REHABILITATION OF A MOUND SYSTEM

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by

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Richard J. Otis

Since 1972, mounds have been used successfully to treat and dispose of wastewater from single family homes in Wisconsin. They have been used on shallow permeable soils or on deep slowly permeable soils, both of which are unsuitable for conventional soil absorption systems. A 1979 survey of over 640 systems operating in the state found only 3 failures, all by surface seepage (Harkin, et.al., 1979). These failures were traced to faulty construction and were easily corrected. Groundwater monitoring at the sites of 33 systems surveyed in detail indicates that the treatment that they provide equals or exceeds treatment conventional soil absorption systems provide.

The success with the Wisconsin mound can be attributed to a number of factors. Construction of the infiltrative surface in a select fill material, provision of uniform effluent application through pressure distribution networks, and the requirement for more careful site evaluation design, construction and construction supervision by the State of Wisconsin contribute to the low failure rate. However, the most significant factor may be the low average daily loadings of the mounds. In the mounds studied, the average daily loadings were approximately 30 percent of the design loadings (Harkin, et. al., 1979). Therefore, as the use of mounds increases, particularly for larger waste flows, greater numbers of failures may be experienced when actual loadings approach the design loadings. However, because of the design features incorporated into them, failing mound systems would seem to have a greater likelihood of being rehabilitated successfully than failing conventional systems. If true, this would be a significant advantage of mounds over conventional systems.

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Failure of a mound system designed to treat and dispose of the sanitary wastes from a small industry in Wisconsin provided an opportunity to learn more about the design of large mounds and methods of rehabilitation. This paper discusses the investigative procedures used to determine the causes of failure, rehabilitation techniques used, and design features that should be incorporated into systems of this type.

TROUBLESHOOTING MOUND FAILURES

The cause of subsurface soil absorption system failure can be very complex. Failure may result from improper siting, design, construction, maintenance, overloading, or a combination of these. It can manifest itself by sewage backups, seepage over the ground surface or contamination of the groundwater. In conventional trench and bed systems, symptoms of failure are often similar regardless of the cause and diagnosis is hampered because the system is buried. Therefore, prescription of an effective method of rehabilitation is difficult.

Because mounds are built above the natural ground surface in a select uniform fill, diagnosis and treatment of mound failures is simplified. There are three basic symptoms of mound failure: 1) seepage out the sideslope above the mound's base, 2) seepage out the base of the mound, and 3) contamination of the local water table. Because these symptoms are distinct from one another, it is much easier to diagnose the cause of failure and prescribe treatment than with conventional systems. In addition, the design features of the mound facilitate effective rehabilitation. The symptoms, causes of failure and suggested rehabilitation techniques are listed in Table 1.

Table 1. Methods of Mound Rehabilitation

Failure Symptom	Cause of Failure	Corrective Action	Rehabilitation Techniques
Seepage from mound sideslope	Overloading of gravel/fill infiltrative surface	Reduce hydraulic loading	•Flow reduction •Increase infiltrative area
		Reduce high strength waste loading[a]	•Segregate or treat high strength wastes and oxidize clogging mat
Seepage from mound base	Overloading of fill/soil infiltrative area	Reduce liquid application rate	•Flow reduction •Increase downslope fill •Increase mound length along contour
Waste contamination of water table	Insufficient treatment	Reduction in fill wetness following wastewater application dose.	•Reduce dosing volume •Increase perforation density in distribution network •Increase fill depths

[a]Pertains to non-domestic wastes.

CASE STUDY

Background

Failure of a mound constructed for a small but quite successful Wisconsin industry provided an opportunity to test diagnostic and rehabilitation techniques. The mound was originally constructed in November, 1976, when the firm expanded its operation. It was built to treat and dispose of toilet and shower room wastes generated by 65 employees, the firm's projected estimate of the maximum number of employees over the next ten years.

The natural soil at the plant site is Lamartine silt loam, a shallow, somewhat poorly drained soil overlying creviced limestone bedrock suitable for a conventional trench or bed system. Depths to bedrock over the site ranged from

0.3m (1 ft.) to 2.1m (7 ft.) with mottling occurring 0.4m (15 in.) to 1.1m (44 in.). Percolation rates measured at 0.6m (24 in.) ranged from 122 cm/day (30 min/in) to 183 cm/day (45 min/in).

