CALCULATING THE NITRATE CONCENTRATION IN GROUND WATER BELOW MASS DRAINFIELDS

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Introduction

Published reports have recently been reviewed by the Bureau of Sewage and Water in an attempt to more accurately predict the impact of a mass drainfield on the concentration of nitrate in the ground water. As a result of this review, the method of estimating the ground water nitrate concentration has been modified slightly to reflect what is currently known.

A Two Step Process

The following description explains the two step process which is used to estimate the nitrate concentration of ground water near a mass drainfield. The first step estimates the amount of rain water which infiltrates into the ground and dilutes the nitrate. The second step uses a mass balance equation to estimate the ground water nitrate concentration.

Step I

Calculating Rainwater infiltration

The Formula

There are a number of ways of calculating rainwater infiltration. For consistency, we are using the following formula. The number 74 is a constant that converts the input information to gallons per day.

Equation I

(R) X (D) X (74) average gallons of dilution rain water per acre per day

Where:

R = absorbed rainfall in inches

D = Acres available for infiltration of the rain

An Explanation of the Variables

The absorbed rainfall (R) is the number of inches of rain which infiltrates into the ground. Typically, this will be 50 percent of annual rainfall according to the Soil Conservation Service. Other values can be used if justified by the SCS Runoff Curve Number. Virginia has an average annual rain fall of 40-42 inches according to the National Oceanic and Aerospace Administration, so (R) would be about 20 inches. Some areas of the state receive more rainfall than the average of 40 inches. Data to that effect will be reviewed. Also, very flat areas may absorb more than the 50 percent average. Data from the Soil Conservation Service Runoff Curve Number is reviewed on a case by case basis if a consultant believes that 20 inches of rain water infiltration is not a correct value.

The dilution area (D) is the area where rain can infiltrate into the soil and dilute the nitrate in the ground water. Typically, it is the adjacent area owned, or controlled with an easement, by the system owner. The dilution area does not include the area under buildings, paved parking lots and other impermeable facilities unless provisions are made to return the runoff from these facilities into the ground water. No structures can be built on the dilution area for the life of the soil absorption field. A plat must be provided by the en and the dilution area must be clearly marked off. Any existing or proposed buildings must also be shown on the plat.

Special cases sometimes occur where the infiltrative capacity of the dilution area has been modified. A gravel parking lot is a good example of a modified infiltrative surface. For the purpose of determining infiltrative area, the Soil Conservation Service reports that gravel parking lots absorb 70% of the rainfall. Other values for other modified surfaces will be reviewed, based on the SCS Runoff Curve Number on a case by case basis.

Step 2

Mass Balance Calculation

Once the average number of gallons of infiltrated rainfall is calculated, step two, the mass balance calculation, can be done. To use the mass balance approach the following information must be known:

1. The number of gallons of wastewater equivalent to the amount of nitrate being produced (see explanation below).

2. The nitrate concentration of the wastewater.

Nitrate Equivalent

Soil absorption fields are hydraulically sized based on water use as listed in Table 4.6 of the Sewage Handling and Disposal Regulations. However, the nitrate concentration data that we arc using is based on flows less than those shown in Table 4.6. An adjustment must be made when you are estimating the potential amount of nitrate being produced.

NOTE: This downward adjustment is only done when nitrate concentrations are being calculated. The hydraulic sizing of the system is based on the information in Table 4.6 of the Sewage Handling and Disposal Regulations.

For the purpose of calculating the nitrate equivalent loading rate for residential buildings, use 65 gpd/person. Remember there are two people per bedroom. The equivalent nitrate loading rate for a restaurant is 20 gpd/seat. The nitrate equivalent loading rate for other establishments will be determined at a future date.

