Container-piles for the safe excavation of 'hot spots' and (Dioxin) dumps

Pilots conteneurs pour le déblaiement sûr des 'points chauds' et depôts dioxineux

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SYNOPSIS: It is generally assumed that dioxin-containing waste cannot be excavated from a dump due to serious health risks. Now an innovative method called the "CONTAINER-PILE option" (patent pending) was developed. It was derived from state-of-the-art civil-engineering and off-shore technology. Container-piles are multifunctional, large hollow steel tubes (with cross sections of 4 - 10 m²) wich are driven side by side into a dump (or a contaminated site) and so fill themselves with up to 100 m³ contaminated material. The bottom of the container-pile is sealed in situ and a cover is welded on top. Thus the waste inside each container is isolated.

CONTAINER-PILES may be used to excavate (even the most toxic) waste dumps and contaminated soils, as well as only the "hot spots" therein. The main advantages are a strongly reduced vapour and dust emission; a strongly increased excavation, handling, transport and storage safety, both for personnel and neighbouring residents; reduced transport and storage volume; possibilities for strongly reduced remediation and treatment costs, depending on the type of contaminants, contaminant distribution and location.

Delft Geotechnics is a Research and Consulting Institute and therefore wishes to be independent of patent advantages. Therefore it sold the patent rights to the subsidiaries of two of the largest dutch contractors, i.e. Heijmans Environmental Technology in Rosmalen and Ecotechnology in Utrecht.

1. OBJECTIVES AND SCOPE OF WORK

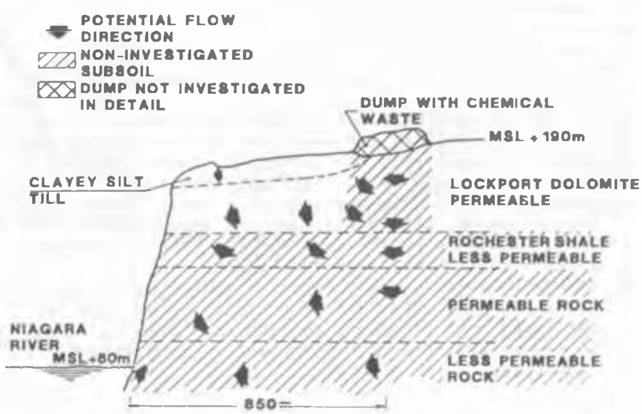
The Hyde Park Landfill is located in the Town of Niagara Falls, New York State, USA. The site is approximately 600 meters from deep gorge formed by the Niagara River downstream from the Niagara Falls. During the period from 1954 to 1975, Occidental Chemical Company (OCC, formerly Hooker Chemicals and Plastics Corporation) disposed of 70,000 tons of chemical waste (liquids and solids, in bulk and in drums) on much of the 6 hectares site up to 10 meters deep (figure 1). Many of the wastes are known to be hazardous materials. Of special concern is dioxin or 2,3,7,8-TCDD. The United States Environmental Protection Agency (EPA) states that about 900 kilograms of this chemical are present in the 20,000 tons of Non-Aqueous Phase Liquids (or NAPL, which are liquid organical waste chemicals primarily consisting of oils and bottom stills of the chemical industry) representing the largest amount of dioxin in any dump in the world. Several toxic chemicals have been found in the groundwater near the Niagara River, thereby threatening the safe drinking water supply of 4.5 million Canadians and 1.5 million Americans around Lake Ontario. US EPA, New York State and Occidental Chemical Company (OCC) designed a Requisite Remedial Technology Program (RRT) whereby the hazardous waste remains on the fill with only containment and treatment of the plume contaminants before they enter the Niagara River (Hannink et al. 1988).

The Canadian Government and Pollution Probe Foundation, an environmental advocacy group in Toronto, have stated that the RRT program is insufficient in eliminating the threat to Canadian drinking water users, since the chemicals dissolved in the NAPL may escape the monitoring and pumping systems of the proposed RRT. They state that the RRT should include also excavation of the hazardous waste. US EPA, however, states that excavation would cause serious health risks for neighbouring residents due to toxic dust and vapour emissions.

Pollution Probe contracted Delft Geotechnics to conduct a pre-feasibility study regarding the technical feasibility of excavating the dioxin-bearing hazardous waste using proven techniques, and to determine the measures necessary to conduct the excavation safely without endangering human health or the environment. Delft Geotechnics brought the study under the umbrella of SIBAS, the Joint Institute for Policy Analysis which coordinates policy analysis studies of the six largest technical institutes (including Delft Geotechnics and TNO) in the Netherlands representing 8000 scientists and support personnel.

