MONITORING A SEPTIC TANK/LEACH FIELD SYSTEM

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ABSTRACT

A study is in progress at Lake George examining the transport and removal in the soil of nutrients from a septic tank/leach field system. Of primary concern is the possibility that nitrogen and phosphorus compounds originating from the septic tank may reach surface waters. Groundwater samples taken from driven well points were analyzed to determine the removal and transport of the nutrients. The study to date indicates that there is no significant adverse effect on Lake George from the septic tank system.

INTRODUCTION

The control of lake water quality is very important to the residents around Lake George. In addition, tourists and other non-residents who enjoy the lake for its many recreational uses consider this lake's water quality to be a most important issue. Recreation is an economic factor for the communities surrounding the lake, but it is not the only use of this lake. Many of the homes around Lake George use the lake as a drinking water supply. Therefore, it is evident that pollution must be controlled so the lake will remain a desirable recreational area and the water quality will continue to meet drinking water standards.

The numerous septic tanks serving the less congested areas of Lake George have in the past few years become suspect of their potential for the nutrient enrichment of the drainage basin. While much information is contained in the literature on the eutrophication of surface waters, very little can be found on the potential nutrient loadings of these waters from septic tanks.

The nutrients most commonly limiting eutrophication of surface waters are phosphorus and nitrogen. Lake George has been shown to be phosphorus-limited (Fuhs, 1972). The purpose of this study is to investigate the transport and removal in the soil matrix of phosphorus and nitrogen from a septic tank/leach field system.

BACKGROUND

Nitrogen from septic tanks occurs mainly in two forms: organic nitrogen and ammonia nitrogen (Hall, 1975). Organic nitrogen is hydrolyzed to ammonia in the anaerobic and biologically active environment of a properly operating septic tank. In the aerobic absorption field, both of these forms will be converted to nitrate (NO_3^-) within the first few inches of soil surrounding the absorption trench (Dudley and Stephenson, 1973; Preul and Schroepfer, 1968; Kurtz, 1970; Lance, 1972; Walker *et al.*, 1973). Nitrate is very soluble and is stable in aerobic soil environments (Hall, 1975). It is leached quite readily through the unsaturated zone to the groundwater. Soil saturated with groundwater may present a micro-aerobic environment where denitrifying bacteria are able to convert nitrate to nitrogen gas which is released to the atmosphere.

In order to avoid adversely affecting lake water quality, total nitrogen concentration in the groundwater reaching the lake should be less than 0.3 mg N/L (Vollenweider, 1968).

Most organic phosphorus is hydrolyzed in a septic tank to the orthophosphate (PO_4^{3-}) ion. This is the most stable form of phosphorus in the soil environment (Sikora *et al.*, 1976). It is also a form easily available to algae as a phosphorus source in surface waters, where growth is frequently phosphorus-limited. For these reasons it is very important that phosphates be removed from a septic tank effluent before it reaches the receiving water.

Phosphate removal is accomplished by a number of mechanisms, many of which are not well understood. Perhaps the most important of these is rapid removal, or sorption. Phosphates are readily adsorbed on many soils, particularly clays (Bolt and Bruggenwert, 1978). In soils containing clay, phosphates have been shown to react with soluble iron and aluminum oxides originating from the clay minerals to form insoluble iron- and aluminum-phosphate compounds (Coleman, 1944). Therefore, a soil system with a higher clay content will have a greater capacity for phosphate removal.

In calcareous groundwater areas, phosphates may be precipitated as calcium phosphates, and at high pH values as hydroxyapatite, which are retained in the soil (Jones and Lee, 1977). This is a more permanent removal mechanism than adsorption. There can be other precipitation reactions of phosphates in the soil matrix, as well as biological immobilization and plant uptake. Biological immobilization can occur virtually anywhere in the soil. Plant uptake is generally a combination of uptake by deep-rooted plants and utilization by shallow-rooted plants of phosphates leached upward by capillary action of groundwater.

While adsorption sites on soils are used up as phosphates are adsorbed, the adsorptive capacity of a soil system is continuously regenerated by the precipitation mechanisms discussed above. In fact, it has been suggested by Jones and Lee (1977) that soils may have an infinite capacity to remove phosphorus because of these mechanisms, and therefore the ability of a soil system to remove phosphorus may be independent of prior exposure to phosphorus.

