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SMALL SCALE WASTE MANAGEMENT PROJECT

Effects of Hydrogen Peroxide As a Chemical Treatment for Clogged Wastewater Absorption Systems

by

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FIELD AND LABORATORY STUDIES OF HYDROGEN PEROXIDE EFFECTS ON SOIL PROPERTIES

The research reported in this paper is in three parts: (1) controlled field experience with Porox^R, (2) laboratory studies of hydrogen peroxide effects on critical soil properties, and (3) evaluation of commercial experience with Porox^R in Wisconsin.

Field Experience with Porox^R

This research developed as a continuation of previous field experiments on the effects of wastewater loading rate and application frequency on long-term acceptance rates of soils (Hargett et al. 1981). These studies (1978-81) utilized a unique replicated experimental design with 18 in situ systems of known infiltrative surface area and no side-wall absorption (Figure 1). The infiltrative surface of the systems was at 71 cm below grade, in the well-structured silty clay loam subsoil of the Plano series (fine-silty, mixed, mesic Typic Argiudolls). Details on construction specifications, experimental management and response to loading history is provided in Hargett et al. (1981).

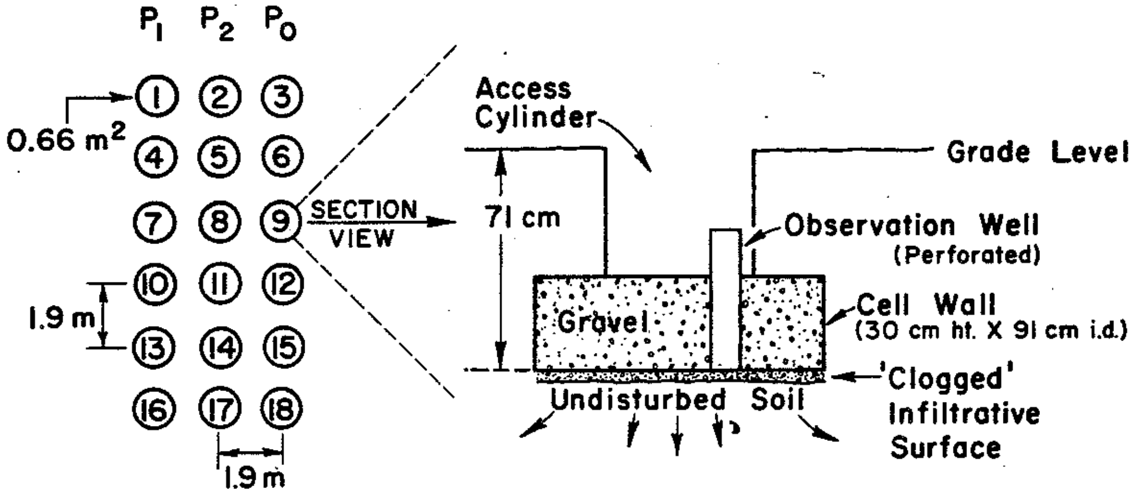

Figure 1. Site layout, section view, and Porox^R treatment scheme of experimental field systems. P_0-control systems (1, 4, 7, etc.), P_1-systems treated once with H_2O_2, P_2-systems treated twice. See Hargett et al. (1981) for previous system history.

After the previous experimental objectives were satisfied, wastewater application to the systems was ceased in September 1980. The systems were drained naturally and rested for nine months, until May 1981. During this period the infiltrability of the systems increased from an average of 16 percent of their initial infiltration rate (%IIR) to 32 %IIR or 1.8 percent per month. The objective of rehabilitation was to prepare the systems for additional wastewater application experiments. Because nine months of rest did not accomplish this goal, hydrogen peroxide treatment was utilized to attempt rehabilitation of selected systems. The decision to use the Porox^R treatment was based on the assumption that the application would restore the treated systems to 75 to 100 percent of their initial infiltration rate (Harkin, 1977a).

Porox^R Treatment of Field Systems: Twelve systems were chosen for chemical treatment. The other six systems were withheld from H_2O_2 treatment, to continue study of natural resting. These control systems (in the column marked "P_0" in Figure 1) also served as a control for comparison to the treated systems. A few days before the Porox^R application, infiltration rate (IR) was measured on all systems. In June 1981, a standard commercial

EFFECTS OF HYDROGEN PEROXIDE AS A CHEMICAL TREATMENT FOR CLOGGED WASTEWATER ABSORPTION SYSTEMS

by

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For a soil wastewater absorption system that has been properly sited, sized, designed, installed and maintained, the only reason for failure is natural clogging. If clogging causes failure, the only recourse is to construct a new system or arrange for frequent pumping or to rehabilitate the system. Prolonged resting of the system and treatment with chemical agents to declog are two basic approaches to rehabilitation.

A wide variety of additives have been used in attempts to improve soil absorption system performance. The Manual of Septic Tank Practice (Public Health Service, 1967) advised that out of over a thousand commercial products for septic systems, none had been proven effective. Jawson (1976) used clogged sand columns to evaluate several commercially available septic tank additives as well as common acids, bases, and oxidizers to determine their effectiveness as declogging agents. This work showed that none of the commercially available nostrums were effective in increasing the infiltration rate of clogged sand columns.

