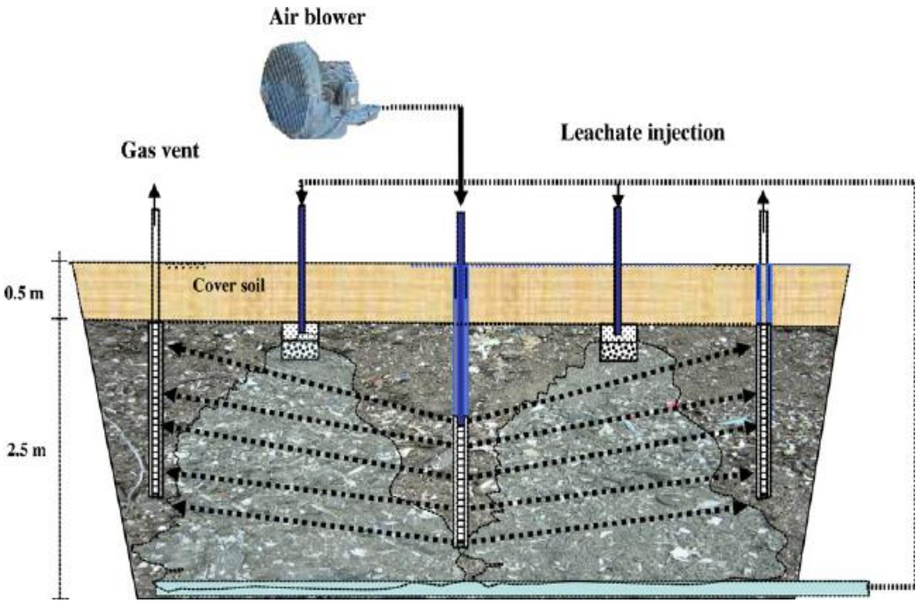
Bioreactor landfill

Defining characteristics	Narrative
General	Historically, landfills have been the most common method of waste disposal and remain so in many places around the world today. In particular, sand and gravel pits and borrow areas are commonly used as primitive landfills. A bioreactor landfill changes the goal of landfilling from waste storage to waste treatment (Pacey et al, Undated). In addition to improved design of sanitary landfill features, bioreactor landfill designs incorporate a leachate recirculation system that augments waste decomposition kinetics, and accelerates landfill stabilisation.
Siting and land use	Landfill siting requires rigorous geotechnical, environmental and economic studies to ensure that the best available science is used and local environmental and safety concerns are taken into account. In this regard, a facility location decision must be informed by expertise in diverse areas and stakeholder/public consultations, and validated through a permitting process. Ultimately, land requirements for installation of a bioreactor landfill depend on its design life span, topography and hydrogeology of the milieu.
Design (components) and Operation	Bioreactor landfills have common features with sanitary landfills as follows: 1) stormwater management system; 2) landfill liner; 3) leachate collection system; and 4) gas collection and recovery system, and two other distinguishing features; 5) leachate recirculation system; and air injection system. Stormwater control systems play a crucial role diverting surface runoff from the landfill and protecting it from flooding. Typical infrastructure includes detention basins, diversion berms and cutoff ditches. A landfill liner made of a low conductivity natural or synthetic material (compacted clay or geotextile) is laid out at the bottom of the landfill to prevent or delay the migration of leachate (loaded with micro-organisms, organic and inorganic contaminants) into underlying aquifers and nearby surface water bodies. A typical leachate collection system is made up of hydraulically connected drainage material, leachate collection pipes, riser pipes and submersible pump that collectively function to remove leachate impeded by the liner at the base of the landfill. Failure to control leachate build-up and its removal will most likely cause seepage from the sides and slope instability. A gas collection and recovery system makes it possible for gas generated from waste through biochemical reactions to be pumped out of the landfill to prevent spontaneous fires, gas migration onto adjacent properties, and for use as an energy resource if desirable. A typical set-up includes one or more vertical/horizontal wells strategically positioned within the landfill, a header system to connect gas collection wells to a gas pumphouse system. To purify landfill gas (LFG) for end users, carbon dioxide (CO_2) can be removed by dissolving in water or potassium hydroxide (KOH). In the event LFG is not needed, it can be oxidised using a flare system (Hirshfeld et al .1992, Humer and Lechner, 1999). Noting that water is usually the limiting constraint to microbial activity in a landfill, the primary purpose of a leachate recirculation system is to increase the moisture content of waste contained in the landfill and thereby promote its degradation by micro-organisms. Leachate and/or water can be added by several methods including spray irrigation, surface ponding, sub-surface infiltration, [80] at rates consistent with the moisture absorption capacity of landfill waste, expected leachate outflow rates and capacity of the leachate collection system. An air injection system consisting of vertical screened wells or a horizontal system of pipes connected to blowers injects compressed air into the waste matrix to enhance aerobic decomposition of landfill waste, and reduce the toxicity of methane and waste produced in landfill (Powell et al, 2006). . Similar to sanitary landfills, bulldozers are used to spread and compact solid waste after