Nitrate Concentration

The potential nitrate concentration is based on an average ammonium ion concentration of 60 mg/l for residential wastewater (EPA, 1980). Fifty percent of this is volatilized, or otherwise lost before it gets into the water table as nitrate. Ninety-nine percent of the rest of the ammonium ion is converted to nitrate under aerobic conditions (EPA, 1980). Therefore, for our purposes, 30 mg/l of potential nitrate is present in residential wastewater. Other studies (Siergist, et. a!, 1984) reported that restaurant wastewater has only 80 percent of the nitrogen present in residential wastewater, so we use a potential nitrate concentration of 24 mg/l for restaurant wastewater. Recall that this is based on 20 gpd/seat for the purposes of estimating the nitrogen loading rate for a restaurant.

Mass Balance

We can estimate the number of gallons of rainwater which infiltrates into the ground on average each day. Further, we can estimate the average number of gallons of wastewater produced each day, and the potential nitrate concentration of the wastewater. With this information, we can estimate the nitrate concentration of the ground water leaving the property using a mass balance concept and the following equation:

Equation 2

$$\frac{\text{No. of gallons of wastewater}}{\text{No. of gallons of ww + dilution}} \times \begin{matrix}\text{concentration}\\ \text{of the}\\ \text{wastewater}\end{matrix} = \begin{matrix}\text{nitrate}\\ \text{concentration}\\ \text{of the aquifer}\\ \text{in mg/l}\end{matrix}$$

Interpreting the Results

The nitrate concentration of the aquifer should not exceed 10 mg/l. This level was established based on EPA drinking water standards. The level may be changed to 5 mg/l (proposed Department of Health mass drainfield regulations) to allow for a margin of safety.

Recommendations

If the calculations show that the nitrate concentration in the ground water exceeds 10 mg/l, the engineer has the following options:

1. Increase the size of the dilution area.

2. Reduce the nitrate loading rate by producing less wastewater. This would have to be an actual reduction in use i.e., fewer bedrooms or fewer seats in a restaurant. The use of low flush toilets reduces the hydraulic load, but the amount of nitrogen produced per year stays the same.

3. Provide some method of reducing the potential nitrate concentration of the wastewater. This would require treatment which removes the ammonium ion.

4. Submit detailed documentation which shows that rainfall exceeds the state average, that infiltration is greater than 50 percent of rainfall, or that the potential nitrate concentration of the wastewater is less than average.

Example Nitrate Concentration Problem

The following is an example calculation to estimate the ground water nitrate concentration near a mass drainfield.

- Information provided by the engineer:
- Rainfall, R = 40 inches per year
- Percent of rainwater which infiltrates, 50 percent
- Dilution area, D = 5 acres
- Type of wastewater, residential
- Number of bedrooms, 12
- (Three homes with 4 bedrooms per home all disposing to a common drainfield)
- Hydraulic loading rate 150 X 12 1800 gallons
- Equivalent nitrate loading rate = 130 X 12 1560 gallons
- Potential nitrate concentration 30 mg/l (residential waste)
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Step 1: Calculate R, the number of inches of rain that infiltrate the site per year.

R = 40 inches/year rainfall X 0.5 = 20 inches per year

Step 2: Use equation one to calculate the average daily dilution from rainwater.

20 inches X 5 acres X 74 = 7400 gallons per day per acre year

Step 3: Use equation two to calculate the nitrate concentration leaving the site.

1560/(1560 + 7400) X 30 mg/l = 5.2 mg/l

This value of 5.2 mg/l will not exceed the ground water nitrate standard of 10 mg/l.

Note: If this were a restaurant, the equivalent nitrate loading rate would be based on 20 gpd/seat and the potential nitrate concentration would be 24 mg/l.

References

Environmental Protection Agency, 1980. Design Manual-Onsite Wastewater Treatment and Disposal. EPA Publication No. 625/1-80-012.

Siegrist, R.L, D. L. Anderson, and J. C. Converse, 1984. Commercial Wastewater On-Site Treatment and Disposal. Proceedings of the Fourth National Symposium on Individual and Small Community Sewage Systems. ASAE Publication No. 07-85. p. 217.