The mound was located over the deepest soil. It was designed for 2.8 m^3/d (750 gpd). A medium sand (75% between 0.25-2.0 mm) was used as the fill material. The gravel bed was 3.1 m (10 ft.) by 18.6 m (60 ft.) with a design loading of 5 cm/day (1.24 gpd/ft^2). A basal loading rate of 2 cm/day was used to design the 13.7 m (45 ft.) by 27.5 m (90 ft.) mound.

In June, 1978, the mound failed. The firm expanded its facility during the previous summer and now had 165 employees. Footings for the new building were located in the upslope side of the mound and a gravel parking lot surrounded the remainder. Since another expansion with an additional 50 employees was already in progress, the mound required upgrading.

Rehabilitation I

Inspection of the mound showed the seepage to be coming through the observation vent in the gravel bed. Hand augering revealed that the sand fill next to and below the gravel bed had such a low moisture content that a cast could not be formed. The clogged zone below the gravel bed extended 3 to 5 cm. (1 to 2 in.) into the fill. Severe clogging of the gravel/fill infiltrative surface was diagnosed as the problem. Hydraulic overloading was certain but the severity of the clogging suggested that certain waste products could be contributing to the problem.

Because of the present loadings and the projected increases, the mound would have to be enlarged to handle the flow. Soils downslope from the mound were suitable for such an expansion. However, before plans for an expansion could be drawn up, it was necessary to estimate the average daily flow. Water meter readings were not helpful to determine waste volumes since much of the water used is evaporated for cooling purposes. Instead, estimates were obtained from the liquid waste hauler who was keeping the septic tanks pumped down to prevent waste discharge from the mound. His records indicated waste volumes of approximately 20.3m^3/d (5000 gpd).

A water conservation program was initiated immediately. It included repair of leaking fixtures, reduction of the in-plant water pressure from 551.6 kN/m^2 (80 psi) to 172.4 kM/m^2 (25 psi) and installing toilet tank inserts to reduce flush volumes. These measures reduced the average daily flows to 4.9 m^3/d (1300 gpd) or approximately 75 percent. A broken float valve in a toilet tank accounted for most of the reduction.

The plant was also inspected for possible sources of process wastes. It was discovered that water soluble gases, gum arabic and other industrial chemicals were entering the system during equipment cleanup. To eliminate these wastes, a special cleanup sink was installed from which the wastes could be evaporated and the residue hauled away.

In October, 1978, the mound was expanded. The top of the mound was stripped off and the gravel bed removed. The area to the sides and downslope of the mound was plowed and sand fill added to increase the mound dimensions to 21.4 m (70 ft.) by 33.5 m (110 ft.). The gravel bed was expanded to 9.2 m (30 ft.) by 21.4 m (70 ft.) providing a treatment and disposal capacity of 9.9 m^3/d (2600 gpd).

Rehabilitation II

Two years later the mound failed again. The number of employees had increased to 190 and a fourth expansion estimated to add an additional 50 employees was underway. The failure symptom was the same as before but this time pumping records indicated the average daily flows to be approximately 7.6m^3 (2000 gpd) nearly 20 percent less than the mound's design capacity. Peak flow exceeded the design capacity occasionally. Further expansion was not possible because the existing mound occupied the only area on the site with suitable soils.

Since hydraulic overloading did not appear to be the problem, the plant was inspected again for sources of process wastes. It was learned that the janitorial slop sinks were being used to wash up equipment because the special sink was inconvenient for the workers. The sinks were caged and locked. Hoping this would eliminate the troublesome wastes, chemical oxidation of the clogging mat was proposed to restore the infiltrative capacity. In the meantime, all toilets would be replaced with low flush fixtures to accomodate the new expansion.

In November, 1979, the gravel bed was treated with 1700 1 (450 gal.) of a 10 percent solution of hydrogen peroxide. The oxidant was pumped through the distribution piping after the bed had been drained completely. The treatment was completed within 2 days and the mound was put back into service immediately.

Rehabilitation III

By January, 1980, the mound failed for the third time. Once again, the symptoms were the same. There were now 215 employees and the average daily flow had increased to nearly 11.4 m^3/d (3000 gpd). The toilets had not yet been replaced and a fifth expansion was planned.

