RESEARCH REPORTS

SEPTIC TANK/ WATER SOFTENER

POTENTIAL EFFECTS OF WATER SOFTENER USE ON SEPTIC TANK SOIL ABSORPTION ON-SITE WASTE WATER SYSTEMS

by: Small Scale Waste Management Project
University of Wisconsin-Madison and
The Geological and Natural History
Survey University of Wisconsin-Extension.

THE EFFECT OF HOME WATER SOFTENER WASTE REGENERATION BRINES ON INDIVIDUAL AEROBIC WASTEWATER TREATMENT PLANTS

by: The National Sanitation Foundation
Ann Arbor, Michigan

RESEARCH AND EDUCATION IN WATER QUALITY
WATER QUALITY RESEARCH COUNCIL

Water Quality Association®

RESEARCH REPORTS
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EXECUTIVE SUMMARY

In the mid 1970s, various regulatory agencies were requesting the enactment of regulations to prohibit the discharge of water softener recharge wastes to private sewage disposal systems due to several assumed adverse effects. The most frequently mentioned assumed adverse effects were as follows:

1. Is the salt-brine discharge from water softener regeneration toxic to the bacteria in the treatment system?
2. Does the flow rate and volume of backwash and regeneration water discharged from a water softener have an effect on the settling and floatation process causing carry-over of solids into the drain field?
3. Does water softener regenerational discharge reduce the percolation of water through the soil in seepage fields by causing swelling of soil particles?

The Water Quality Research Council supported studies conducted by scientists at the University of Wisconsin—Madison, small scale waste management project and the National Sanitation Foundation to provide documented answers to these questions. The answers to these questions as a result of the studies are as follows:

1. The tests confirmed that water softener waste effluents actually caused no operational problems in the typical anaerobic or the newer aerobic home treatment plants.
2. The volume of wastes from properly installed and maintained water softeners (about 50 gallons per regeneration) are added to the septic tank slowly and are not of sufficient volume to cause any deleterious hydraulic load problems in septic tank systems. In fact they are lower in volume and rate of addition than wastes from many automatic washers.
3. Finally, it was determined that water softener regenerational wastes not only did not interfere with septic tank system drain field soil percolation but actually could, under some circumstances, improve soil percolation particularly in fine-textured soils.

The important and beneficial difference is that septic tank effluents containing water softener effluents contain significant amounts of calcium and magnesium, which counteract the effect of sodium and help maintain and sustain soil permeability.

The studies concluded that it is better to discharge water softener wastes to septic tank systems than to separate dry wells or ditches. The only disadvantage being that some additional water must pass through the system.

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INTRODUCTION

This report deals with the effects of water softener backwash water and regeneration wastes on small sewage disposal systems. Although technical in nature, the layman will find an interpretation of the data which he may understand.

Thus, Part I provides a simple explanation of individual treatment systems, states the nature and source of the problem posed to researchers, and provides a simple explanation of the research results suitable for nontechnical government officials, the homeowner, or busy executive. The conclusion is based on the data furnished by the detailed reports which follow it.

Part II is devoted to a study by the Department of Soil Science at the University of Wisconsin—Madison. This work evaluates the effect of water softener regenerational effluent on private septic tank soil absorption waste disposal systems. Emphasis here is on soil hydraulic conductivity in septic tank seepage fields.

The National Sanitation Foundation study to determine the effect of softener regenerant effluent on aerobic-type individual treatment systems is detailed in Part III. This study evaluates the effect of softener regenerant wastes on the action of the treatment plant itself.

It is expected that scientists will derive more from this report than lay people. In part, this reflects the complexity of soil chemistry and the need for nontechnical people to depend upon the work of experts. Be that as it may, it is our hope that every reader will discover something of value in what follows.

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PART I

An estimated 20 million on-site household sewage disposal systems are in place in the United States. Many of these systems have operating problems from time to time. It is natural that homeowners, local contractors, installers, and regulatory personnel should look for the reasons for these problems, and perhaps inevitable that some of these people should blame water conditioning equipment.

The supposition that could be used to eliminate water softeners might be as follows: everyone knows that lack of or excessive amounts of salt will kill bacteria, and if a home with a softener has a problem, it could be caused by the softener. Anyway, it is better to advise against softeners, which might cause a problem, than to take a chance.

No matter what the reasoning, the questions concerning the effects of water softener regeneration wastes on these private sewage disposal systems are not new, and the industry has collected a good deal of information on the subject over the years. For a long time, the Water Quality Association could answer inquiries with references to the literature, and a statement that Industry experience showed no problems which could be realistically blamed on softeners. In general, these answers appeared to be acceptable, and the Water Conditioning Industry faced no major restrictions on the use of water softeners in more than twenty-five (25) years.

In the mid 1970s, however, serious questions concerning the use of water conditioners began to appear. First, a county in one state, and then some other jurisdiction in another state enacted regulations prohibiting the discharge from softeners to private sewage disposal systems. Later, entire states adopted similar restrictions. The Industry was faced with a serious problem of reduced use of water conditioner devices, and research to answer questions concerning potential adverse effects was given top priority by the Water Quality Association.

