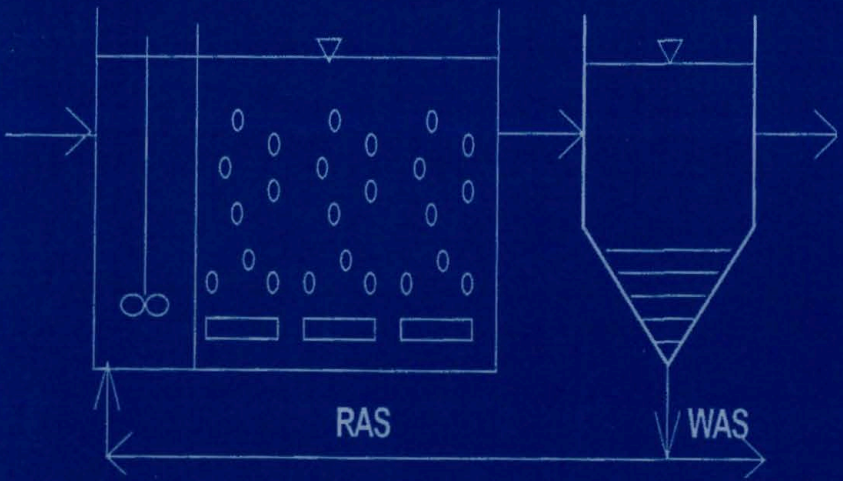
Advances in Water and Wastewater Treatment



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ADVANCES IN WATER AND WASTEWATER TREATMENT

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Impact of Global Warming Concerns on Wastewater Treatment Plant Design and Operation

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Abstract

This paper provides an overview of the impact of global warming concerns on wastewater treatment plant design and operation. The issues surrounding global warming concerns are discussed, along with the linkage between global warming and greenhouse gas emissions. US greenhouse gas emission inventories are reviewed, along with the role of wastewater treatment plants in reducing such emissions. It is found that process related emissions from wastewater treatment plants are less than 1 % of total greenhouse gas emissions. Limited flexibility exists to reduce process-related emissions. One of the principal options is to minimize CH_4 emissions at the expense of CO_2 emissions by stabilizing biodegradable organic matter aerobically rather than anaerobically, or by capturing and combusting any CH_4 produced. The global warming potential of CH_4 is 21 times higher than that of CO_2. Principal options for reducing greenhouse gas emissions involve selection of biosolids reuse options and energy consumption measures. Landfilling of waste biosolids should be avoided as this leads to CH_4 emissions. Agricultural reuse can reduce greenhouse gas emissions if land management practices increase soil organic carbon content and/or if crops are grown that can be used to produce renewable fuels (such as ethanol). Greenhouse gas emissions can also be reduced by energy conservation measures that reduce the use of fossil fuels, or the consumption of energy produced from them. Greenhouse gas emissions may be considered during the evaluation of alternatives for upgrading wastewater treatment plants, or as part of an overall emissions inventory.

Keywords

Global warming, greenhouse gases, emissions, wastewater treatment plants, design, operation, carbon dioxide, methane

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Introduction and Purpose

With the on-going publicity that greenhouse gas emissions and their potential impact on global warming has produced, we have all become sensitized to this global environmental issue. As discussed immediately below, concern exists that the earth's temperature is increasing and that this is a result of emission of the so-called greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4). Since one of the principal objectives of wastewater treatment is the stabilization of biodegradable organic matter (i.e. its conversion to CO_2 and CH_4), it is reasonable to expect that global warming concerns may affect wastewater treatment plant design and operation. The purpose of this paper is to provide an overview of global warming concerns and discuss their potential impact on the design and operation of wastewater treatment plants.

Overview of Global Warming

What is Global Warming?

Evidence suggests that the earth's temperature is increasing. Figure 1 presents global mean surface temperatures for the period of 1861 to 1996 using the year 1930 as a reference point, as developed by the IPPC (1996).

