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IMPACTS OF BIOCOVER COMPOSITION ON GREENHOUSE GAS EMISSION

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Abstract
It is generally estimated that gas, which generates more than half of the greenhouse gas (GHG) emission from waste industries in landfills, is seen as a serious environmental problem worldwide. It is therefore essential to promote management methods to reduce GHG emissions from landfills as well as other sources. One way of achieving this is the usage of different types of biocover applied to them. The aim of this study is to clarify the impact of the biocover created on GHG emissions. An experiment was conducted in laboratory conditions that studied the effectiveness of biocover developed in the laboratory. Three experimental columns with a diameter of 160 mm and a height of 1500 mm were created. Active compost saturated with water at a thickness of 500 mm was used as a source of methane, a permeable layer of sand at a thickness of 300 mm was further formed and finally covered with biocover. Biocover represented 60% of fine-fraction waste, 20% of soil and 20% of compost. The experiment was launched on June 6, 2022, and the first measurements were made two weeks later. All measurements were performed with the CRDS gas measurement device Picarro G2508 (Picarro Inc., USA California). All data analysis was carried out using Descriptive statistics methods. The largest reduction in emissions is projected directly for methane emissions, as biocover technology is appropriate to reduce methane emissions. Other GHG emissions are also expected to be reduced. NH_3 emission measurements were also carried out to investigate the impact of the biocover on it. This experiment shows that the biocover created is effective and can be composed of material that has already been served. The experiment is intended to continue to obtain long-term data on the development of biotransformation and to develop more promising approaches in the future to reduce GHG emissions from landfills.
Key words: Reduction of methane emissions, greenhouse gas mitigation measures, biodegradation, waste disposal.

Introduction

Emissions from municipal landfills can have a significant impact on the local and global environment. By simplifying landfills, local impacts with odour emissions and global impacts with greenhouse gas (GHG) emission can be caused (Pecorini & Iannelli, 2020). The surface of landfills is an interface to an agitating waste layer and atmosphere where the air we breathe is located. It is therefore very important to separate it with a cover or biocover. A well-established biocover is capable of reducing GHG emissions from a landfill, and if it is still composed of a part of the waste, it also reduces its size and allows it to be used as a valuable raw material (Hakemian & Rosenzweig, 2007). The presence of CH_4 and O_2 in landfill biocover provides the necessary conditions for bacteria capable of distributing methane gas. It could become a natural process if we use biocover (Scheutz, Kjeldsen, & Bogner, 2009).

GHG emissions from landfills come from aerobic and anaerobic biological removal of waste. Extensive research has been carried out on GHG emissions from landfills which demonstrate the relevance of this problem (Zhang *et al.*, 2019). Various studies have also demonstrated that bioocovers are suitable for landfills (Bogner *et al.*, 2005; Barlaz *et al.*, 2004; Huber-Humer & Lechner, 2001; Huber-Humer, 2004). Planned biocoverings of a thickness of 40 cm or of a more than 40 cm or more have not been systematically studied (Perdikea, Mehrota, & Patrick, 2008).

The developed biocover technology will be used to reduce emissions to smaller or older landfills where methane production or combustion is not profitable. Biocover can be used in landfills with low methane production potential, such as pre-treatment waste storage facilities.

The aim of this study is to clarify the impact of the biocover created on GHG emissions.

Materials and Methods

The overall performance of the biocover system is determined by measuring greenhouse gas (GHG) emissions, in particular by focusing on CH_4 emissions. The biggest advantage of biocover is methane oxidation, pictured in Figure 1. More than half of the CH_4 concentration as a result of the interaction with O_2 constitutes carbon dioxide and water. In this way, CO_2 is released into the air and at a significantly lower concentration of CH_4 (Scheutz *et al.*, 2011). The largest methane gaze is one of the most dangerous for our climate, with the most attention being paid during the experiment.

