EVALUATION OF LEACHATE EMISSIONS - MID AUCHENCARROCH EXPERIMENTAL PROJECT

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Abstract

This paper presents and evaluates the long term behaviour of the Mid Auchencarroch experimental landfill site in the UK. Assessment of the landfill behaviour is made, based on particular characteristics of leachate emissions, as a result of different disposed waste input materials, landfill conditions and waste mass treatment. Projections and comparisons are made of some characteristic biodegradation parameters of the produced landfill emissions, making useful conclusions.

Key words: Environmental engineering, landfill emissions, public health, landfill design, waste biodegradation, solid waste management.

Introduction

Sanitary landfill remains an attractive disposal route for municipal solid waste, because it is more economical than alternative solutions. It is accepted that the landfill biodegradation processes are complex, including many factors that control the progression of the waste mass to final stage quality (DOE, 1995; Fleming, 1990; Koliopoulos, 2000; Tchobanoglous *et al.* 1993). The landfill gas and leachate generation is an inevitable result of the solid waste biodegradation in landfills and their study is necessary for efficient designs, controlling air and groundwater pollution (Fleming 1996; Tchobanoglous *et al.* 1993).
A plethoric flow and use of resources characterize our society in an unsustainable way. Waste management is the discipline that is concerned with resources once society no longer requires them. A successful sustainable development requires a continuous change and harmonization to the life cycle of our society, bearing in mind its current-future necessities (Vlavianos-Arvanitis, 1991; Koliopoulos, 1999). Therefore, the problem is transferred to the dilemma on how can we manage our waste better. Sanitary landfill has been shown to have lower environmental costs. Selection of the right landfill and

operational procedure are of the upmost importance if small urban areas are to be served effectively. Clay soils enable cost effective engineering to prevent leachates entering the water table from landfill sites.
During biomass's fermentation there are five phases of waste biodegradation in a landfill bioreactor. Phase I is the initial adjustment phase. In Phase I, biological decomposition occurs under aerobic conditions, because a certain amount of air is trapped within the landfill. In Phase II, identified as the transition phase oxygen is depleted and anaerobic conditions begin to develop. As the landfill becomes anaerobic, nitrate and sulphate, which can serve as electron acceptors in biological conversion reactions, are often reduced to nitrogen gas and sulfide. In Phase III, the acid phase, the microbial activity initiated in Phase II accelerates with the production of significant amounts of organic acids, increased concentrations of COD (chemical oxygen demand) and lesser amounts of hydrogen gas. In Phase IV, the methane fermentation phase, a second group of microorganisms, which convert the acetic acid and hydrogen gas formed by the acid formers in the acid phase to CH_4 and CO_2, becomes predominant. In phase IV leachates have neutral pH. Phase V, the maturation phase, occurs after the readily available biodegradable organic material has been converted to CH_4 and CO_2 in Phase IV. In this phase COD, BOD (biochemical oxygen demand) and TOC (total organic carbon) concentrations have been reduced. Also, the rate of landfill gas generation diminishes significantly in Phase V, because most of the available nutrients have been removed with the leachate during the previous phases (Augenstein, *et al.* 1991; EMCON, 1980; Koliopoulos, 2000; Tchobanoglous *et al.* 1993).
The use of controlled landfill projects is necessary for quick site stabilization of landfill gas and leachate emissions, during waste biodegradation. The use of controlled batch anaerobic bioreactors accelerates waste biodegradation in short periods, minimizing any associated environmental risks due to landfill emissions (Elliott *et al.* 2001; Friis *et al.* 2004; Koliopoulos, 2000). Any uncontrolled dumps have to close so as to avoid any threats to the public health and to protect the environment.