[80] through wells or infiltration trenches

	it has been deposited by trucks. Daily waste deposits are also covered with soil to reduce odours and provide a firm base upon which vehicles may operate.
Cost	According to Clayton and Huie (1900), annual solid waste disposal costs are estimated at 1.9USD/ton for sanitary landfill facilities handling 100 tons of waste or less in a day. At lager facilities receiving 1,200 tons of waste or higher volumes in a day, the average cost is approximately USD0.65/ton. For bioreactor landfills, additional costs arise from associated fuel/energy consumption needed to inject air and/or leachate into the landfill (Lou and Nair, 2009). Upfront cost may however be partially upset if LFG recovered is used as a source of energy. Similar to sanitary landfill, costs may be compounded by external physical and social costs (Hirshfeld et al., 1992).
Supporting infrastructure	Vehicle wheel cleaning facilities Strategically located scientific monitoring equipment
Advantages	A bioreactor landfill has several advantages. Chief amongst these is the acceleration of degradation processes which speed up the production of landfill gas (LFG), enhance the feasibility of LFG recovery for useful purposes, increase disposal capacity vis-à-vis sanitary landfills, and significantly shortens landfill stabilisation timescales (Powell et al., 2006; Murphy et al., 1995). Overall, bioreactor landfills offer a more sustainable option for waste management (Pacey et al, Undated).
Disadvantages /Challenges	Whereas, leachate management is one of the key strengths of landfill bioreactors, it could also be its weakness. Owing to the heterogeneity of landfill waste and influence of added liquid on air distribution within the waste matrix, differential settling of landfill waste may be induced by addition of liquids. Thus, a tight operating range of moisture content is needed to avoid: 1) compromising the efficiency of the gas collection system; and 2) disruptive back pressure, backflow and leachate surging at injection well heads (Oxarango et al., 2011) N_2O emissions from aerobic bioreactor landfills may be a possible concern in relatively new refuse. the oxidation of methane and non-methane hydrocarbons may also increase CO concentrations from other in-situ processes (Powell et al., 2006). The successful operation of a bioreactor landfill depends upon the degree of control an operator has over dynamic processes occurring within the landfill, underpinned by monitoring and adjusting relevant biological, chemical, and hydrological variables (Pacey et al, Undated).
Abatement potential	LFG capture and flaring (i.e., conversion of CH_4 to CO_2) reduces the global warming potential (GWP) of landfill emissions by 95%. Under controlled conditions, LFG generation is significantly enhanced (Pacey et al, Undated, Reinhart and Townsend, 1997). All things being equal, the mitigation potential of a bioreactor landfill could be twice as large as that of sanitary landfill because of the former's rapid stabilisation coupled with the additional disposal capacity stabilisation entrains.
Level of penetration	Bioreactor landfills are a completely new technology



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Further Reading

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