

Landfills and Their Environmental Impacts

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Introduction:

Landfills have left their mark on human history. They have been a major mode of waste removal for thousands of years, and important in keeping human populations away from any hazardous waste materials (e.g., paint and cleaning products), or waste byproducts. However, ever since their creation they have been a technology that has constantly been altering the biology of the surrounding environment they are built in, in an irreversible way. This new biotechnological hybrid causes drastic changes in naturally occurring bacterial populations that decompose the municipal waste, and to the ecology of fauna native to areas adjacent landfills.

The Technology:

In 2003, the Environmental Protection Agency (EPA) estimated that 56% of the refuse generated in the U.S.A is disposed of in landfills (EPA, 2003). The remaining 44% of trash is disposed of using other methods (e.g., burning or recycling). Municipal solid waste landfills are large plots of land or excavated sites that are specifically designed to receive and hold municipal waste (e.g., household appliances, paper, and plastic), or waste generated in residential or commercial areas. Municipal solid waste landfills can also accept some hazardous waste materials like paint, cleaning products, and other household chemical products, as well as the industrial waste created by some companies (EPA, 2003). A typical municipal solid waste landfill consists of a layer of compacted soil (clay based), followed by a plastic liner and topped with a leachate collection and removal system (EPA, 2003). Leachate occurs when water, usually from rain, permeates through the deposited waste. As the water permeates the waste it leaches out some of its constituents, the result being water contaminated with solute from the waste. Waste is brought in from the surrounding towns and cities via dump trucks and deposited on top the leachate collection layer. Once the waste is dumped, other machinery is used to compact, spread and bury the layer of waste, and the process is repeated until the landfill is completely filled or “capped”. Leachate is drained, collected and shipped to a leachate recovery facility where it is treated. If the leachate is left on site, there is the chance that it could leak into groundwater sources, contaminating human and animal drinking water (EPA, 2003). Groundwater sources can also be contaminated if there is a breach in the plastic liner layer, so there are many strict guidelines landfill owners must abide by to maintain a healthy landfill ecosystem and stay in operation. Even though these strict guidelines exist landfills are very difficult to establish due to high public opposition, expensive land and operation costs and environmental concerns (EPA, 2003).



<http://www.ci.columbia-heights.mn.us/images/pages/N476/Landfill.jpg>

Fig. 1. Depicted above is an average landfill site in Minnesota. In 1984 the EPA developed the Hydrologic Evaluation of

Landfill Performance (HELP) model to assess leachate loads at landfills. It was estimated that with an average of 2.5 in of rain a month and with the leachate capture layer being 90% efficient, in a 25 acre landfill 500,000 gallons of leachate is produced per month. That's 6,000,000 gallons per year (Wilson et al., 2011).

The Bacterial Biology:

Landfills are not without their environmental concerns. Their sheer existence is enough to change an entire ecosystem's ecology, no matter where in the world they are located. Bacteria exist almost everywhere on Earth, and given the conditions they need to survive they can quickly establish huge populations through asexual reproduction. Some bacteria like methanogens, or methane producing bacteria, however, require a very specific habitat in order to establish huge bacterial populations. Before a landfill is established these methanogens exist in very low numbers as their preferred habitat is far from naturally occurring near human populations. These types of bacteria are heavily limited in regards to where they can thrive in almost all ecosystems (Themalis & Ulloa, 2006).

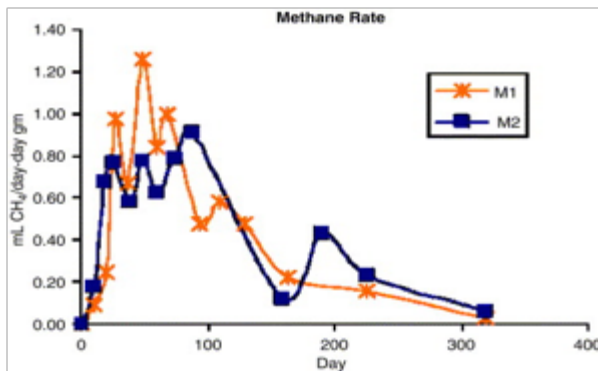


Fig 2. Above is a graph showing how methanogenesis would occur over time in a landfill. This graph is the result of a laboratory experiment; methanogenesis was monitored using lab apparatus. M1 and M2 denote separate trials (Themalis & Ulloa, 2006).

The Avifauna Biology:

Birds are attracted to landfills. They provide the animal with an easy habitat in which they can forage and obtain easy meals. Before the establishment of a landfill these fauna could be found foraging, dwelling, and/or breeding in ecosystems adjacent the landfill. For example the two most common avian landfill visitors in northern Ohio are the American Herring Gull and Ring-Billed Gull, *Larus smithsonianus* and *Larus delawarensis* respectively (Belant et. al, 1995). They used to form large groups on large bodies of water in the region and used to use these ecosystems to forage for food. Both gulls have now taken to using the Erie, Huron and Ottawa county landfills to forage for easy food. In a study done by Belant et. al., 699,350 individual birds belonging to 42 different species were recorded visiting these three landfills in just 958 observation periods. Below is a histogram from the same study that shows that these gulls are found in the three landfills in great numbers almost all year around, except during their breeding season when they migrate further north (Belant et. al., 1995).

