Options for Treating Landfill Leachate

There are several options for treating leachates with BOD and COD below 5,000 to 10,000 mg/L. The treatment method of choice depends on the composition of the leachate, how the leachate composition varies over time (eg. under different weather conditions), specific bacterial contaminants that may be present and the local temperature and its seasonal variation.

Some of the methods mentioned below use bacteria to achieve reduction or oxidation of contaminates in the leachate. In all cases, only Class 1 bacteria as defined by the United States Department of Agriculture (USDA) is used. This means that the bacteria are unconditionally safe; for example, any Class 1 bacteria may be used on food crops. The bacteria are non-toxic, non-infectious, and non-opportunistic. These bacteria use the carbon, nitrogen and other materials in the leachate as sources of food and energy in order to reproduce. If certain required nutrients are not present in the leachate, they must be added. In this way, bacteria turn the contaminants in the leachate into carbon dioxide, water and other usually harmless substances. Most of these bacteria can reproduce down to 5 degrees C. Since the bacterial activity doubles every 10 degrees or so, higher temperatures (at least up to around 40 C) result in shorter residence times (faster processing).

There is often no one "best" technical or engineering solution. Factors like land utilization, the desire to achieve secondary benefits (such as methane production), ease of implementation, operating cost and capital cost are all factors that will influence the final choice. The purpose of this introduction is to present a range of possible options so the landfill operators can let us know which method or methods might be preferred. Another possibility is for the landfill operators to rank the approaches presented here. We can then discuss any or all options with them and compare the costs and benefits of each so that together we can arrive at an agreement of the demonstration system that should be built.

Methods Based on the use of Bacteria

1. Batch Treatment in Open Ponds

For this process, the leachate is pumped into an open pond and a mix of bacteria (the choice of bacteria is based largely on the leachate composition and contaminates it may contain) is added. Normally, the pond is aerated, sometimes heated and sometimes it is necessary to add specific nutrients. The BOD is measured every few days and the COD is measured at least daily at several locations. It normally takes about 2 weeks for the BOD and COD to be reduced from 2,500 mg/L to under 300 mg/L but the actual time depends on the pond temperature, bacterial contaminants or poisons that may be present and the nutrient level in the leachate. A water analysis and actual, in place, tests will determine the residence time required for treatment at any particular pond temperature. Although long term variation in the leachate composition can be expected (variation over times longer than a few weeks), short term changes are not expected to occur. This means that a complete chemical analysis should only be needed about once a week. The primary reason for such an analysis is to identify changes in the nutrient and contamination levels so remedial action can be taken.

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Pond treatment is an extremely reliable and low-cost means of reducing the BOD and COD but the process must be monitored closely to determine when the desired end point has been achieved (because the results depend strongly on the temperature and the amount of sunlight received by the pond, the residence time of the leachate in the pond is difficult to predict with precision until some actual operating experience in this environment is obtained. Another potential disadvantage is that the shallow ponds (about 1 meter in depth) require a large land area for the volumes being considered here. New bacteria is added to each batch. Electricity, bacteria and manpower are the main direct operating costs. We currently estimate that the cost of bacteria will be under 10 Yuan per MT of leachate for a well-engineered, full-scale plant capable of treating up to 2,000 MT/day but several factors such as temperature and a requirement for faster processing might increase this cost.

2. Continuous Flow Systems

Continuous flow (CF) systems usually require less space than batch treatment ponds. Because they can be enclosed more easily (but at increased construction cost), they are much more efficient to heat. They operate well in cold climates. CF systems may cost more to build and operate than batch pond systems.

A Low-Cost Continuous Flow System

The batch pond treatment approach described above can be modified to use less space but more energy by using “ditches”, essentially long, narrow ponds. The ditch is initially filled with the leachate and seeded with the selected bacterial mix. The leachate is aerated and mixed to ensure that no stratification occurs. Bacteria impregnated membranes may be placed across the ditch so that all leachate flows through one or more of these for additional bacterial action. These act like small, in-line bio-reactors and can compensate for a decreased bacterial activity when the outside temperature is lower. Although there is the added cost of bacteria, this extra cost is usually less than the cost of heating the leachate in order to increase the bacterial activity. Once the COD gets near the desired level, the leachate is very slowly drained or pumped into a holding pond where bacterial action continues. Just prior to this release from the ditch, a BOD sample is taken. Since it takes 5 days to obtain a BOD result, the holding pond should have a capacity for 5 days of input as described below (once some operating experience is obtained, we will know the relationship between COD which is measured very quickly and the BOD; thus, it should be possible to eventually reduce the size of these holding ponds).

A Multi-Purpose Continuous Flow System

Another option for continuous flow, bacterial action systems is to use tanks (usually tall vertical cylindrical vessels) that contain membranes impregnated with bacteria through which the leachate is forced to flow. The environment inside the tank in the vicinity of the membranes is designed to promote bacterial growth (to feed off the contaminants in the leachate).

