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# Project Summary

# Determination of Toxic Chemicals in Effluent from Household Septic Tanks

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**The presence of volatile organics was evaluated in raw domestic sewage that was generated in a subdivision and treated by a large 5-year-old commuarnity septic tank from which the solids had been pumped just before this study. Analyses showed the presence of priority pollutants in the raw sewage. Essentially no removal of these compounds occurred during the 2-day detention in the septic tank. The priority pollutants generally showed higher levels during the weekend, probably reflecting leisure activities and use of related chemicals (paint thinners, grease removers, toilet bowl cleaners, etc.). Most of the other volatile compounds were hydrocarbons, and their removal by the septic tank generally decreased with increasing molecular weight. Several organosulfur compounds showed substantial increase as a result of anaerobic degradation processes in the septic tank.**

***This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

Onsite disposal of sewage is widely practiced in rural areas and urban fringes, but it has received relatively little attention from regulatory agencies or research institutes. For example, little comprehensive information is currently available to document successes and failures of onsite disposal systems and the resulting health implications. In the State of Washington, the census noted 403,910 septic tanks or cesspools and 14,464 other individual systems such as aerobic units or ponds. Such systems represented 34.7% of all housing units. A current survey in the State of Washington also indicates the presence of more than 500 large onsite systems serving hospitals, schools, restaurants, and subdivisions. Because the septic tank effluent is directly returned to the soil through infiltration into the subsurface drainfield, considerable public health concern exists over groundwater contamination and pollution of drinking water wells. A recent study showed such widespread contamination in major parts of central Pierce County south of Tacoma.

In previously published studies, only the efficiency of the septic tank with respect to BOD, SS, and grease removal was evaluated; the trace organics present in domestic sewage and in septic tank effluent were not measured. The present study was conducted to collect such data. The aim was to measure the presence of volatile priority pollutants in domestic sewage as it entered a large community septic tank system. The study also evaluated the removal of these compounds in the anaerobic septic tank by analyzing effluent samples collected from the distribution box.

## Materials and Methods

This study used a community septic tank serving 97 homes in the Oakbrook 6 subdivision located south of Tacoma, Pierce County, Washington. The homes are located on four streets served by a 200-mm (8-in.) gravity sewer that discharges into a wetwell. A 10.1-L/s (160 gpm) submersible centrifugal pump transports the waste to the septic tank. The unit contains 84,935 L (22,440 gal) liquid volume in the first compartment and 42,468 L (11,220 gal) in the second compartment. The raw sewage sample was collected through the manhole from the inlet-T before the sewage mixed with the contents of the first compartment. The effluent sample was collected from the distribution box located 4.57 m (15 ft) downstream from the effluent-T.

The sewage was collected with an all glass and teflon, custom-made sampler. The sewage was drawn by suction through a 0.5-in. telfon intake line with a 100-ml glass syringe. When the syringe was in the drawn position, a teflon solenoid valve closed the intake line and opened the discharge line. When the syringe content was subsequently displaced, it flowed through the discharge line to a collection device with a floating plunger to prevent losses of volatile organics. The septic tank effluent was collected using a similar sampler that drew from below the liquid surface in the distribution box. The samples were collected as 24-hr composites during a 7-day continuous period.

The volatile organics were removed from the aqueous sample with a purge and trap method. A modified Hewlett/Packard 7675A* purge and trap sampler was used to purge 10 ml of liquid with nitrogen gas at a rate of 20 ml/min. The volatile organics that were stripped from the liquid were subsequently absorbed when the nitrogen passed through a Tenax GC trap. The trap was subsequently heated, and the volatile organics were backflushed and trapped in the initial 0.5-m portion of a 30-m fused silica WCOT column with an SE-54 stationary phase chilled by liquid nitrogen. After removal of the cryotrap and flash heating of the column, the volatiles were separated in the gas chromatograph and detected by mass spectrometry. A computer library system containing spectra of 30,000 compounds was used for a spectral comparison with each detected compound.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

## Results and Discussion

### Flow Measurements

Flow data were obtained both from the water usage records of the Lakewood Water District Company and from measurements in the wetwell. The water usage data show a baseline of 58.7 L/min (15.5 gpm), which usage triples to 219.5 L/min (58 gpm) during the summer months because of extensive usage. The frequency distribution of the flow rates shows several maxima corresponding to usage in a household with 1, 2, 3, 4, 5, 6, or 7 persons, respectively. The median household with 3.2 persons uses 897 L/day (237 gal/day). The usage ranges from 329.3 L/ person per day (87 gal/ person per day) for a one-person household to 242.2 L/ person per day (64 gal/ person per day) for a seven-person household.

