Leachate Recirculation and Bioreactor Landfills as Sustainable Development

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Introduction

A waste is defined as "a moveable object which has no direct use and is discarded permanently" (LaGrega, Buckingham, & Evans, 2001). Sustainability is defined as, "of or relating to a lifestyle involving the use of sustainable methods". (Merian Webster Online 2009). Can a landfill be sustainable? If the methods used in design and construction will prolong the life of the landfill, or help sustain the environment, then it can be sustainable.

Although recycling and source reduction are very important aspects of today's solid waste management, there will be a need for landfills far into the future, and therefore, there is a need for sustainable designs for landfills. A typical landfill design consists of an impermeable liner, municipal solid waste with daily cover (cover varies) and finally an impermeable cap when the landfill has reached its height restriction or capacity. Leachate recirculation takes a different, more sustainable approach. The idea of leachate recirculation has been around for a long time, but has only been seriously developed since the late 1990's (Mehta, et al. 2002). Leachate is collected and redistributed in this process in order to increase the moisture content of the waste, thereby increasing the microbial activity and accelerating the decomposition of the organic matter within the waste. By increasing the rate of decomposition, the production of energy producing gas can be accelerated. Leachate recirculation also promotes faster settling and extends the capacity of the landfill by increasing the density of the waste (Mehta, et al. 2002). A bioreactor is similar but much more controlled than simply recirculating leachate; bioreactors are described more later.

Simple Leachate Recirculation

Leachate recovery is required of all landfills. Moisture contents in typical landfills range from 15 to 35 percent (Reinhart, et al. 2004), this is outside the optimal range (35 to 45 percent) for biodegradation and ultimate settling of the site. The decomposition caused by microorganisms turns the mass of the waste into methane and carbon dioxide (Townsend, et al. 1996), therefore, a moisture content that is optimal for the organisms is optimal for the entire site. The introduction of leachate recirculation has been shown to increase the moisture content. The following are two studies that were done to evaluate the possible benefits of leachate recirculation:

In north-central Florida in the early 1990's, a leachate recycle system was developed to test the effects on landfill stabilization. A stabilized landfill is less likely to have environmental impacts in the future (Townsend, et al. 1996). There were a total of four infiltration ponds that were constructed on top of buried waste that ranged from one to five years old. The ponds were initially filled with leachate and leachate was pumped into the ponds to keep it full. The ponds were left to infiltrate the waste over a period of nearly two years. They were drained after more than 1.2 million gallons of leachate had infiltrated the cell. Finally, more waste was placed on top of the drained ponds in typical landfill operations with no additional leachate introduced. A separate part of the landfill was not introduced to the leachate and used as a control cell (Townsend, et al. 1996). Borings were taken at 24, 27 and 32 months. Tests were run in a laboratory to determine moisture content, volatile solids content, and biological methane potential (BMP) of these samples; temperature measurements were taken onsite (Townsend, et al. 1996). These measurements were compared to the control cell and showed a greater decomposition of the areas exposed to the leachate with the greatest area of settlement where the central portion of the pond was located (Townsend, et al. 1996). This shows that most of the decomposition happened in the area where the most moisture was available to the buried waste.

Moisture content was found by recording the moist weight of the sample, drying it, and then weighing the oven-dried sample. Moisture content percent was figured by dividing the water weight that was lost in drying by the dry sample weight (Mehta, et al. 2002). The moisture content before and after circulation was found to be 31.3 percent and 45.7 percent, respectively (Townsend, et al. 1996). The final moisture content was an average and varied according to how close the sample was taken relative to the pond area.

A second study was performed in California in the mid 1990's. Two cells were filled with municipal solid waste (MSW), one to be the control cell and the other the enhanced cell. Both cells were left for over six months to observe settlement and other characteristics to show that any changes were due to the introduction of leachate. After this six-month period (with similar results for both cells), shallow "pits" were excavated into the enhanced cell. These pits were lined with tire scraps and filled with a combination of leachate and storm water runoff. The leachate mix was allowed to infiltrate the enhanced cell for a period of over three years while being supplied with leachate from the recirculation system (Mehta, et al. 2002). Similar tests were performed as described above. The moisture content varied with how close the boring samples were taken to the pits. The benefits of simple leachate recirculation were clear but varied. Of the three borings in the enhanced cell, the highest moisture content was 38.8 percent. The lowest moisture content was in the boring furthest from any of the pits and it measured 31.7 percent by weight. When compared to the control cell there was a substantial increase in moisture content. The average for the control cell borings was 16.9 percent (Mehta, et al. 2002). The decomposition depends on the moisture content and the moisture content varied according to how far the borings were from the pits. A better way of recirculating the leachate is needed to ensure a more evenly distributed moisture content.