Such a basic system is capable of processing many different waste streams simply by choosing the bacteria to match the constituents of the stream. For treating landfill leachates, this approach requires a relatively high capital investment and operating cost but it provides a high degree of process control. One advantage of chambers where the environment can be controlled (different environments can even be created at different elevations in the tank) is the possibility of having an aerobic environment in one region and an anaerobic environment in another (in the same tanks or in tanks placed in series). This configuration is used to build bio-digesters that turn food waste, green waste and a variety of animal products and waste into methane gas, protein rich food that can be used for feeding chickens and shrimp and nitrogen-rich, certifiably organic compost that can reduce or eliminate the need for nitrogen fertilizers. This approach should be considered for processing the "high quality" component of the raw garbage that is now being dumped in the landfill. This is a very practical means of extracting useful energy and materials from the material now being discarded. Implementing this approach might reduce the amount of leachate that must be processed but it will never eliminate the need for leachate processing.

Methods Based on Physical and Chemical Processes

It is possible to reduce the BOD and COD from extremely high levels to below 5 mg/L by adding chemicals and/or various forms of energy to oxidize and then precipitate the contaminates from solution. Chemical methods increase the amount of reaction product materials that must be managed and they tend to have considerably higher operating costs (although the initial capital investment may be low). In general around the world, chemical methods are being replaced by electrochemical methods. These methods use electrical energy, usually in the form of a current passing through the solution, in combination with oxidizing agents and sometimes ultraviolet light to remove contaminates from the solution. Treatment effectiveness is controlled by the electrode material and shape, the amplitude-time characteristics of the energizing electrical current, the use of an alignment magnetic field, where in the treatment cycle the oxidizing agent(s) and ultraviolet light are injected and the treatment sequence. There are many decades of experience worldwide with such methods as well as several well-proven treatment methodologies.

Treating landfill leachate is a very standard application of electro-flocculation (efloc) that has been implemented in many areas under similar conditions. Typically, the leachate would be passed through an efloc cell with no added oxidation in order to remove the easiest materials. A second stage where oxygen, ozone or hydrogen peroxide is added will, if needed, reduce the BOD and COD to below 5 mg/L and usually produces fully oxidized, non-toxic waste products that can be disposed of in a landfill.

The main operating cost is manpower and electricity but these methods have a relatively high capital cost. They remove contaminates that do not contribute much to the BOD and COD; for example they are very effective at removing trace quantities of heavy metals. These systems are also very compact when compared to bacterial methods that use ponds. When installed as a system of many units operating in parallel, one has an easy means of performing routine maintenance and for adding capacity as it is needed. Most systems are designed around a basic modular configuration that can handle from 25 to 100 cubic meters per day. Large systems can have dozens of such modules operating in parallel under the control of a single master unit. Once set up for a particular set of processes, efloc systems run with little human attention.

Cost of a 100 MT per Day Demonstration Unit

Even an approximate comparison of costs among these different approaches requires knowing the results of several tests. First, a complete chemical analysis of the leachate is needed. This will determine if a bacterial approach is even possible. Since much of the leachate is already the result of bacterial action, is it very likely that a bacterial method can be used to perform the required BOD and COD reduction. Assuming that a bacterial method can be used, we present the following preliminary and non-binding cost estimates for demonstration systems.

Batch Processing Using Ponds

We have a strong preference for using newly constructed small ponds so it is known that no contamination other than the leachate is present (an existing pond might be contaminated). In order to be able to process an average of 100 MT/day, the pond should hold about 2,000 MT with a depth not to exceed 1 meter. (a pond about 50 by 50 meters). The pond must be aerated and mixed so there will be a good reaction environment. An initial sample will be tested for BOD and COD and the COD will be measured every day to monitor progress. It may be necessary to evaluate 2 or 3 mixtures of bacteria in order to determine the best one for this location and environmental conditions. All of the facilities, including pond construction, and services would be provided by the landfill management. We will supply the bacteria and an on-site person on a continuous basis for the first two weeks of the testing and thereafter as needed for the success of the project. Depending on the types of bacteria that are selected for trial, each test sequence will require from $5,000 to $10,000 to cover our direct costs and the cost of the bacteria that is needed. These demonstration tests could begin almost immediately.

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Continuous Flow Processing Using Ponds

The costs and other considerations are the same as for the batch processing described above. These demonstration tests could begin almost immediately.

A Multi-Purpose Continuous Flow System

We are currently researching the cost of a small demonstration system; it will be about a week before we can give an approximate cost for this demonstration.

Electrochemical Processing Methods

An electro-flocculation system able to handle from 25 to 150 MT/day will cost around US$1 million. If there is a need for many such systems, we would set up manufacturing facilities in China; this might lead to a modest decrease in cost. The variation in throughput (treatment volume) is due to our uncertainty of the actual chemical analysis of the leachate. Efloc systems do a lot more than just reduce the BOD and COD but they are extremely reliable systems for achieving the required reduction in BOD and COD. They are compact when compared to the pond methods described above. It would take about 4 months to build an efloc system and get it to Shanghai.

This information sheet was downloaded from:
http://www.emtec.co.th/options-for-treating-landfill-leachate.html

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