ON-SITE REMOVAL OF VOLATILE ORGANIC CONTAMINANTS FROM SOILS--TWO CASE STUDIES

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Abstract

Target clean-up levels for contaminated soil have been established by regulatory agencies at various Superfund and industrial sites. However, the clean-up levels are highly inconsistent and typically vary from state-to-state and site-to-site. The lack of a firm target level has often induced responsible parties to merely excavate contaminated soils for disposal in a licensed secure hazardous waste landfill. This remedial alternative may appear to be the easiest solution as it eliminates negotiations with regulatory agencies, decreases the potential for public awareness, and temporarily solves the immediate problem. However, this "acceptable" method of remediation has not only imposed extreme financial burdens on the responsible parties; it has often resulted in additional liabilities due to inadvertent releases from one of these so-called "secure" facilities. The continued use of landfills represents "short-term remediation," particularly in view of the Environmental Protection Agency's (EPA's) proposed Resource Conservation and Recovery Act (RCRA) rule that establishes the frame work for banning most hazardous wastes from landfills by 1990. The land disposal restrictions provision of the new RCRA amendments clearly indicates Congress' intent to shift from landfilling to alternative management techniques (e.g., waste minimizing, substitution with non-hazardous substances, waste reclamation). Where these management techniques can not be applied, the proposed program will require treatment of many waste streams prior to land disposal.

Over the past several years, SMC Martin has developed and implemented an innovative on-site technique for the removal of volatile organic compounds (VOCs) from granular soils. This technique has been found to be cost effective, mobile, and requires a minimal amount of technology. In addition, the treated soils can often be returned to the original excavation or disposed of on-site.

Introduction

The two case studies presented in this paper demonstrate the feasibility of the shredding/aeration process to remove VOCs from soils. The results of these studies indicate that significant removal of VOCs from sandy soils can be achieved in a timely and cost effective manner. Both case studies presented were conducted on the same soil type and are geographically separated by only ten miles. In Case Study #1, trichloroethylene (TCE) was the major contaminant, although a variety of VOCs were also present. In Case Study #2, TCE was the only contaminant. Both studies were conducted in response to accidental spills and were conducted with the approval and assistance of the Delaware Department of Natural Resources and Environmental Control (DNREC).

Description of Soil Shredder

SMC Martin evaluated several potential soil aeration devices prior to selecting the Royer Model 365 soil shredder. The Royer Model 365 device was selected for the following reasons:

- The two-stage aeration process provides good soil to air contact.
- The Model 365 has sufficient capacity to process the required volume of contaminated soil in a timely and cost effective manner.
- The Model 365 is mobile and can be readily transported to the site.

Figure 1 is a general diagram of the Model 365 which identifies the various dimensions and specifications listed in Table 1.

<u>Soil Shredding/Aeration Process</u> (Royer 1981)

The soil shredding/aeration operation is accomplished in a four-step process that:

- Provides two-stage mixing of material;
- Aerates material before and after discharge;
- Breaks down and shreds clods and oversize materials into uniform-size particles;
- Automatically and continuously separates non-shreddable material from the end-product.

After the material is loaded into the receiving hopper of the shredder, it is carried to the top of a flighted conveyor where it cascades onto the shredding belt. The high speed shredding belt churns and tosses the material while closely-spaced rows of tempered steel shredding cleats on the belt produce a continuous raking action to shred and aerate the soil. Only particles of a preselected size are discharged

FIGURE I

SOIL SHREDDER DIMENSIONAL GUIDELINES

(Royer 1981)

The dimensional side and top views below identify the locations of the various dimensions listed on Table 1.