The biocover composition was measured using the CRDS gas measurement device Picarro G2508

(Picarro Inc., USA California). Emissions were measured both from and without the biocover system so that the actual and total reductions in GHG emissions from biocover could be assessed. Each camera was measured for 250 seconds (Grinfelde *et al.*, 2017).

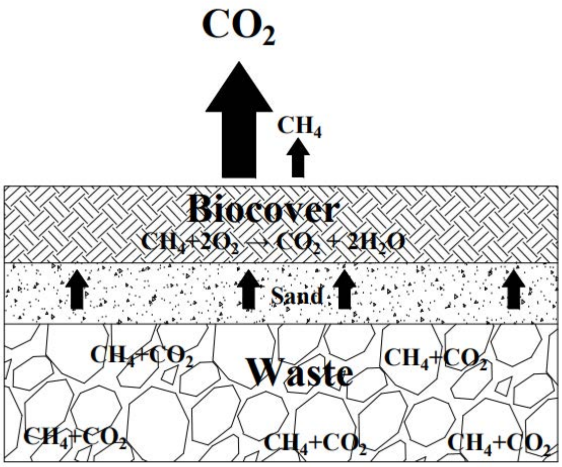

Figure 1. CH_4 and CO_2 flow from landfill through sand and biocover.

NH_3 emissions were also occurring during the measurement and are not one of the GHG emissions. It was determined because the measuring equipment also measures this gas, and its interest was applied to measurements and data analysis. Possibly, however, the installation of biocover also influences the release of this gas.

The experimental part of the study partly used the data already obtained on the dynamics of methane emissions and the analysis performed during the first three months of the experiment (Siltumens *et al.*, 2022). This helped to continue the experiment, already with a small pretext.

The whole course of the experiment was done in the laboratory, creating tube columns. Water-saturated compost was selected as a source of GHG emissions, which was mixed with small fraction waste. This constructed mass was placed at the bottom of the tube at a thickness of 500 mm. In order not to mix the compost with the bio-coating, a layer of sand was placed on top of it at a thickness of 300 mm. Finally, the biocover was applied at a thickness of 400 mm (Figure 2).

A fine fraction of waste, soil and compost was selected as a biocover stock. They were mixed in such proportions: 20% soil, 20% compost and 60% fine fraction of waste. Biocover composition is considered in Figure 3.

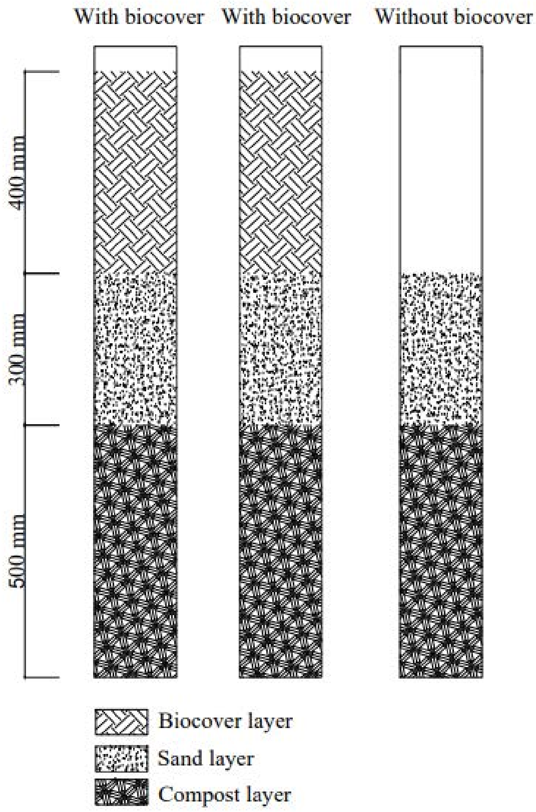

Figure 2. Schematic representation of experimental tubes.

Three tube columns were created during the experiment, two with bicover and one without. This is due to a comparison of GHG emissions with and without biocover, as well as a more realistic repetition and accurate data. Tube columns are shown in Figure 4 and and mesurment process in Figure 5.