The most widely used septic tank system is shown in Figure 1. The sewage is received from the home into the septic tank where the organic matter present is partially digested, and solids are collected. Relatively clear water is discharged from the tank to the soil through a suitable distribution system.

Figure 2 is an example of a typical single compartment septic tank. The sewage enters at one end which is properly baffled to prevent bypass flow and reduce turbulence. In the main part of the tank, less buoyant solids settle to the bottom of the tank, and the lighter than water oils, greases, and solids rise to the top as shown in Figure 3. Under ideal conditions, much of the soluble organic matter, heavy solids, and floating greases are digested by the bacteria normally present in the sewage. Since these bacteria operate in the absence of air, this digestive process is called "anaerobic."

Ideally, by the time the wastewater passes through the baffled outlet of the septic tank, through the distribution box and into the disposal field, most of the suspended solids and organic matter have been removed. The water then is passed into the drain field in which perforated pipe or tile with open joints allow the water to trickle out into the trenches. These trenches are commonly bedded with gravel or crushed stone which further distributes the water as it is applied to the soil absorption field.

The most frequent questions asked of the industry researchers in regard to possible adverse effects of water conditioning equipment are as follows:

1. Is the salt-brine discharged from a water softener toxic to the bacteria in a septic system?
2. What effect does the flow rate and volume of backwash and regeneration water discharged from a softener have on the settling and floatation process by reducing the digestion time in the septic tank, thus causing carry-over of solids into the drain field?
3. Since sodium is contained in the regeneration solutions of softeners and sodium is known to cause certain soils to swell and thus reduce the percolation (hydraulic conductivity) of water through the soil, how severe is this effect on the soil going to be?

Studies conducted by scientists at the University of Wisconsin—Madison, small scale waste management project and the National Sanitation Foundation in 1978-1979 confirmed the results of earlier, but less definitive studies, and were in complete agreement with earlier assumptions and conclusions of the Water Conditioning Industry.

1. These tests confirmed that water softener waste effluents actually exert a beneficial influence on a septic tank system operation by stimulating biological action in the septic tank and caused no operational problems in the typical anaerobic or the new aerobic septic tanks (as shown in Figure 4).
2. The volume of softener wastes (about 50 gallons per regeneration) are added to the septic tank slowly and are not of sufficient volume to cause any deleterious hydraulic load problems in septic tank systems. In fact they are lower in volume and rate of addition than wastes from many automatic washers.
3. Finally, it was determined that water softener regenerational wastes not only should not interfere with septic tank system drain field soil percolation but actually might improve soil percolation, particularly in fine textured soils.

   The results confirmed earlier government tests (1954) which had reached the same conclusions, but were questioned because they were interpreted to be in contradiction to the scientific literature on irrigation which demonstrates adverse effects of high sodium water on soil structure and permeability especially in clay-type soils. It was known that when fresh water was used on irrigated soils with a high proportion of exchangeable sodium, reduced conductivity occurred as the high total salt levels were diluted with the irrigation waters.

The important and beneficial difference is that water softener effluents contain significant amounts of calcium and magnesium, which counteract the effect of sodium and help maintain, and sustain soil permeability.

The studies concluded that it is better to discharge water softener wastes to septic tank systems than to separate dry wells or ditches.