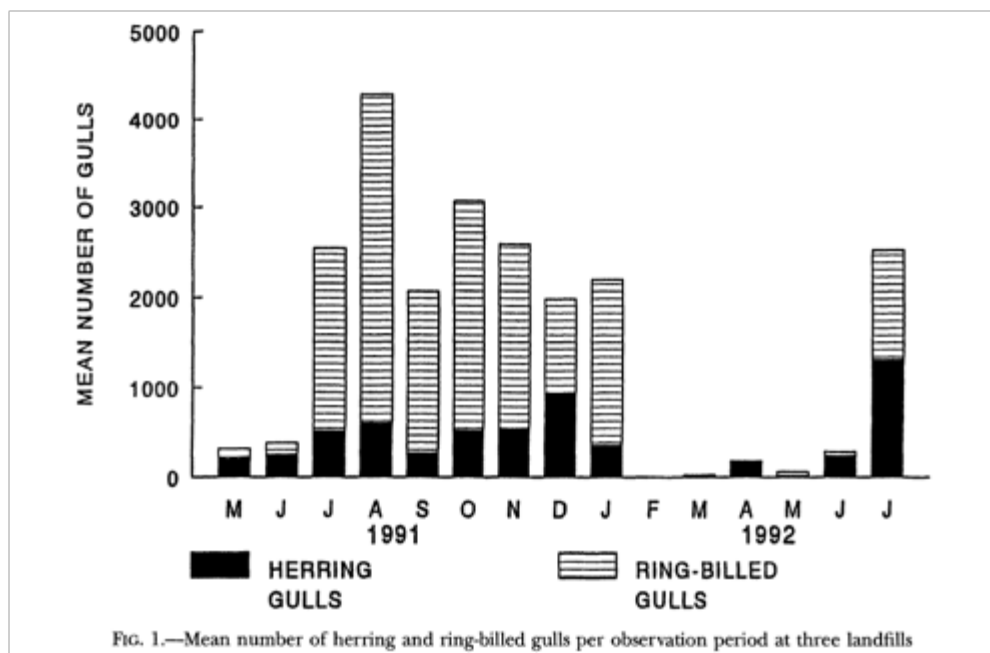


FIG. 1.—Mean number of herring and ring-billed gulls per observation period at three landfills

Fig. 3. This graph very clearly shows that the avifauna have readily adapted to using landfills as an alternate habitat for foraging when off their breeding grounds (Belant et. al., 1995).

The Bacteria-Landfill Hybrid:

Almost immediately after it's creation a landfill becomes a biotechnological hybrid, a new ecosystem for different organisms. The landfill ecosystem goes through many shifts and exists in different decomposition life stages. Each life stages itself is characterized by the dominant type of bacteria present at that moment. The first stage is the aerobic stage, where oxygen is taken up through the soil by aerobic bacteria in the waste layer resulting in an oxygen poor environment and a switch to fermentation by bacteria (Themalis & Ulloa, 2006). Next is the anaerobic stage where hydrolytic and fermentative bacteria hydrolyze polymers (e.g. cellulose, proteins and lipids) into monomers (e.g. simple sugars, amino acids and long carboxylic chains) (Themalis & Ulloa, 2006). These products are then further fermented into hydrogen, carbon dioxide, acetate and short-chained carboxylic acids. As acetate is produced it becomes a new source of carbon for the bacteria and as a result the pH of the system neutralizes. This neutralization begins to cause hydrogen producing acetogens to oxidize short-chained carboxylic acids, a thermodynamically unfavorable reaction in the presence of excess hydrogen (Themalis & Ulloa, 2006). The Acetogens must then grow alongside Hydrogen Consuming bacteria, or methanogens who produce methane. Landfills will always end with methanogenesis, and provide the habitat methanogens need to thrive, but this was an unintended consequence. Once methanogenesis begins it can last anywhere from 8-40yrs, pumping harmful methane gas into the atmosphere and helping drive climate change (Micales & Skog, 1997 & Themalis & Ulloa, 2006).

The Avifauna-Landfill Hybrid:

Due to the high number of birds foraging in landfills and the huge populations of bacteria that grow in landfills, fauna have a high risk of contracting and spreading disease. This is easily done when these animals are in such close proximity in such large numbers. Another big risk concerns birds and aircraft. If a landfill is too close to an airport there is a much higher incidence of bird-plane collisions, which affects both bird populations and humans (Burger, 2001 & Belant et. al., 1995).

Where Landfills are Now:

Already scientists have discovered new ways to decrease the impacts landfills have on the environment via methane emissions and attracting large bird populations. Methanogenesis can be prevented if fermentative bacteria

remain more productive than methanogens, however, methanogenesis is a natural last step for a healthy landfill ecosystem so this may not be a viable solution. Methane gas can be harvested and burned though, which in turn decreases our reliance on fossil fuels and provides a new source of renewable energy (Themelis & Ulloa, 2006). The process of harvesting the gas is expensive and highly inefficient, but I predict with time and technological advancements these systems will gain in efficiency and further increase the amount of methane captured (Spokas et. al., 2006). The use of LARD's or Long Range Acoustic Hailing Devices has proved successful in deterring birds from foraging in landfills (DeFusco, 2007). They are extremely loud right now, but newer technologies would help make this a more accessible option for many towns and cities, by reducing the sound.

Predictions for the Future:

Landfills are a biotechnological hybrid that we rely on and therefore they will likely never completely disappear. They will likely also never release the grasp that on surrounding ecosystems, continuing to alter the biology of bacteria and fauna, and on their current course eventually humans. Humans will likely improve upon the current design of landfills and on the technologies used there to decrease the negative environmental impacts landfills have. In time methane gas produced in landfills will be the major fuel we use to power our world, lowering our reliance on fossil fuels. Newer landfills would also limit access by fauna from surrounding ecosystems with both physical barriers and improved sound barriers. Keeping fauna out of our landfills would lower the risk of fauna transferring diseases between each other and to us, and decrease bird-plane collisions. Landfills will go from having negative environment impacts, to working to help decrease both our carbon footprint and the effect we have on surrounding ecosystems.

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