Georgia Department of Public Health

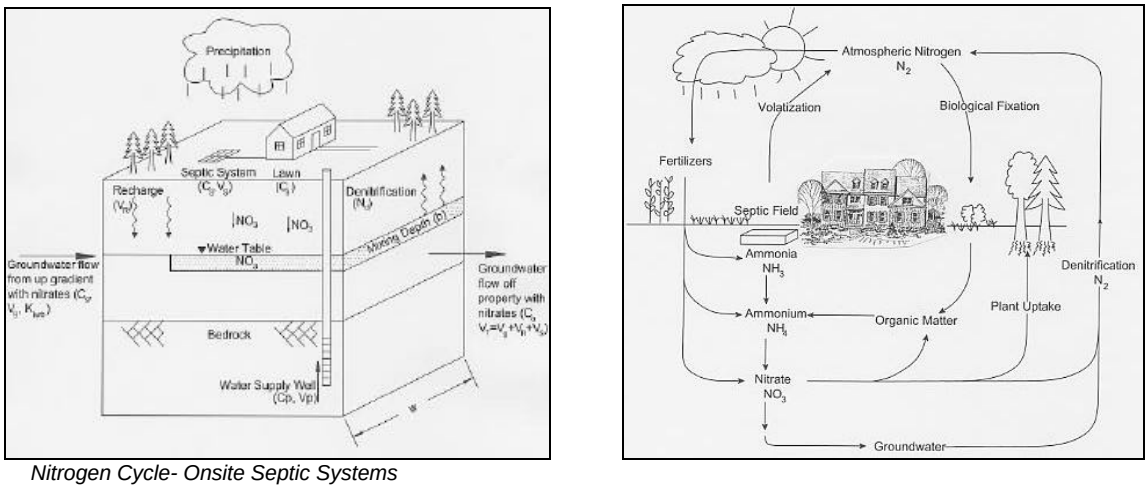
Georgia Onsite Sewage Management Systems

A Nitrate Mass Balance Model for Georgia

Impact of Onsite Sewage Systems on Ground Water Concentration of Nitrogen

Background

Mass Balance models for lot sizes have been developed by Trela (1978), Whermann (1984), Baurman (1985), Tinker (1986), Frimpter (1990), Hantzsche (1993) and others. Variations to the different methods range from simple to complex and accuracy can vary greatly. However, the planning of minimum lot sizes considers the impact of nitrogen loading by an onsite septic system. The mass balance approach can provide an approximation of the condition of ground water by estimating nitrate concentrations.



Nitrogen Cycle- Onsite Septic Systems

Minimum lot size is based on nitrates being diluted to drinking water standards of 10 mg/l or less. The maximum daily sewage flow for each lot or parcel of land shall not exceed 600 gallon per acres when served by a non-public water supply (GA Manual for On-site Sewage Management Systems, 2007).

Two Step Process:

1) Estimate the amount of rain which infiltrates into the ground.
2) Use a mass balance equation to estimate ground water nitrate concentrations.

STEP 1- Calculating Rainwater infiltration

(R) X (D) X (74) = Average gallons of dilution rain water/acre/day

R = Absorbed rainfall in inches. 50 percent of annual rainfall is used. (*Soil Conservation Service, Runoff Curve Number,1986*). Some areas of the state receives more or less rainfall and infiltration is affected by slope, vegetation, soil moisture, etc. however, 50% is used to determine the state average. Georgia has an average rainfall of 50 inches per year (NOAA)
D = Dilution Area. Acres available for infiltration of the rain
74 = a is constant that converts inches of annual rainfall into gallons per day

STEP 2- Mass Balance Calculation

1) The total numbers of gallons of wastewater equivalent to the amount of nitrate being produced.

2) The nitrate concentration of the wastewater

Peak flow for residential usage is 150 gallons per day per bedroom. Nitrogen concentration for residential wastewater is ~ 60 mg/l (EPA, 2002). Fifty percent is volatilized, or lost before the wastewater infiltrates the ground (EPA, 1980). We can estimate the gallons of both rainfall and waste water infiltration and we can estimate the nitrate concentration in that wastewater. We can now determine the impact of the septic system on the ground water quality. EPA Drinking Water Standards require that nitrate concentrations should not exceed 10 mg/l.

Example Mass Balance Equation

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

- R=25 inches. 50% of GA average annual rainfall of 50 inches/yr (NOAA)
- D=1 acre lot size, dilution area
- Number of bedrooms, 4 bedrooms at 150 gallons/day=600 gallons of waste water
- Nitrogen concentration of residential waste water is 60 mg/l
- Nitrate concentration=30mg/l, 50% of nitrogen because of denitrification (volatilized nitrite)

Example Equation

Step 1: (R)x(D)x(74)= Total inches of rainfall/acre/day
(25 inches)x(1 acre)x(74)=1850 gallons/acre/day

Step 2: $\left(\frac{\text{Gallons of Wastewater}}{\text{Gallons of Wastewater + Rainwater}}\right)\left(\text{X Concentration of waste water}\right) = \text{Nitrate Concentration}$

$$\left(\frac{600\ \text{gals/day}}{600\text{gals}+1850\ \text{gals}}\right) \text{X } 30\ \text{mg/l} = 7.35\ \text{mg/l}^*$$

* *A margin of safety is necessary because of factors such as drought conditions, lawn fertilizers, varying impervious infiltrative area, etc.*

References

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

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United States Department of Agriculture (1986). *Urban hydrology for small watersheds*. Technical Release 55 (TR-55) (Second Edition ed.). Natural Resources Conservation Service, Conservation Engineering Division.