Waste Management 32 (2012) 2374–2384

Contents lists available at SciVerse ScienceDirect

Waste Management

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

Aerobic in situ stabilization of Landfill Konstanz Dorfweiher: Leachate quality after 1 year of operation

G. Öncü *, M. Reiser, M. Kranert

Institute of Sanitary Engineering Water Quality and Solid Waste Management, University of Stuttgart, Bandtäle 2, 70569 Stuttgart, Germany

ARTICLE INFO

Article history:
Received 5 December 2011
Accepted 6 July 2012
Available online 29 August 2012

Keywords:
Aerobic in situ stabilization
Landfill
Leachate quality

ABSTRACT

Modern landfill understanding points out controlled operation of landfills. Emissions from landfills are caused mainly by anaerobic biodegradation processes which continue for very long time periods after landfill closure. In situ landfill stabilization aims controlled reduction of emissions towards reduced expenditures as well as aftercare measures. Since April 2010, a new in situ stabilization technique is being applied at a pilot scale landfill (BAIV) within Landfill Konstanz Dorfweiher. This new method utilizes intermittent aeration and leachate recirculation for waste stabilization. In this study, influence of this technique on leachate quality is investigated. Among many other parameters, leachate analyses were conducted for COD, BOD_5, NH_4–N, NO_2–N, NO_3–N, TKN and chloride besides continuously on site recorded pH, electrical conductivity and oxidation–reduction potential (ORP). Results from leachate quality analyses showed that biological activity in the landfill was accelerated resulting in initial higher leachate strength and reduced emission potential of landfill. During full scale in situ aeration, ambient conditions differ from optimized laboratory scale conditions which mainly concern temperature increase and deficient aeration of some landfill parts (Ritzkowski and Stegmann, 2005). Thus, as a field application results of this study have major importance on further process optimization and application.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Over the years since the sanitary landfills are used for waste deposition, environmental public awareness is increased and resulted in various environmental regulations (Technical Instructions on Municipal Solid Waste (TASi, 1993), German Waste Storage Ordinance (AbfAblV, 2001) and German Landfill Ordinance (DepV, 2009)). As a direct consequence of these legal developments, many landfill sites are being closed and converted into the aftercare period in Germany. Today, these landfills are still emitting landfill gas and highly polluted leachate to the environment, since many of them are not equipped with sufficient protection barriers and collection systems. Investigations in old landfills as well as laboratory scale research showed that, emissions under anaerobic conditions may continue for very long time periods after landfill closure. This period is in the order of decades for landfill gas and sometimes centuries for leachate emissions, since anaerobic degradation is a very slow process (Christensen and Kjeldsen, 1989; Hudgins and Harper, 1999; Krümpelbeck, 2000; Ritzkowski et al., 2008). To accelerate biodegradation and to reduce emission potential of landfills, aerobic landfill stabilization technology has been developed within the recent years. This method offers rapid stabilization of waste, decreased production of methane gas and reduced organics in the leachate besides minimized odor emissions. Moreover, it could eliminate needs and expenditures for off-site leachate treatment (Heyer et al., 2005a,b; Read et al., 2001; Rich et al., 2007). When combined application of in situ aeration and leachate recirculation is considered, a recognizable reduction in leachate quantity is achieved besides enhancement of leachate quality (Bilgili et al., 2006, 2007; Borglin et al., 2004).

In this study, the influence of intermittent in situ aeration and leachate recirculation on leachate quality is investigated at field scale. The results obtained after 1 year of operation are presented.

2. Materials and methods

2.1. Project description

To overcome problems which arise from both leachate and gas emissions and to further develop technology of landfill stabilization, a pilot project was planned and named as "TANIA", (Totale Aerobisierung zur Nachsorgeverkürzung durch Intervallbelüftung von Abfalldeponien, Aerobic stabilization of landfills by interval aeration to reduce aftercare period). The stabilization strategy enabled in this project combines already known methods (i.e. leachate recirculation and aeration). This new approach is named as EISBER (Extensive Intervallbelüftung mit Sickerwasserrückführung und

* Corresponding author. Tel.: +49 711 685 65409; fax: +49 711 685 63729.
E-mail address: guelsen.oencue@iswa.uni-stuttgart.de (G. Öncü).

0956-053X/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.wasman.2012.07.005

Biologischer Emissionsreduzierung, Extensive interval aeration with leachate recirculation and biological emission reduction). In comparison to the already applied methods, EISBER differentiates itself with three new innovative characteristics which are intermittent aeration with different pressure levels, implementation of biological emission reduction by a surface biofilter and recirculation of leachate (Kranert et al., 2009). In Fig. 1, a basic scheme of the process is summarized.

2.2. Site description: Landfill Konstanz Dorfweiher, section BAIV

Landfill Dorfweiher is in the district of Constance (Landkreis Konstanz) which is located south of the State of Baden Württemberg, Germany. Between 1966 and 2009, municipal waste, commercial waste and sewage sludge were deposited in Landfill Dorfweiher. It has an area of 220,000 m^2 and a volume of 5,500,000 m^3. As base liner, there exists 1 m mineral sealing above 10–30 m boulder clay. Above base sealing, a leachate collection system was installed. For this research project, a pilot area of ca. 1.0 ha was selected and named as BAIV within Landfill Dorfweiher (Fig. 2a and b). BAIV was used as final deposit for household waste and household-waste-like commercial waste between 1996 and 2003. The project on BAIV was started in 2007 with preliminary investigations. Site construction and installation of equipments continued until end of 2009. During site construction, portions of deposited waste in section BAIV were excavated and analyzed for waste properties. The average composition of deposited waste was determined as 24% organic waste, 15% recyclables, 8% light packaging fraction and 53% residual waste. The average water content was 40% referred to wet mass. Defined volume of waste samples were taken from the excavated material and weighed. By this means, average bulk density was found as 1115.75 kg/m^3. With air and water pycnometry methods, average free pore space was determined as 9%. In addition, respiration index for 4 days (RI_4) was measured as 10 mg O_2/g TS.