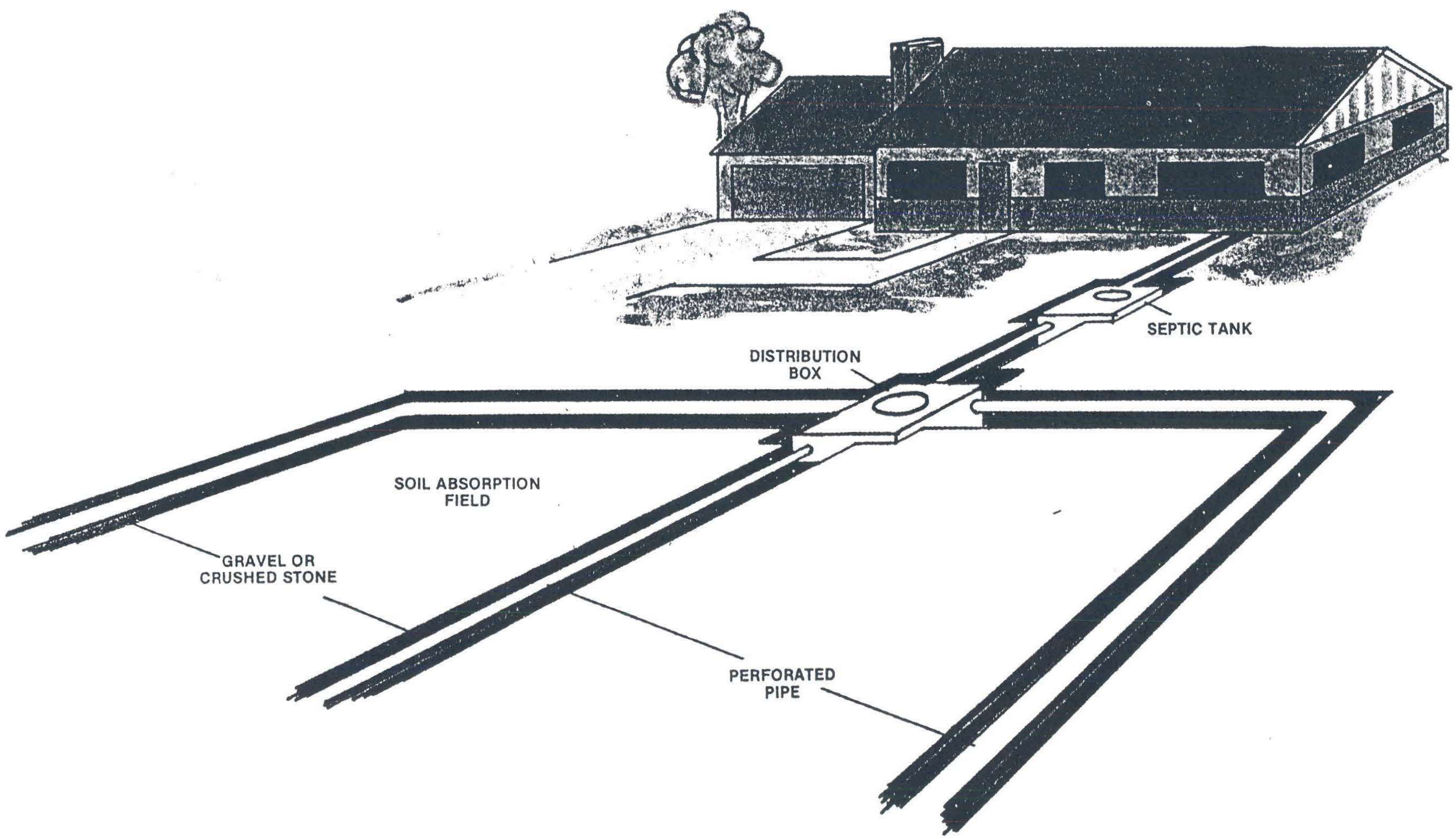

Figure 1 — A Typical Household Septic Tank System.

