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Characteristics of odors emitted from municipal wastewater treatment plant and methods for their identification and deodorization techniques

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ABSTRACT

Odors emitted from municipal wastewater treatment plants belong to a group of pollutants, which is the main cause of people complaining about atmospheric air quality. The limitation of emissions of unpleasant odors generated by wastewater treatment plants by using appropriate deodorization methods is omitted on numerous occasions. This can have a negative influence on public trust and the quality of atmospheric air. The article presents basic information on the characteristics of odors from wastewater treatment lines and wastewater processing and management lines in a model biological wastewater treatment plant conducting the biogas recovery process and also information is provided on deodorization methods, such as odor masking, biofiltration, thermal disposal and diffusion through activated sludge dedicated to neutralization of odors in biological treatment plants. The main focus is on the field olfactometry technique, which is one of the tools used in environmental protection. Its application facilitates performance of tests concerning the assessment of olfactory properties of odorants in polluted air.

Contents

1. Introduction

Municipal waste landfills, wastewater treatment plants and other plants where air pollution is generated used to be built on

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the outskirts of cities. At present, due to progressing urbanization, the distance between residential areas and such plants has decreased. Odors and other air pollutants are a growing problem, which is not only ecological one, but also a social one (Fang et al., 2012; Aatamila et al., 2011). The municipal wastewater treatment process, which allows reduction of odor emissions, is often omitted and the unpleasant smell of atmospheric air and the smell of treated water may have a negative impact on the community's life (Agus et al., 2012). Over the past decade, an increase in the number of residents' complaints on the occurrence of onerous odors in atmospheric air in areas adjacent to large industrial and municipal plants. As a result, the interest in the environmental impact of wastewater treatment plants has been growing and EU Member States are spending more and more money on limiting odor emissions and deodorization (Kim et al., 2014).

For technological reasons, wastewater treatment plants always occupy a large surface area, ranging from several to more than a dozen hectares and, as a result, are often considered responsible for odor emissions. On many occasions, large plants are regarded as responsible for emissions of unpleasant odors despite the fact that the largest quantities of odors are not emitted by the plants. Even the surface area occupied by small treatment plants with the throughput of up to 550 m^3 a day is relatively high; however, the range of odor impact does not usually exceed 200 m (Bruszkiewski and Skorupski, 1999). However, it is important to have on mind topographic and meteorological conditions. On the basis of analyzing the results of the research conducted so far, it can be concluded that concentrations of volatile organic compounds in the area of the treatment plant occur at relatively low levels as compared to the level of these pollutants in areas, where wastewater is discharged from sanitation tanks, composting plants or municipal landfills. Odors emitted from such installations stimulate human olfactory receptors, cause unpleasant olfactory sensations and can have a significant impact on the quality of the environment (Fang et al., 2012; Bruszkiewski and Skorupski, 1999).

The article specifies characteristic groups of odorants emitted into the air at individual stages of the wastewater treatment process and excess sludge management. The assessment of odor emissions was conducted for the model wastewater treatment plant where mechanical, biological and chemical wastewater treatment is assumed together with biogas recovery from excess sludge and burning of post-fermentation residues. In the article, air pollutant emissions are assessed from individual technological systems, which can be found at a wastewater treatment plant, and technological treatments are described, which can reduce odor emissions. Also, deodorization methods were also described, which can be used at wastewater treatment plants, and the field olfactometry technique, which is presented as a tool enabling specification of odor intensity, which, indirectly, makes it possible to control emissions of odorous substances. Its application allows verification of complaints from residents related to the impact of onerous odors occurring near municipal wastewater treatment plants. It can constitute a tool allowing the monitoring of the environment condition to maintain its appropriate quality.

2. Characteristics of odor emissions for municipal wastewater treatment plant areas

A wastewater treatment plant is a complex network of interconnected technological systems with different process conditions at every stage of the treatment. Wastewater, which reaches each treatment plant, may differ considerably in terms of their physical and chemical properties, which defines an appropriate technology. As a result, various groups of air pollutants can be generated at each stage wastewater treatment and sludge management. All kinds of processing media, runoff water and stormwater as well as precipitation reaching treatment plants, together with wastewater, may cause the formation of precursors of odoriferous compounds. Alcohols, volatile fatty acids, aldehydes and ketones are carbohydrate decomposition products. Ammonia is produced as a result of fat and protein distribution. Hydrogen sulfide is generated during anaerobic decomposition of sulfur-containing proteins. Decay processes of vegetables may cause emissions of carbon disulfide and mercaptans into the atmosphere. Decay processes of fish, veal, poultry waste and hot spices can contribute to emissions of ethylamine, trimethylamine and indoleamines (Fang et al., 2012). Wastewater can be a mixture of all of the aforementioned kinds of waste. A high contribution of industrial waste, e.g. from the oil industry, the tanning industry or the cosmetic industry and food waste may result in the presence of a broad range of odorants and precursors of their formation (El-Shafai et al., 2004; Annadurai et al., 2003). As a result, the identification and quantitative determination of chemical compounds, which cause unpleasant sensations, often prove to be very complex, especially if the composition of the odorous mixture is conditioned by the presence of various groups of odorous compounds (Hort et al., 2009; Agus et al., 2012). Table 1 presents basic information about the characteristics of selected odorous compounds emitted from municipal wastewater treatment plants.

It should be noticed that volatile compounds are not the only group of odorants and pollutants released into the air by municipal wastewater treatment plants. Hydrogen sulfide and ammonia belong to the group of three basic pollutants occurring in the air above the area, where wastewater treatment plants are located, which are released in the largest amounts (Agus et al., 2012). On the premises of wastewater treatment plants that occupy a small area, the concentrations of hydrogen sulfide and methane are usually below the limit of detectability of average measuring systems used for determining concentrations of these chemical compounds (16.7 $\mu g/m^3$ of air). Ammonia, on the other hand, usually occurs at higher concentrations (from 0.39 mg/m^3 to 0.56 mg/m^3), especially in the area of facilities used for mechanical and biological treatment of wastewater (Fang et al., 2012). The values of pollutant concentrations in the air in the areas surrounding small wastewater treatment plants do not constitute a hazard to the environment or human health and, therefore, their treatment is often regarded as economically unjustified (Bruszkiewski and Skorupski, 1999). The problem is more serious in areas with entities with a much larger and usable surface area, where hundreds of thousands cubic meters of wastewater are treated every day and thousands of cubic meters of primary and excess sludge are processed further.

Two basic process lines can be distinguished on the premises of municipal wastewater treatment plants with a large surface area:

- wastewater treatment line called the wastewater line,
- sludge processing and management line called

the sludge line.

Zones can be separated within each of them, in which a specific group of air pollutants is emitted. Depending on the wastewater treatment or processing technology use, other types of odoriferous compounds are emitted. The majority of odors emitted at a treatment plant, regardless of the emission zone, are generated during anaerobic processes. This emission is related to a low oxygen content in the treated wastewater, processed sludge and with the conditions, under which a technological process is conducted (aerobic or anaerobic) (Shao et al., 2014). Reduced sulfur compounds are mostly odors edited during processes of anaerobic treatment and during wastewater and sludge processing (Liu et al., 2012). The majority of odorants emitted as a result of solid