From our preliminary investigations (Hannink et al. 1988) it appears to be feasible to excavate the Hyde Park dioxin-bearing wastes under a Safe, Temporary, Air-tight, Regulated-atmosphere, Self-contained (S.T.A.R.S.) cover without endangering human health or the environment, using proven technologies and/or using the container-pile (patent pending) system. It will be feasible to store the waste in containers in a fully inspectable and controllable, temporary facility for up to 100 years on the site.

Figure 1. Geological setting and pollution plume pathways of Hyde Park Landfill



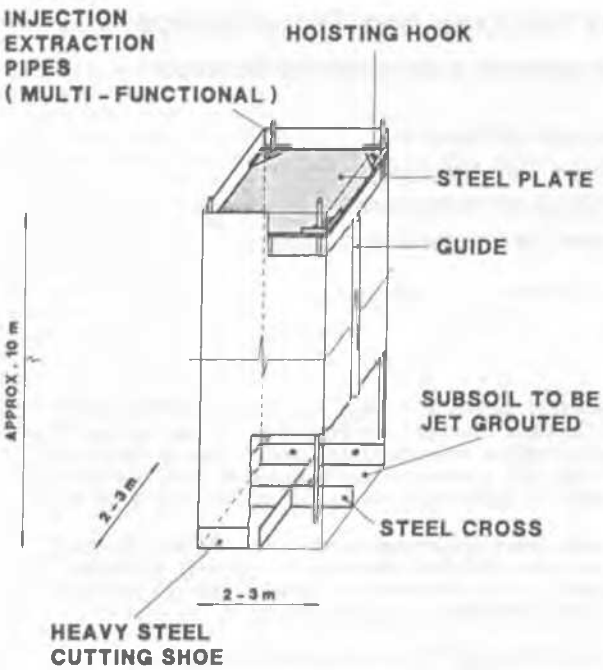


Figure 2. Example of a container-pile design

Delft Geotechnics performed the civil-engineering part of the study, whereas the Study and Information Centre for Environmental Research of TNO performed the studies on the environmental hygiene aspects such as dust emission and air-filtering, the safety risks and the waste treatment and transport. The container-pile option was a spin-off result of the civil-engineering part of the study by Delft Geotechnics and is presented here.

2. INVENTORY OF EXCAVATION TECHNIQUES

At present the following dry and wet excavation techniques are available:

A. within open pits with natural slopes
B. within open and structured pits, that is within:
   1. sheet piled walls
   2. diaphragm walls
   3. piled walls
   4. Berliner walls
   5. stabilized (grouted) slopes and bottom
   6. frozen slopes (and bottom).
C. within container-piles
D. combinations of available techniques
E. within and under caissons
F. with the aid of dredging and/or pumping equipment.

These techniques may need the aid of drainage and can be applied in compartments.

Four of the excavation techniques have been selected for Hyde Park Landfill, considering the size of the dump, the depth of the waste, the hazardous wastes to be expected and the geological setting. They are:

A. Excavation within **open pits** with natural slopes. Excavation may take place over the whole dump or progressively over the dump. It can be assisted with purge wells and drainage techniques.
B. Excavation within **walls** formed by sheet piles and/or steel profiles. This **structured pit** may be used for the whole dump or moved progressively over the dump. It may be assisted with purge wells and drainage techniques.
C. Excavation within container-piles, which are big hollow steel pipes (see figure 2) driven into the dump side by side (see figure 3) and which, when hauled out, will constitute containers for the waste which can be handled, transported, used as chemical reactor vessels and stored in (temporary) storage facilities. Container-piles can be used over the whole site or in sections of the site. A patent for the container-piles is pending.
D. Any combination of the three above techniques.

The open pit and structured pit techniques are standard construction techniques which have been used world-wide over a considerable period of time. The **open-pit** technique may have only restricted application at Hyde Park Landfill because of stability problems (due to the 70,000 tons of chemical waste, especially the 20,000 tons liquid organical chemical wastes, and other industrial sludges) and therefore potential dust emissions risks.