One innovative management tool advanced to control severe clogging is the application of hydrogen peroxide (H_2O_2) to oxidize the soil-clogging organic material and thus restore soil permeability (Harkin et al. 1975; Jawson, 1976). A patent was issued to the Wisconsin Alumni Research Foundation (WARF) for the hydrogen peroxide treatment process (Harkin, 1977a). WARF coined the name Porox^R, a registered trademark for the process.

The Porox process has been claimed to be effective in restoring infiltrative capacity in some wastewater absorption systems, especially those in sandy soils (Harkin, 1977a, 1980). In other soil conditions, the Porox^R treatment has been rated as from ineffective to unpredictable and even deleterious (Urban Systems Research and Engineering (USRE), 1982; Hargett et al., 1983). WARF continues to control patent rights for Porox^R. Until 1983, WARF granted exclusive license to firms using the process nationwide. Porox^R is no longer being actively promoted.

The purpose of this paper is to report the results of research on the hydrogen peroxide treatment concept. Details regarding side effects of the process and the viability of the treatment are presented.

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Porox[R] treatment was applied to 12 systems designated in Figure 1 as P_1 (treated once) and P_2 (treated twice). The treatment was administered by On-Site Sanitation Services, Inc. (OSSS), licensed Porox[R] vendor. The treatment consisted of 1 cm of pre-mixed 10% Dupont Tysul-WW H_2O_2* applied to the infiltrative surface via observation wells (Figure 1). This application resulted in a mass loading rate (MLR)+ of 1.49 kg/m^2 of pure H_2O_2. Foaming and steam was detected at the infiltrative surface via the system observation port, typical of reported reactions (Harkin et al. 1975; Jawson, 1976; Harkin, 1977a).

After several days had elapsed, to ensure all residual H_2O_2 had decomposed, infiltration rates of all 18 systems were measured and then confirmed by a second measurement. Systems treated with Porox[R] had lower infiltration rates. Based on these results and the recommendation of OSSS and Harkin (1977b), a second Porox[R] treatment was elected for six of the systems (column denoted by P_2 in Figure 1). The second treatment was administered in August 1981, again by OSSS. This treatment consisted of the same HLR, 1 cm, but an H_2O_2 concentration of 20 percent. This corresponds to an MLR of 2.98 kg/m^2 of pure H_2O_2. Several days later, infiltration rates were measured and confirmed on all systems.

<u>Infiltration Rate Response</u>: The 18 systems can be considered as six replicates of each of the three basic Porox[R] treatments - a control group (P_0), a once-treated group (P_1), and a twice-treated group (P_2). Figure 2 presents infiltration rate data for the experimental systems plotted as infiltration rate response versus time. Values shown have been normalized to a percent of the initial infiltration rate (%IIR) to correct for the effect of natural soil variability. Initial infiltration rates for the 18 systems averaged 202 cm/day (std. dev. = 42 cm/day). Each point in Figure 2 represents mean values for four systems in each Porox[R] treatment (P_0, P_1, P_2). This includes Systems 7-18 (Figure 1). Systems 1-6 are excluded from Figure 2 because of their pre-Porox[R] IR variability, associated with previous lower wastewater loading rates and a lesser degree of clogging.

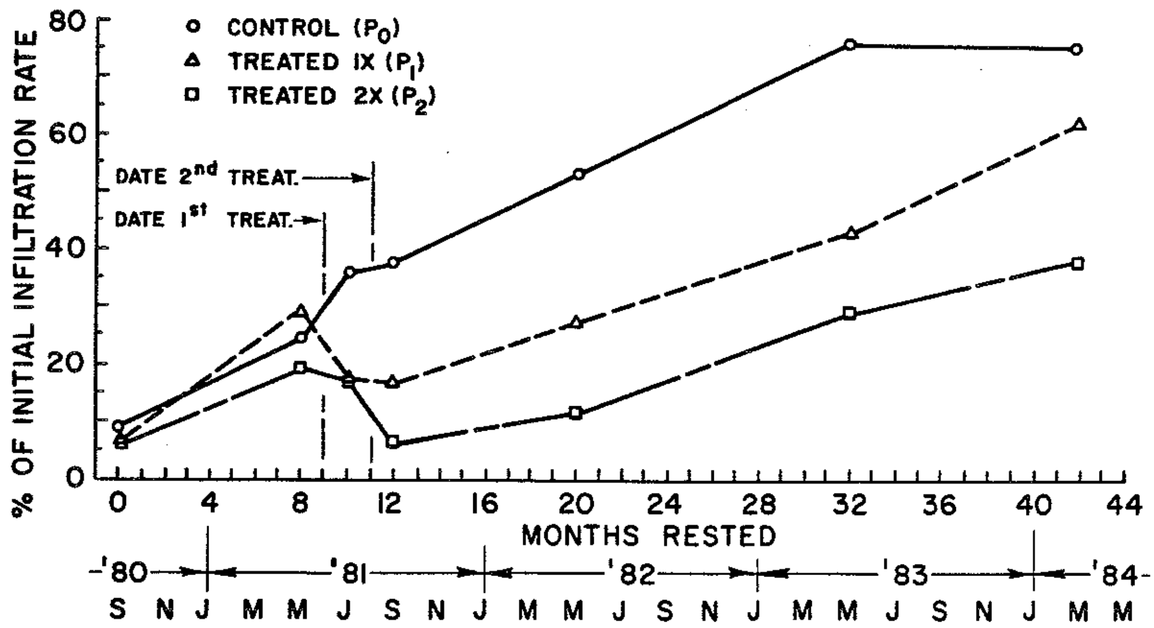

Figure 2. Infiltration rate response to resting and Porox[R] treatments - experimental field systems. Each symbol is mean of %IIR for four systems. Mean initial IR for all 18 systems = 202 cm/day.