The flow measurement at the wetwell consisted of determining the interval between sequenced pump switch-on times. The flow rate during the day was calculated with the holdup volume in the wetwell. The average calculated flow was 44.7 L/min (11.8 gpm), which is 24% less than that calculated with the usage data. This discrepancy indicates that about a quarter of the used water does not reach the septic tank and is lost through evaporation (clothes dryer, plant evapotranspiration, sewer leaks, etc.). The highest discharge rates and the highest standard deviation were noted around 9 p.m.

### Presence of Trace Organics

The efficiency of the volatile organic analysis (VOA) using the purge and trap unit was evaluated using surrogate compounds spiked at 20 ppb in the liquid before purging. The results show a median recovery of 91% for bromochloromethane, 90% for 1,4-dichlorobutane, and 82% for $D_6$-benzene (Figure 1). However, the standard deviations were substantial at this low concentration level.

The organics were measured in the samples during an intensive, week-long monitoring followed by six additional samplings, the last of which occurred on January 23, 1982. The results are summarized in Table 1 and indicate that dichloromethane was found in all samples. Toluene followed in frequency of detection. These two compounds were also found in the water collected from the 125-ft-deep monitoring well adjacent to the drainfield. The analysis during the week-long monitoring was initiated on Monday, September 22, and it was terminated on Sunday, September 28, 1980. The volatile organic fraction typically contained 40 to 50 compounds at a concentration >1 ppb, but only five were identified as priority pollutants.

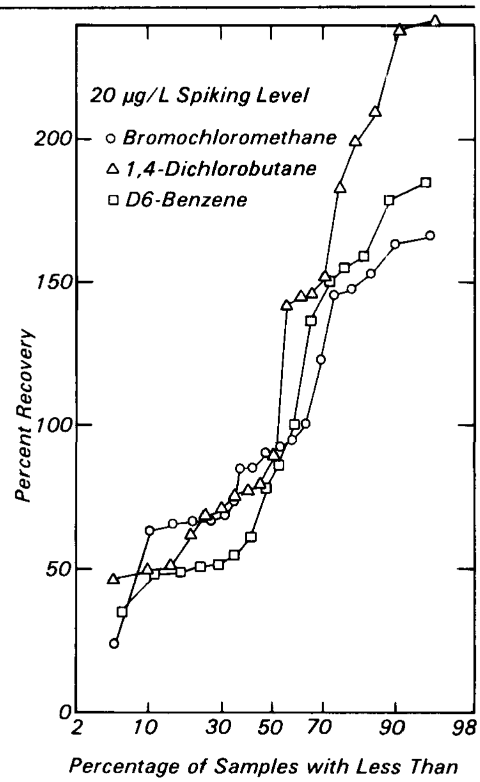


*Figure 1.* *Normal frequency distribution of surrogate recovery.*

Toluene was the most prevalent among the priority pollutants, with an average concentration of 34.6 µg/L in the raw sewage and 38.8 µg/L in the effluent. The toluene, which originates from cleaning solvents and paint thinners, reached its maximum concentration of 47.8 µg/L in the influent on Friday, and 56.9 µg/L in the effluent on Sunday. The shift in the maximum toluene concentration by 2 days may be a result of the detention time, which was estimated at approximately 2 days.

Dichloromethane, which likely originated from chlorinated tapwater, was present in the next highest concentration (9 µg/L) and also showed its highest level on Sunday. No lag was detected between effluent and influent, however. Chloroform showed its maximum concentration (5 µg/L) in the influent on Saturday, and the effluent showed a second maximum on Sunday (0.8 µg/L), representing a 1-day shift. Tetrachlo-