The project area BAIV possesses 1 m thick mineral sealing above boulder clay layer as well as leachate collection system. No gas extraction system has been installed; however, a compost biofilter layer was applied over the project area. Residual gaseous emissions during aeration are passively treated by the compost biofilter layer. Above biofilter, methane emissions from BAIV are being measured by TDLAS – Gasfinder®2.0 system. Measuring landfill methane concentrations by flame ionization detector (FID) is considered to be a standard method (Rettenberger, 2004, after Zhu et al., 2010). However, FID is not completely appropriate for landfill methane monitoring while in most cases methane is emitted from area sources (or multiple points) rather than point sources (Reiser et al., 2009; Zhu et al., 2010). Methane measurements by FID may result disturbed emission rates due to hot spots. However, TDLAS – Gasfinder®2.0 system overcomes the drawbacks by measuring average methane concentrations continuously over an optical path up to 1000 m without further interference, which is suggested to be a more precise method to define areal methane emissions (Zhu et al., 2010).

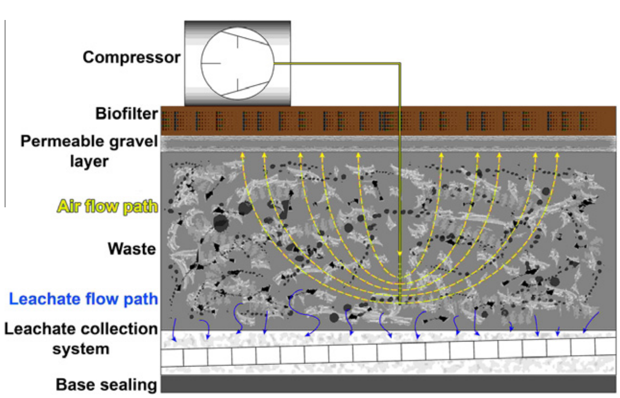

Fig. 1. Basic scheme of the process in Landfill Konstanz Dorfweiher (Kranert et al., 2009).

The landfill section BAIV is equipped with 64 temperature and 24 gas sensors that are located at different depths within the landfill and biofilter. By this means, the aeration process can be controlled continuously.

2.3. Aeration strategy and leachate recirculation

During preliminary investigation period, it has been determined that some areas of the landfill are densely packed in comparison to the other areas within a short distance. On the other hand, large areas with leachate accumulation were detected. Such formations in the landfill are expected to inhibit gas and leachate distribution during in situ aeration. It has been concluded that, to achieve better distribution of air and to displace accumulated leachate, an intensive pressurized aeration regime is beneficial for BAIV. For this purpose, 80 lances were constructed in a 10 m grid over the pilot area BAIV to achieve air distribution (Fig. 2c). Based on waste material analyses (RI_4 = 10 mg O_2/g TS) and landfill properties (low free air space, leachate accumulation, very dense areas), the initial air demand was estimated between 900 and 1200 m^3N/h. To release methane and leachate which is located in the pore spaces of waste, a higher initial aeration rate was preferred. Due to the aforementioned landfill properties it is more likely that problems in air distribution thus oxygen utilization might occur. Therefore, approximately three times of the air demand calculated based on RI_4 was initially used. For air supply, three compressors with differential pressures of 0.4 bar, 1 bar and 4 bar are being used. At the areas where leachate is accumulated, connection to the high pressure compressor (1 bar) was preferred. 36 lances out of 80 lances were connected to the high pressure compressor. All lances are also connected to the very high pressure compressor which is operated at 4 bars with intervals up to a couple of pressure pulses in an hour. By 24 gas sensors gas composition as well as the utilized oxygen in the landfill can be continuously monitored. In Fig. 3, the average gas composition over the landfill is illustrated. Likewise, by 64 temperature sensors located at different depths, the intensity of aerobic degradation at different parts of the landfill can be evaluated by monitoring the temperature profile (Fig. 4). Referring to the temperature and gas concentration readings, aeration rate for the next stage of the process is adjusted. For instance, when temperature sensors at a part of the landfill show a steep increase, the following actions could be taken; the nearby aeration lances are closed, the overall aeration rate is reduced (depending on the size of the area affected by temperature rise) or the duration of aeration is reduced.

Since April 2010, BAIV is being intermittently aerated with different pressure levels. Applying different pressures, varying from continuous low pressure flow to short high pressure pulses, enables better distribution of air also in the deeper parts of the landfill. In addition, high pressure pulses change the favored flow paths both for air and leachate helping to disturb leachate ponds within the landfill. Therefore, portions of waste subject to aerobic degradation are increased. Moreover, installation of aeration lances allows adjustment of air supply to different regions, considering the necessity due to degree of biological activity.

The aeration of pilot section BAIV was started with an air flow rate of ca. 1350 Nm^3/h (ca. 0.028 Nm^3/Mg TS $*$ h). Initially, continuous aeration strategy was applied. However, as a result of exothermic processes, temperature profile at some areas in the landfill was increased up to 70 °C (Laux et al., 2010). To avoid

Download English Version:

https://daneshyari.com/en/article/4472215

Download Persian Version:

https://daneshyari.com/article/4472215

Daneshyari.com