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ORIGINAL ARTICLE

Performance study of biofilter developed to treat H_2S from wastewater odour

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Abstract Biofiltration is an efficient biotechnological process used for waste gas abatement in various industrial processes. It offers low operating and capital costs and produces minimal secondary waste streams. The objective of this study was to evaluate the performance of a pilot scale biofilter in terms of pollutants' removal efficiencies and the bacterial dynamics under different inlet concentrations of H_2S. The treatment of odourous pollutants by biofiltration was investigated at a municipal wastewater treatment plant (WWTP) (Charguia, Tunis, Tunisia). Sampling and analyses were conducted for 150 days. Inlet H_2S concentration recorded was between 200 and 1300 mg $H_2S.m^{-3}$. Removal efficiencies reached 99% for the majority of the running time at an empty bed retention time (EBRT) of 60 s. Heterotrophic bacteria were found to be the dominant microorganisms in the biofilter. The bacteria were identified as the members of the genus Bacillus, *Pseudomonas and xanthomonadacea bacterium*. The polymerase chain reaction-single stranded conformation polymorphism (PCR-SSCP) method showed that bacterial community profiles changed with the H_2S inlet concentration. Our results indicated that the biofilter system, containing peat as the packing material, was proved able to remove H_2S from the WWTP odourous pollutants.

1. Introduction

Hydrogen sulphide is a colourless compound which can be found in natural gases as well as in volcanic gases and hot springs. Hydrogen sulphide is generated as a by-product by many industrial activities such as petroleum refining, pulp, paper manufacturing and wastewater treatment plant (Barona et al., 2004). It has a very typical smell of rotten eggs and it can be smelled at low concentrations (about 0.5 ppb) (Busca and Pistarino, 2003).

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Several processes, such as scrubbing, adsorption and condensation, have been proposed for the treatment of waste gases. The physicochemical methods that have been used to remove pollutants from gas emissions have relatively high energy requirements and high chemical and disposal cost (YanLing et al., 2006).

Biofiltration is one of the most important biological processes of waste gas treatment and of odour control. Successful applications of this technology have been reported in wastewater treatment, petrochemical and tobacco industries (McNevin and Barford, 2000; Duan et al., 2006). This process has been increasingly regarded as the best available control technology owing to its high removal efficiencies, its low initial and operating cost and the easiness of its maintenance (Kikuchi, 2000; Busca and Pistarino, 2003). A biofilter consists of a container of organic material, populated with micro-organisms, through which contaminated air is usually passed upwards. The contaminated air stream is concurrently or counter-currently contacted with a liquid phase that provides nutrients and conditions to keep the viability and activity of the biofilm. In concurrent mode, contaminated air and liquid phase are sprayed from the top of the bed although this is kept to a minimum to prevent bed settling. But in the counter-current mode, contaminated air is sprayed from the bottom of the bed and the liquid phase is sprayed from the top of the bed. The contaminated gases pass through the biofilter bed, pollutants are transported into the biofilm where they are used by bacteria as a carbon source, an energy source or both (Ortiz et al., 2003; Ma et al., 2006). Through oxidative reactions, organic contaminants are converted to odourless compounds, such as carbon dioxide, water vapour, and organic biomass. When degrading inorganic compounds such as hydrogen sulphide, autotrophic bacteria utilise carbon dioxide as a carbon source resulting in the production of new biomass and sulphate or elemental sulphur (Barona et al., 2004; Andersson and Grennberg, 2001). Various bioactive media have been used as a packing bed such as compost, soil and horse manure. Packing medium should have a high surface area, high air and water permeabilities, and should provide a good surface of microbial growth. It plays an important role in air and water distribution, as well as the mass transfer (Song and Kinney, 2000). Biofilter performance is highly dependent on several parameters such as pH, temperature, adequate moisture content and inlet and outlet of H_2S. It also depends on the microbial community of the packed bed. The understanding of the microbial structure and diversity is important for biofiltration operation. However, only limited information is available on the microbial communities involved in the biofiltration of odourous pollutants. Currently, several molecular techniques, such as denaturing gradient gel electrophoresis (DGGE) and SSCP, have been used to study microbial communities. PCR-SSCP method offers a simple, inexpensive and sensitive method for studying the microbial diversity from several ecosystems. It can give a more objective picture of the bacterial community (Khelifi et al., 2009).

The objective of this study was to investigate the effects of the H_2S loading rate, firstly on the biofilter performance (e.g., elimination capacity, removal efficiency) and secondly on the bacterial diversity and dynamics. Various physicochemical and microbiological parameters were monitored, including H_2S concentration, moisture content, pH, Chemical oxygen demand (COD), sulphate concentration and colonies forming units (CFU). The bacterial communities of the biofilter were examined by the PCR-SSCP technique.

2. Material and methods

2.1. Experimental design

Biofilter system was designed according to previous work (Omri et al., 2011) and it is schematically displayed in Fig. 1. This Biofilter has a cubic form with a height of 2 m, an outside width of 5.4 m and an inside width of 4.9 m. It was packed with peat (German Company: NEVEMA GmbH) which has a height of 1 m and a porosity of 60%. The concentration of H_2S was unstable in the inlet of biofilter. It ranged between 200 and 1300 mg m^{-3}. Therefore, the loading rate is sometimes higher than microbial capacity, affecting the microbial stability. These problems were countered to some extent by using higher EBRT (60 s). Treated wastewater was used as the nutrient solution and it was sprayed from a nozzle at the top of the biofilter. This irrigation maintains the bed moisture and provides the essential nutrients for the microbial activity, as well as the removal of the by-products produced during the biological reaction. The flow rate of the irrigation solution was constant.

2.2. Odourous gas collection

The gas concentration on the sampling points in the biofilter system was periodically monitored. The gas samples were collected in Tedlar bags on the sampling points and were analysed immediately to avoid sample deterioration.

2.3. Sampling and analyses

Analyses were performed for the inlet and outlet gases, the irrigation liquid phase and the peat packed bed biofilter. Peat

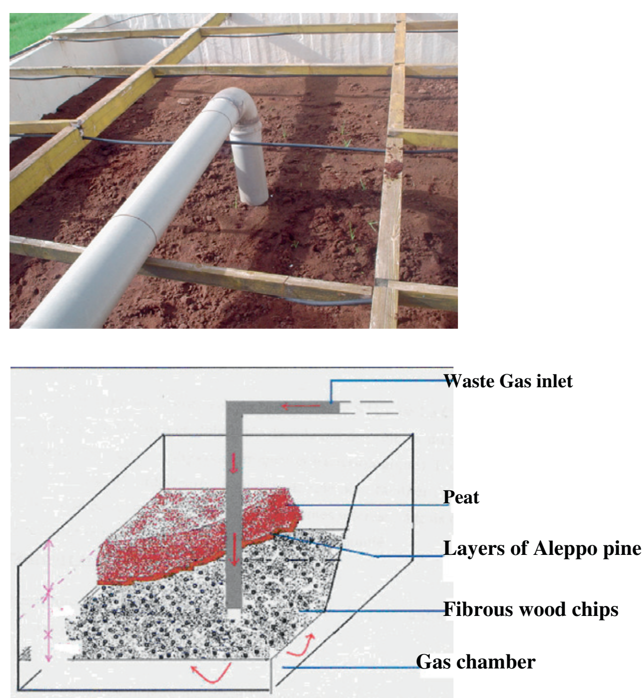

Figure 1 Pilot scale biofilter.