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*The mention of trade names or commercial products in this report does not constitute endorsement or preference for use by SSWMP-UW.
+Mass loading rate (MLR in kg/m^2) of pure H_2O_2 = hydraulic loading rate (HLR in cm) x 14.65 x concentration decimal.

Figure 2 documents the deleterious effect of the hydrogen peroxide treatments on soil infiltration rate. Of the 12 systems treated in June 1981, eight declined in %IIR and the others changed negligibly or rose slightly. The systems that received Porox^R averaged 25 %IIR in May, about the same as the control mean, but declined to 17 %IIR after treatment. Meanwhile, the control group continued to rise from May to July. The systems treated a second time with Porox^R (P_2) declined even more to an average of only 6 %IIR, lower than their historical low infiltrative capacity even when severely clogged (Hargett et al. 1981). Analysis of variance showed treatments, P_0, P_1, and P_2 to be significantly different ($p = 0.05$) from one another (SAS Institute, 1982; Hargett et al., 1983).

The infiltraton rate behavior of all 18 systems has been monitored periodically for over three years since the Porox^R treatments. No wastewater has been applied to any of the systems during this period. Figure 2 evidences the slow but significant natural reclamation of the rested systems (P_0) with an average of over 75 %IIR after 42 months of rest. It appears that although the Porox^R-treated systems were initially severely damaged, some systems are gradually improving their infiltrative capacity. The P_1 systems appear to be slowly recovering from the treatment effects, with last-measured values above 65% of IIR in May 1984. In comparison, the P_2 systems averaged less than 40 %IIR nearly three years after their last H_2O_2 treatment.

Assessment of Hydrogen Peroxide Effects on Soil Hydrodynamic Properties

Three experiments were designed to address the issues of soil suitability to the Porox^R process, reagent concentration and loading rate, and potential side effects of the treatment. Because the previous field experience had documented negative impacts on soil physical properties, these studies emphasized measurement of physical characteristics. In the first experiment, the effects of H_2O_2 upon the permeability of non-clogged, undisturbed soil cores were assessed. Ancillary to this investigation, the second study evaluated the impact of H_2O_2 applications upon soil structure and porosity using micromorphometric techniques. In the last experiment, columns from each of four benchmark soils were clogged by continuous wastewater application and then treated with H_2O_2.

Effects of H_2O_2 on Soil Infiltration Rate--Non-clogged Soil Cores: In this experiment, non-clogged, undisturbed soil cores representing a wide range of subsoil properties were treated with H_2O_2 to examine the reagent's effects on soil hydraulic properties. This approach was quite advantageous in expediting the evaluation of a wide range of H_2O_2 concentrations and loading rates and their effects upon common subsoil conditions. A concurrent column experiment utilized four of the same soils to examine H_2O_2 effects on clogged soils.

Methods: Twenty-five subsoil horizons from 13 previously characterized soil series type locations were used in this experiment (Hargett et al. 1983). These soils represented an extremely wide range of textural characteristics, with sand, silt and clay content varying from <1-89, 5-75, and 6-82 percent, respectively. The undisturbed subsoil cores used in this study were collected in 7.62 cm i.d., 7.62 cm length sample rings using a Uhland-type sampling device adapted to use with a truck-mounted hydraulic probe (Hargett et al., 1983). Standard physical characterization was conducted on all soils.

In order to test the hypothesis of no significant H_2O_2 effect on soil infiltration rate, we used a simple treatment scheme. For all 25 soils, we utilized four H_2O_2 concentrations (6.25, 12.5, 25, and 50 percent), and at least one hydraulic loading rate (HLR)(0.63 cm). This resulted in a range of mass loading rates (MLR) of 0.58 to 4.61 kg/m^2. For three of the soils, we broadened the range of HLR and MLR to 0.32 to 1.26 cm, and 0.29 to 9.22

kg/m^2, respectively. Our range of treatments encompassed essentially all of the concentration, and hydraulic and mass loading rate combinations used by all previous researchers and commercial practitioners. A minimum of two replicate cores were utilized for each H_2O_2 treatment and four replicate controls for each soil type.

Soil infiltration rate of the soil cores was measured using concentric-ring permeameters (CRP), described by Hargett (1982). These instruments eliminate boundary flow problems associated with traditional laboratory core techniques for Ksat (McNeal and Reeve, 1964; Hill and King, 1982). Center region flow is taken as representative of the core. Sample preparation and CRP operation is detailed by Hargett (1982).