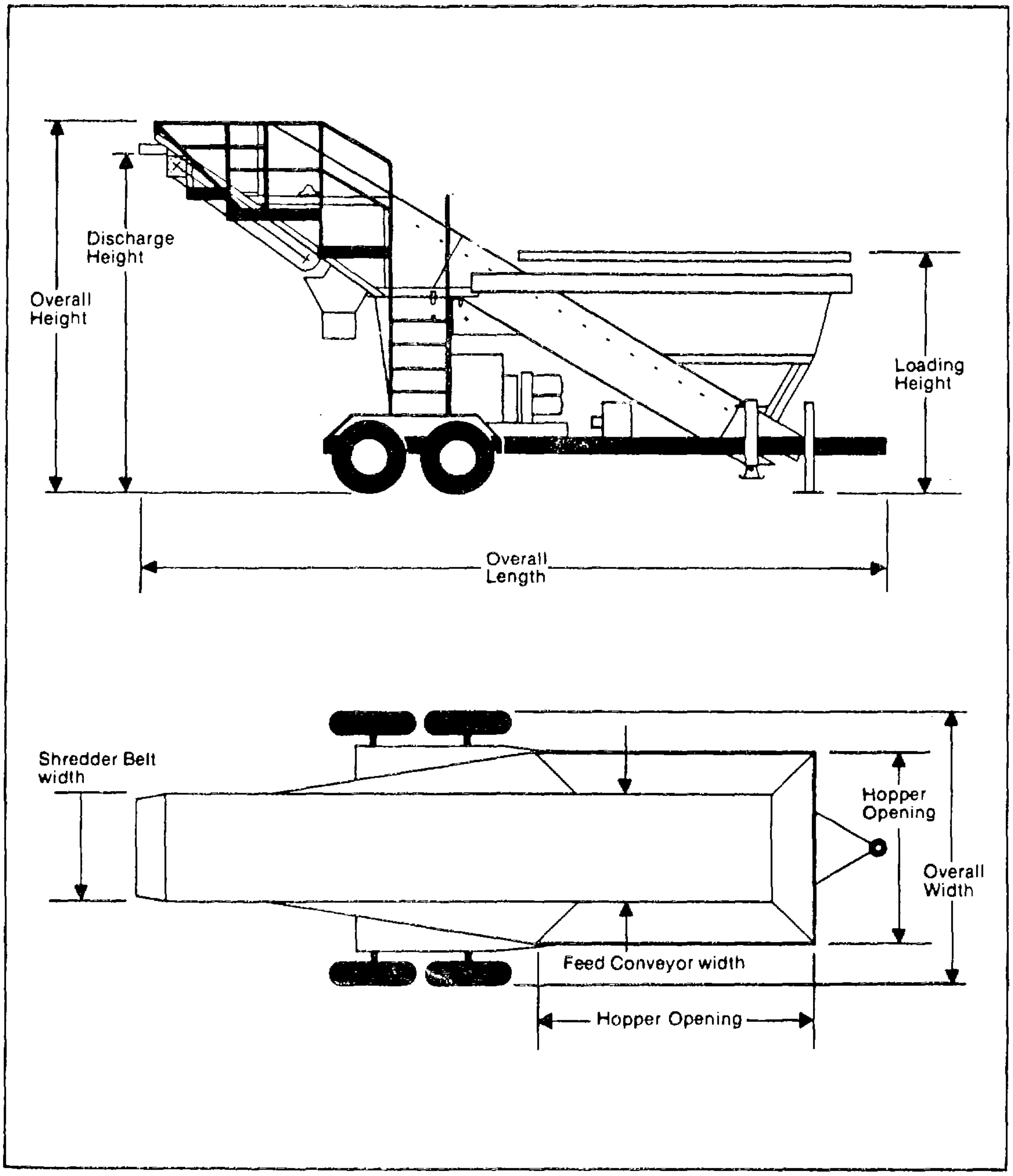


TABLE 1

DIMENSIONS AND SPECIFICATIONS FOR
ROYER MODEL 365
SOIL SHREDDER
(Royer 1981)

Input Processing rate (maximum to shredding belt)	125 cu.yds./hr ($95m^3$)
Overall dimensions L x W x H 3.65m)	22' x 8' x 12' (6.7m x 2.43m x
Loading height	8'2" (2.49m)
Discharge height	10'5" (3.17m)
Hopper capacity (level)	4.4 cu.yds. ($3.37m^3$)
Receiving hopper opening	5'6" x 8' (1.67m x 2.43m)
Recommended loader size	3 cu.yds.
Feed conveyor width	30" (760mm)
Shredding belt width	36" (912mm)
Power Plant 4-cylinder engine.	226 cu.in. 4 cycle diesel Mfr. rating - 72 hp Cont. oper. - 56 hp
Weight	9,200 lbs. (4,175 kg)
Vibrating stone grate	Yes
Trash-away conveyor	12'L x 16" w
Lump breakers	Yes

through the adjustable, variable-sweep fingers while oversize clods are forced back for further processing. Non-shreddable material such as sticks, stones, metal, glass, etc., are automatically rejected from the end product and discharged through a trash chute away from the shredded soil. This process thoroughly mixes the soil and produces a more uniform material. Thus, the sampling difficulties often associated with large volumes of soil having varying contaminant concentrations is overcome. Figure 2 details the process.

Shredder Loading

A small track-mounted front-end loader (Figure 3) was used to load contaminated soil into the shredder. The rate of soil loading generally exceeded the rate of soil shredding allowing the shredder to operate continuously until each pass was completed.

Soil Discharge

The shredded soil discharged from a height of approximately 10.5 feet through the variable-sweep fingers located at the end of the shredder belt (Figure 2, item 3). The stream of shredded soil traveled approximately 20 feet in an upward arc before striking the ground where it cascaded downward to form piles as shown in Figure 3.

Background Case Study #1

Case Study #1 was a RCRA-permitted solvent recovery facility that collected materials amenable to purification by distillation. The materials were distilled, purified, and returned to the owners for reuse. The still bottoms removed during the distillation process were drummed as hazardous waste and stored on-site for off-site disposal.

