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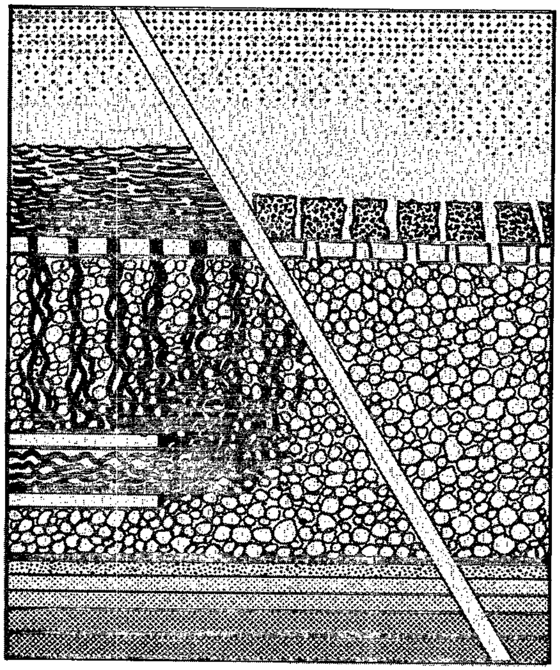
An Emerging Technology

Vacuum-Assisted Sludge Dewatering Beds

An Alternative Approach



Vacuum-Assisted Slu

Introduction

Nearly all wastewater treatment facilities require a means of handling and disposing of sludges generated by the treatment processes. Often, the sludge handling process involves the dewatering of the liquid sludge to reduce the sludge volume and produce a relatively dry sludge cake for additional treatment or less costly treatment and disposal. Due to the relative simplicity of operation, sand drying beds have been widely utilized for sludge dewatering at many small and medium sized treatment plants. Larger treatment plants often utilize mechanical sludge dewatering systems because the land area required for sand beds is excessive.

Vacuum-assisted sludge dewatering beds (VASDB) combine several features of both sand drying beds and mechanical dewatering systems. Potential advantages of VASDB in comparison to sand drying beds include:

- Reduced area needs
- Greater operational control

Advantages over mechanical dewatering systems include:

- Lower costs
- Ease of operation

Due to their potential advantages, vacuum-assisted sludge dewatering beds should be considered by communities and their consultants when sludge dewatering is proposed.

Description and Operation

Vacuum-assisted sludge dewatering beds closely resemble sand drying beds in appearance. A cross section of a typical VASDB is shown in Figure 1.

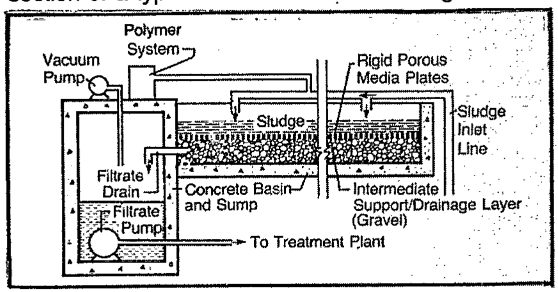


Figure 1. Typical Section of Vacuum-Assisted Sludge Dewatering Bed

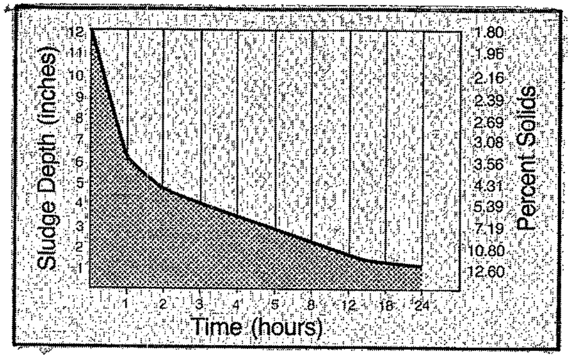


Figure 2.Dewatering Curve (Aerobically Digested Sludge)

A list of typical facilities using vacuum-assisted sludge drying beds is presented in Table 2.

