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Analysis of Potential Exposure to Components of Municipal Solid Waste in a Mechanical Biological Treatment †

Marta Wiśniewska

Faculty of Building Services, Hydro and Environmental Engineering, Warsaw University of Technology, Nowowiejska 20 Street, 00-653 Warsaw, Poland; marta.wisniewska.89@wp.pl; Tel.: +48-22-234-54-07

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Abstract: Municipal waste treatment plants are a special kind of municipal facility, which, in addition to the benefits of waste management, are also an important source of energy from the biogas captured. However, the processes and unit operations carried out at waste management plants are associated with the emission of dust and chemical compounds. This paper presents the results of research aimed at analyzing indoor air conditions at a biogas plant having an installation for mechanical-biological waste treatment in places where employees work. Tests include measuring the respirable and non-respirable dust fractions and measuring volatile organic compounds (VOCs) and ammonia (NH_3).

Keywords: ammonia; dusts; municipal waste; volatile organic compounds

1. Introduction

Anaerobic stabilization is probably one of the most promising technologies for processing organic waste into bioenergy, including methane rich biogas and fertilizer products [1,2]. In New Zealand, anaerobic stabilization is considered to be the most attractive waste management solution due to its environmental and economic benefits [3]. From the beginning of the 20th century, anaerobic digestion has been widely used at sewage treatment plants in the European Union and in many developed countries in the Asian subcontinent [4]. Thi et al. [5] compared different ways of processing food waste and pointed out that anaerobic digestion may be appropriate in temperate developing countries. Anaerobic digestion brings lower costs for collection, transport, and brings economic and environmental benefits [6].

These plants, in which the processing of municipal waste is inseparably connected with the emission of process gases [7], may contribute to the creation of harmful working conditions for the plant operators. The main air pollutants in waste management plants include, among other dusts, volatile organic compounds (VOCs) and ammonia (NH_3) [8,9]. All these pollutants can have a negative impact on the health and well-being of plant workers. The World Health Organization (WHO) has recognized volatile organic compounds as the most important indoor air pollution. Indoor air is considered harmless when the total VOC content is below 100 g/m^3. Of the approximately 500 volatile compounds found so far and present in indoor air, only a few turned out to be pathogenic. Nevertheless, it is believed that many of them contribute to the occurrence of such symptoms as allergies, headaches, loss of concentration, drying and irritation of the nasal mucosa, throat, and eyes, etc. [10–12].

In Europe, there are legal regulations specifying the air conditions at workplaces. These include European Directives [13–15]. In Poland, there are also legal regulations specifying the maximum permissible concentrations and intensities of agents harmful to health and the working environment [16]. In 2016, the United States Environmental Protection Agency (USEPA) published the Compliance Monitoring Strategy for the Toxic Substances Control Act (TSCA), which provides guidance to employees of EPA and authorized states with respect to administering and implementing an Agency program for TSCA compliance monitoring [17].

The paper presents the results of measurement tests of dust, ammonia, and volatile organic compounds at one of the biogas plants processing municipal waste in Poland.

The aim of the study is to analyze the concentration values of the tested compounds in terms of their harmfulness to employees operating a mechanical-biological waste treatment plant in accordance with the Directive and the influence of various factors on the obtained test results.

2. Materials and Methods

The subject of research within the framework of this work is a plant for mechanical-biological treatment (MBT) of municipal waste. A methane fermentation process is used to stabilize the biodegradable waste fraction. During this process, biogas is released, which is captured, treated, and cogenerated into energy through the biogas plant. The plant is equipped with a waste storage hall, mechanical treatment hall, and fermentation preparation. The fermentation process is carried out under dry mesophilic conditions. The technology used requires loading and unloading of the input material by means of an employee-operated loader. Tests of air dust pollution were carried out in two measurement points: In the waste unloading hall and in the sorting cabin. In the unloading hall, two people work as cleaners, potentially exposed to airborne dusts. Their work includes activities on the belt with a shredder, cleaning and sorting waste, and cleaning the hall. The hall is equipped with mechanical and gravitational ventilation system. The exposure time is 450 minutes. Eight people work in the sorting booth at the sorter's stand to sort waste on the line, and clean the booth. The sorting cabin is equipped with local extraction and the exposure time is 450 minutes. In Figure 1 the technological scheme of analyzed waste treatment plant was presented.

Figure 1. The technological scheme of analyzed waste treatment plant.

The research includes the content of the inhalable fraction of free crystalline silica in the dust (colorimetric method)—according to the PN-91/Z-04018/04 standard; the inhalable fraction of the dusts containing crystalline silica from 2% to 50% (filter-weighting method)—according to the PN-91/Z-04030/05 standard and the respirable fraction of the dusts containing crystalline silica from 2% to 50% (filter-weighting method)—according to the PN-91/Z-04030/06 standard [18,19]. In addition, the study also includes the determination of chemical compounds in the air in all halls served by employees (both in the mechanical and biological part using the MultiRae Pro gas detector (RAE Systems, Inc., San Jose, CA, USA). These compounds include ammonia and volatile organic compounds (VOCs). Dust tests were performed in one measurement series and chemical tests in six. During the determination in each of the halls, temperature and relative air humidity were measured at a height of 1.5 m by a portable device from Kestrel, model 4500 NV.

3. Results and Discussion

As a result of dust pollution tests, it was found that the weighted average concentration of dust—inhalable fraction and respirable fraction—does not exceed the maximum permissible concentrations (WEL) specified in the Regulation [16] (the maximum permissible concentration for the inhalable fraction is 2 mg/m^3 and for the respirable fraction is 4 mg/m^3). In the case of ammonia, the results obtained were also not exceeded during any of the measurement series (the maximum concentration for ammonia according to [16] is 14 mg/m^3). Volatile organic compounds (VOCs), expressed as a sum, are not listed in the Regulation [16]. The highest concentration of volatile organic compounds was observed in the waste storage hall, where most of the mixed waste was located, and in the fermentation preparation hall.

4. Conclusions

In the studied plant, no values of dust and ammonia concentrations higher than the maximum permissible concentration described in the Polish Regulation were found [16]. However, due to the variability of various factors at the plant site, such as the amount and type of delivered waste or occurring failures disrupting the operation of the mechanical-biological waste processing plant, it is advisable to control the tested parameters during the year. In accordance with the BAT (best available techniques) conclusions for waste treatment [20], the parameters tested (dust, ammonia, and volatile organic compounds) should be tested once every six months.

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