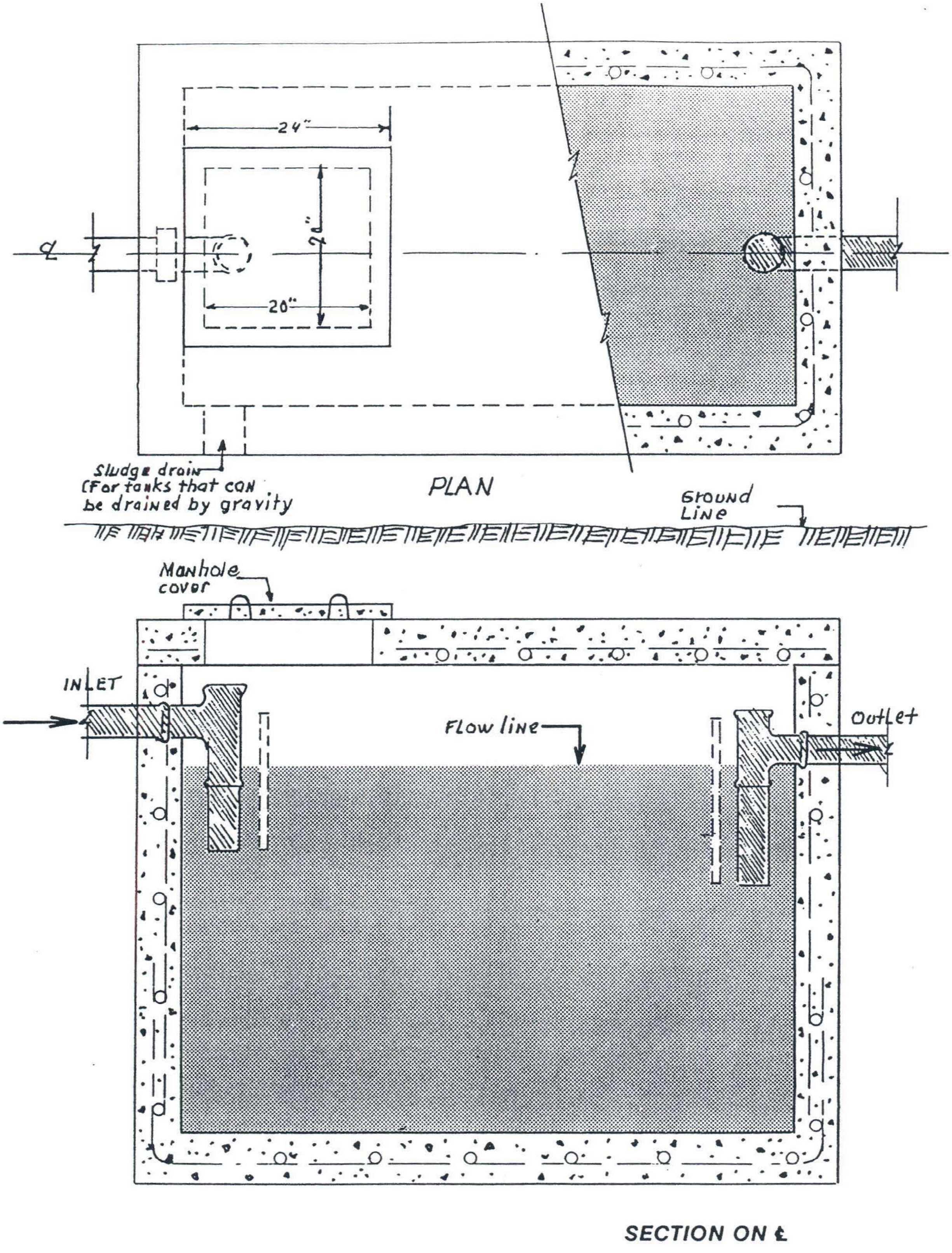

Figure 2 — Single-compartment septic tank.

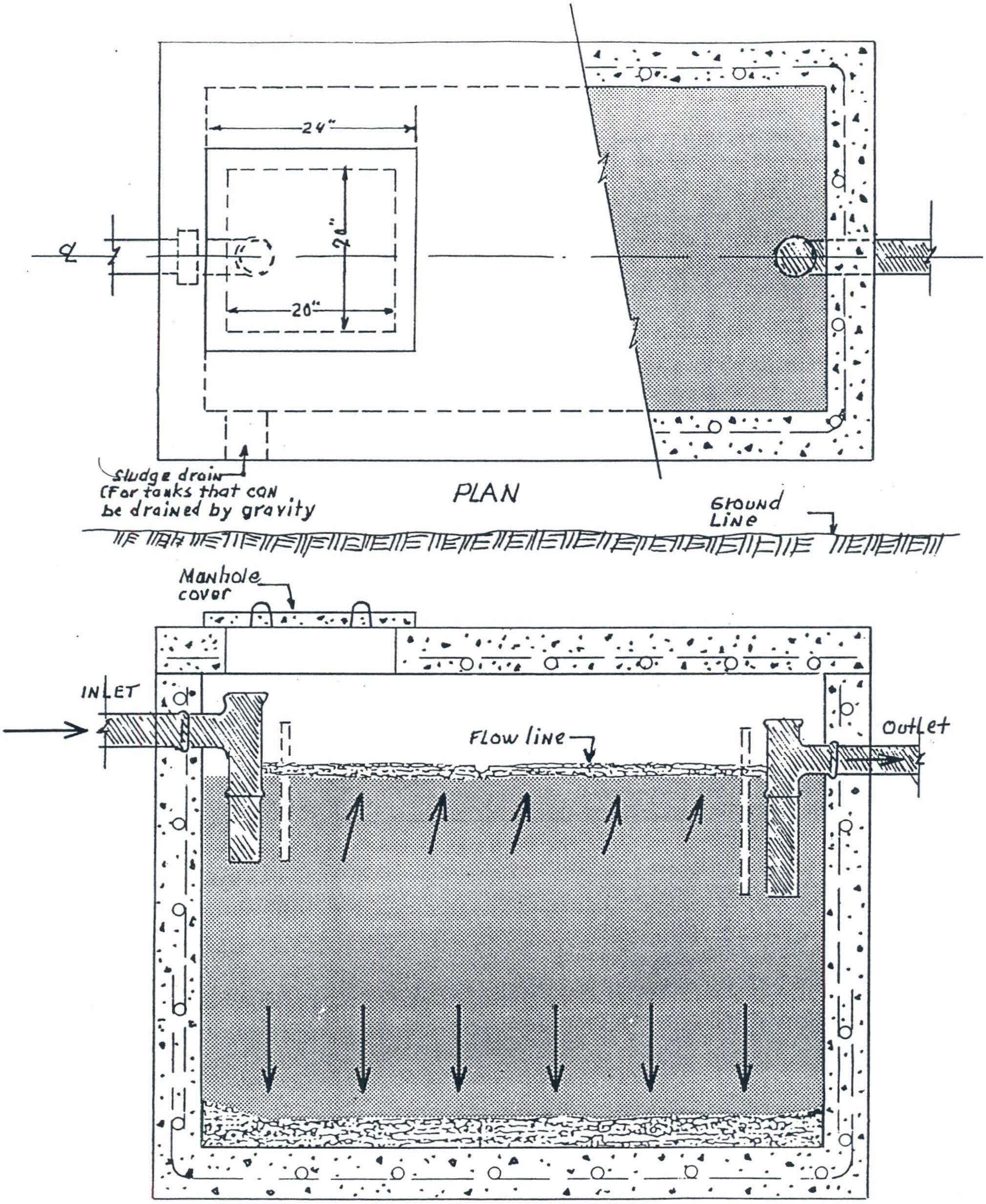

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Figure 3 — Single-compartment septic tank.

