USE OF OPEN AND BURIED INTERMITTENT SAND FILTERS AS A LOW-COST CLUSTER TREATMENT ALTERNATIVE

Diane G. Perley

Intermittent sand filter systems recently built in New York State demonstrate that sand filters can serve as a low-cost wastewater treatment technology ideally suited for use by small clusters of homes. Open and buried sand filters have been used in several installations as the sole secondary treatment process for wastewater flows from 13-400m^3/d. Sand filters are adaptable for use under varying site constraints and are not restricted by poor soils, high groundwater or dense pockets of population. Operation of the sand filters has shown their suitability for use in close proximity to homes, the relatively small amount of land necessary and the appropriateness of the low level of maintenance for small communities.

APPLICATION OF SAND FILTERS

Although the U.S. Environmental Protection Agency (U.S.E.P.A.) published a brochure on intermittent sand filters in 1984 under the heading "An Emerging Technology," basic design parameters for sand filters have not changed much since the 1930's. In 1930 there were 383 municipal sand filter treatment plants in 19 states (Stanley, et al., 1937). Today, sand filters are again gaining popularity as a municipal wastewater treatment option.

Six municipal intermittent sand filter systems have been constructed in New York State in the past 3 years through the U.S.E.P.A. construction grants program. Seven additional sand filters are being designed and will be built for other communities in the State within the next year.

Land Requirements

Land requirements for open and buried sand filters to treat wastewater from 100 homes are approximately 0.13ha and 0.40ha, respectively. Additional land would be required for buffer areas and primary treatment. The small amount of land necessary makes use of sand filters feasible for existing subdivisions such as Nob Hill, in the Town of Newburgh, New York, where failing septic systems in a localized area required off-site treatment and disposal but a limited amount of undeveloped land was available.

Proximity to Homes

Because sand filters require only small amounts of land area, collection sewer costs can be reduced by locating the wastewater treatment system near the homes served. In the Town of Byron in western New York State, homes in the three hamlets of North Byron, Byron and South Byron discharge inadequately treated sewage to the nearby stream because poor soils and high groundwater cause septic system failures. Three buried sand filters, one for each hamlet, will eliminate the need for approximately 3km of interceptor

The author is: Diane G. Perley, Project Manager, Small Community Assistance Program, New York State Department of Environmental Conservation, Albany, New York.

se which would be necessary for a conventional centralized treatment sys... Because each hamlet's wastewater will be collected and treated locally, no development pressure will be placed on the surrounding farm land.

If a sand filter must be located less than 150m from a home, a buried sand filter may be preferred. However, no odor complaints have been reported from an open sand filter in Gardiner, New York where an open dosing chamber receiving septic tank effluent is located only 105m from a home.

Effluent Quality

References have shown the ability of intermittent sand filters to achieve better than secondary quality effluent (U.S.E.P.A., 1980) for BOD_5 and suspended solids. For many small communities, such as the tiny hamlet of North Byron, soil and groundwater conditions make subsurface discharge impossible. North Byron's location on a small stream requires a high level of treatment prior to surface water discharge of their wastewater. With only 17 homes to share the costs, an intermittent sand filter will be built at North Byron as the cost-effective means to achieve the stringent effluent requirements of BOD_5 and suspended solids of 15mg/1.

Absence of surface receiving waters made it necessary for the Town of Montgomery, Orange County, New York to build a sand filter followed by overland flow which discharges to a dry ditch and eventually flows to an intermittent stream. Two other communities in the Town of Chester, Orange County, use overland flow as tertiary treatment prior to discharge to intermittent streams.

Energy Use

Intermittent sand filters treating effluent from a facultative pond have been considered one of the most energy-efficient wastewater treatment systems available which is not dependent on local soil or groundwater conditions (Middlebrooks and Middlebrooks, 1979). If topography is favorable for gravity flow through the sewer system and at the treatment plant site, it is possible to operate an entire collection and treatment process without electricity. Careful selection of treatment system appurtenances has allowed six communities in New York State to build sand filter treatment systems with no electrical power at the treatment site. This eliminates monthly electric bills and the need for back-up generators. The appurtenances which make it possible to build a sand filter treatment system without outside power are mechanical dosing siphons, dose counting mechanisms, drop-feed type tablet chlorinators, and cascades to provide reaeration. References on onsite system design (U.S.E.P.A., 1980) describe the use of these mechanisms.

Primary Treatment

Because references (McClelland, 1977) have shown little difference in effluent quality between sand filters treating aerobic unit and septic tank effluents, all of the sand filter treatment systems recently built in New York State use septic tanks for primary treatment. The septic tanks are either located at each home, as part of a small diameter septic tank effluent collection system, or at the treatment site. If septic tanks are used within the sewer system, a small septic tank is often provided at the treatment site as an extra precaution to prevent any solids deposition in the dosing chambers. Location of the primary treatment at the individual home septic tanks also has the advantages of the shallower slope allowed for the sewers and a smaller land area needed for the treatment site.

Design Parameters

Sand filters for communities in New York State are generally designed for dosing 2-4 times per day with application rates of 120-200 l/m^2-d for open filters and 40 l/m^2-d for buried filters. Other parameters for design of intermittent sand filters have been previously presented elsewhere (U.S.E.P.A., 1980; Otis, 1981) and will not be discussed here. Design information concerning sand filters for treating effluent from municipal wastewater stabilization ponds (U.S.E.P.A., 1983) is also available.