In the fall of 1984, the facility reported a recycling still explosion and fire to the DNREC. At the time of the explosion, witnesses reported observing fluids flowing off a concrete pad and infiltrating into the soil. Subsequent investigations were conducted by DNREC personnel. An organic vapor meter indicated the presence of volatile organics in the soil adjacent to the concrete pad. At that point, DNREC issued an order to implement soil removal, conduct ground-water monitoring, waste analysis, and to cease operations.

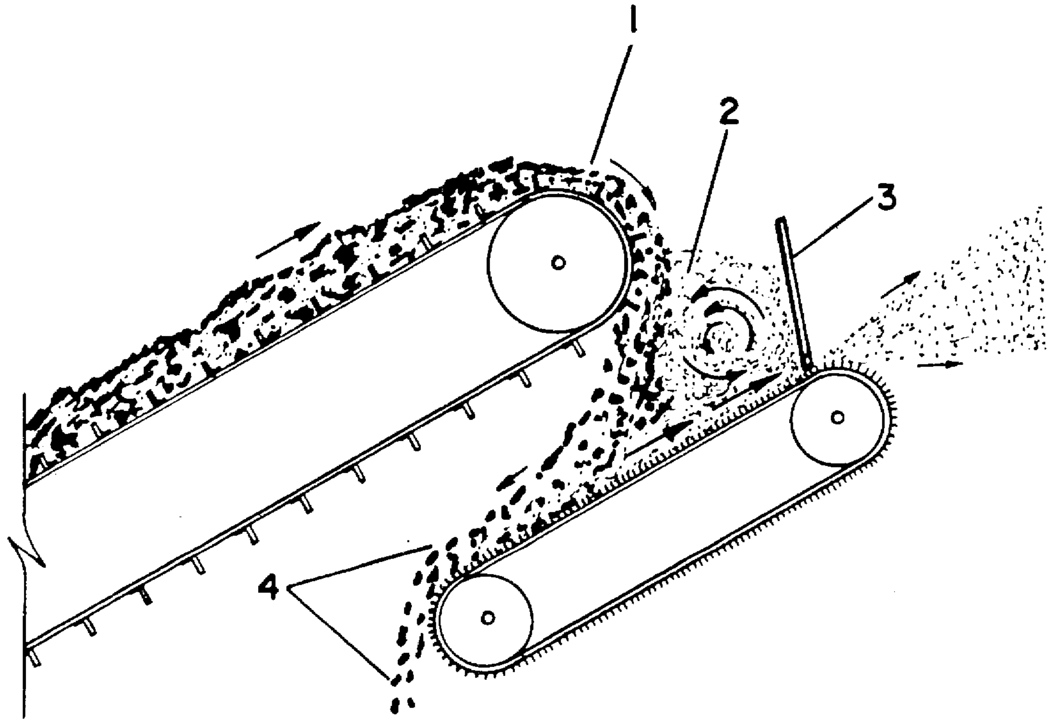
When the operators did not comply, DNREC installed monitoring wells at the site which identified high concentrations of VOCs in the ground water. DNREC subsequently excavated the contaminated soil. Based on the dimensions of the excavation pit (length 100' x width 35' x depth 10'), the volume of the excavated material was estimated to be 1,300 yds^3. Due to the large volume of contaminated soil, limited operating area, and the need to obtain the most representative samples possible, the contaminated soil was divided into eleven sections or "lots", each ranging in volume from 100 yds^3 to 150 yds^3.

DNREC contracted with SMC Martin to perform a feasibility study to identify remedial alternatives. On the basis of this study, DNREC elected to treat the contaminated soils with on-site shredding/aeration and to

FIGURE 2

OVERVIEW OF
SOIL SHREDDING/AERATION PROCESS

(Royer 1981)



OPERATION (1) Flighted conveyor unloads hopper-delivers soil mix ingredients into shredding belt. (2) High-speed, cleated belt shreds ingredients....aerates and thoroughly mixes with a violent churning, tumbling action. (3) Fully processed mix discharges. Adjustable fingers (variable sweep) permit selection of coarseness of mix discharged. (4) Over-size materials move back for additional processing....sticks, stones and other nonshreddables are rolled back for discharge through trash chute.

Figure 3

Shredder Loading and Soil Discharge

backfill the treated soils in the original excavation. SMC Martin was retained to design the process, train, and supervise DNREC personnel in its operation and complete a report detailing the findings of the soil shredding/aeration project.

Objectives

The primary objective of the shredding/aeration operation was to remove VOCs from contaminated soil and to demonstrate the effectiveness of the shredding/aeration process as an efficient and cost-effective treatment method for the removal of VOCs from soil. Secondary objectives included selection of appropriate equipment; development of preliminary economics for a full-scale system; and the identification of research needs or considerations for future applications.

Operational Routine

To insure adequate treatment prior to backfilling and to allow for the continuous processing of "new" lots, previously treated lots were moved to a staging area while awaiting analytical results. Each lot was processed through the shredder on an individual basis. If analytical results for the lot of concern were not acceptable, the lot was returned to the shredding operational area for further processing. A flow diagram illustrating this rationale is shown in Figure 4.