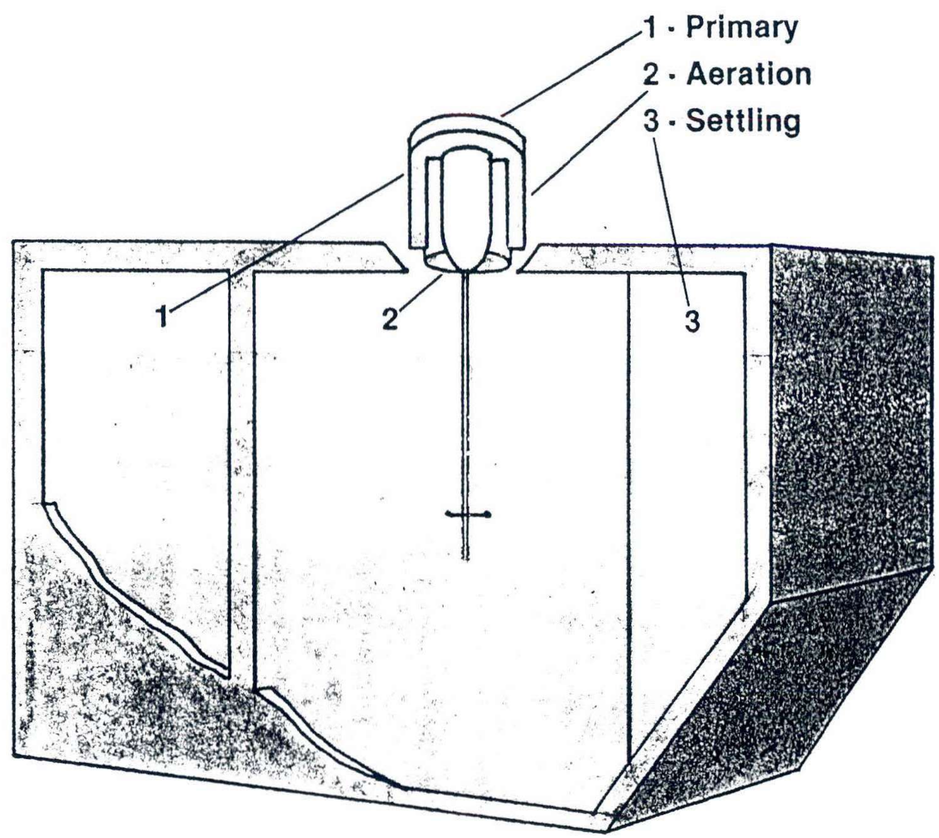

Figure 4 — Aerobic Septic Tank.

PART II

The Water Quality Research Council issued a grant to the University of Wisconsin—Madison, to study the "Potential Effects of Water Softener Use on Septic Tank Soil Absorption On-Site Wastewater Systems," and they arrived at the conclusion as summarized in Part I. The University was specifically requested to evaluate the earlier findings by conducting a literature search and conducting laboratory and field tests to reach sound conclusions with the emphasis being placed on the effect of water softener brine effluent in soil, the least credited portion of earlier research.

The following is a synopsis of the study performed by the Small Scale Waste Management Project College of Agricultural and Life Sciences, entitled, "Potential Effects of Water Softener Use on Septic Tank Soil Absorption On-Site Wastewater Systems." A copy of the full report is made a portion of this document.

Introduction

In areas with hard water sources, household water softeners are used to remove Ca and Mg ions from the water supply in exchange for Na ions. During the regeneration of the water softener, a common salt solution ($NaCl$) is added to displace Ca and Mg ions held on the exchanger and the waste consisting of Mg and Ca ions and some excess Na is discarded and often disposed of through a floor drain in the household. In non-sewered areas this water must pass through the septic tank soil absorption system.

Based on mixed-ion and demixed-ion models for the swelling of montmorillonite clay minerals, possible effects on the hydraulic conductivity (HC) of soil under soil absorption systems were estimated for the septic tank effluents studied. On the basis of these estimates, the hydraulic conductivity of the soil under the soil absorption system would not be expected to drop below a threshold value of 85 percent of the maximum saturated hydraulic conductivity under the conditions studied. Therefore, the addition of water softener regeneration wastes to soil absorption systems is not believed to be a problem in soils that would meet normal site evaluation criteria. This is in agreement with the results of the one study reported in the literature which involved effects of salts in septic tank effluent on soil HC. However, reduction of HC might be expected if water of low salt concentration (m_0) such as rainwater were added after septic tank effluent containing water softener waste had been applied to the system, and possibly if all of the water passing into the septic tank had been softened and the regeneration water containing the removed Ca and Mg and excess Na was not passed through the septic tank.