3. THE CONTAINER-PILE OPTION

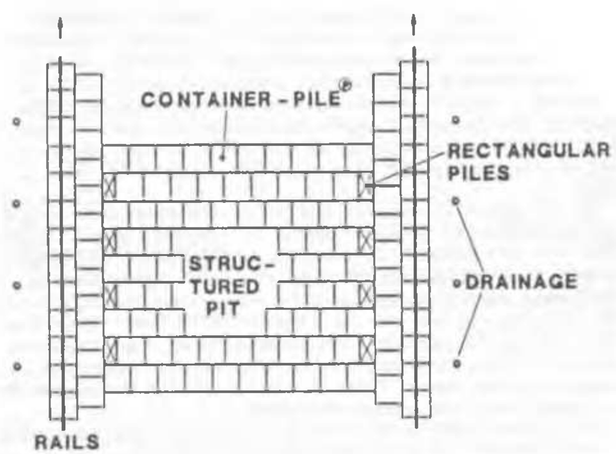
3.1 Description of container-piles

Combining existing piling and exploration equipment, and geotechnical and off-shore techniques it is possible to design a big bailer, in this report named a container-pile (see figure 2), to seal the waste in situ (i.e. in the subsoil itself) and subsequently to remove the container-piles with the waste. For example, at present there exist bailers and vibrocorers which are in use in the field of geotechnical site investigations and which can sample/extract soil columns. In the field of off-shore foundation technology a regular use is made of open tube steel pipes with diameters up to 3 m and lengths up to 100 m. The cross-section of the piles may be rectangular or circular.

A number of piles can be installed in the dump side by side, for example in compartments. After recovery of the inside of a compartment the remaining piles will form a structured wall (see figure 3). The recovered piles contain the waste.

The hollow steel container-pile must have a considerable cross-section, for example between 4 and 9 m^2, and a specially designed toe with a cutting head and probably valves. These valves must prevent that the solid waste will fall out of the container-pile when the pile is recovered. Moreover, the pile toe has to be grouted.

Figure 3. Top view of an example of a container-pile layout



The few percent of contaminated material inbetween adjacent piles can be minimalized by optimization of the pile-layout, e.g. by using smaller diameter cilindrical piles inbetween large diameter cilindrical piles. This rest material should be removed with more conventional excavation equipment. Prior to removal it may be grouted or treated otherwise.

3.2 Development stage

Most parts of this new method have been used in full scale in piling and exploration techniques in the fields of geotechnics and off-shore constructions. As a combination they have not yet been tested for the proposed dimensions and application. However, the container-pile concept, to be regarded as an innovative technique, is at this stage developed to the feasibility level, based on extensive analysis. The implementation of a final program will be based on a thoroughly tested prototype. A demonstration program with field test can be performed in a relatively short period. The container-pile option needs rather simple operating procedures with heavy but conventional earth moving equipment and transport means.

3.3 Advantages and applications

The advantages of the container-piles are:
- Can be used as foundation piles.
- Form a structured wall.
- Isolate contaminated soil and waste from the surrounding area and from the contents of surrounding piles, and therefore prevent cross-contamination and further migration of (different types or classes of) toxical and/or chemical substances.
- Can be used to excavate toxic wastes and polluted soils. Both a complete dump or only its "hot spots" can be excavated. The container-pile option can be particularly cost-effective for old and derelict industrial areas, where in many cases during decades slightly soluble oils and tars have been migrating tens of meters deep into the subsoil and the groundwater. Using the container-piles as "apple-corers" such deep sitting concentrated chemicals can be removed selectively, without excavating the whole area.
- Using container-piles as an excavation and transport tool prevents the usual 20 - 40% volume expansion due to excavation of soil and waste, yielding a large reduction on the total volume of material to be transported and/or stored.
- Using container-piles greatly reduces the emission of toxic dusts and hazardous vapours compared to traditional excavation techniques. **Only** during the **removal** of each (about 100 m^3 of waste containing) pile some emission might occur.
- Form secure containers for safe handling and transport: after cleaning the hull of the container-piles (figure 5) further contact with the hazardous contents of the piles is impossible.
- The container-piles can be used as "chemical reactor vessels" for treatment and conditioning of the contaminated material inside the containers, e.g. by extraction or injection of gases and liquids for detoxification and/or immobilization (grouting) of the hazardous materials.
- The waste and contaminated soil can be characterized before or after installation of the container-piles, and can be classified according to the type of required handling (e.g. non-hazardous, slightly hazardous, hazardous, extremely hazardous) and treatment (e.g.: can be used as backfill; should be disposed on municipal/hazardous waste dump; should be treated in a low/high temperature oven; can be treated with extraction/immobilization techniques). This is very cost-effective since transport and treatment licences and costs vary widely for different classes of waste. Treatment costs may vary from roughly 50 to 1000 US $ per ton excavated material.
- After cleaning the container-piles they themselves are sealed containers, which can be easily inspected and controlled, and which can be easily handled, transported and stored with standard heavy equipment.

