



# BIOLOGICAL FILTRATION FOR THE REMOVAL OF NITRATE FROM POTABLE WATER SUPPLIES

## INTRODUCTION

Biological filtration processes for the removal of targeted contaminants from drinking water supplies are based on the growth of heterotrophic bacteria that derive energy from organic compounds, or autotrophic bacteria that derive energy from inorganic compounds. Both types of bacteria are indigenous, non-toxic beneficial bacteria that can be either aerobic or anaerobic. They form bacterial communities that produce oxidation or oxidation / reduction reactions with an organic or inorganic electron donor / acceptor respectively.



These bacteria take the place of a chemical oxidant, or a reducing agent, resulting in the biodegradation of contaminants. Biological filters use a variety of filter media including sand, granular activated carbon, proprietary media, etc. on which the bacteria grows. As water flows through the filter media the naturally occurring bacteria in the raw water form colonies that react with contaminants to produce a biomass which converts the contaminants to non-toxic by-products and, in some processes, precipitants. Biofilters are backwashed periodically with filtered water to remove excess biomass, non-toxic by-products and precipitants that can be disposed of to a sanitary sewer, pond, drying bed, filter press, membrane lined tank, etc.

Numerous groundwater supplies have nitrate levels that exceed the Environmental Protection Agency's maximum contaminant level (MCL) of 10 mg/L. Drinking water that contains high levels of nitrate can reduce the oxygen carrying capacity of the blood which can cause shortness of breath in adults, blue baby syndrome in infants, and other health issues, such as cancer, liver, kidney or reproductive issues.

Traditional methods of removing nitrate from potable water supplies include reverse osmosis (R.O.) or ion exchange (IX), both of which are effective. However, each process has a high capital and operating expenses, and each produces large amounts of brine waste that must be disposed of to a brine processing plant or to sewer that will accept brine.

# BIOLOGICAL NITRATE FILTRATION

Biological Filtration removes nitrate from potable water supplies by the process of denitrification. This process removes nitrate by converting nitrate ( $\text{NO}_3^-$ ) to non-toxic nitrogen gas ( $\text{N}_2$ ) which is released into the atmosphere. Capital, operating and chemical pretreatment expenses are reduced when compared to IX or R.O. systems. Both autotrophic and heterotrophic bacteria processes can remove nitrates from water supplies. Autotrophic bacteria do not require an external carbon source to augment their activity. However, they are low growth rate bacteria and have low nitrate removal. Heterotrophic bacteria are fast growing, provide a high rate of nitrate removal and can be augmented with a carbon source such as acetic acid to enhance biological activity. The raw water quality environment necessary to provide optimum nitrate-reducing bacteria growth includes the following parameters:

- a) D.O.: Less than 0.20 mg/L or as close to zero as possible
- b) pH: 7.5 to 8.0
- c) ORP: +50 to -50 MV
- d) Water temperature: 77°F to 86°F

## NOTES:

1. Nitrate removal biofiltration processes include the following:
  - An anoxic bioreactor vessel with sand media. Nitrate reducing anaerobic bacteria colonies grow on the sand and produce a biomass that use nitrates as a source of oxygen to convert nitrates to non-toxic nitrogen gas.
  - A media filter to remove excess biomass and contaminants.
  - A disinfection chemical feed system downstream of the filter.
2. Nitrate and nitrite (a result of nitrate reduction) are acute contaminants that cause immediate acute health effects.
3. An electron donor and nutrient such as acetic acid ( $\text{CH}_3\text{COOH}$ ) is fed into the raw water to ensure development of a healthy anaerobic bacteria colony.
4. Anaerobic bacteria colonies usually require 2 to 4 weeks to develop naturally.
5. Nitrate removal biofilters operate more effectively when they are running 24 hours per day with infrequent backwashing.
6. Biological nitrate filtration systems are significantly less expensive to operate compared to the cost of operating ion exchange and membrane systems (E.g. capital expense, resin / membrane replacement costs and brine disposal).
7. The backwash water from a biological nitrate removal process is non-toxic and can be disposed of to a sanitary sewer.
8. Nitrate removal biological filtration is not listed as a Best Available Technology (BAT). A comprehensive field pilot study under the direction of a consulting engineer must be conducted, with the approval of the Health Department, to confirm treatment parameters and efficiency. Continuous water quality control and monitoring of critical parameters must be included in the pilot study protocol.