The osmotic potentials of septic tank effluents were determined to be between -0.21 and -0.77 bars. Many bacteria divide and grow most rapidly at an osmotic potential of -14 bars. This potential corresponds to a $NaCl$ concentration of about 300 meq/liter (15,000 mg/liter as $CaCO_3$). Therefore, added salts from the addition of water softener regeneration waste would decrease (make more negative) the osmotic potential of the septic tank effluent and bring it closer to the optimum levels reported for bacteria.

ABBREVIATIONS AND SYMBOLS

ESP — exchangeable sodium percentage
HC — hydraulic conductivity
m_0 — salt concentration
SAR — sodium absorption ratio

CONCLUSIONS FROM LITERATURE REVIEW AND SEPTIC TANK EFFLUENT ANALYSIS

Based on the analysis of data collected concerning the concentration of salts in septic tank effluents and reviews of the literature on soil hydraulic conductivity and bacteriological activity the following conclusions were made:

1. Based on Na and total salt concentrations of septic tank effluents and calculations of the effect of swelling pressure on soil hydraulic conductivity, regeneration waters discharged to properly sited soil absorption fields from a normally operating water softener should not have a significant deleterious effect on the hydraulic conductivity of the absorption field. This conclusion is supported with only one actual study with septic tank effluent.
2. Addition of water containing very little soluble salt (such as rainwater) to an absorption field equilibrated with effluent containing softener salts *might* result in swelling and dispersion of clays and lowered hydraulic conductivity in the absorption field.
3. Softening of all of the water delivered to the septic tank without the discharge of the regeneration water of the softener *might* cause swelling and dispersion of clays and reduced hydraulic conductivity in the seepage field.
4. Based on reports in the literature, the presence of salts from the softener regeneration waters should have no deleterious effect on the osmotic potential difference between wastewater and the microflora in a septic tank or aerobic treatment system. We should point out, however, that the media used for the salt tolerance studies bear little resemblance to septic tank effluent.

POTENTIAL EFFECTS OF SALTS FROM WATER SOFTENER REGENERATION ON THE HYDRAULIC CONDUCTIVITY OF SOILS UNDER SEPTIC TANK SOIL ABSORPTION FIELDS

Proper functioning of a septic tank-soil absorption field system depends on a sufficient hydraulic conductivity (HC) in the absorption field to dispose of the wastewater. The well known effects of high-Na waters lowering the HC of irrigated soils has caused some people to question the wisdom of disposing of wastewater from water-softener regeneration into septic tank systems. The purpose of this review is to determine under what conditions these wastewaters might pose a threat to the proper functioning of the disposal system and whether there is any justification for stopping wastes from water softener regeneration from being disposed of through septic tank-soil absorption field sewage disposal systems.

THEORETICAL CONSIDERATIONS

Hydraulic conductivity depends on the porosity and the pore-size distribution of the soil. Swelling of the soil results in enlargement of the very narrow spaces between clay particles at the expense of the large pores. Swelling reduces the HC of the soil.

Swelling (and shrinking) occurs upon wetting (and drying) of the soil. The amount of swelling depends on the concentrations of the dissolved salts in the soil solution and the relative proportions of monovalent and divalent ions. Swelling varies with the clay mineral type, organic matter, pH, and mechanical stress.

Two models have been used to relate the relative salt concentration and soil swelling. The mixed-ion model is used to calculate swelling pressures assuming monovalent and divalent ions are uniformly distributed over clay surfaces. The demixed-ion model assumes a nonuniform ion distribution and estimates swelling which is one term used in an emperical equation for estimating HC.

EFFECTS OF Na SALTS ON HC OF SEPTIC TANK SEEPAGE FIELDS

HC Experiments with Septic Tank Effluent

Very little research has been done on the relationship between the chemical composition of septic tank effluent and the HC of the soil under the seepage field. Winneberger and Weinberg (1976) make the following statement regarding the effects of Na in septic tank effluent on HC: "A search of the literature disclosed that losses of permeabilities of Na-labile soils occurred when infiltrating fresh waters contained high concentrations of Na, but when the same high concentrations of Na were in sewages, permeabilities of the soils were not much changed. The Na-labile soils were startlingly resistant to high Na concentrations in infiltrating sewages when investigators were trying to demonstrate what they believed should have occurred."