Methods and Materials

Description of the experimental project

This paper assesses the leachates' long term behaviour of Mid Auchencarroch experimental anaerobic landfill site in Scotland. The experimental batch bioreactor Mid Auchencarroch is a field scale facility, constructed in order to assess a number of techniques that promote sustainable landfill. Mid Auchencarroch (MACH) experimental landfill, is an Environment Agency, DTI and industry funded research facility. It has been capped since 1995. The experimental variables are waste pretreatment, leachate recirculation and co-disposal with inert material. The project consists of four cells each of nomimal volume 4,200 m^3. The disposed waste synthesis for the untreated and pulverised waste input is respectively: Paper-Card: 27%&34%; Plastic film 6%&7%; Dense plastic 5%&8%; Textiles 3%&3%; Misc.combust. 3%&3%; Misc. non-combust.0.5%&2%; Glass 5.5%&7%; Putrescibles 38%&24%; Ferrous metal 6.5%&8%; Non-ferrous metal 1.5%&2%; Fines 4%,2% (Koliopoulos 2000; Wingfield-Hayes, 1997). In figure 1 is presented a plan of MACH site.

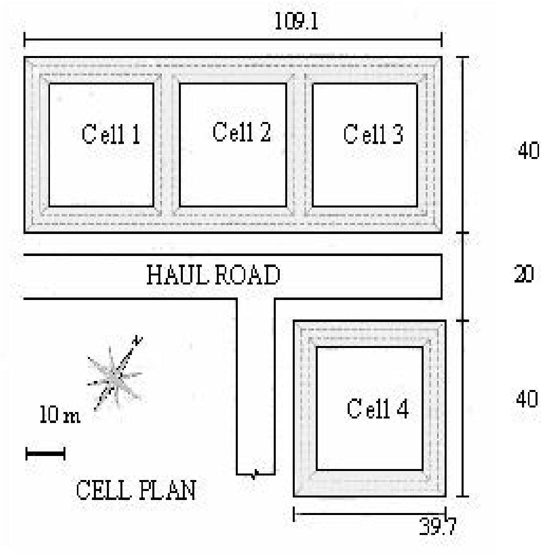

Figure 1. Plan of MACH experimental site.

In cells 1 and 3 there is pretreatment by wet pulverisation and in cells 2 and 4 the disposed waste is untreated. In cells 1,2 and 3 there is recirculation of leachate and in cell 1 there is addition of inert material around 20% by volume. This project develops and assesses techniques to enhance the biomass's degradation, and pollutant removal processes for Municipal Solid Waste (MSW) landfill. The wet-flushing bioreactor landfill model is seen as the method of achieving the goal of sustainability. The MACH landfill data, which were used for the examining evaluation, cover the 22-month life cycle of waste biodegradation in MACH landfill. The estimations of the main leachate concentration parameters change with landfill age for the particular sites in time and they can be defined as presented below in table 1 (Tchobanoglous *et al.*, 1993; Koliopoulos, 2000).

Table 1. Landfill leachate characteristics in time.

Parameter	0-5 yr	5-10 yr	10-20 yr	<20 yr
BOD_5 (mg/l)	4,000-30,000	1,000-4,000	50-1,000	<50
COD (mg/l)	10,000-60,000	10,000-20,000	1,000-5,000	<100
Ammonia (mg/l)	100-1,500	300-500	50-200	<30
pH	3-6	6-7	7-7.5	6.5-7.5
Chloride (mg/l)	500-3,000	500-2,000	100-500	<100
Sulphate (mg/l)	50-2,000	200-1,000	50-200	<50

Operation of MACH experimental case study.

Waste biodegradation.

For the MACH the biodegradation rate is evaluated according to the COD, TOC and pH indicative characteristic biodegradation indexes of the produced leachate emissions. In figures 1,2,3 and 4 are presented the Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC) concentration trends in time for the four MACH cells (Koliopoulos, 2000). COD could be characterized as the most hazardous leachate characteristic in relation to groundwater and site contamination (Tchobanoglous *et al.* 1993).

