Suppression of methane generation during methanogenesis by humic substances modified with Fe(III)

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Global warming can cause a significant increase in methane emissions from vast wetlands into the atmosphere as a result of melting permafrost. However, it was shown that presence of humic substances (HS) and Fe³⁺ in these territories can inhibit the release of CH₄. This effect is associated with HS and Fe (III) used by anaerobic methanogenic microorganisms as a terminal electron acceptor [1]. However, it was revealed that the donor/acceptor capacity of HS, extracted from various sources, varies greatly due to differences in their chemical composition [2]. When studying the efficiency of biogas accumulation under the action of natural anaerobic consortia in the presence of different HS, it was found that fulvic acids samples introduced into the nutrient medium at a concentration up to 10 g/L stimulated the accumulation of biogas production, but 10 g/L of potassium humate modified with naphthoquinone led to reduction of CH₄ synthesis [3].

The introduction of various concentrations of chemically modified humic compounds (HS) with Fe(III) into the media with free and immobilized anaerobic consortia accumulating landfill gases was studied. The following composite materials were used: Fe(III) hydroxide fulvate, Fe(III) hydroxide 1,4-naphthoquinone potassium humate, Fe(III) hydroxide potassium humate.

The maximum decrease (up to 40%) of the methanogenic parameters (the efficiency of biogas production and the proportion of methane in biogas composition) under the action of anaerobic cell consortia being in suspended and in immobilized form, was observed when 1,4-naphthoquinone potassium humate enriched with Fe(III) hydroxide was used. The introduction of Fe(III) hydroxide fulvate led to a slight decrease in the amount of accumulated biogas and the percent of CH₄ in it. At the same time, the yield of biogas accumulated under the action of immobilized cells of the anaerobic consortium at the same concentrations of composite HS with Fe(III) was 5-20% higher than the yield of biogas accumulated under the action of suspended cells. In general, the additional enrichment of HS with Fe (III) did not lead to a significant decrease in the efficiency of methanogenesis in comparison with native HS. This may be due to the fact that the additional enrichment of HS by Fe(III) leads to a decrease in the acceptor properties of HS by formation of a stable complex with Fe(III). In this regard, it may be necessary to use other combinations of substances with HS to enhance the suppression of CH₄ synthesis.

The obtained results constitute important information that can be taken into account in the further development of scientifically grounded approaches to effective and directionally controlled suppression of gas emissions at real landfills.

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References

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