The only study found that dealt directly with the problem of water softener salts on HC was by Weibel, et al. (1954). They found that at no time during the experiment did the action of the tank seem to be impaired by the weekly salt additions. Effluent from the tank receiving softener-waste salt was passed through columns of Brookston silt loam as was effluent from a tank receiving no softener waste. The investigators found that the salt effluent caused less clogging and maintained higher HC than the regular septic tank effluent. They tested aggregate stability and concluded that the brine effluent caused more damage to the soil structure. Actually, they did not make a valid test for structural stability because they used distilled water which would naturally cause swelling and structural breakdown in soils of high ESP such as those receiving the high salt water. To represent structural stability under conditions encountered in a septic tank seepage field, they should have used the septic tank effluent from the tank which did not receive softener wastes as this would be the material with the lowest salt concentration that would probably be used in that system. The authors' conclusion that "soil structure is more damaged by the salt effluent" is not only in direct contradiction to their preceding statement that "percolation rates are maintained at a higher value under salt effluent than normal effluent" which would require a less swelled condition, but is based on a method of measurement which would be valid only if the seepage field were to be flushed with water of very low m_0 such as rainwater.

PROBABLE EFFECTS BASED ON ANALYSIS OF SEPTIC TANK EFFLUENT

Because of almost complete absence of experimental data on effects of septic tank effluent composition on HC, the mixed-ion and demixed-ion models were used with measured values of sodium and total salts in septic tank effluents with and without water softeners to estimate HC around operating soil absorption systems. Considering only soils that should pass the percolation and assuming that a HC of 85% of maximum would be an acceptable flow for extended use of the soil absorption system it was found that, for the septic tank effluents evaluated, none should create soil hydraulic problems because of salt loadings. Based on this analysis, it is recognized that fresh waters such as rainwater added to the soil absorption after the effluents containing sodium salts may result in soil swelling and reduction of HC.

Conclusions

The salts in the wastewaters from regeneration of water softeners would appear to create no hydraulic conductivity problem in septic tank seepage fields. In fact, the only study which addressed this problem directly indicated that hydraulic conductivity was increased over soil receiving sewage effluent without the salt additions. However, lowered hydraulic conductivity might result from water softening if all of the house water were softened and if the regeneration wastes were *not* allowed to enter the seepage field. In this case, almost all of the divalent cations would be removed resulting in high SAR and relatively low m_0.

POTENTIAL EFFECTS OF SALT FROM WATER SOFTENER REGENERATION ON BACTERIAL ACTIVITY IN SEPTIC TANKS

The main functions of a septic tank are to provide a favorable environment for decomposition of organic waste and to act as a settling chamber for undecomposed solids. Optimal functioning of a septic tank or aerobic treatment unit depends on microorganisms decomposing and altering some waste materials while they carry on their normal metabolic processes. These organisms should remain viable and maintain the capacity to grow and divide. Therefore, the wastewater must contain a source of energy material and nutrients, tolerable pH and temperature, and sub-lethal concentrations of toxic substances.

Besides the waste materials being treated by the microorganisms, there are also salts present that may have originated from the source water, from waste material or, in some regions, from additions due to operation of a water conditioner. These salts, along with other substances dissolved in the water, create an osmotic water potential to which the microorganisms must adapt.

Within the cell, where metabolic reactions occur, there is a high concentration of organic and inorganic substances. This concentration may be considerably higher or lower than that in the solution around the cell. Therefore, an appreciable osmotic potential difference may be created across the surface layers of the cell, and water will tend to migrate in the direction of the lower water potential. Migration of water into the cell will result in osmotic pressure build-up and in extreme cases, may lead to cell rupture; however most cells can resist a considerable osmotic pressure. Migration of water out of the cell will lead to plasmolysis and possible death of the cell.

It is the purpose of this review to establish the potential for adequate functioning of microorganisms in septic tanks and aerobic units with and without the addition of water-softener regeneration waters based on the osmotic potentials of the solutions. Effects of specific ions including Na and C1 are not reviewed.

Osmosis

Osmosis is the process where a solvent moves spontaneously from one region to another lower solvent activity. It occurs when a semi-permeable membrane separates two regions of the same solvent containing different amounts of solute. Of major concern to the functioning of cells is the difference in solute concentration between the interior of the cell and the surrounding solution.

Little information concerning solution conditions of high osmotic potential (low salt concentration) or particularly of fluctuating salt concentrations were found in the literature.

The Septic Tank

The septic tank is a large container made of concrete or steel with an inlet and an outlet. Wastewaters enter the tank and pass under a baffle. Some of the material in the water floats to the surface forming a scum and some settles producing a sludge. Dissolved and suspended material pass with the water past an outlet baffle to the soil absorption bed.

Bacteria in the septic tank alter the form of some of the solids present and use some as an energy source. The products of decomposition then pass to the soil absorption bed. The effectiveness of these bacteria will depend on the populations present and the nature of the extracellular solution.

POSSIBLE EFFECTS THE USE OF WATER SOFTENERS MAY HAVE ON FUNCTIONING OF SEPTIC TANKS

Because proper functioning of a septic tank depends on the presence of an active bacteria flora, any beneficial or detrimental effects of soluble salt addition would result from the added material influencing the flora.