Sampling and Analysis

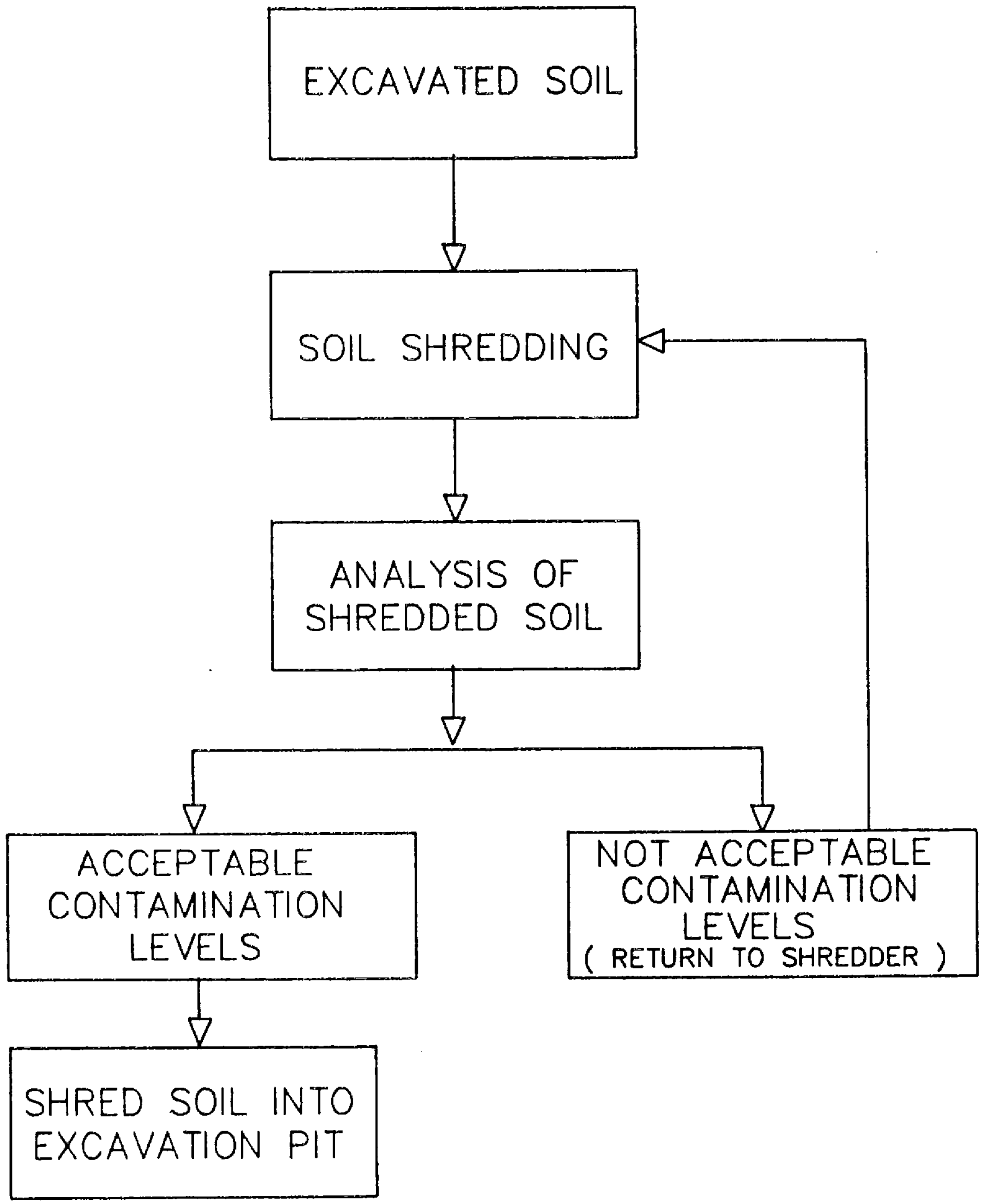
One hundred twenty-two (122) samples of the shredded soils were collected during the shredding operation. The soil samples were analyzed for grain size, pH, moisture content, and total volatile organics.

Two methods of sample collection were used to sample soils after each pass through the shredder. In the first method, a ten-gallon galvanized steel tub was used to collect the shredded soil as it discharged from the shredder. The galvanized tub was allowed to fill with the shredded soil for approximately two minutes or until full. After the tub was full, ten to twelve soil cores were removed from the tub using a chromium-plated tube sampler. The tube sampler was inserted through the entire depth of soil in the tub and resulting cores were placed directly into sample jars. The soil cores were approximately three-quarters of an inch in diameter and six inches in length.

In the second sampling method, the chromium-plated tube sampler was used to obtain soil cores directly from the shredded piles of soil. Approximately six to eight cores were obtained at various locations from depths ranging from one to three feet below the surface of the shredded soil piles.

In both sampling methods, an organic vapor meter was used to identify "hot spots" of contaminated soils to ensure collection of worst case samples.