The weather prevented any immediate action other than trying to reduce the waste flow. The water conservation program cebtered around the washrooms. Micropher toilets (Model LF-210) with a 2 1(0.5 gal.) flush assisted by compressed air replaced seventeen of the heavily used toilets within the four buildings. Manual flush valves were installed on the urinals and automatic shut-off valves were installed on many of the faucets. This program reduced the flow to an average of 3.2 m^3/d (850 gpd) with peak flows less than 4.5 m^3/d (1200 gpd). On an employee basis the peak flows were reduced by 65 percent from 57 l/d (15 gpd) to 20 l/d (5.4 gpd).

The success of the conservation program made it possible to consider rehabilitation of the mound by another chemical oxidation treatment or reconstruction of the gravel bed. In spring, the mound was opened to determine its condition. The gravel bed was still ponded and the sand fill very dry. The infiltrative surface was covered with a thin gelatinous layer speculated to be due to the industrial chemicals and the sand was blackened 10 to 15 cm (4 to 5 in.) below the gravel/fill interface. Except for isolated pockets, the fill/natural soil interface was normal in color. Either the gelatinous layer was resistant to the hydrogen peroxide or the dose used was insufficient.

Rather than attempt another chemical treatment with uncertain results, reconstruction of the gravel bed was planned. The pumping chamber was redesigned also to eliminate large peak flow loadings. However, by summer, the fifth addition was well underway and the mound site was to be eliminated by a planned sixth addition. Additional land was purchased for a new mound but the decision has not been made to go ahead with its construction pending the availability of sewers within 5 years.

DISCUSSION

While it is not possible to determine with certainty the success of the rehabilitation techniques attempted, lessons learned from this case study will be useful in the future for rehabilitating failed systems and designing large mound systems.

Because of the mound's design features, effective rehabilitation appears to be feasible. Replacement of the gravel bed and/or expansion of the mound were two methods used with some success to increase the absorption capacity of the mound. Since mound construction does not damage the natural soil, the same soil and fill material can be used over. This eliminates the need for a replacement area, a significant advantage over conventional systems.

Chemical oxidation of the clogging mat at the gravel/fill infiltrative surface was not found to be an effective technique under the circumstances encountered. Such a technique would seem to be very effective because the infiltrative surface is elevated in a medium sand fill and a pressure distribution network is already in place to provide uniform distribution of the chemical throughout the bed. However, the causes of the failure must be identified and corrected before treatment begins. In this case, hydraulic overloading and entry of exotic waste products continued after treatment, rendering the technique useless.

Establishing a water conservation program was very effective in reducing the total waste flow. Repair of fixtures, reduction of water pressure and installation of toilet tank inserts reduced flows by nearly 50 percent. Later replacement of conventional toilets with 2 l(0.5 gal.) flush toilets reduced flows by 65 percent.

Gravel beds wider than 3 m(10 ft.) in mounds constructed of medium sand fill over shallow permeable soils appear to be possible. Current design guidelines limit bed widths to 3 m (10 ft.) to prevent saturation at the fill/natural soil interface (Bouma, et. al., 1975). Examination of this interface in the field indicates that this zone did not saturate when the bed was expanded from 3 to 9.2 m (10 to 30 ft.) and the mound received waste flows near the design loading. However, there may be a limit to the width of the beds to prevent severe clogging. The center of the bed showed deeper penetration of the blackened clogged zone which may have resulted in lower infiltration rates. The cause is unknown but could be due to 1) slow diffusion of oxygen from the sides of the bed into the fill below the mat resulting in slower decay of clogging material in the center of the bed, or 2) one dimensional flow under the center of the bed versus three dimensional flow under narrow beds or near edges of large beds. This aspect of large systems needs to be investigated further.

Design of subsurface disposal systems for larger establishments can be associated with may uncertainties. It is extremely difficult to predict present and future waste flows accurately. Safeguards should be built into these systems to protect the disposal system. Peak flows should be attenuated and daily applications limited so they do not exceed design loadings. Flow reduction techniques are a necessary part of design. In this way, potential failures can be corrected before they occur.

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