The saturated cores were secured in the CRP assembly, and an appropriate concentration and volume of H_2O_2 was applied according to the experimental design. Infiltration rate was determined for control cores while saturated, however, cores receiving hydrogen peroxide applications were allowed to react for 48 hours. This allowed more than adequate time for the H_2O_2 decomposition reaction to go to completion. Moreover, the primary purpose of waiting this period was to maintain a "real world" analogy to what occurs when a soil absorption system is treated. When a commercial Porox[R] treatment is administered, the absorption system and septic tank are typically dewatered by pumping to minimize dilution of applied reagent. Because the septic tank is customarily sized to have a capacity of at least two days of waste flow, the infiltrative surface of the system will not experience inundation for at least that period.

<u>Results</u>: For nearly all soils any application of H_2O_2 reduced the infiltration rate of the soil. Figure 3 presents the experimental results with each of the 25 soils classified into one of six general textural groups. In 23 of the 25 soils, the mean of the control treatments was greater than the mean of the combined H_2O_2 treatments. Analysis of variance (SAS, 1982) showed these differences to be significant ($p = 0.05$) in 16 of the soils. In 22 of the 25 soils, all H_2O_2 treatments resulted in lower infiltration rates than the control samples. In 15 soils, the soil infiltration rate for the mean of all treated samples, expressed as a percent of controls, was less than 10.

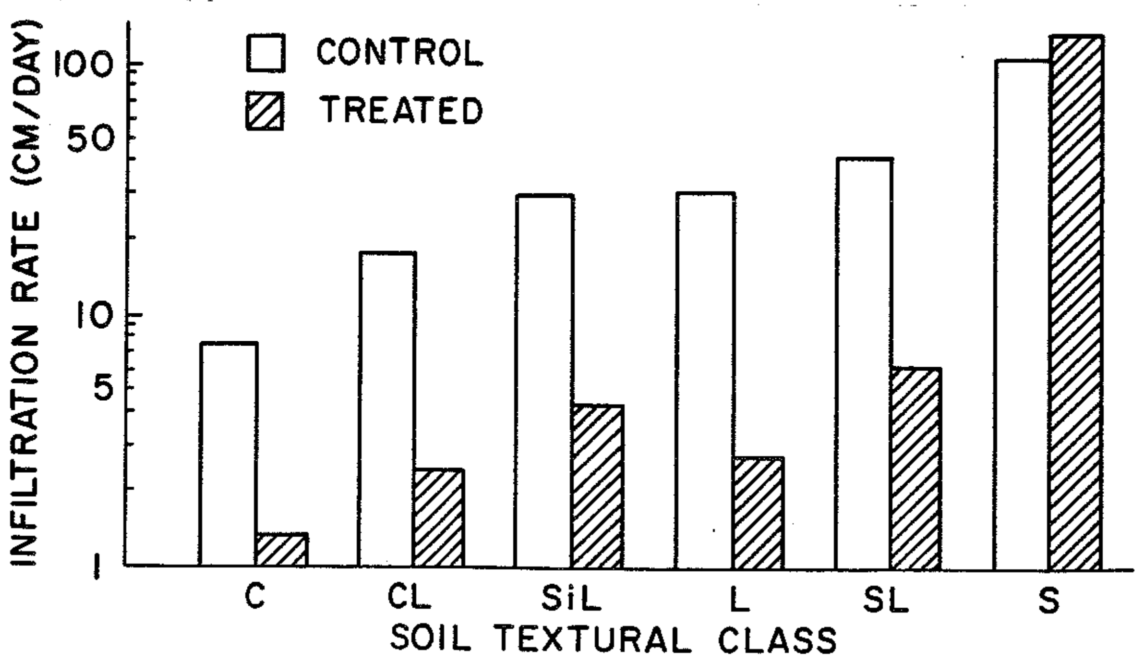

Figure 3. Effect of H_2O_2 on infiltration rate of generalized soil textural groups--non-clogged soil cores. Treated values represent mean of all cores subjected to any level of H_2O_2.

From Figure 3, it is clear that sandy soils have a response to H_2O_2 distinctively different from other soils. Only the two very sandy, structureless soils (86+% sand) did not experience deleterious effects on infiltration rates associated with the application of H_2O_2. This same soil was the only one used in the original H_2O_2 experimentation by Jawson (1976).

The explanation for these results appears to be relatively straightforward. The maximum natural organic matter content of any of these subsoils was about 0.65 percent, with some soils as low as 0.06 percent. Despite this very low organic sink for consumption of free O_2, upon addition of H_2O_2 to the soil cores, a violent reaction ensued. This reaction would typically begin as a gentle bubbling or effervescence, but would rapidly progress, especially for higher H_2O_2 concentrations, to an extremely violent boiling reaction after one to two minutes. For high MLR, this exothermic decomposition of the H_2O_2 often evolved steam and some heat. For most soils the boiling loosened and incorporated 10 mm or more of soil into the solution. In some soils the lower concentrations did not cause a boil, but rather a continuous slow effervescence with a progressive volume expansion of the sample, in some cases up to 50 percent. This was apparently caused by reagent penetration into the soil with H_2O_2 decomposition incorporating gas bubbles within the soil fabric. After about five minutes, the H_2O_2 decomposition reaction subsided and the soil suspension was gradually deposited in a graded fashion onto the roiled, but intact soil below.