EXPERIMENTAL PROCEDURE

The area of study is a lakeshore residence near the southern end of Lake George in Dunham Bay, N.Y. The home is occupied 12 months of the year and has many visitors throughout the summer months. The leach field is located approximately 120 feet (36 m) from the lake. The lawn in front of this house slopes gently toward the lake and is interspersed with rock outcroppings.

Eight observation wells were driven between the leach field and the lake and a control well was driven behind the house (see sketch). All nine wells were driven into the groundwater table at the time of installation, but only six of them, including the control well, have continuously yielded sufficient quantities of water for complete sampling and analysis.

Human wastes contain chlorides which may be used as tracers in both surface and ground waters. Chlorides in groundwater have been shown to be indicators of discharges from septic systems (Jones and Lee, 1979; DeWalle and Schaff, 1980). In this study, chlorides were used as indicators that the effluent plume of the system was being sampled.

Chloride concentrations were measured by an ion-specific electrode. The sensitivity of this method is 1 ppm.

For phosphorus determinations, the samples were filtered through 0.45-µm pore size filters shortly after sampling. Filtrable reactive phosphorus (FRP) is composed almost entirely of orthophosphate. FRP was determined by the stannous chloride method (Standard Methods, 15th ed., Method 424E). For total filtrable phosphorus (TFP) determinations, the filtered samples were digested by the persulfate digestion procedure (Standard Methods, 15th ed., Method 424C:III). The digested samples were then analyzed by the stannous chloride method to obtain total filtrable phosphorus. The minimum detectable concentration of the stannous chloride method (for digested and undigested samples) is 3 µg P/L.

Kjeldahl nitrogen is the sum of organic nitrogen and ammonia nitrogen. Kjeldahl nitrogen was determined by first digesting and distilling the samples via the kjeldahl digestion procedure (Standard Methods, 15th ed., Method 420A) and then analyzing the distillate using the nesslerization method with a photometric finish (Standard Methods, 15th ed., Method 417B). This method is accurate to about 100 µg N/L. All results obtained below this value are represented as "<100" µg N/L.

Nitrate concentrations were determined using the brucine method (Standard Methods, 14th ed., Method 419D). This method is recommended for no less than 100 µg N/L, so all results obtained below this value are represented as "<100" µg N/L.

SKETCH OF SITE

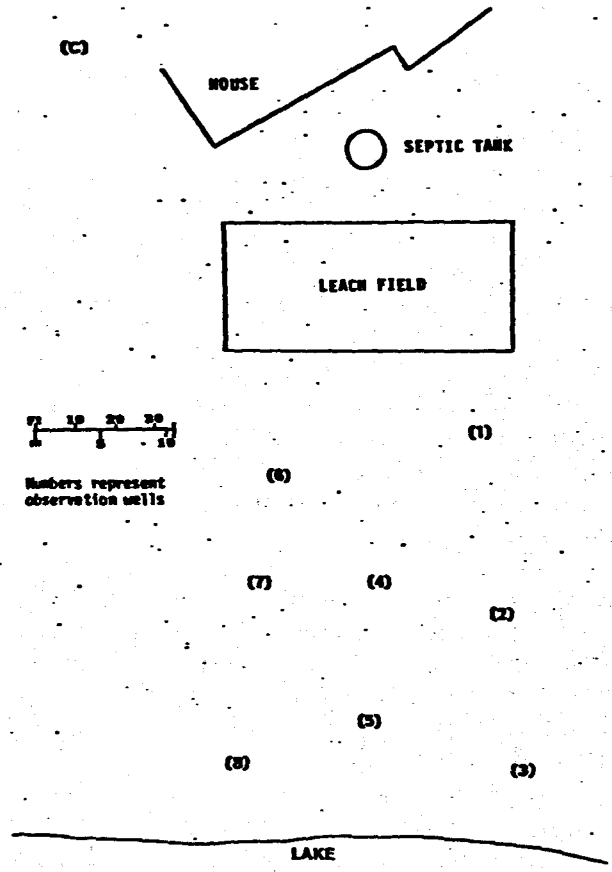

TABLE OF RESULTS

UNITS

$[NO_3^-]$ = [µg N/L]
KN = [µg N/L]
TFP = [µg P/L]
FRP = [µg P/L]
$[Cl^-]$ = [mg Cl/L]