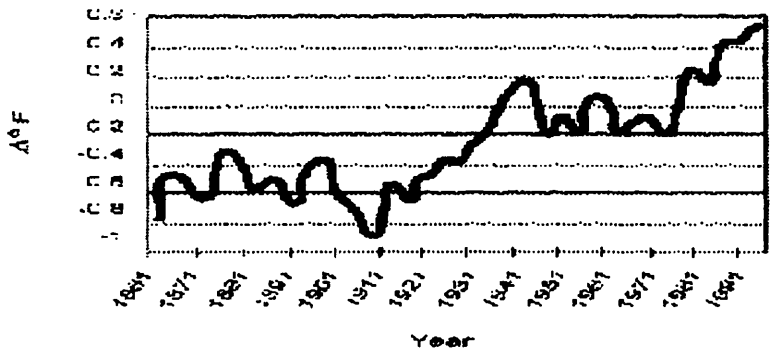

Figure 1
Global Temperature Changes from 1861 to 1996

Temperatures varied randomly in the early part of this data record, but they have increased steadily since about the turn of the century for a total increase on the order of 0.3 to 0.6 °C (0.6 to 1.2 °F). The nine warmest years in the 20th century have occurred in the last fourteen years. In fact, 1998 was the warmest. The snow cover in the Northern atmosphere and floating ice in the Arctic Ocean have reduced, and sea level has risen between 10 and 25 cm (4 and 10 inches) over the past century. Weather patterns have changed, with an increase in average precipitation as well as in

the frequency of extreme rainfall events. All of these changes are symptomatic of a general increase in the average temperature of the planet.

What is Causing These Changes?

This question is a cause of intense scientific debate. Are these global changes just natural fluctuations with a variety of natural causes? Possibly yes. As illustrated in Figure 2, global temperatures have historically fluctuated with a primary cycle of about 100,000 years and mixed or secondary cycles ranging from 23,000 to 41,000 years (Masters, 1991). We are all aware that ice ages have occurred which caused vast glaciers to cover significant portions of the Northern Hemisphere. But, the on-set of the temperature changes described above at about the same time as increased global industrialization suggests that it is a result of anthropogenic (i.e, human-induced) activity. Moreover, changes to the atmosphere that are a result of anthropogenic activities provide a potential explanation for these increasing temperatures.

The earth's atmosphere contains gases with heat trapping properties, including water vapor but also compounds such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Sunlight reaches the earth in the form of short wavelength radiation. The wavelength for emitted radiation is a function of the temperature of the body emitting it (Masters, 1991). The median wavelength for solar radiation is 0.5 μm (since the mean temperature of the sun is 6,000 °K, about 10,000 °F). A portion of the solar energy reaching the earth is reflected, while the remainder passes through the atmosphere and is adsorbed by the earth. The earth radiates some of this adsorbed energy since its temperature is higher than the surrounding space. Because the earth's temperature is lower than that of the sun (the mean temperature of the earth is about 15 °C, equal to 60 °F or 288 °K), it radiates energy at a much longer median wavelength of 10.1 μm. The greenhouse gases (CO_2, CH_4, and N_2O) adsorb energy within the wavelength spectrum of the energy emitted by the earth and prevent its passage back into space. This is referred to as the "greenhouse" effect, as illustrated in Figure 3. Without this effect, the earth's temperature would be about 60 °F (33 °C) lower than it is, making life as we know it impossible. Thus, this energy-trapping feature of the atmosphere is positive with respect to life on earth.

Industrialization has caused increased releases of greenhouse gases into the atmosphere, resulting in increased concentrations of these energy-trapping gases in the atmosphere. Figure 4 presents long-term trends in atmospheric CO_2 concentrations, while Figure 5 presents shorter-term trends in atmospheric CO_2 concentrations. Atmospheric CO_2 concentrations are currently increasing at a rate of about 0.5 %/yr. Figure 6 illustrates similar trends in CH_4, which is currently increasing at a rate of about 0.8 %/yr. Comparison of the trend in short-term atmospheric CO_2 concentrations with the trend in global mean temperatures presented in Figure 1 clearly illustrates a correlation between them. Controversy exists whether a direct cause and effect relationship exists between anthropogenic CO_2 emissions and the global temperature increase currently occurring. However, with the known mechanistic relationship between greenhouse gas concentrations and temperature it is