Location	Plant Size	Number of Beds
Sunrise City, FL	4.5 mgd	2
Portage, IN	3.5 mgd	6
Clarksville, IN	0.9 mgd	2
Casey, IL	1.0 mgd	2
Lumberton, NC	10.0 mgd	2
Sheridan, WY	4.4 mgd	8
Grand Junction, CO	12.5 mgd	16
Geneva, IL	4.0 mgd	1
Woodbridge, IL	4.0 mgd	4
Taylors, SC	7.5 mgd	2
Hilton Head, SC	1.2 mgd	1
Union City, IN	1.5 mgd	2
Pittsfield, IL	1.6 mgd	4
Sullivan, IL	0.5 mgd	3

Table 2.Typical Vacuum-Assisted Sludge Drying Bed Installations

Design Considerations

Evaluation of the use of vacuum-assisted dewatering beds must consider potential limitations as well as benefits. The following conditions may limit the applicability of the VASDB process:

- Treatment of highly viscous sludges
- Treatment of sludges which have a high concentration of fine solids and/or grease

- Large treatment facilities where a continuous sludge flow system may be more appropriate
- Facilities requiring a consistently very dry sludge cake (dry solids above 20 percent)

Experience with raw sludge applications to VASDB is limited and the use of VASDB with raw sludges should be carefully evaluated. In most cases, digestion of the sludges prior to application to the drying beds is practiced. Also, providing a means of periodically cleaning the beds to prevent possible problems due to the presence of greases in the sludge should be considered. Beds are cleaned after every use and at most VASDB installations, chemical agents are used to wash the surface on a regular basis.

Costs

The construction costs for vacuum-assisted sludge dewatering beds indicate that this system offers the potential for significant cost savings compared to other dewatering systems. In Table 3, the actual construction costs for VASDB systems are compared to estimated costs for conventional open sand drying beds, a rotary vacuum filter, and a belt filter press system for wastewater flows of 1 and 5 million gallons per day. The comparison assumes approximately 2,000 pounds of aerobically digested primary and secondary dry solids per million gallons of wastewater flow and return of the filtrate to the plant influent. The actual cost of a VASDB system is dependent upon site-specific treatment conditions. The major factors which influence the cost are sludge volume, dewatering time required, and the sludge loading rate.

System	Design Flow 1 MGD	5 MGD
Vacuum Assisted Dewatering Beds	\$158,000[1]	\$1,068,000[1]
Open Sand Beds	\$330,800[2]	\$2,632,500[2]
Rotary Vacuum Filters	\$382,500[2]	\$4,252,500[2]
Belt Filter Press	\$173,300[2]	\$2,463,800[2]

[1]Derived from actual 1984 construction cost data.

[2]Derived from *EPA Dewatering Municipal Wastewater Sludges - Design Manual 1982* (EPA 625/1-82-014). Adjusted to 1984 dollars

Table 3. Construction Cost Comparison (1984 Dollars)

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Objective	Extract excess water from waste sludge.
Loading Rates	Varies - 0.75 to 1.5 pounds of dry solids per square foot per day typical.
Bed Size	20 x 40 foot units standard.
Number of Beds	Minimum of 2 recommended. Total number based upon daily sludge volumes and loading rates.
Chemical Conditioning	Polymer addition to improve dewatering normally practiced.
Total Cycle Time	Varies from 8 to 48 hours. 24 to 48 hours typical for digested sludges.
Percent Solids in Cake	Varies with type of sludge, cycle time, and loading rate. Normal range is 10 to 20 percent.
Cake Removal	Manual, rubber tired loader, or vacuum truck.
Major Components	• Rigid porous media plates. • Gravel support/drainage media. • Concrete containment basin. • Vacuum pumps. • Filtrate pumps. • Polymer system. • Concrete or steel sump.
Climatic Protection	Covered beds recommended for northern and/or wet climates.
Filtrate	Returned to treatment facility.
Solids Capture	> 99 percent.

Table 1. Design Features of Vacuum-Assisted Sludge Dewatering Beds

open sand drying beds with chemical addition. This indicates the area required for drying beds could be reduced by as much as 90 percent when utilizing VASDB in place of open sand drying beds.