The effect of the violent H_2O_2 decomposition reaction on the structured soils also explains the response of the sandy soils to H_2O_2. These sands are structureless and have high particle size uniformity. Structure does not play a significant role in their porosity, and there are too few fines to form a hydraulically resistant graded deposit after H_2O_2 boiling. Thus, it appears that sands are somewhat immune to the physical deterioration in permeability effected on structured, finer textured soils.

<u>H_2O_2 Effects on Soil Porosity and Micromorphology</u>: The purpose of this experiment was to visually assess the effects of H_2O_2 applications on porosity, pore continuity, and structure. Two soils used in the previous laboratory study were selected for similar H_2O_2 treatments to be followed by analysis of thin-sections. These soils were a well-structured loam and a structureless sandy loam (borderline loamy sand).

<u>Methods</u>: Details regarding sampling procedures, sample preparation, experimental design, and reagent application is provided by Hargett et al. (1983). Replicate samples of each soil (non-clogged) were subjected to applications of 0.63 cm (HLR) of 0.625, 12.5, 25, or 50 percent H_2O_2, duplicating the experimental scheme used in the core study. Thin-sections were prepared and standard petrographic polarizing and dark field microscope techniques were used to count and classify pores larger than 0.02 mm (Hargett et al. 1983).

<u>Results</u>: Figures 4A and 4B display pore drawings made from representative sections of control and H_2O_2-treated cores of the pedal loam. In Figure 4A, the size and continuity of natural structural pores (>0.02 mm) is quite apparent and explains its moderately high permeability. However, when treated with H_2O_2, even at a low concentration (6.25 percent), the structure and attendant porosity were destroyed and numerous non-connected vesicular pores and vughs developed. The result (Figure 4B) was a hydraulically resistant styrofoam-like fabric. Total porosity (>0.02 mm) was about doubled in the top few cm of soil. In the granular soil, the random, structureless orientation of particles resulted in relatively few pores larger than 0.02 mm in the hand-packed control samples. In contrast, sandy samples treated with H_2O_2 (not shown) were riddled with large vesicular, and non-connected pores, similar to Figure 4B.

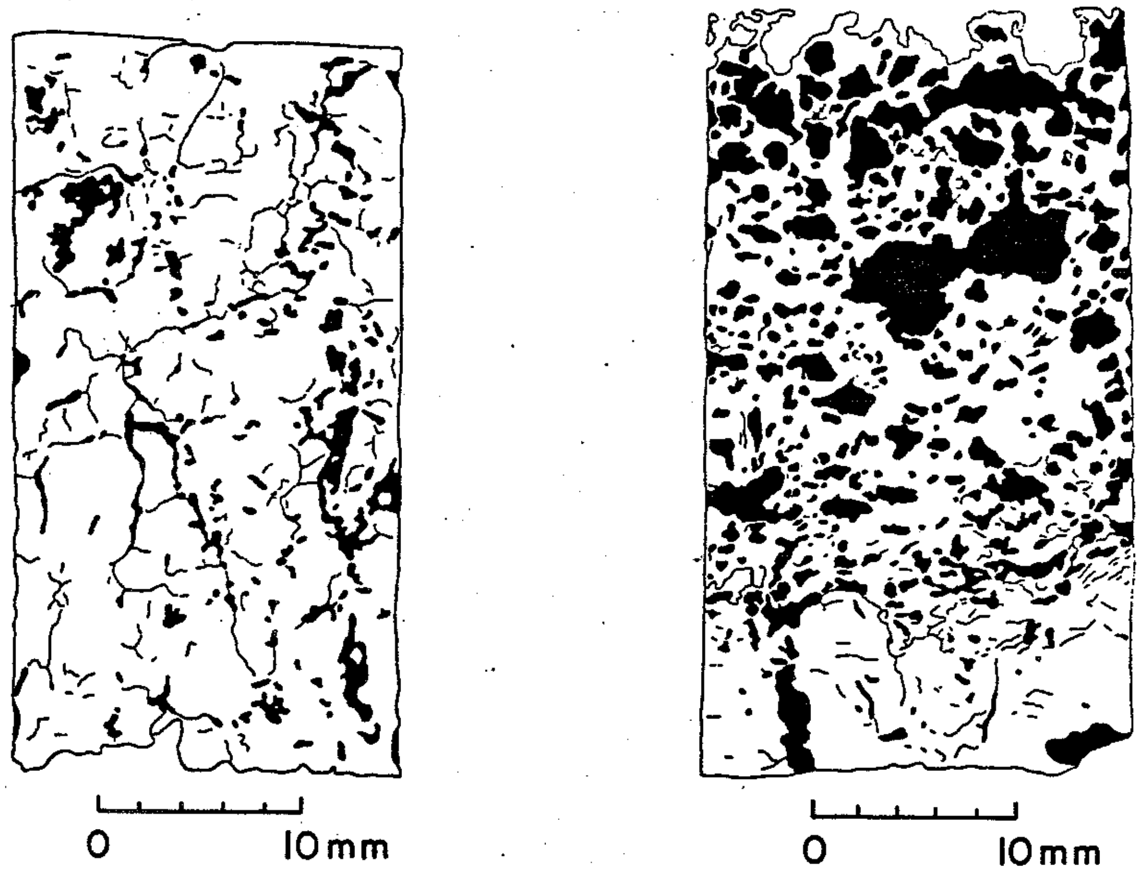

Figure 4. Pore sketch of vertical thin-sections of undisturbed loam. Figure 4A (left) displays interconnected and continuous character of structural porosity in untreated control sample (pores > 0.02 mm in black). Figure 4B shows porosity of same soil treated with 0.63 cm cm of 6.25% H_2O_2. Despite dramatically increased macro-porosity, pore continuity and attendant permeability is decreased significantly.