ADAPTATIONS OF SAND FILTERS

To effectively adapt sand filters for use under various circumstances, it is essential that the basic treatment principle behind the operation of sand filters be recognized. Intermittent sand filters use a biological wastewater process. Any site constraint which will inhibit functioning of the treatment organisms must be overcome. For example, high groundwater must be compensated for by the use of an impervious liner to prevent the groundwater from interfering with aeration of the filters between doses.

Open and Buried Sand Filters

Before more details are provided on the many variations of sand filters, the two basic forms of sand filters, open and buried, should be discussed. Recirculating sand filters, usually a process used to increase effluent quality for open sand filters, will not be dealt with here since presently there are no municipal recirculating sand filters in New York State. Although most of the sand filters being designed today are open because their higher application rates reduce the size and cost of the filters, both open and buried sand filters have advantages. A brief summary of the characteristics of each is that open sand filters are smaller, take less space, but require more maintenance while buried sand filters are larger, but require less maintenance. Free access of open sand filters allows for maintenance and rejuvenation of their ability to accept wastewater but is offset by the requirement for raking, weeding and other maintenance. Other advantages of these two basic types of sand filters are evident from the design criteria for each.

Table 1. Adaptations of Intermittend Sand Filters for Use Under Varying Site Conditions

Site Condition	Sand Filter Adaptation
High groundwater	Impervious liner
High precipitation	Pole barn or other cover
Cold climate	Buried sand filter, insulated cover, or modified operation
No surface water for discharge	Overland flow to dry ditch, subsurface discharge
High level of treatment required	Cascades to increase D.O., recirculating sand filters, overland flow tertiary treatment
No electrical power at treatment site	Dosing siphons, mechanical dose counters, drop feed tablet chlorinators, cascade reaeration

Other Sand Filter Variations

Table 1. provides a listing of methods used to overcome site constraints for the use of intermittent sand filters. All of these techniques have been used in New York State except the use of an insulated cover over an open, or more appropriately called a free-access, sand filter.

OPERATION OF SAND FILTERS

Management

Sand filter wastewater treatment systems have advantages over the management of onsite systems since difficulties arise in gaining public acceptance of municipal management of onsite treatment and perpetual access to individual homeowner's properties is necessary for maintenance of onsite wastewater systems. Sand filter systems serving clusters of homes are managed just as any other centralized wastewater collection system. In New York State, sewer districts can own, operate and maintain wastewater treatment systems for non-contiguous areas. Thus, one sewer district could manage several sand filters for clusters of homes or could combine onsite systems in out-lying areas, a cluster for a subdivision and a central collection system for the "downtown" area with a separate user charge for each wastewater system.

Operation and Maintenance

The ability of an intermittent sand filter to continue to function with no attention presents the potential problem of it being ignored until a crisis occurs. Communities must understand that, although sand filters are comparatively a low-maintenance wastewater treatment system, they are not no-maintenance systems. In fact, open sand filters require a substantial amount of raking and weeding to clear off the annual growth of weeds. As one community in New York State learned the hard way, it is easier to use a small garden tractor towing a rake to eliminate the two inch weeds than to wait until they are four feet high and it takes weeks to pull them out by hand.

The primary advantage of sand filters is that the level of maintenance necessary is appropriate for small communities. Once they understand the functioning of the system and the purpose of the sand beds, anyone can weed them. It may be possible to include weeding and raking of the sand beds in the municipality's highway department schedule. A part-time certified wastewater treatment plant operator, possibly shared with another community, could oversee operation of the plant and take care of other maintenance items such as adjusting the dosing siphons and reporting effluent quality data to regulatory agencies.

Rotation of the use of the sand filter beds to allow for rejuvenation of the sand's ability to accept wastewater without clogging is another important maintenance function. This is especially important for buried sand filters where the top layer of sand, and the attached biological clogging mat, cannot be removed. Sand filters in New York State are generally designed to allow one bed to rest and rejuvenate. Most facilities have 3 or 4 sand beds and are designed to treat the peak design flow with one bed resting.

To prevent ice development on open sand beds from interfering with operation in severe winter conditions, the top layer of sand can be raked into a ridge and furrow configuration (U.S.E.P.A., 1983). The ice layer formed should remain bridged on the top of the ridges allowing infiltration beneath it. Two open sand filters have been used through several winters in New York State and have reported no ice problems. Additional open filters recently constructed will verify the usefulness of the technique of raking the sand into a ridge and furrow configuration.

Costs

Construction costs of sand filters do not provide a complete view of actual costs, since only after several years of operation and maintenance are the total costs of any wastewater treatment system evident. Local site conditions, size of the treatment system, and local bidding conditions all impact construction costs. These influences are evident from the wide range of costs for sand filters built through the U.S.E.P.A. construction grants program in New York State. For three open sand filters recently built under the construction grants program in New York State, bid prices for construction of complete sand filter treatment plants ranged from $85.00/m^2 to $220.00/m^2 of sand filter.

It should be noted that all of these systems were built under the U.S.E.P.A. construction grants program. If communities were to use municipal staff or small contractors with non-federal wage rates, significantly lower costs might be achievable.

CONCLUSIONS

Intermittent sand filters in New York State have shown their applicability for use under a wide variety of circumstances. The adaptability of sand filters as a treatment system, the treatment method not being dependent on local soil and groundwater conditions, the appropriate level of maintenance, and the ability to achieve better than secondary treatment quality effluent, all point to expanded use of intermittent sand filters for small clusters of homes in the future. The low costs of construction and operation and maintenance of sand filters makes it a viable method for small communities to eliminate wastewater disposal problems.

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