FIGURE 4
FLOW / LOGIC DIAGRAM



The samples were analyzed for VOCs by gas chromatography (GC). The minimum detection level varies with individual compounds but is generally less than 5 parts per billion (ppb).

Presentation of Data Case Study #1

Analytical results indicated that repeated shredding/aeration of soils decreased VOC concentrations, moisture content, and grain size while pH remained relatively unaffected.

A total of eleven different batches (lots) of soil were treated. Soils were sampled after each pass through the shredder. Graphic presentations of the total volatile organics, moisture content, and pH for one of the eleven lots are shown in Figures 5, 6, and 7. The VOC removal trend shown in Figure 5 was typical of all eleven lots. VOC concentrations are expressed in parts per billion (ppb), pH is in standard units, and moisture is in percent by weight.

Background Case Study #2

Case Study #2 was a confidential client who uses TCE in degreasing operations. A spill of TCE occurred when a pipe providing TCE to a degreasing unit broke while the machine was operating in its automatic cycle. The TCE traveled to an exterior wall where it exited the building onto the soil adjacent to the building. Soil sampling was conducted to determine the vertical and horizontal extent of contamination. The delineated soils were subsequently excavated and stockpiled on site. The resulting volume of soil was approximately 200 yds^3. The stockpiled soils were placed on and covered by plastic sheeting while awaiting treatment. Several treatment alternatives were evaluated. A demonstration project was conducted, on the excavated soils, to illustrate that the natural volatility of TCE could be exploited if a mechanism for maintaining soil to air contact could be provided. Aeration by shredding was selected due to the excellent soil to air contact provided during the shredding process. At the completion of the shredding/aeration operation, the treated soils were spread thinly on-site.

Sampling and Analysis

Operational routines and sampling methods as described in Case Study #1 are the same for Case Study #2. Twenty-six samples were collected during the shredding operation. Six samples of the treated soils were collected during the spreading operation. One week later, four more samples of the treated soil were collected. The samples were analyzed for trichloroethylene (TCE) by gas chromatography (GC). The minimum detection level by this method is approximately 5 parts per billion (ppb).

Presentation of Data - Case Study #2

Analytical results indicated that repeated shredding/aeration of the soils decreased VOC concentrations. A graphic presentation of the range of TCE concentrations at the end of each pass is shown in Figure 8. VOC concentrations are expressed in ppb. No TCE was detected in any of the

FIGURE 5
TOTAL VOLATILE ORGANIC CONCENTRATIONS
OF INDIVIDUAL SAMPLES AFTER EACH PASS
(TWO SAMPLES / PASS)

