COVER STORY

LANDFILLING AND ITS IMPACTS ON WATER

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Aerators being used as part of the leachate treatment process

The Malaysian National Privatisation of Solid Waste Management (NPSWM) aims to promote efficient, safe, and reliable management of solid waste collection, transfer, treatment and final disposal. Part of the goals aimed through the NPSWM is that in the context of environmental management, in particular water resources protection, all waste management facilities will be constructed, operated and maintained according to internationally accepted Solid Waste Management (SWM) technical standards.

Landfilling is the most common method in dealing with solid waste disposal. Be it with the advent of incineration and waste reduction and recycling methods, the ultimate disposal of unwanted material is through landfill, mainly because of its relative simplicity and cost associated with the landfill method. At present, landfilling technology has progressed from disposing solid waste in open dumps to placing processed waste (i.e. shredded refuse or segregation of unrecoverable wastes) in properly managed sanitary landfills.

A sanitary landfill is an engineered facility designed and operated in a manner that minimises environmental hazards and public health, by spreading refuse into thin layers, compacting the refuse to an acceptable volume, and applying compacted cover material at the end of each operating day.

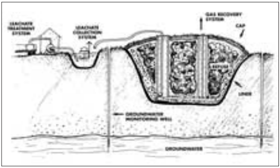
Prior to the creation of these secure sites, SWM concessionaires are generally required to operate existing disposal sites from which its operations are absorbed from relevant Local Authorities (LAs). While most disposal activities at these sites have improved greatly, it must be said that most of the sites were not developed and sited properly as proper landfill facilities. As evident from the various landfill takeover exercises, most of the characteristics described previously are lacking.

BACKGROUND OF LANDFILL OPERATIONS

Since its inception in 1995, Alam Flora Sdn. Bhd. (AFSB) has taken over the operations of 20 landfills within its concession area, where currently 18 are in operation and 2 are closed. To date, AFSB has managed to upgrade both operations and infrastructure at all its landfills. For landfilling operations, our main objective is to reduce surface water infiltration so that environmental repercussions can be averted. Operational elements according to international sanitary landfilling procedures that has been successfully implemented are:

- *Waste placement according to an approved filling plan for individual sites*
- *Waste compaction using appropriate landfill equipment and adequate compaction rates*
- *Waste covering on a regular basis using soil*
- *Site upgrades through construction of perimeter berms, leachate treatment plants, drainage systems, weighbridges, gas vents, and security fencing*
- *Upgrading and maintenance of site drainage system so that excessive surface water infiltration and runoff can be minimised*
- *Constant monitoring of environmental parametric qualities such as ground and surface water, ambient air, noise, odour, and gas emission.*

The waste management hierarchy adopted by AFSB revolves around the fact that solid waste can be



Schematic Diagram of a modern landfill

turned into a resource. Even though waste disposal has the least priority according to the hierarchy, it is not in any way considered the lowest in importance.

EFFECTS OF LANDFILLS TO WATER BODIES

Leachate is the result of surface water infiltration and moisture content of the waste, which percolates through the decomposing waste bed to form a highly polluting liquid. The quality of leachate is principally the result of physical, chemical, and biological processes that occur within the waste bed. It has been accepted that leachate from sanitary landfills contain larger pollution loads than raw municipal sewage or many industrial wastewaters (Qasim and Chiang, 1994). Waste decomposition occurs within two stages in a landfill, namely, aerobic decomposition that utilises the available and remaining oxygen within the covered waste bed, followed by anaerobic decomposition carried out by facultative (acetogenic) bacteria. The resulting low pH caused by the formation of volatile fatty acids (VFAs) and carbon dioxide (CO_2) will solubilise inorganic compounds to produce a liquid with high ionic strength. The produced VFAs are then converted to methane (CH_4) and CO_2 by methanogenic bacteria. Bearing in mind that this process is continuous until all the nutrient resources are depleted, the liquid that is produced from the decomposition process will effectively have a high pollution potential. Also, since leachate is filtered through various types of organic waste, it will have pathogenic content. More often than not, the degree of pathogen contamination by leachate is much less than that of untreated sewage of domestic origin.