Figure 3. Coposition of the biocover (20% soil, 20% compost and 60% fine fraction of waste).

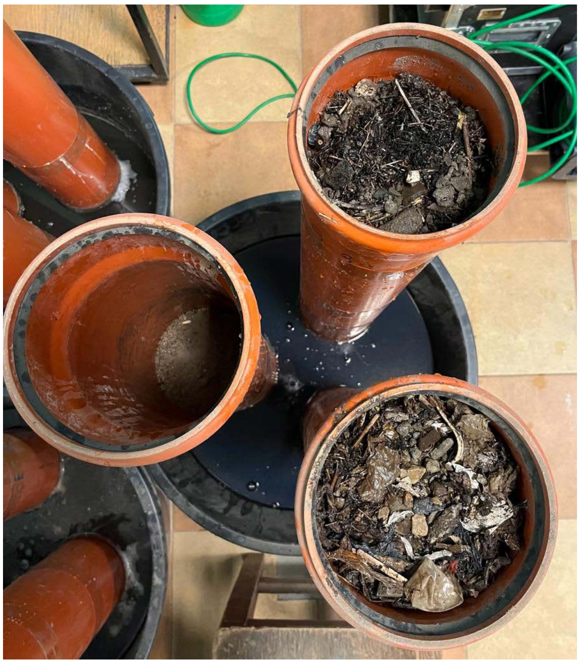

Figure 4. Three experimental tubes. Two with a layer of biocover, one without.

Figure 5. Performing measurements for experimental tubes. The humidity and temperature of biocover are determined. The results obtained are given to a measuring device that determines the amount of emissions. In parallel, emissions measurement is carried out.

The experiment was launched on 6 June 2022, when all the necessary raw materials were brought in. The first measurements were made two weeks from the time of installation. This was done with a view to making the biocover sit and settle down. Measurements were carried out on a weekly basis, for 9 months. A total of 36 measurements were made. Columns created each week were sprinkled with 250 mL of water to prevent completely drying and mimic field conditions.

A suitable lid was found for experimental tubes before the measurement work was carried out. Two tubes were added to the lid, one for air intake and the other for air discharge (Figure 5). At the beginning of the measurements, the lid was placed on the particular tube and pumped through the air outlet pipe to the CRDS gas measurement device Picarro G2508 (Picarro Inc., USA California) (Figure 6). The air flow rate in the tube was 5 mL s^{-1}. In order to avoid entering the surrounding air into the measuring equipment, a seal was fitted to the pipe cover, thereby creating a closed measurement environment.

Figure 6. CRDS gas measurement device Picarro G2508 (Picarro Inc., USA California) with a vacuum pump. This combination enables the measurement process.

CRDS gas measurement device Picarro G2508 (Picarro Inc., USA California) displays the emission amounts obtained in real time during the entire measurement period (Figure 7). It allows you to follow a specific emission level for the entire measurement period (250 seconds). It was used to follow a tick or have a closed measurement environment, which is very important for quality data acquisition.

Figure 7. Real-time amount of CO_2 emissions 82 seconds.

Results and Discussion

The data was analyzed using the descriptive statistics method. This method was selected because it provides a clear overview of the properties of the dataset.

Quantitative emissions data from CRDS gas measurement device Picarro G2508 (Picarro Inc., USA California) were processed using the descriptive statistics method. Minimum and maximum values were obtained, mean and standard deviation (Table 1). The resulting values allow you to see these differences between using and not using bicover. These data will be used in the next phase in the creation of box plots to more easily compare the results obtained.