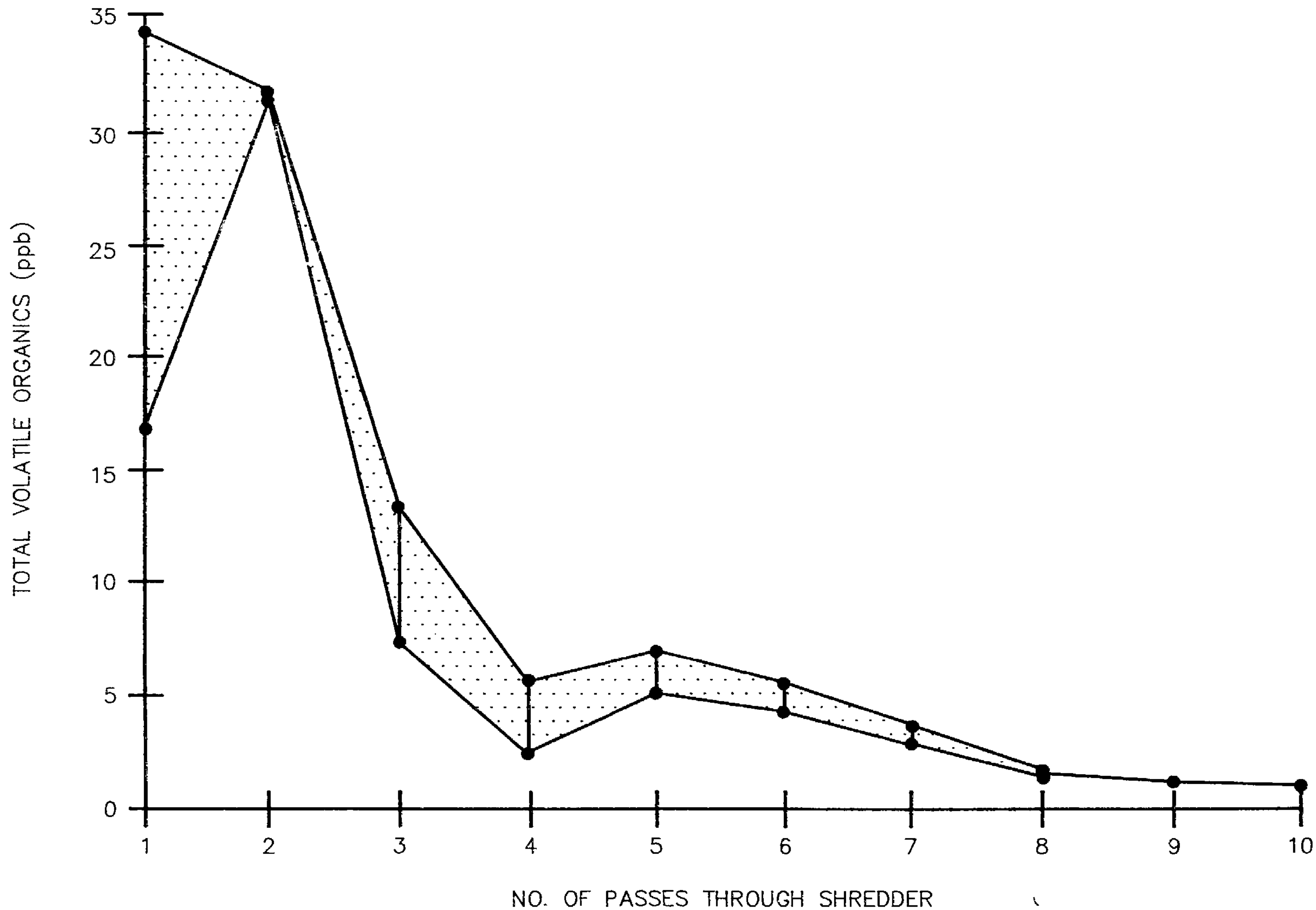


FIGURE 6
MOISTURE CONTENT
OF INDIVIDUAL SAMPLES AFTER EACH PASS
(TWO SAMPLES / PASS)

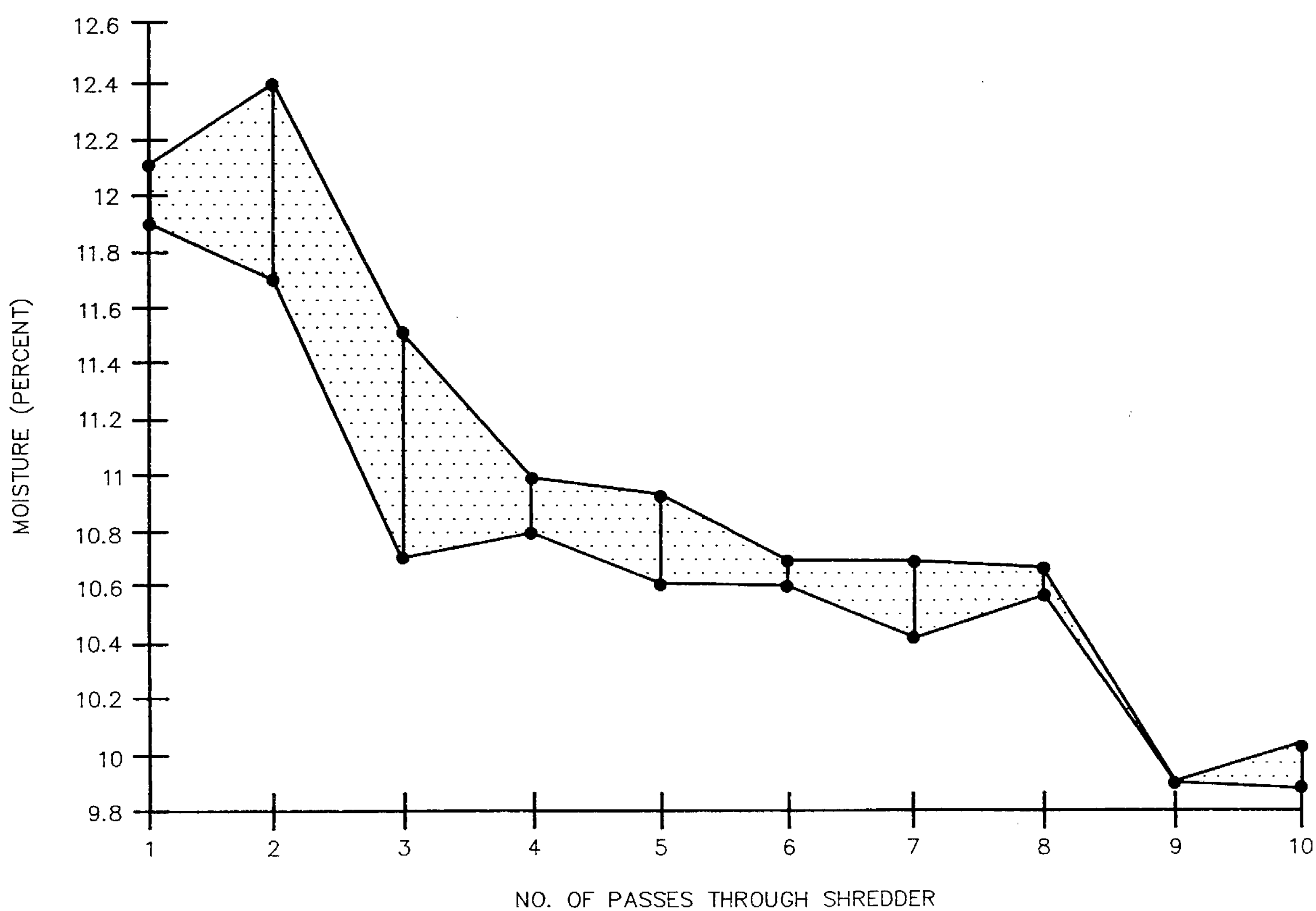


FIGURE 7
pH OF INDIVIDUAL SAMPLES
AFTER EACH PASS
(TWO SAMPLES / PASS)