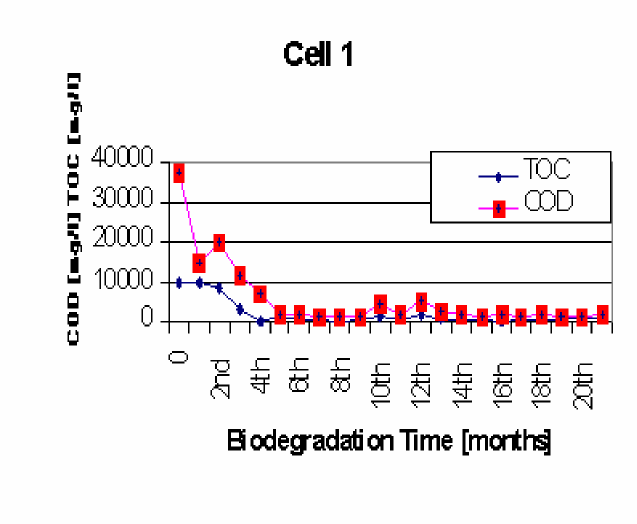

Figure 1. COD & TOC concentrations for MACH Cell 1.

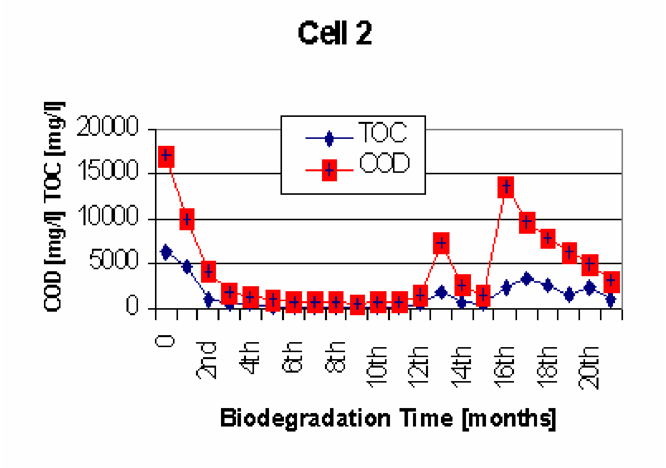

Figure 2. COD & TOC concentrations for MACH Cell 2.

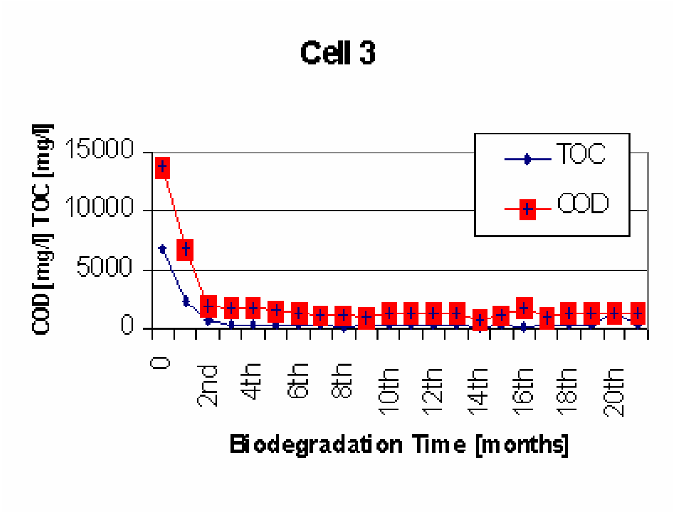

Figure 3. COD & TOC concentrations for MACH Cell 3.