In both soils, the particles were totally reoriented, with clays, hydrous iron oxides, and the small amount of organic matter present, dispersed and redeposited onto the walls of the new pores. These materials appear to have combined to form a fairly significant "glue" which functions to hold the pores intact in the sandy soil. This phenomenon partially explains the structural integrity despite very low density of these vesical-filled samples during thin-section preparation, and the hydraulic resistance of soils with such a high total porosity.

Effects on Infiltration Rate--Clogged Soil Columns: In these experiments, soil columns representing a wide range of subsoil properties were clogged with wastewater and subsequently treated with H_2O_2. This experiment was designed to link the previous studies on H_2O_2 effects on permeability of natural, non-clogged soils to the reality of chemical rejuvenation of clogged systems.

Method: Four benchmark subsoils from the non-clogged core study were utilized in this experiment. These soils included clay loam, loam, silt loam and light sandy loam textures, with sand, silt and clay percentages varying as 16-78, 10-64, and 12-37, respectively. Sampling methods, column preparation, wastewater loading and the H_2O_2 treatment scheme are discussed in detail in Hargett et al. (1983). Column failure was defined as wastewater infiltration rates less than reasonable long-term acceptance rates (LTAR)(design loading rates) for the specific soil conditions of each column group. When the columns in each soil type reached this low wastewater acceptance rate, they were declared failed and were subjected to chemical rehabilitation efforts. The period required to achieve clogging varied from 40-90 days of continuous ponding with septic tank effluent (Hargett et al., 1983).

A treatment scheme similar to that employed in the study of undisturbed soil cores was applied to the column experiment. An HLR of 0.63 cm and H_2O_2 concentrations of 6.25, 12.5, 25, and 50 percent were used. Two random replicates from each of the cl, l, and sil column groups (eight columns each) were subjected to one of the four treatments, with an MLR range of 0.58 to 4.61 kg/m^2. In the case of the sl soil, with 24 columns, a broader range of 12 treatments with an MLR range of 0.29 to 9.22 kg/m^2, was used.

Results: Figure 5 presents the response to H_2O_2 treatment of the four soil types, combining all treatment levels. Comparing the pre-treatment (clogged) infiltration values to the post-H_2O_2 treatment rates for the three finer textured, structured soils demonstrates the general ineffectiveness of H_2O_2 to declog the soil. Among these soils (cl, l, sil), and for all four H_2O_2 concentrations, there were only two cases of statistically significant differences ($p = 0.05$) before and after treatment; these reflected declines in infiltration rate. In fact, post-treatment declines were observed in 75 percent of these columns. In contrast, the sandy loam columns receiving treatments identical to the finer textured soils (HLR and MLR same) displayed an increase in infiltration rate. These differences were statistically significant in three of four treatments. An important lesson from this comparison is that of the magnitude of post-treatment infiltration rates. Even in the sandy soils, in no case did post-treatment values approach even 25 percent of initial infiltration rate values.

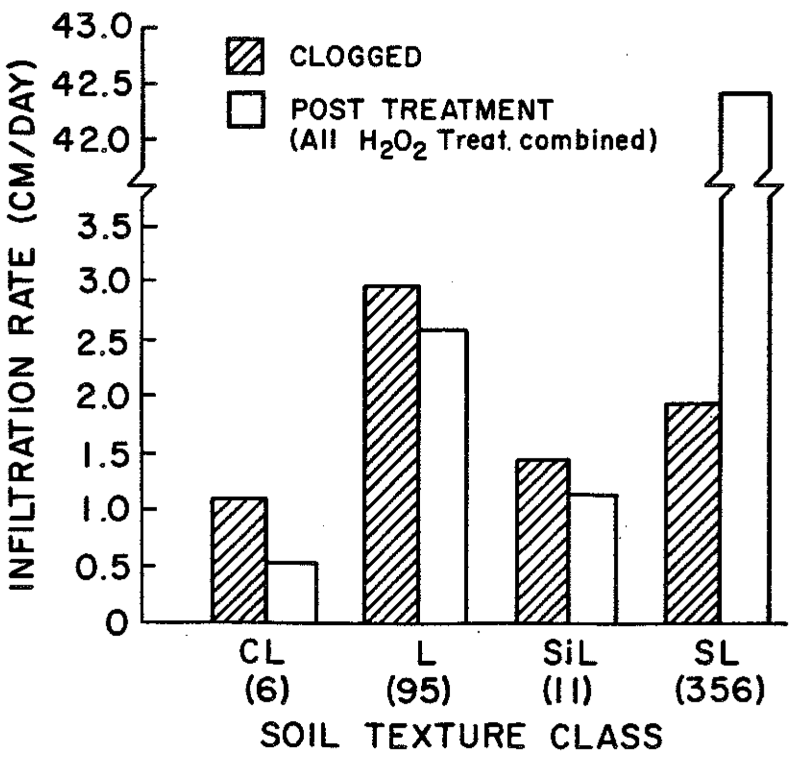

Figure 5. Infiltration rate response of wastewater-clogged soil columns to H_2O_2 treatment. Value in parenthesis, e.g. (95) is mean pre-clogging infiltration rate in cm/day for each soil texture.