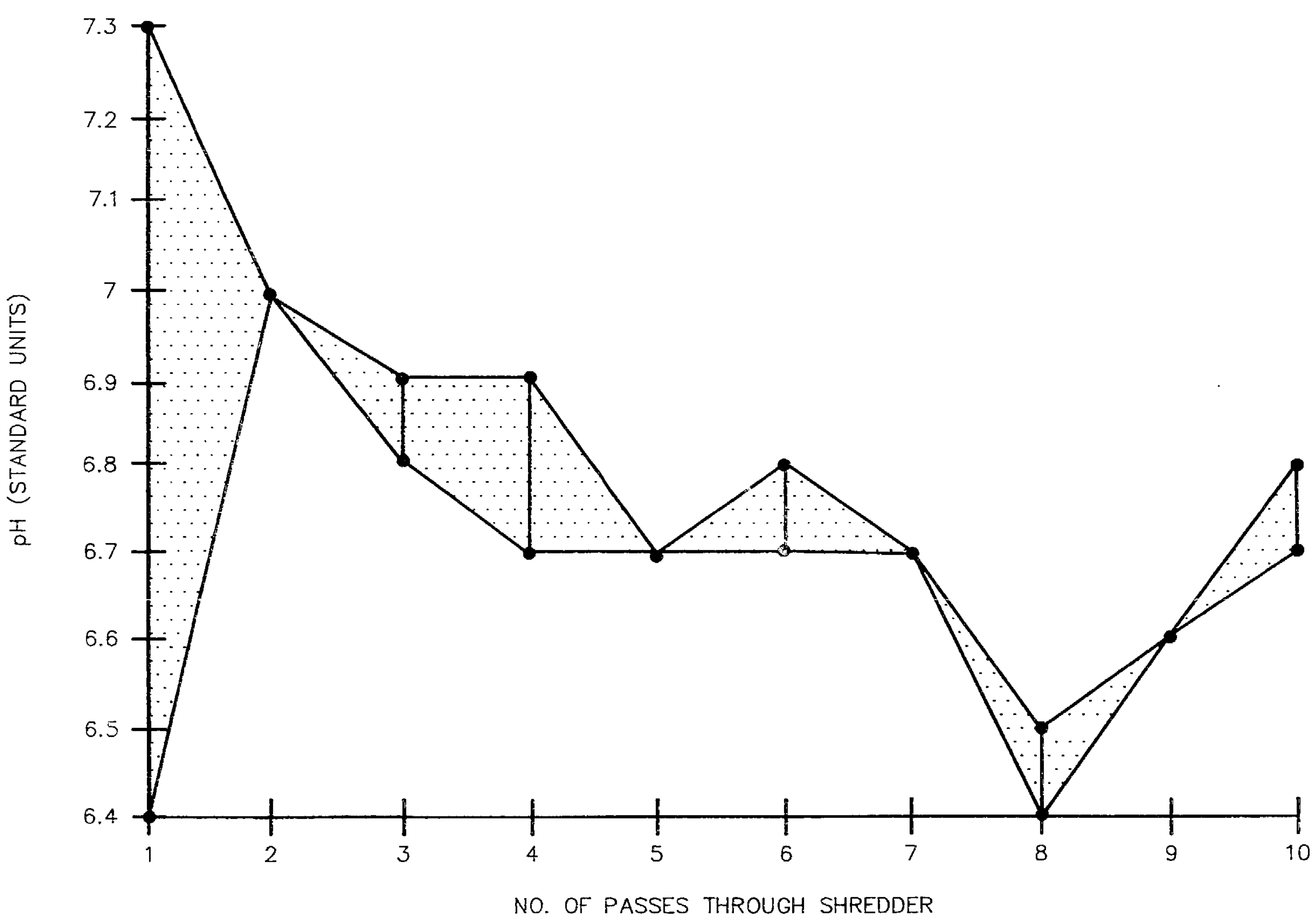
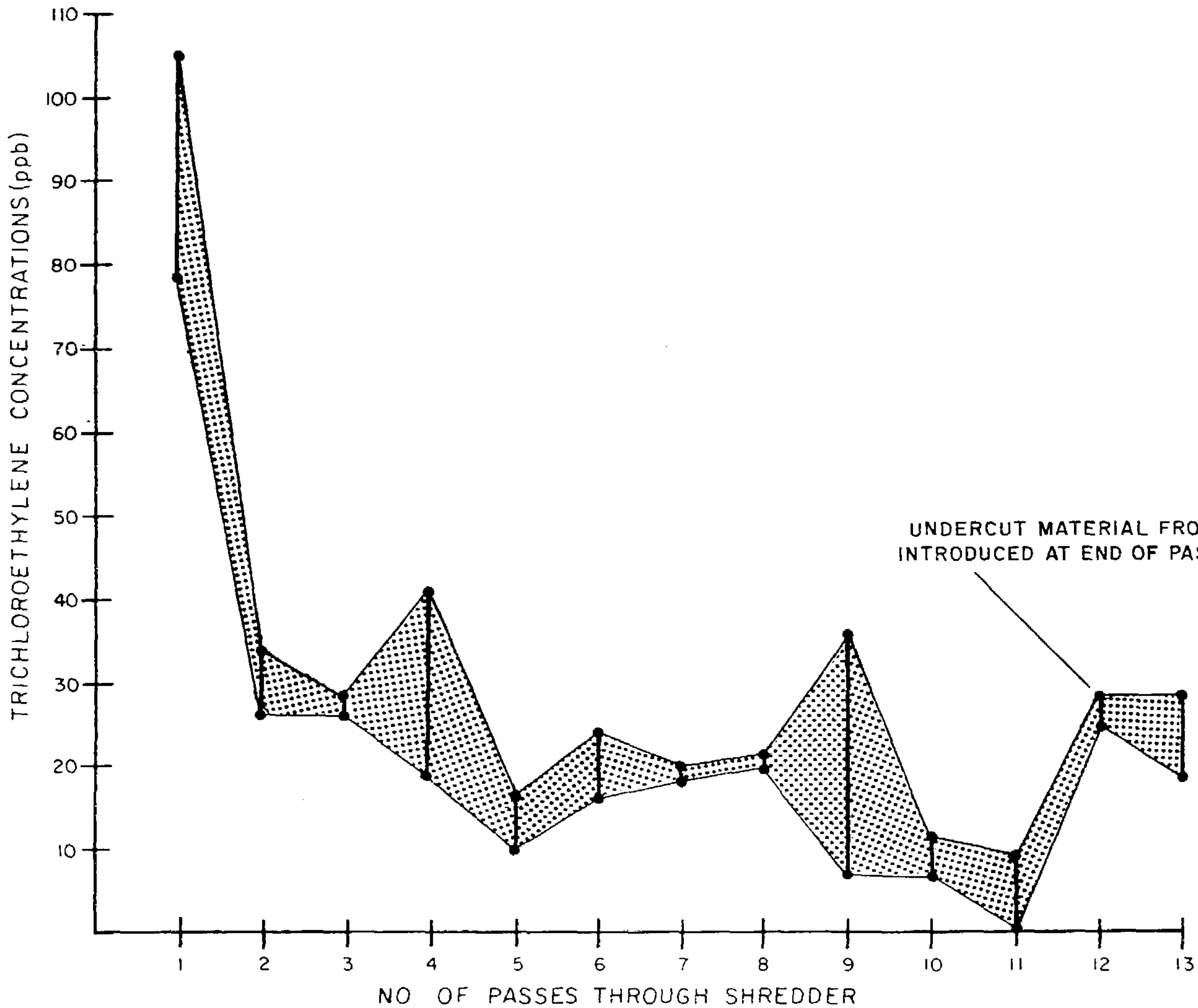