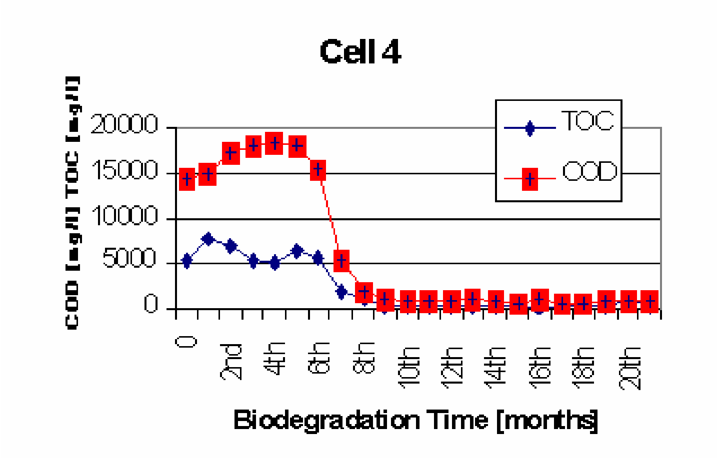

Figure 4. COD & TOC concentrations for MACH Cell 4.

Evaluating the above results it is clear that there was the greatest depletion of carbon and COD pollutants at cell 1. Moreover, cell 4 presents higher max COD concentrations due to the fact that there has been disposed higher waste fraction of biodegradable carbon content in it than at cell 3 and 2. In figure 5 are presented the pH values for the examining MACH cells.

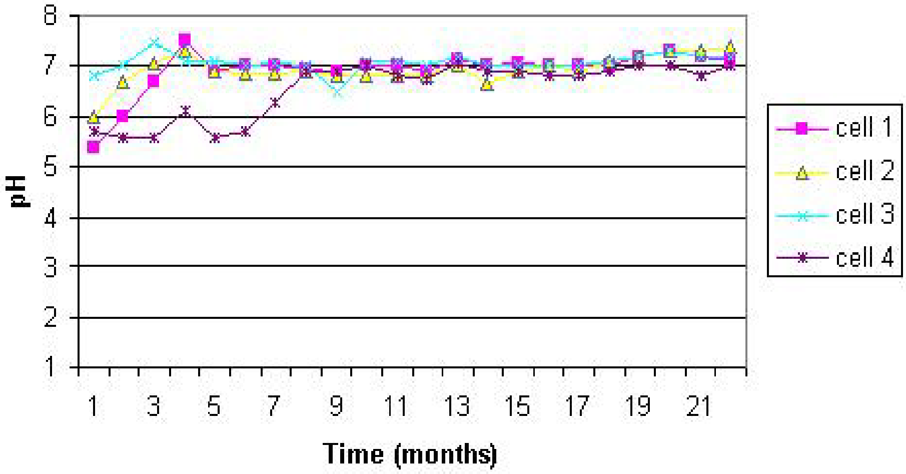

Figure 5. pH values for MACH Cell 1,2,3 and 4.

Experimental results and discussion

According to the above presented experimental measurements Cell 2 presented temporarily high risk between the 15th and 21st month. The latter can be explained due to the fact that leachate recirculation began in November 1996. However, ph values show that acid environment there was in the first months of waste fermentation and neutral one when MACH's stabilization took place in time. According to pH values for the MACH cells is concluded that quick landfill stabilization has been achieved in time. In the end, all the TOC and COD concentrations present great reduction after 1996. The latter fact certifies the quick Mid Auchencarroch batch bioreactor stabilization.

Conclusion

According to the presented experimental results the best waste biodegradation existed in cell 3, as well good organic depletion presented cell 1, minimizing both their emissions and associated environmental risks in short time. Leachate emissions were reduced in short time, showing that quick site stabilization was achieved in time. Monitoring networks, dynamic numerical models and geographical information systems or other digital spatial databases could be used so as to keep records and control of landfill emissions in time.

Long-term liability can be minimized when waste is efficiently treated to a point where no further degradation will occur, protecting the environment from long-term landfill emissions. At Mid Auchencarroch experimental project it was clear that the co-disposal with inert material is sustainable as well as the pretreatment by wet pulverisation since the recirculation of leachate expedite the waste biodegradation. It is therefore suggested that further investigation of batch bioreactors is needed for different landfill conditions.

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