CONTROL WELL

$[NO_3^-]$ = 180
TFP = 9.3
FRP = <3
$[Cl^-]$ = 1.5

(6) $[NO_3^-]$ = 4600
KN = <100
TFP = 11.7
FRP = 6.1
$[Cl^-]$ = 6.0

(7) $[NO_3^-]$ = 180
TFP = 12.9
$[Cl^-]$ = 4.0

(2) $[NO_3^-]$ = 8200
KN = <100
TFP = 12.0
FRP = 7.9
$[Cl^-]$ = 9.7

(8) $[NO_3^-]$ = <100
KN = <100
TFP = 10.9
FRP = 7.4
$[Cl^-]$ = 14.7

(3) $[NO_3^-]$ = <100
KN = <100
FRP = 5.3
$[Cl^-]$ = 11.8

LAKE

$[NO_3^-]$ = <100
KN = <100
FRP = 3.7
$[Cl^-]$ = 6.0

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RESULTS

The chloride concentrations found in wells 2, 3, 6, and 8 were significantly higher than in the control well. This indicates that these wells are most likely in the effluent plume of the system. The chloride concentrations in wells 2, 3, 6, and 8 and in the lake decreased through the fall and winter months, either due to a decrease in loading on the system or an increase in dilution by groundwater flow.

Kjeldahl nitrogen (KN) concentrations in all wells were below 100 µg N/L. This was expected because of the conversion of organic and ammonia nitrogen forms to nitrate during percolation.

The highest nitrate concentrations were found in wells 2 and 6, the two closest to the leach field. These values are well over ten times higher than the background level found in the control well. This is a further indication that these wells are in the effluent plume of the system (Jones and Lee, 1979; DeWalle and Schaff, 1980). Well 7, located about 50 feet (15 m) from the leach field and 30 feet (9 m) downslope from well 6, showed a marked reduction in nitrate concentration from that of well 6. Wells 3 and 8, located about 100 feet (30 m) from the leach field, yielded the lowest nitrate concentrations. These are similar to the background level found in the control well and below the sensitivity of the test. In the wells nearest the lakeshore (wells 3 and 8) the total nitrogen concentrations were less than 200 µg N/L and lower than could be determined by the measurement techniques used.

All observation well samples contained FRP concentrations less than 10 µg P/L, a commonly accepted threshold value for eutrophication of surface waters (Vollenweider, 1968). Within one standard deviation, all the groundwater FRP levels overlapped. This shows that the FRP concentration in the groundwater does not vary significantly and that sufficient removal was accomplished within 20 feet (6 m) of the leach field.

CONCLUSIONS

Sufficient conversion of kjeldahl nitrogen to nitrate seems to have taken place during percolation of the effluent through the unsaturated zone so that the concentration of kjeldahl nitrogen in the groundwater remained below 100 µg N/L.

Within 50 feet (15 m) of the leach field, the total nitrogen concentration was low enough for the groundwater to be received by the lake without seriously increasing the nitrogen pool.

Since the FRP concentrations in the groundwater did not vary significantly between the leach field and the lake, it can be seen that most or all removal of FRP took place during percolation and that little or no further reduction in FRP concentration was effected once the effluent reached the saturated zone.

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DISCUSSION

Question - How long has field been in use?
LaDuc - 12 years.

Fuhs - Are you planning to do a mass balance?
Answer - No.

Collins - Did you take any samples within each field?
Answer - No.

Kopache - We have observed growth of filamentous algae on the lake in front of this lot.
Answer - It may be because of the house next door.

Collins - This system may be quite unique in that there was several truck loads of sand brought in when the system was installed, therefore it is probably not a representative system, do you agree?
Answer - Yes, it was not picked as such.

Stross - You indicated that 6 μg/l ortho P from leachfield effluent in the lake, this would be a nutrient bath for the algae!
Answer - The commonly used criteria for leachfield operations is that the effluent be below 10 μg/l optho P.