*Table 1. Occurrence of Volatiles in Septic Tank Samples*

| Compound | Tap n=2 | Influent n=13 | Effluent n=13 | Scum n=2 | Sludge n=2 | Well n=1 |
|---|---|---|---|---|---|---|
| | *Percent of Samples in which Compound was Present* | | | | | |
| Dichloromethane | 100 | 100 | 100 | 100 | 100 | 100 |
| Chloroform | 0 | 62 | 62 | 0 | 0 | 0 |
| Trichlorofluoromethane | 0 | 0 | 0 | 50 | 0 | 0 |
| Bromomethane | 0 | 0 | 15 | 100 | 50 | 0 |
| 1,1,2-Trichloroethane | 0 | 0 | 8 | 8 | 0 | 0 |
| Trichloroethane | 0 | 8 | 8 | 50 | 0 | 0 |
| 1,1,1-Trichloroethane | 0 | 0 | 8 | 0 | 0 | 0 |
| 1,3-Trichloropropene | 0 | 8 | 0 | 0 | 0 | 0 |
| Benzene | 0 | 0 | 15 | 100 | 50 | 0 |
| Chlorobenzene | 0 | 0 | 0 | 0 | 50 | 0 |
| Toluene | 0 | 85 | 85 | 50 | 0 | 100 |
| Ethylbenzene | 0 | 15 | 23 | 100 | 100 | 0 |

roethene was generally low during the week, but it reached a maximum on Monday (8 μg/L in the influent and 1 μg/L in the effluent). Benzene was detected only on Wednesday.

A log-normal frequency distribution graph of the aromatic compounds showed the presence of benzene only in the scum and sludge layer. Although benzene was not detected in the influent, it was detected on two occasions in the effluent, possibly as a result of discharged solids from the scum or sludge layer. Toluene showed no removal in the septic tank and very little accumulation in the scum and sludge layer. Low removals were also noted for the chlorinated compounds.

The generally low removals of the volatile organics was further reflected by the similarity of the reconstructed total ion current of the volatile organics in the influent and effluent of the septic tank. A tabulation of the 48 compounds (Table 2) shows that the majority are hydrocarbons, including both aliphatic and cyclic structures. Several compounds reflect the presence of anaerobic degradation processes occurring in the sewer line or septic tank. High concentrations were noted for 2-propanone, 2-ethyl-4-methyl-1-pentanol, and 4-methyl-2-propyl-1-pentanol—all likely originating from anaerobic decomposition processes. Large increases were also noted for several biogenic organosulfur compounds such as carbon disulfide, methanethiol (methylmercaptan), dimethyl disulfide, and dimethyl trisulfide. The largest increase was noted for methanethiol. Small increases were noted for compounds with larger molecular weights, probably reflecting the greater difficulty with which bacteria generate these larger compounds. The low-molecular-weight alkylated benzenes show a significant removal, probably because of biodegradation; but the results show no removal for higher-molecular-weight compounds. The hydrocarbons showed the highest removals at intermediate molecular weight and lower removals at larger molecular weights, probably because of reduced volatilization. The increase noted for several of the low-molecular-weight hydrocarbons may be a result of their formation as intermediates in the breakdown of larger-molecular-weight hydrocarbons.

## Conclusions

The present study has important implications for assessing the environmental impact of septic tanks. Since little removal of the volatile priority pollutants occurs, these compounds will be discharged through the subsurface drainfield and may enter the groundwater. Volatilization is a removal mechanism in the septic tank, but this mechanism will not be effective in the presence of a thick scum layer and during subsurface drainage and migration. Some biodegradation of several organosulfurs and hydrocarbons is likely to occur during soil migration, especially since aerobic conditions generally prevail. However, the chlorinated organics and most of the branched or cyclic hydrocarbons are less likely to be degraded by bacterial action and are expected to migrate considerable distances in the soil. A related study noted substantial migration of low-molecular-weight chlorinated solvents away from a landfill in Delaware.

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**Table 2.** *Volatile Compounds Found in Septic Tank (Sunday)*

