Waste Management 30 (2010) 228–235

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Physico-chemical and biological treatment of MSW landfill leachate

L. Castrillón [a], Y. Fernández-Nava [a], M. Ulmanu [b], I. Anger [b], E. Marañón [a,*]

[a] Chemical Engineering and Environmental Technology Department, University Technology Institute of Asturias (IUTA), University of Oviedo, Campus of Gijón, 33203 Gijón, Spain
[b] Institute for Non-ferrous and Rare Metals (IMNR), 102 Biruinţei Bvld, Bucharest-Pantelimon, Romania

ARTICLE INFO

Article history:
Accepted 13 September 2009
Available online 25 October 2009

ABSTRACT

This paper analyses the evolution of the physico-chemical characteristics of the leachate from the Central Landfill of Asturias (Spain), which has been operating since 1986, as well as different treatment options. The organic pollutant load of the leachate, expressed as chemical oxygen demand (COD), reached maximum values during the first year of operation of the landfill (around 80,000 mg/L), gradually decreasing over subsequent years to less than 5000 mg/L. The concentration of ammonium, however, has not decreased, presenting values of up to 2000 mg/L. When feasible, recirculation can greatly decrease the organic matter content of the leachate to values of 1500–1600 mg COD/L. Applying anaerobic treatment to leachates with a COD between 11,000 and 16,000 mg/L, removal efficiencies of 80–88% were obtained for organic loading rates of 7 kg COD/m^3 d. For leachates with lower COD (4000–6000 mg/L), the efficiency decreased to around 60% for organic loading rates of 1 kg COD/m^3 d.

Applying coagulation–flocculation with iron trichloride or with aluminium polychloride, it was possible to reduce the non-biodegradable organic matter by 73–62% when treating old landfill leachate (COD: 4800 mg/L, BOD_5: 670 mg/L), also reducing turbidity and colour by more than 97%. It is likewise possible to reduce the non-biodegradable organic matter that remains after biological treatment by adsorption with activated carbon, although adsorption capacities are usually low (from 15 to 150 mg COD/g adsorbent). As regards ammonium nitrogen, this can be reduced to final effluent values of 5 mg/L by means of nitrification/denitrification and to values of 126 mg/L by stripping at pH 12 and 48 h of stirring.

1. Introduction

The sanitary landfill method continues to be widely used in different countries for the final disposal of solid waste material due to its economic advantages. In 2006, 60% of the MSW (municipal solid waste) produced in Spain was deposited in landfills. At a sanitary landfill, the waste is placed on the ground and extended in thin layers (cells). These layers are then compacted to reduce their volume and covered periodically with a suitable material.

The degradation of the organic fraction of the waste in the landfill in combination with the percolation of rainwater produces a liquid called "leachate" (Kjeldsen et al., 2002). Diverse leachate treatments have been reviewed by Renou et al. (2008). Leachate can be recirculated to the same landfill (Pohland and Al-Yousfi, 1994; De Rome and Gronow, 1995; Wang et al., 2006; Bilgili et al., 2007; Benson et al., 2007) or treated by different biological and physico-chemical methods. The biological methods applied to remove organic matter and ammonium nitrogen are aerobic, anaerobic and anoxic (Berrueta and Castrillón, 1992; Hoilijoki et al., 2000; Im et al., 2001; Canziani et al., 2006). A great variety of physico-chemical methods, such as flocculation–precipitation (Aziz et al., 2007; Tatsi et al., 2003), activated carbon adsorption (Rodríguez et al., 2004), chemical oxidation (López et al., 2004; Chan et al., 2007; Tizaoui et al., 2007), membrane filtration including reverse osmosis (Ushikoshi et al., 2002) and nanofiltration (Trebouet et al., 2001), have also been employed to treat leachates.

The aim of the present research study was to analyse the evolution of the characteristics of the leachates generated at the centralized landfill site at La Zorera, Asturias, Spain, and the application of different treatments to these leachates in order to remove their major pollutants. As this landfill site has been in operation since January 1986, the composition of the leachate has changed over time. An extension of the landfill was undertaken in 2004 and waste has been landfilled in this new area since 2005, thus producing two kinds of leachate: "young" leachate and "old" leachate.

2. Operating method

Leachate samples were collected from the sanitary landfill on a monthly basis over different periods in 20 L plastic bottles, transported to the laboratory, stored at 4 °C and subsequently characterized. Physico-chemical analyses (pH, conductivity, turbidity, colour, COD, BOD_5, ammonium nitrogen, volatile acidity, iron and

* Corresponding author. Tel.: +34 985182027; fax: +34 985182337.
E-mail address: emara@uniovi.es (E. Marañón).