As previously discussed, the sandy loam soil was subjected to a wider range of H_2O_2 treatments (12), with MLR of 0.29 - 9.22 kg/m^2. Eleven of the 12 treatments resulted in improved infiltration rates, and eight of these proved significant ($p = 0.05$). Figure 6 presents the results of this experiment with infiltrability expressed as %IIR. Comparing pre- and post-H_2O_2 data within treatments, it is apparent that the lowest mass loading rates had the least effect on infiltration rate. As either concentration, or hydraulic or mass loading rate increased, infiltration rate also generally increased. For the broader range of treatments in the sandy soil, no H_2O_2 treatment resulted in infiltration rate recovery greater than 33 percent of initial values. This highest rate of recovery in the sandy loam was associated with the highest mass loading rate used, 9.22 kg/m^2 (1.26 cm of 50% H_2O_2). However, this application rate far exceeds those used by commercial vendors and likely exceeds the maximum practical cost that could be charged for a Porox^R treatment.

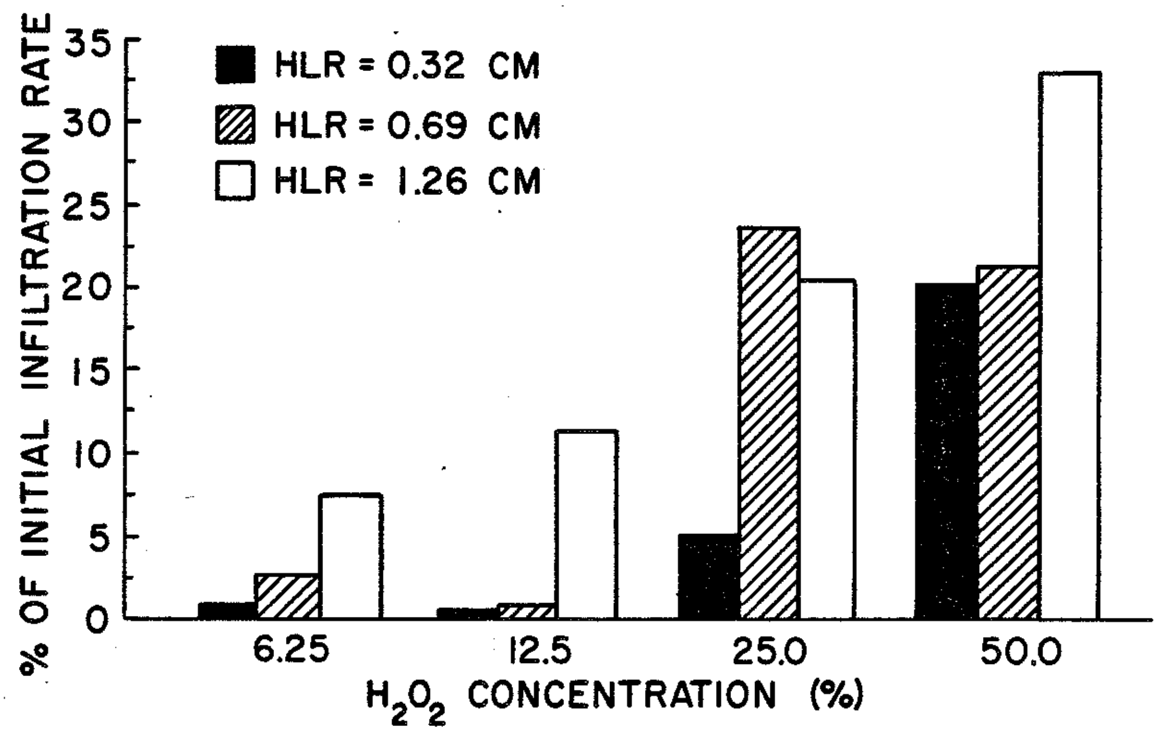

Figure 6. Effect of H_2O_2 treatments on infiltration rate of wastewater-clogged sandy loam columns. Mean initial IR for all 24 columns = 361 cm/day.

Examination of Commercial Experience in Wisconsin

Survey of Porox^R Clients: In order to gain insight into the "real world" commercial experience with Porox^R, a user survey was designed. On-Site Sanitation Services (OSSS), Stoughton, WI, acted as commercial cooperator in this study. OSSS provided records of all 45 of its Porox^R clients between 1977 and 1982, the date of the survey. These records provided quite valuable, but variable information regarding site and soil conditions, system design and performance, history and Porox^R treatment specifications.

A concise, but comprehensive battery of survey questions was devised to collect information on soil, site, and system conditions as well as wastewater generation characteristics of the facility. Queries also focused on failure symptoms before Porox^R treatment, satisfaction with the treatment, and system performance after the treatment. The confidential telephone survey was conducted by the University of Wisconsin Survey Research Laboratory (WSRL) using expert non-biased interviewers and professional survey techniques.