Landfills as Bioreactors

There are several types of bioreactors that have been designed: aerobic, anaerobic and a combination of the two. A bioreactor is defined in the National Emissions Standards for Hazardous Air Pollutants (NESHAP) as a MSW landfill (or part of) that has a liquid, other than leachate, added in a controlled manner to reach a specific moisture content that is intended to accelerate the process of biodegradation (Reinhart, et al. 2004). In a bioreactor, microorganisms are utilized to decompose the waste (Bioreactor Brochure 2004). This process, as described by NESHAP, limits a bioreactor as an anaerobic process in which only liquid is added. There are, however, aerobic types of "bioreactors" as well.

An aerobic bioreactor utilizes similar techniques as a wastewater treatment facility. A liquid (which is usually a combination of leachate, storm water runoff, sewage sludge, or other nonhazardous liquids) is introduced to the MSW through pipelines running through the waste (Bioreactor Brochure 2004). The liquid is circulated to attain an average moisture content throughout the waste of between 35 and 45 percent by weight of water (Bioreactor Brochure 2004). While sufficient moisture content is being achieved, aeration commences through a separate pipeline to provide the oxygen needed for the microorganism's respiratory functions (Bioreactor Brochure 2004). The system is now like an aeration basin in a wastewater treatment facility. The microorganisms feed on the organic matter while using the oxygen provided through aeration. The aerobic process produces no methane which can be beneficial if a sufficient methane collection system is not in place. Aerobes also grow faster and require more energy. The aerobes get their energy by consuming more organics, which means there is faster biodegradation.

The anaerobic process is similar to the aerobic process in that it requires a circulation of the same liquids. This process also requires similar moisture contents. The difference is that no aeration is required. The microorganisms are anaerobic, which means they do not need oxygen to survive (Bioreactor Brochure 2004). This is a slower process than the aerobic process but faster than in typical capped landfills. This process does produce methane gases that can be burned and turned into energy, so a sufficient methane collection system needs to be in place. Most landfills produce methane but in this situation it is created up to twice as fast, which causes the production life of methane from the landfill to be much shorter (Bioreactor Brochure 2004). The same amount of methane is produced, so the advantage is that it will not have to be monitored and maintained as long.

A third type of bioreactor is a combination of the two previous in that they are aerobic and anaerobic. As lifts of waste are created, pipelines are installed to initially provide pumped air. This air is pumped in to keep the lift in an aerobic state. While the new lift is being created, the lift underneath that has been completed is having liquid pumped in and is in an anaerobic state.

Conclusions

With the advances that have been made in leachate recirculation and landfills as bioreactors, it can be seen that a more sustainable landfills can be constructed with a longer life expectancy and a shorter time period for environmental impact. The estimated recovery of space due to a well distributed leachate recirculation operation is between 15 and 35 percent (Bioreactor Brochure 2004).

With a well-engineered landfill, more methane can be collected over a shorter period of time and turned into energy. Instead of it taking decades for organics in MSW to decompose, it can be done in a matter of years, which leads to the accelerated stabilization of the site (Bioreactor Brochure 2004). The cost of these additions to a landfill can be somewhat offset by the saved cost of treating or trucking away the leachate.

Sustainability is an important part of any civil engineer's career. The future is ours to design and the impacts that we make, as civil engineers, need to be considered. If we are to exist in the future, then sustainability must be a part of our jobs every day. When advances have been found that can be utilized in design and construction that will sustain our infrastructure and environment, they should be used. Further development of already used practices is also very important for all of us as engineers.

Our definition of waste is something moveable that no longer has a purpose and is discarded permanently. If we are using our "waste" for power, is it no longer waste? If we are discarding our knowledge and abilities on practices that are outdated and unsustainable, are our engineering skills waste? Yes to both!

Works Cited

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