Other studies reviewing the possible salt effects showed that, at the calculated amounts of salt added from a water softener, bacterial populations should not be adversely affected (Weickart, 1976). This was based on a 15-lb. salt addition resulting in 10 lbs. of $NaC1$, 3.2 lbs. of $CaC1_2$ and 1.4 lbs. of $MgC1_2$ added to a 750-gallon tank. This amounts to 0.16% $NaC1$, 0.51% $CaC1_2$ and 0.022% $MgC1_2$.

Septic tank effluent samples analyzed in this study had osmotic potentials (Table 6.5) of −.23 to −.51 bars for those without water softeners and from −.21 to −.85 bars for those systems with water softeners. This is an average of −.36 bars and −.51 bars for systems without and with softeners, respectively. This is considerably above the range considered optimum (−5 to −20 bars) for most bacteria and where most is known about the osmotic effects. For the effluents sampled, it would be expected that the bacteria would not be operating at the optimum level and that if anything, the use of water softeners should improve the solution environment.

Though no sampling was made in this study of the sludge and scum layers Wiebel, et al. (1954) reported a 1.2 percent salt concentration in this region. This is equivalent to −10 bars of osmotic potential which is within the optimum level for most bacteria.

Conclusions

The osmotic potential difference between bacteria and their supporting solution is a major factor in controlling bacterial activity. For many bacteria, including some types found in septic tanks, the optimum osmotic potential of the solution passing around the cell is between −5 and −20 bars. The average osmotic potential of septic tank effluent for tanks not receiving water softener wastes was found to be −0.36 bars and for tanks receiving the wastes it was −0.51 bars. Other regions of the tank have been reported to have 1.2% NaC1 equivalent when water softener backwash was added (Weibel, et al., 1954) or −10 bars osmotic potential. Salts added to septic tanks from water softeners should decrease the osmotic stress on microorganisms due to osmotic potential difference.

PART III

To complete this study, the Water Quality Research Council issued a grant to the National Sanitation Foundation to demonstrate The Effects of Home Water Softener Waste Regeneration Brine on the Performance of Individual Aerobic Wastewater Treatment Plants.

The following is a synopsis of the study performed by NSF entitled, "The Effects of Home Water Softener Waste Regeneration Brines On Individual Aerobic Wastewater Treatment Plants." The National Sanitation Foundation is the Nation's acknowledged expert on small sewage disposal systems. A copy of the full report is included as part of this document.

Introduction

This study was undertaken to demonstrate the effects or lack of effect of home water softener water regeneration brines on the performance of individual aerobic wastewater treatment plants.

Previous studies demonstrated the tolerance of extended aeration treatment processes for raw wastewater containing various levels of salinity. Other methods of sewage treatment have been unaffected by chloride concentrations up to 8,000 mg/L. Kincannon and Gaudy determined that while "slug" doses of up to 30,000 mg/L of sodium chloride (NaCl) did decrease substrate removal rates in activated sludge, "they did not appear to cause serious distress to the system." *Escherichia coli* have been found to adapt to gradual changes of NaCl up to 80,000 mg/L, and *Aerobacter aerogenes* can withstand concentrations up to 145,000 mg/L. Five-day biochemical oxygen demand is unaffected by NaCl concentrations up to 10,000 mg/L after acclimatization periods of one to five days. All these levels of salt content are far in excess of that which would be found in an individual aerobic wastewater treatment plant which receives home water softener regeneration wastes.

TEST PROCEDURE

Two "identical" concrete home aeration plants with no effluent filtration were specified for the study (see Figure 4). Those plants were to be listed by NSF for conformance with Standard No. 40, with Class II effluent characteristics.

The plants used for the study can be characterized as utilizing preliminary sedimentation, mechanical aeration, and final sedimentation with surface skimming. The capacity of the aeration compartment was 600 gallons, and the manufacturer's specified design rated capacity, 500 gallons per day (gpd).

The plants were purchased from a local distributor and installed and operated *for approximately six months* at the NSF wastewater equipment testing facility in Chelsea, Michigan.

Dosing during the study was intended to simulate use by a family of five persons at a rate of 50 gallons per person per day (i.e., flow was controlled at 250 gpd). Influent was raw wastewater from the Village of Chelsea, Michigan, fed in accordance with the dosing pattern used in the NSF Standard 40 testing programs.

During testing under "normal" operating conditions, one plant was operated as a control; i.e., dosed in accordance with protocol design. Influent to the second plant included, in addition to the raw wastewater equivalent to control plant dosing, regeneration wastes from a home water softener, Water Refining Company Model 1120. The softener was operated in accordance with the manufacturer's instructions and set to regenerate at 1:00 a.m., Tuesday, Thursday, and Saturday. Softener wastes entered the test plant as surges, typical of actual home use.

Conclusions From Tests

Water softener regeneration wastes demonstrated no adverse effects on home aerobic wastewater treatment plant performance, even when stressed by loading at a rate simulating ten (10) persons (twice the average use rate).

There was no difference in performance between days in which the plant received regeneration wastes and days in which it did not.