The survey data confirmed that homeowners know very little about their septic systems and very little about what they purchased in a Porox^R treatment. Nevertheless, several important characterizations of product users and Porox^R performance can be inferred. For example, a very important observation with regard to post-treatment system performance deals with the issue of water conservation. Half of the respondents indicated that they had significantly reduced flows to their system after treatment. Implementation of significant, and in some cases extreme water conservation is routinely recommended by many Porox^R licensees in conjunction with a treatment; some vendors also market flow reduction hardware (USRE, 1982). This obviously complicates analysis of the Porox^R treatment effect, as opposed to the unique and singular effects of reduced wastewater loadings.

A total of 35 percent of the respondents reported periodic or constant system failure as either backup or surfacing after the Porox^R treatment. Interestingly, 78 percent stated that they were satisfied; thus some homeowners were apparently satisfied with the treatment although failure continued or reoccurred. Fifty-nine percent indicated they would recommend the service; an additional 27 percent would give the treatment a provisional recommendation. Asked how they would describe the longevity of the treatment, responses were: long-lasting - 29 percent, temporary - 24 percent, and 40 percent did not know. As to the dependability of Porox^R, 44 percent of the respondents qualified the treatment as dependable, 18 percent as undependable.

Inspection of Porox^R-Treated Systems: After the telephone survey was completed, 26 of the 45 respondents were randomly selected for a brief follow-up personal interview. Where possible, the wastewater absorption system was inspected and any symptoms of failure or problem operations were noted. The follow-up site visits were more revealing than the telephone survey with regard to post-treatment performance. Of the 26 systems examined, three (12 percent) had been totally replaced and three (12 percent) were being pumped on a regular basis for relief and to avoid backup or surfacing. Inspection of the systems revealed that 19 (73 percent) of the systems were experiencing severe continuous ponding (all > 18 cm). These observations verify that for most systems treated Porox^R did not have a long lasting positive effect.

In another follow-up in October 1984, we attempted to inspect only systems installed in sandy soils, and with more recent Porox^R treatments. Three such systems were located, all treated commercially between 1.5 - 3 years prior to inspection. All three systems were in soils considered highly suitable for subsurface absorption systems. Each system was of bed configuration, sized and designed according to standard practice (Otis et al., 1981). Occupancy and wastewater flows appeared to be well within design. Inspection revealed all three systems to be continuously ponded. One system treated two years previously was judged as failing with 61 cm of ponding above the infiltrative surface and symptoms of imminent surface breakout. The other two systems in sandy soils had approximately 12 cm of continuous ponding, but appeared to be functioning adequately. This experience, combined with the sandy loam column results, suggests that additional research in sands is warranted.

SUMMARY

This paper is a condensed version of recent SSWMP research which refutes the efficacy of the hydrogen peroxide technique as originally prescribed and questions its application for a broad range of soils. The results of each component of this study stand as the foundation of our conclusions and recommendations as follow.

Conclusions

Rigorous critical review of the literature does not support the use of H_2O_2. Most previous research was conducted only on sands, or disturbed soils, and therefore can not be extrapolated to a broad range of natural soil conditions. Much of the earlier work suffers from lack of replication and experimental control, or inappropriate methodology. This work suggests that the effectiveness of H_2O_2 in restoring the permeability of clogged soils is at best partial, and highly variable, even in sands.

Field studies of controlled, replicated, in situ systems, previously clogged with wastewater, showed that systems treated with a standard commercial Porox^R treatment suffered significant and long-lasting losses of infiltrative capacity. A second treatment resulted in further declines. Control systems, allowed to rest naturally, responded with significant increases in permeability.

Laboratory studies on non-clogged cores representing a wide range of soil textural conditions documented that H_2O_2 can do severe damage to the infiltrative capacity of non-sandy soils. Loss of permeability was generally dramatic regardless of H_2O_2 concentration or mass loading rate. Only sand textures were not hydraulically damaged by H_2O_2.

A micromorphometric study of the effects of H_2O_2 on soil porosity, in both structured and granular soils, verified that the oxidant completely destroyed natural structure and pore continuity. Structural units and interpedal pores were eliminated by H_2O_2. The soil particles were dispersed and many non-connected, vesicular pores were incorporated into the soil fabric. Total and macro-porosity were much increased, but pore continuity and concomitant permeability were markedly reduced.

Attempts to restore the permeability of wastewater-clogged soil columns using H_2O_2 proved unsuccessful. Any H_2O_2 treatment of clogged columns of structured loamy soils generally resulted in slight declines in infiltration capacity, even below the clogged state. High H_2O_2 loading rates produced some improvement in permeability in clogged sandy columns, but the greatest reclamation achieved was only 33 percent of initial values.

A survey and inspection of Wisconsin soil absorption systems treated commercially with Porox^R, one to five years previous, confirmed that the treatment effects, if positive, were at best short-lived. Of 29 systems inspected, three had been totally replaced and 20 were experiencing severe continuous ponding.

Recommendations

Based on the results of this research, we do not recommend application of hydrogen peroxide to wastewater soil absorption systems, especially in non-sandy soils. Further, the information available thus far is not strong enough to support use of the treatment even on sands, except perhaps in extenuating circumstances. Before general use in sands is prescribed, we recommend further research be conducted to assess H_2O_2 effects and effectiveness in sandy soils, to include mound and fill systems.

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