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TECHNOLOGY EVALUATION

Demonstration Bulletin

Biological Denitrification Process

EcoMat, Inc.

Technology Description: EcoMat, Inc. of Hayward, California (EcoMat) has developed a 2-stage *ex situ* anoxic biofilter biodenitrification process. The process is a fixed film bioremediation, using biocarriers and specific bacteria to treat nitrate-contaminated water. Unique to EcoMat's process is a patented mixed bed reactor that retains the biocarrier within the system, thus minimizing solids carryover. Fixed film treatment allows rapid and compact treatment of nitrate with minimal byproducts. Methanol is added as a source of carbon for cell growth and for metabolic processes that remove free oxygen. The resulting oxygen-deficient environment encourages the bacteria to consume nitrate. Methanol is also important to assure that conversion of nitrate proceeds to the production of nitrogen gas rather than to the more toxic nitrite intermediate.

The mechanism for anoxic biodegradation of nitrate consists of two sequential denitrification reactions. Oxygen must be consumed to a dissolved oxygen concentration of <1 mg/L. In the first denitrification step, the bacteria are forced to substitute the nitrate as the electron acceptor and the nitrate is reduced to nitrite. In the second step, the nitrite is further reduced to nitrogen gas. Nitrite production is an intermediate step and there is no *a priori* reason to assume that the second reaction is at least as fast and/or favored as the first reaction in the presence of a specific bacterial population. Consequently, any evaluation scheme must establish that there is no buildup of nitrite, particularly since the nitrite-nitrogen maximum contaminant level (MCL) is only 1 mg/L, one tenth that of nitrate. High concentrations of nitrate and high nitrate/methanol ratios may also affect the concentration of residual nitrite in a particular process configuration.

A simplified process diagram of the EcoMat treatment system used during the demonstration is shown in Figure 1. The system is composed of two major components: a biodenitrification system and a polishing or post-treatment system. The biodenitrification system is intended to convert nitrates in the groundwater to nitrogen, thus reducing nitrate concentrations. The post-treatment system destroys or removes intermediate compounds generated during the biological breakdown of nitrate and removes bacteria and suspended solids that are not attached to the biocarrier. The post-treatment system can also incorporate treatment for other contaminants, such as VOCs, that may be present in the influent.

Biodenitrification is conducted in two reactors, identified as R1 and R2 on Figure 1. The majority of the oxygen removal step is conducted in R1 where aerobic bacteria reduce dissolved oxygen levels of the influent. Methanol is metered to the tank to encourage the bacteria to begin consuming nitrate. The resulting oxygen-deficient water is pumped from the bottom of R1 to the bottom of R2, which is densely packed with biocarrier media (1 cm) which have the appearance of small foam cubes. A patented mixing apparatus within R2 directs the incoming water into a circular motion, thus assuring intimate contact with the biocarrier. Within R2, the majority of denitrification occurs by anaerobic bacteria that are continually fed methanol and populate on the large mass of biocarrier media. After a sufficient retention time, depending on concentration and goal, denitrified water drains by gravity to an overflow tank, which allows for a continuous and smooth transfer to the post-treatment system and removal of entrained bacteria and media.

Depending on the presence of other contaminants, the post-treatment system consists of a series of varying sized filters downstream of one or more contaminant-specific treatment units. For instance, ozonation may be used to oxidize any residual nitrite to nitrate and to deactivate/destroy all residual biological materials leaving the biodenitrification unit. If VOCs are present, an air stripper and/or carbon adsorption unit can be used. If state regulations require chlorination of drinking water, then chlorine can be added as a post-treatment, or directly to the overflow tank immediately following denitrification.

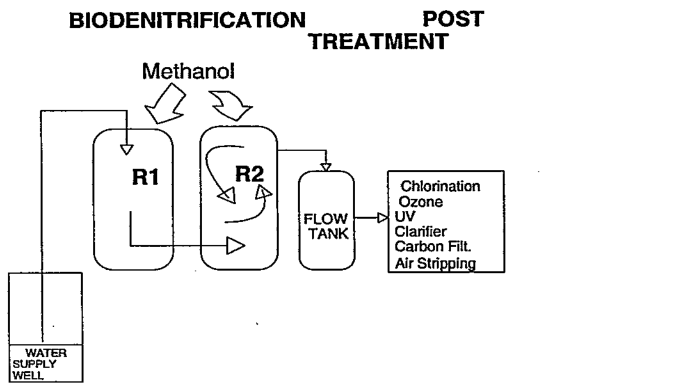

Figure 1. Simplified Flow Diagram

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Waste Applicability: Anoxic biodenitrification using one or more biocarriers should be applicable to industrial wastewaters and leachate from commercial, industrial and hazardous waste sites containing various nitrate concentrations, as well as for treatment of groundwater (the medium treated during the demonstration). The presence of other contaminants could play a significant role in the effectiveness and viability of the overall treatment system. For example, if volatile chlorinated hydrocarbons are present along with nitrate, a post-nitrate treatment system (e.g. carbon filters) may be necessary to remove those compounds to acceptable levels.

Demonstration Results: A SITE demonstration of the EcoMat biodenitrification system was conducted at the location of a former public water supply well in Bendena, Kansas. This study, which occurred from May until December of 1999, was conducted in cooperation with the Kansas Department of Health and Environment (KDHE). The KDHE provided a small building and necessary utilities for the EcoMat systems. In addition, the state is analyzing water samples independently.

The demonstration focused on treating contaminated water from the Bendena Rural Water District No. 2 Public Water Supply (PWS) Well No.1. This former railroad well, constructed in the early 1900s, was at one time the sole source of water for the town of Bendena. The primary contaminant in the water is nitrate from uncertain sources ranging from 20 to 130 mg/L. Low concentrations of VOCs, particularly carbon tetrachloride (CCl_4), in the groundwater is a secondary problem ranging from 2 to 31 µg/L.

EcoMat's main goal of the study was to demonstrate that its biodenitrification system could reduce incoming nitrate-N in excess of 20 mg/L to a combined nitrate plus nitrite concentration below 10 mg/L. A second goal of the study was to demonstrate that the post-treatment system used would produce treated water that would meet applicable drinking water standards with respect to nitrate-N and nitrite-N; and that the final effluent would not contain turbidity of greater than 1 NTU, detectable levels of methanol (1 mg/L), increased levels of biological material or suspended solids, and will have a pH in the acceptable 6.5 to 8.5 range.

To evaluate both the biodenitrification system and the post-treatment system adequately, water samples were collected from four specific points along the entire process. These were: 1) an influent sample point between PWS #1 and R1; 2) a partial treatment sample point between R1 and R2; 3) an intermediate effluent sample point between the biodenitrification system and post-treatment system; and 4) a final effluent sample point downstream of the post-treatment system. To assure a statistically adequate number of samples, an average of 30 influent and 30 effluent samples were collected for each of four separate sampling episodes. Over an approximate seven and one-half month period, EcoMat operated its system at a flow between three and eight gallons per minute.

Results from the EcoMat biodenitrification process were encouraging when the entire system was operating at optimal performance. In those instances where the final combined nitrate-nitrite effluent concentration was above the regulatory limit, operational problems (mostly mechanical) were suspected as the primary cause.

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