3.4 Installation and application working procedure

An example of a working method for the container-pile option is shown in figures 4 and 5:
A. Geotechnical and chemical characterization of the types of waste and their location in the dump.
B. Site preparation (levelling by adding clean soil).
C. Installation of container-piles through the clean top-soil down to the bottom of the dump (or deeper if possible, e.g. to facilitate the sealing and to improve the environmental safety of the bottom of the piles by including underlying less contaminated soil layers, which themselves are impermeable or can be easily grouted).

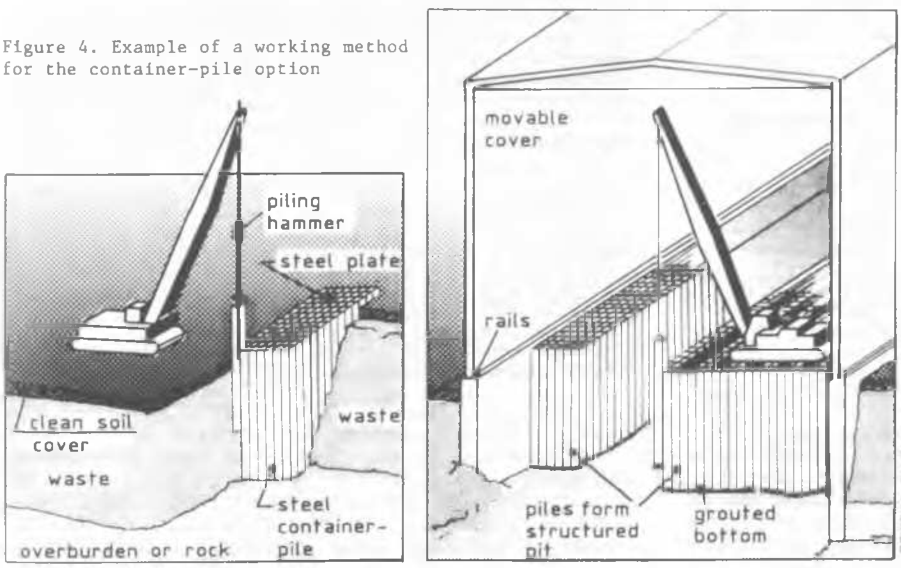


Figure 4. Example of a working method for the container-pile option

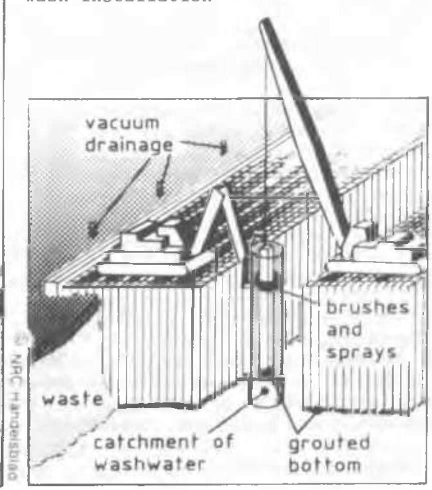


Figure 5. Example of a container-pile wash-installation

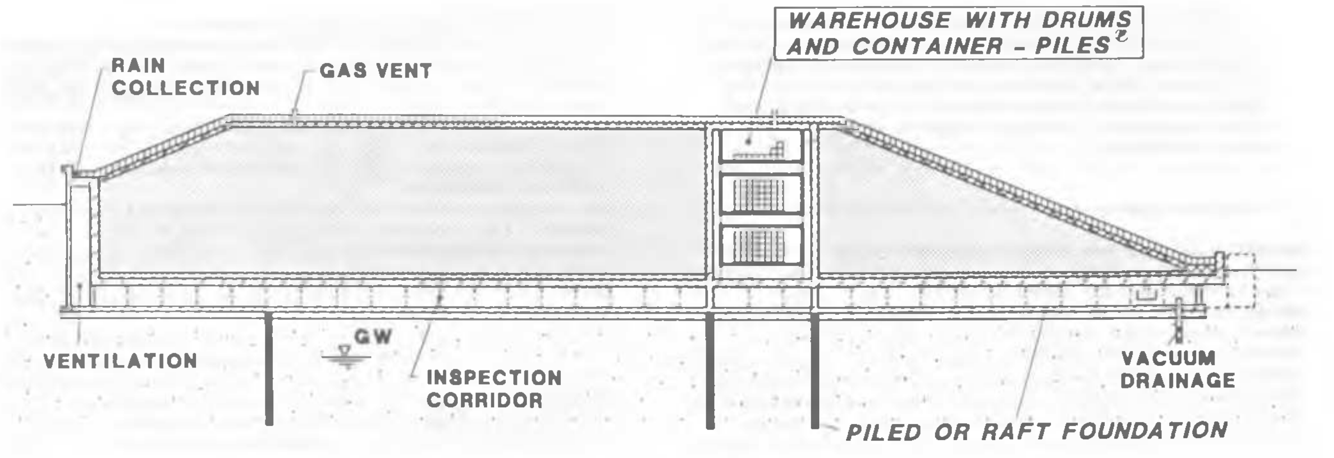


Figure 6.: Example of an inspectable controllable, safe, temporary storage facility

D. Seal the bottom of the piles, e.g. with (jet) grouting.
E. Weld steel plates on the piles and construct pile connections.
F. Place slabs on the pile heads.
G. Optional: extraction of gases and liquids from the container-piles; treatment of the contents of the container pile, e.g. for conditioning, extraction, immobilization or detoxification of the contaminants.

Steps A to G can be executed without cover.

H. Optional (for cases in which too harmful amounts of contaminated dusts or hazardous vapours are expected to occur): install the desired cover. Rails for a small movable cover can be installed on the outer container-piles or on steel profiles/piles outside the area of the container-piles.
I. Pull the container-piles.
J. Clean the outside of the container-piles in the specially constructed container-pile wash-installation. The outflow has te be collected and treated (figure 5).
K. Transport to (temporary) storage facilities.
L. Remove any remaining liquids and solids in the excavation pit, for example with a vacuum excavator. (Prior to recovery of the container-piles a vacuum drainage might have already been installed.)
M. Recover adjacent piles.
N. Outer piles will form a structured pit.
O. Apply backfilling.

4. DECONTAMINATION, HANDLING, TRANSPORT, TREATMENT AND STORAGE OF CONTAINER-PILES

The containers with hazardous waste have to be washed to remove hazardous materials from the outside surfaces before further handling. Proven technologies borrowed from ship hull cleaning procedures can be adapted to clean the container-piles (figure 5).