FIGURE 8
CONCENTRATIONS OF INDIVIDUAL SAMPLES
AFTER EACH PASS (TWO SAMPLES / PASS)



samples collected from the treated soils during the spreading operation. No TCE was detected in any of the samples collected from the treated soil one week after the spreading operation.

Conclusions and Recommendations

Conclusions

Based on review of the data presented in these case studies, the following conclusions are presented:

- Soil shredding is an effective technique for removing VOCs from granular soils.

- Repeated shredding of soils results in an overall decrease in VOC concentration, moisture content, and grain size. The pH remains relatively unaffected.

- This technique is cost effective when compared to other remedial alternatives.

- The degree of effectiveness of this technique must be evaluated on a site-by-site basis and is likely to be dependent on the specific soil and contaminant types as well as relative contaminant concentrations.

Recommendations

Based on the results of these case studies, the following recommendations are presented:

- On-site pilot studies for different soil and contaminant types should be conducted prior to the initiation of full-scale shredding operations.

- Organic vapor analyzers should be used more extensively to identify "worst case" samples for collection.

- The number of samples collected per pass through the shredder should be increased in order to make more precise statistical evaluations of the data.

- The Cation Exchange Capacity (CEC) of the soils should be analyzed on future shredding projects to evaluate the effect of CEC in attenuating contaminants.

References

Royer Foundry & Machine Company. 1981. Bulletin SM-365-R, pp. 1-4.