was supplemented at methanol/NO_3-N ratio of 1.67 (mg/mg), which was much lower than the theoretical value of 2.47 for heterotrophic denitrification. Batch studies showed that sulfur based autotrophic NO_2-N reduction rate was around three times lower than the reduction rate of NO_3-N, which led to NO_2-N accumulation at high loadings.


Simultaneous heterotrophic and sulfur-oxidizing autotrophic denitrification process for drinking water treatment: control of sulfate production
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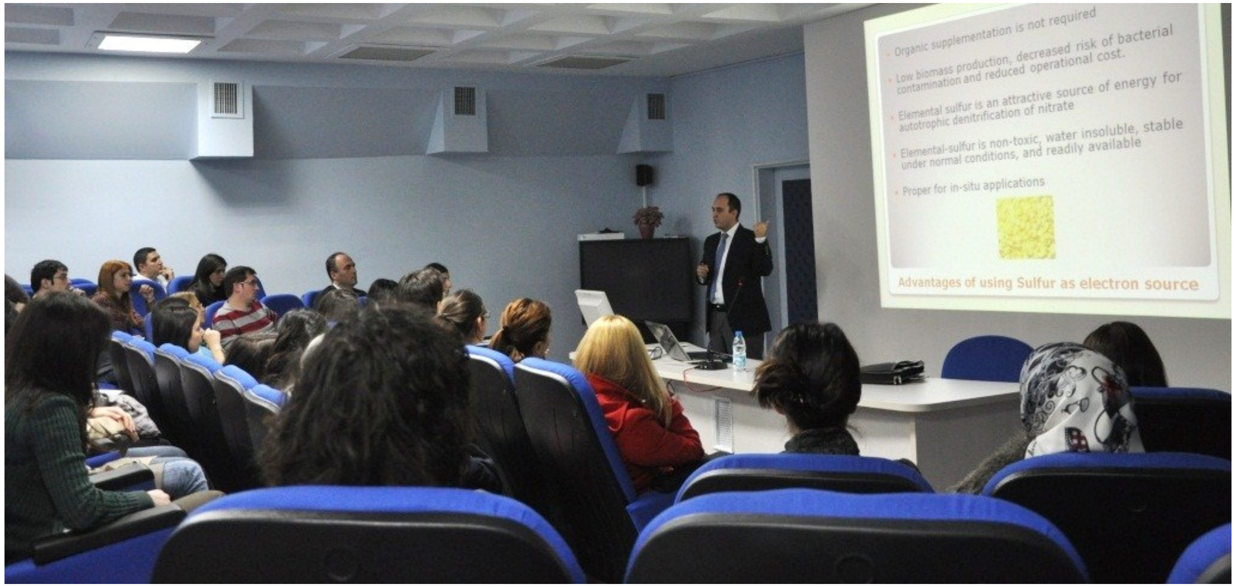
In the USA, between 10 and 25% of ground waters contain nitrate above the maximum allowable concentration.
Some wells in Harran Plain, Sanliurfa, Turkey contain nitrate as high as 180 mg/L NO_3-N and the average concentration for whole plain is 35 mg/L NO_3-N.
Extend of pollution


Organic supplementation is not required
Low biomass production, decreased risk of bacterial contamination and reduced operational cost.
Elemental sulfur is an attractive source of energy for autotrophic denitrification of nitrate
Elemental-sulfur is non-toxic, water insoluble, stable under normal conditions, and readily available
Proper for in-situ applications
Advantages of using Sulfur as electron source