Each cleaned container may be wrapped and sealed in a sheet of impermeable plastic for additional protection. For example, HDPE (high density polyethylene) is generally used to line engineered hazardous waste sites.

Standard heavy equipment can be suitable for transporting container-piles to on- or off-site treatment and storage facilities.

Although safe destruction technologies are being developed on a commercial scale for dioxin-bearing wastes, it may be years before such facilities are permitted and available. Therefore, in most cases, the excavated wastes must be safely stored until safe destruction techniques for them are well accepted and available.

The storage of containers filled with dioxin-contaminated soil is comparable to the above- or below-ground storage of low-level radioactive waste. Nuclear waste has been stored in the Netherlands in a controlled cement storage facility in the village of Petten. These facilities are intended for temporary storage (for periods of up to 100 years) until safe long-term disposal is available. There are separate sections for both reception of the waste and long term storage. The handling occurs by forklift-truck for light containers and by overhead cranes for heavier pieces. The containers are fastened to each other and stacked to allow for visual inspection.

The container-piles can best be stacked in square blocks with the horizontal pipes in each layer perpendicularly to the pipes in the layer below. Sufficient spaces or lanes between the blocks allow for visual inspection. The outer walls and floors of the facility will be visible and fully inspectable. The ground floor is inspectable from a lower lying cellar (figure 6).

5. CONCLUSIONS

CONTAINER-PILES may be used to excavate (even the most toxic) waste dumps and contaminated soils, as well as only the "hot spots" therein. The main advantages are a strongly reduced vapour and dust emission; a strongly increased excavation, handling, transport and storage safety, both for personnel and neighbouring residents; reduced transport and storage volume; possibilities for strongly reduced remediation and treatment costs, depending on the type of contaminants, contaminant distribution and location.

6. REFERENCES

Hannink, G., van der Meer, J.P., Mischgofsky, F.H., Keulen, R.W., van de Velde, J.L. & de Walle, F.B. (1988). Safe excavation of the dioxin containing Hyde Park Landfill in Niagara Falls, New York, USA, in: K. Wolf, W.J. van den Brink & F.J. Colon (eds.), "Contaminated Soil '88" (Kluwer Ac. Publ. Dordrecht/Boston/London) p. 1025.