The performance of vacuum-assisted sludge drying beds is influenced by the following factors:

- Solid and liquid loading rates
- Chemical pre-conditioning of solids
- Cycle time
- Vacuum application characteristics

Data from several different treatment plants indicate dry solids concentrations in the dewatered sludge cake ranging from 8 percent to as high as 23 percent with cycle times of 8 to 48 hours. Typically, the process produces an acceptable sludge cake within 24 hours with a reduction of 80 to 90 percent in the initial sludge volume. A typical dewatering curve for an aerobically digested sludge is shown in Figure 2. Analysis of the drying bed filtrate indicates a solids capture rate of greater than 99 percent.

Annual operation and maintenance costs for vacuum-assisted dewatering beds also exhibit a potential for cost savings over some of the other dewatering systems, particularly for smaller plants. Table 4 compares the estimated annual O&M costs for VASDB, open sand drying bed, rotary vacuum filter, and belt filter press systems. As Table 4 illustrates, the annual O&M costs for mechanical dewatering systems, as represented by the rotary vacuum filter and belt filter press system, may become less than the comparable costs for a VASDB system at 5 MGD and higher flow rates and sludge volumes. This is primarily due to a significant reduction in the labor requirements per unit volume of sludge dewatered for mechanical systems as total sludge volume increases.

	Design Flow	
System	**1 MGD**	**5 MGD**
Vacuum Assisted Dewatering Beds	$25,700[1]	$173,300[1]
Open Sand Beds	$12,500[2]	$131,100[2]
Rotary Vacuum Filters	$57,700[2]	$182,400[2]
Belt Filter Press	$43,700[2]	$137,900[2]

[1]Estimated for actual 1984 projects

[2]Derived from *EPA Dewatering Municipal Wastewater Sludges - Design Manual 1982* (EPA 625/1-82-014). Adjusted to 1984 dollars

Table 4. Annual O & M Cost Comparison

Actual construction and O&M costs for VASDB facilities are lower than those estimated by the EPA design manual. Actual construction costs have been reported at $108 to $179 per square foot, including a cost of $30 to $40 per square foot for enclosures, when required.

Actual operating requirements have been reported as 4 to 10 lbs. of polymer per ton of solids, 17 to 39 kwhrs. of electricity per ton and 4 to 10 man-hrs. per ton. Total O&M costs have been reported at $37 to $104 per ton, depending on the type of sludge, the sludge feed concentration, polymer dosage and cost, dryness of cake, type of removal method, and local labor and electricity costs.

The cost comparison of vacuum-assisted sludge dewatering beds with other dewatering systems will vary with each treatment facility. A detailed life cycle cost analysis which considers both capital and O&M costs should be the basis for final cost comparison.

Sludge from the treatment processes is uniformly applied to the bed to a depth of approximately 12 to 18 inches. During the sludge application, a polymer is normally added to improve the sludge dewatering characteristics. A gravity dewatering phase, during which much of the free water may be removed from the sludge, continues until the sludge forms a relatively dense mat over the media plates. At this point, the vacuum pump is started to create a vacuum in the sump and under the media plates. The vacuum draws additional water out of the thickened sludge mat and continues until the sludge mat begins to crack. Normally, the mat begins to crack after 80 percent or more of the free water is removed. After the sludge mat cracks, air drying of the sludge continues until the dewatered sludge cake achieves the desired dryness. The sludge cake is then removed from the bed for further treatment or disposal. Filtrate from the dewatering process is normally returned to the treatment facility by a float-actuated submersible pump located in the filtrate sump.

The rigid porous media plates form an abrasion resistant, load bearing surface which permits the sludge cake to be easily removed manually or by a rubber-tired loader. The plates also eliminate the need for periodic replacement of the filtering media common with sand drying beds.

The total cycle time for dewatering of the sludge depends upon many factors, including the sludge dewatering characteristics, degree of sludge cake dryness desired, and climatic conditions. Normal total cycle times vary from 8 to 48 hours, with 24 to 48 hours representing typical total cycle times for digested sludges. In comparison, drying times for sand drying beds normally range from 1 to 2 weeks. Due to the reduced drying time and the assistance provided by the vacuum system, VASDB are generally less affected by inclement weather than are sand drying beds.

Design and Performance

As noted in Table 1, vacuum-assisted sludge dewatering beds are typically designed for a dry solids loading rate of 0.75 to 1.5 pounds per square foot per day, which is equivalent to an annual loading of about 275 to 550 pounds per square foot. This compares with typical annual design loading rates of 40 to 60 pounds per square foot for

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