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Review

An overview of principles of odor production, emission, and control methods in wastewater collection and treatment systems

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ABSTRACT

Odorous gases are the most important reason that people register complaints with organizations responsible for wastewater collection and treatment systems (WCTS). Although several studies have been conducted for prevention and control of odorous gases, no comprehensive research exists about recent achievements in this area. The aim of the present study is to collect and categorize the new achievements in preventing and controlling odorous gases in WCTS. Two strategies for controlling odor emissions from WCTS are (1) prevention of odor production and (2) removal of odorous compounds from emissions of WCTS. Between the two, priority goes to preventing odorous compounds' production. Several methods have been developed to prevent odor production, such as increasing oxidation reduction potential; inhibiting the activity of sulfide reducing bacteria; chemical removal of hydrogen sulfide; applying formaldehyde and paraformaldehyde to prevent hydrogen sulfide production; and using fuel cells in hydrogen sulfide inhibition and gradual release of oxygen in gas phase by using MgO_2 or CaO_2. In addition to preventing odorous compounds in WCTS, many other methods have been introduced to remove odorous compounds from emissions of WCTS, such as biofilters; bioscrubbers; biotrickling filters; suspended growth reactors; and membrane bioreactors and scrubbers. Through this review, responsible organizations can find new, effective, and economical strategies to prevent and control odorous gases in WCTS.

Contents

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1. Introduction

Gases that primarily affect the sense of smell are known as the "odorous gases." These gases usually convey a negative and unpleasant sense. When asked to describe the odorous compounds, most people refer to them as unpleasant odors. However, even pleasant and desirable odors may become uncomfortable in high concentrations. In many cases, by cleaning wastewater treatment facilities, removing excess sand and sludge, and optimized operation, odor generation in sewer installations can be dramatically reduced. In some cases, by bringing in clean outside air or by discharging polluted air in indoor facilities, odor-causing pollutants can be reduced. Sometimes discharging polluted gasses outside facilities can lead to protests from local residents. In such circumstances, pollutant control must be achieved through exhaust air treatment (Nielsen et al., 1998; Zhang et al., 2008; Hvitved-Jacobsen., 2002).

Hydrogen sulfide is considered the most important reason for odor emission and corrosion in wastewater collection and treatment facilities. In 1996, Sydney et al. investigated the corrosion of wastewater collection networks in the city of Los Angeles. They confirmed hydrogen sulfide corrosion in 10% of the pipes. The wastewater collection network estimated the loss at US$500 million (Sydney et al., 1996). Kaempfer et al. conducted a similar investigation in 1998 in Germany. They concluded that the damage caused by the lack of hydrogen sulfide control in wastewater collection networks amounted to US$125 million. Vincke (2002) revealed that the damage caused by the hydrogen sulfide corrosion of Belgium's wastewater collection networks was US$2.6 million per year, equivalent to 10% of the nation's wastewater treatment and collection costs (Kaempfer and Berndt, 1998; Antonopoulou et al., 2014).

Despite several studies on prevention and control of odorous gases, no comprehensive paper exists about recent research achievements. The present study collects and categorizes new achievements in prevention and control of odorous gases in WCTS.

2. Odor and odorous compounds in wastewater facilities

Humans and animals recognize the presence of chemical contaminants through stimulation of their smell organs. Odors can be pleasant (perfume, fresh food) or unpleasant (rotten egg, sewage). Individual reaction to smells differs with physiological and psychological aspects. Some people may perceive certain smells as pleasant, while others might perceive them as unpleasant. During the wastewater collection and treatment operation, odor-producing compounds are generated through the anaerobic decomposition of organic matter containing sulfur and nitrogen (Nielsen et al., 1998; Zhang et al., 2008; Hvitved-Jacobsen., 2002). These volatile compounds possess relatively low molecular weight. Odorous compounds have an odor threshold value, the odor unit, in which the odor is not detectable below a given concentration. To measure accurately the odor in water, at least five individuals are needed. Each individual attempts to smell the odor. If they detect the odor, the water is then diluted with distilled water and the process is repeated. The dilution is repeated until the odor is no longer detectable. Ultimately, the odor threshold value is calculated using Equation (1) (Tchobanoglous and Burton, 2003):

$$TON = (A + B)/A \tag{1}$$

Where A is the volume of odorous water, B is the volume of the odorless distilled water used in the test, and TON is the threshold odor number. Three is the maximum acceptable threshold value. The compound that produces the most odors usually possesses low molecular weight. Gaseous compounds with molecular weight higher than 300 g per mole are generally considered odorless. Hydrogen sulfide, one of the most important odor-causing compounds, possesses a molecular weight of 34 g per mole.

Indoles, skatoles, mercaptans, various volatile organic compounds (VOCs), hydrogen sulfide, and ammonia are among the odorous compounds that are capable of producing odor in wastewater collection and treatment facilities. The main odor-producing compounds and their associated information are listed in Table 1. Odor-causing compounds presented in Table 1, rows 1–24, can naturally enter water supplies as the result of biochemical reactions. Compounds presented in rows 25–30 are produced in microbial biofilm layers formed in drinking water distribution networks, in which they are released into the water supply. Compounds presented in rows 31–34 are produced during the