| Volatile Compounds | Scan | µg/L in Influent | Scan | µg/L in Effluent |
|---|---|---|---|---|
| Methane, dichlorodifluoro | 1380 | 0.64 | -- | <0.7 |
| Methanethiol | -- | <0.7 | 1395 | 128 |
| 2-Propanone | 1407 | 18.2 | 1410 | 70.3 |
| Methane, thiobis | 1415 | 23.0 | 1418 | 84.4 |
| Unknown hydrocarbon | 1419 | 2.0 | 1421 | 4.2 |
| Carbon disulfide + dichloromethane | 1422 | 4.2 | 1424 | 10.0 |
| $C_7$ hydrocarbon | 1536 | 13.0 | 1527 | 13.6 |
| Hexane, 3-methyl | 1558 | 8.1 | -- | <0.7 |
| Heptane | 1612 | 6.2 | -- | <0.7 |
| Disulfide, dimethyl | 1754 | 11.6 | 1729 | 29.7 |
| Benzene, methyl | 1842 | 74.4 | 1825 | 16.7 |
| Hexane, 2,5-dimethyl | 1843 | 14.9 | -- | <0.7 |
| Heptane, 3-methyl | 1875 | 5.3 | -- | <0.7 |
| Cyclohexane, 1,3-dimethyl, cis | 1883 | 5.3 | -- | <0.7 |
| Cyclohexane, 1,3-dimethyl, trans | 1890 | 1.2 | -- | <0.7 |
| Cyclohexane, 1-ethyl-2-methyl | 1971 | 1.0 | -- | <0.7 |
| Heptane, 2,4-dimethyl | 2009 | 15.3 | -- | <0.7 |
| $C_{10}$ cyclic hydrocarbon | -- | <0.7 | 2770 | 3.3 |
| Pentane, 2,2,3,4-tetramethyl | 2947 | 9.7 | -- | <0.7 |
| Trisulfide, dimethyl | 2960 | 11.4 | 2941 | 12.7 |
| Heptane, 6,6-dimethyl-2-methylene | 2997 | 6.2 | -- | <0.7 |
| Hexane, 2,2,5,5-tetramethyl | 3000 | 8.0 | -- | <0.7 |
| Branched $C_{10}$ hydrocarbon | 3044 | 3.7 | -- | <0.7 |
| Nonene, 4,6,8-trimethyl | 3074 | 3.4 | -- | <0.7 |
| Hexane, 3,3,4-trimethyl | 3091 | 3.2 | -- | <0.7 |
| Hexane, 2,4-dimethyl | 3124 | 8.3 | -- | <0.7 |
| Benzene, 1,4-dichloro | 3149 | 16.7 | 3134 | 11.5 |
| Pentane, 2,2,3-trimethyl | 3157 | 2.5 | -- | <0.7 |
| $C_{10}$ cyclic hydrocarbon | 3179 | 7.2 | 3168 | 25.1 |
| Benzene, 1-methyl-4 (1-methylethyl) | 3211 | 15.4 | 3205 | 71.6 |
| Heptane, 2,2,4,6,6-pentamethyl | 3221 | 17.1 | 3212 | 7.2 |
| Cyclohexane, 1-methyl-4-(1-methylethyl) | 3229 | 126 | 3221 | 107 |
| $C_{10}$ hydrocarbon | 3238 | 3.6 | -- | <0.7 |
| Hexane, 2,2,5-trimethyl | 3240 | 7.2 | 3231 | 15.5 |
| Hexane, 3,3-dimethyl | 3252 | 38.7 | 3242 | 21.7 |
| Hexane, 2,2,3-trimethyl | 3326 | 45.8 | 3318 | 24.7 |
| 1,4-cyclohexadiene, 1-methyl-4(1-methylethyl) | 3346 | 3.9 | -- | <0.7 |
| Butane 2,2,3-trimethyl | 3349 | 3.9 | -- | <0.7 |
| 1-pentanol, 2-ethyl-4-methyl | 3367 | 21.2 | 3362 | 13.6 |
| Pentane, 2,3,4-trimethyl | 3408 | 11.9 | 3402 | 7.6 |
| Pentane, 2,2,4,4-tetramethyl | 3415 | 4.0 | 3410 | 1.8 |
| Cyclohexane, 1-methyl-4-(1-methylethylidene | 3453 | 9.2 | 3449 | 15.7 |
| 1 pentanol, 4-methyl-2-propyl | 3500 | 13.5 | 3497 | 10.0 |
| Hexane 2,2,3-trimethyl | 3583 | 5.9 | 3579 | 3.4 |
| Cyclohexane (1-methylethyl) | -- | <0.7 | 3606 | 1.9 |
| Bicycloheptane 3,7,7-trimethyl | 3650 | 5.3 | 3652 | 41.6 |
| Heptane, 5-ethyl-2-methyl | 3717 | 5.7 | 3714 | 37.7 |
| Benzene, 1,2,3-trichloro | -- | <0.7 | 3745 | 2.7 |
| Total | | 623 | | 793 |



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*The complete report, entitled "Determination of Toxic Chemicals in Effluent from Household Septic Tanks," (Order No. PB 85-196 798/AS; Cost: $8.50, subject to change) will be available only from:*
*National Technical Information Service*
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