0956-053X/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.wasman.2009.09.013

Nomenclature

BOD_5	biological oxygen demand, 5 days	MSW	municipal solid waste
BOD_7	biological oxygen demand, 7 days	NTU	nefelometric turbidity unit
BV	bed volume	OLR	organic loading rate
COD	chemical oxygen demand	PAX	aluminium polychloride
HRT	hydraulic residence time	UASB	upflow anaerobic sludge blanket

aluminium) were performed over the two days following sampling according to Standard Methods for the Examination of Water and Wastewater (APHA, 1989). pH was measured using a CRISON pH-meter. The different treatments studied were: recirculation to remove biodegradable organic matter, physico-chemical processes to remove non-biodegradable organic matter and/or ammonia (coagulation, ammonia stripping, adsorption with activated carbon) and biological processes (anaerobic, anoxic-aerobic). A scheme of the studied processes is shown in Fig. 1. The treatments have been applied to the leachates generated at the Central Landfill of Asturias over different periods of time and hence to leachates presenting different compositions.

3. Results

3.1. Waste characterization

Asturias is a region on the north coast of Spain with a population of around 1,100,000 inhabitants and a surface area of 10,500 km^2. The region is divided into 78 municipalities and the municipal waste generated is treated at a centralized plant, managed by the Consortium for the Management of Municipal Solid Wastes (COGERSA). This landfill has been in operation since January 1986 and covers a surface area of approximately 250 ha. A selective collection system is currently used for glass, paper and cardboard and packaging waste. In addition, organic waste (mainly green waste and manure) is recycled by composting. Household waste (approximately 480,000 t/year) goes to landfill with energy recovery.

The amount of MSW disposed of at the landfill increased with time up until 2002 (Fig. 2), reaching a value of around 573,000 t/year. This was due to the increasing number of municipalities that dispose of their MSW at this landfill and also to an increase in waste generation. After 2002, the amount of waste going to landfill decreased to values of 466,000 t/year by 2008, mainly due to an increase in recycling of different materials, such as paper and cardboard, glass, package and organic waste. Table 1 shows the composition of MSW in 1986 and 2008. Waste materials were not recycled in 1986. Due to this and other factors, such as changes in population lifestyle, the physical composition of the MSW has varied with time. In 1986, the content in easily biodegradable organic matter represented 52%, while by 2008 it had decreased to 38%.

At the landfill, the waste is spread out in 2.5 m thick layers which are duly compacted so as to obtain a density in the range of 800–1000 kg/m^3. These layers are subsequently covered with soil from the site. The surface area exposed to rainfall is thus minimized and the odours produced during fermentation are either prevented from appearing or are abated. The landfill is located in a geographical zone that is both temperate and rainy. The leachates produced are not usually recirculated, but collected at the bottom of the landfill and subsequently transferred to a treatment plant located on-site.

3.2. Leachate composition

The two factors characterizing a leachate are the volume generated and its composition. Both factors depend on a variety of parameters, such as the type of waste, climatic conditions, and mode of operation. In particular, the composition of landfill leachate depends on the age of the landfill (Nanny and Ratasuk, 2002; Kulikowska and Klimiuk, 2008). The main physico-chemical

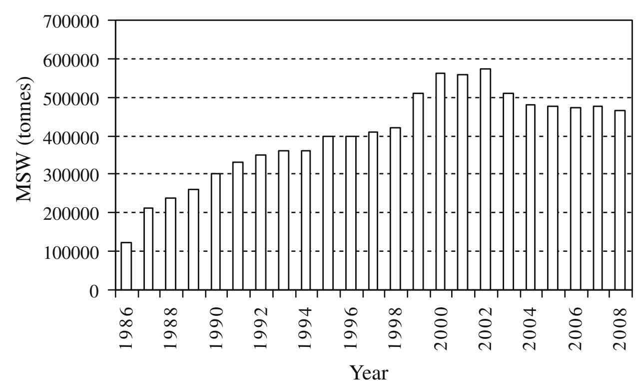

Fig. 2. MSW treated at the Central Landfill of Asturias from 1986 to 2008.

Table 1
Composition of municipal solid waste in Asturias (1986 and 2008).

Component	Mean value (%) 1986	Mean value (%) ± SD 2008
Organic fraction	51.8	38.1 ± 9.8
Paper and cardboard	18.9	20.6 ± 6.3
Plastic	9.0	10.8 ± 6.6
Glass	7.2	5.6 ± 3.1
Metals	3.1	3.6 ± 3.6
Textiles	–	10.8 ± 5.2
Other waste	10	10.5 ± 10.3

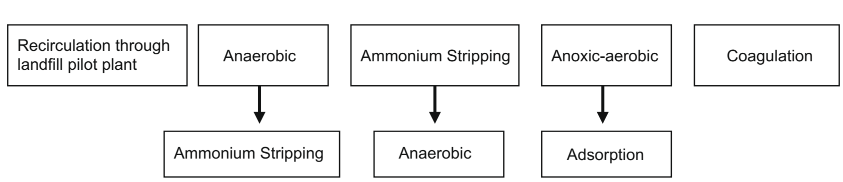

Fig. 1. Treatment options studied for MSW landfill leachate.