An uncontrolled discharge of untreated leachate may result in high amounts of organic material being deposited into nearby water bodies. Organic material such as unconverted VFAs, oil and grease, and phenols may affect dissolved oxygen levels thereby producing a high oxygen demand. Since the diffusion of oxygen from the water surface and from surrounding areas of higher oxygen concentration is slow, anaerobic conditions may occur within the receiving water body. The end products of anaerobic digestion are hydrogen sulfide, methane, and ammonia, which are toxic to most higher organisms (Kiely, 1996). High oxygen demands are made more severe depending on the degree of deoxygenation, which is subject to temperature, dilution of the organic waste, capacity of water body aeration, BOD of the waste, and the amount of other organic materials present in the water body. Therefore, the direct result of organic pollution in water bodies is the reduction of biodiversity, where species that are most tolerant to low dissolved oxygen conditions shall dominate. Ultimately, a severe case of organic pollution may lead to complete deoxygenation, resulting in the elimination of the biota of the water body due to anoxic conditions.

The artificial enrichment, or eutrophication, of waters by inorganic plant nutrients such as nitrogen and phosphorus can also occur in water bodies affected by leachate contamination. While eutrophication is a natural process, "artificial enrichment" in this context describes the liberation of nutrients from the intruding contaminant, causing an unnatural increase in plant nutrient uptake activity. In severe cases of eutrophication, massive algal blooms and extreme aquatic plants fueled by excess nutrients cause an increase in turbidity, leading to starvation and death to plant life, and also having a knock-on effect to animal life. Also, a marked increase in organic detritus caused by seasonal die-off of massive algal populations can result in high decomposition and oxygen demand in lake bottom, thus affecting organisms associated with that area. In addition, eutrophication and subsequently algal blooms will decrease a water body's amenity values as well as for human consumption due to expensive treatment costs and the repugnant issues with putrid and decaying algae.

The nature by which leachate is formed also contributes to the high heavy metal content found in most

A lined cell in a landfill to prevent contamination from leachate generated in the cell

movement of these leachates either above or below ground provides the medium of transport into nearby surface water bodies and groundwater reservoirs. In fact the need to control leachate in order to avoid uncontrolled discharges into the environment has the greatest influence on landfill siting, design, operation, and maintenance costs (Christensen et al., 1995). This is a tacit rule by which landfill planning activities at AFSB will abide by, so that protection and preservation of our water resources can be achieved. ■

leachate samples. The presence of heavy metal ions is due primarily to the alkalinity prevalent with leachate that consists of salts of weak acids and numerous organic acids that are resistant to biological oxidation. Leachate would tend to solubilise and pick up salts if leachate recirculation is practiced at a landfill. Of particular concern are salts of alkali and alkaline earth-metals (sodium, potassium, calcium, and magnesium) where it may provide benefits at lower concentrations, but will become inhibitory to aquatic life at higher levels. Stimulatory combinations of these cations may either act as antagonistic (positive effect by negating the inhibiting influences of another ionic species) or synergistic (combined stimulatory levels of two different ionic species to produce inhibition) properties to microbial and aquatic life (Curi and Eckenfelder, 1980; Leslie Grady et al., 1999). In addition to affected waters having unpalatable taste, concerns of toxic heavy metals or non-metals may arise if the leachate originates from a landfill known to be used for toxic waste disposal.

A landfill development, or similarly for any earthwork development, can also effect the physical well being of nearby groundwater aquifers. Availability and recharging capacities of aquifers may decrease primarily due to the decrease in surface area available for precipitation to infiltrate and recharge the reservoir, mainly due to fully-lined landfill designs and compacted landfill cover systems. In addition, surface water runoff quantities for a particular site may change as a result of landfill development. For instance, downstream water bodies may experience depleted quantities or, conversely, floods due to interference with natural runoff routes. According to Kiely (1996), the health of groundwater reservoirs are hydraulically connected to the land surface, wherein the time of groundwater travel, relative quantity of percolation to recharge the reservoirs, and attenuation capacity of the geological materials all can be affected in various ways.

CONCLUSION

To become a contamination risk element for water resources, an activity or area has to provide a source of contamination, mediums of pollutant transport, and a specific reactor for contaminant production. It is evident that disposed solid waste produces leachate, whereby

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