Table 1

Descriptive statistics data

Variable	Minimum	Maximum	Mean	Std. deviation
N_2O, nmol m^{-2} s^{-1} | Compost + Sand	-0.400	21.100	4.939	4.736
N_2O, nmol m^{-2} s^{-1} | Compost + Sand + Biocover	0.100	35.900	5.164	8.588
CH_4 nmol m^{-2} s^{-1} | Compost + Sand	3.800	125.300	40.109	34.973
CH_4 nmol m^{-2} s^{-1} | Compost + Sand + Biocover	0.600	131.000	25.634	31.866
CO_2, µmol m^{-2} s^{-1} | Compost + Sand	1.300	63.800	13.296	18.290
CO_2, µmol m^{-2} s^{-1} | Compost + Sand + Biocover	1.200	118.000	13.647	22.567
NH_3, pmol m^{-2} s^{-1} | Compost + Sand	-300.000	845.000	224.935	299.827
NH_3, pmol m^{-2} s^{-1} | Compost + Sand + Biocover	-270.000	828.000	143.532	187.981

In the next step, a box plot was created to align the resulting emissions data. Each of the biocover gases was compared separately to collona without biocover.

The first of emissions was analysed for NH_3 emission concentrations. When looking at the created chart (Figure 8), it can be seen that a tube column with biocover has a lower data amplitude and that the data is almost equal to the median. In contrast, a column without a biocover has a higher data amplitude and the median is quite different from the mean of the data. After that, we can conclude that biocover has smoothed out NH_3 flow and stabilized it, as well as reduced it slightly.

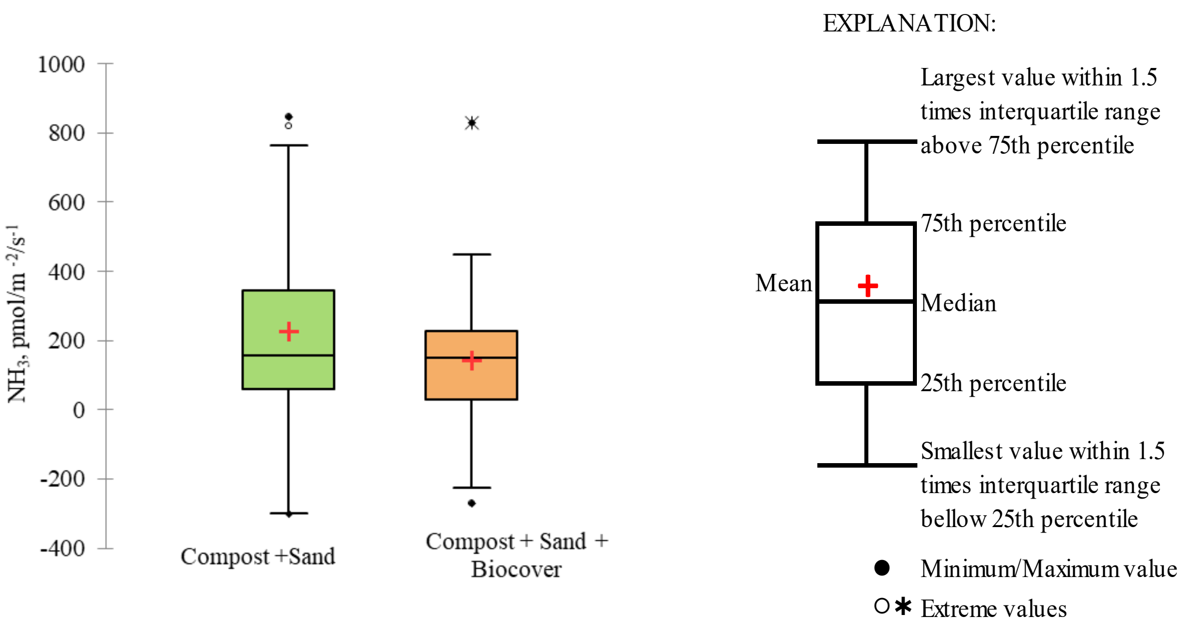

Figure 8. NH_3 emissions by experimental tube columns (NH_3, pmol m^{-2} s^{-1}).

The next analysis was the concentration of CO_2 emissions. When viewing the created (Figure 9) chart, it can be seen that the data ranges are relatively identical for both measurements. Only measurements with biocover have slightly more extreme values. The only difference significantly between the two measurements is that for biocover, most of the data has been concentrated in a smaller amplitude.

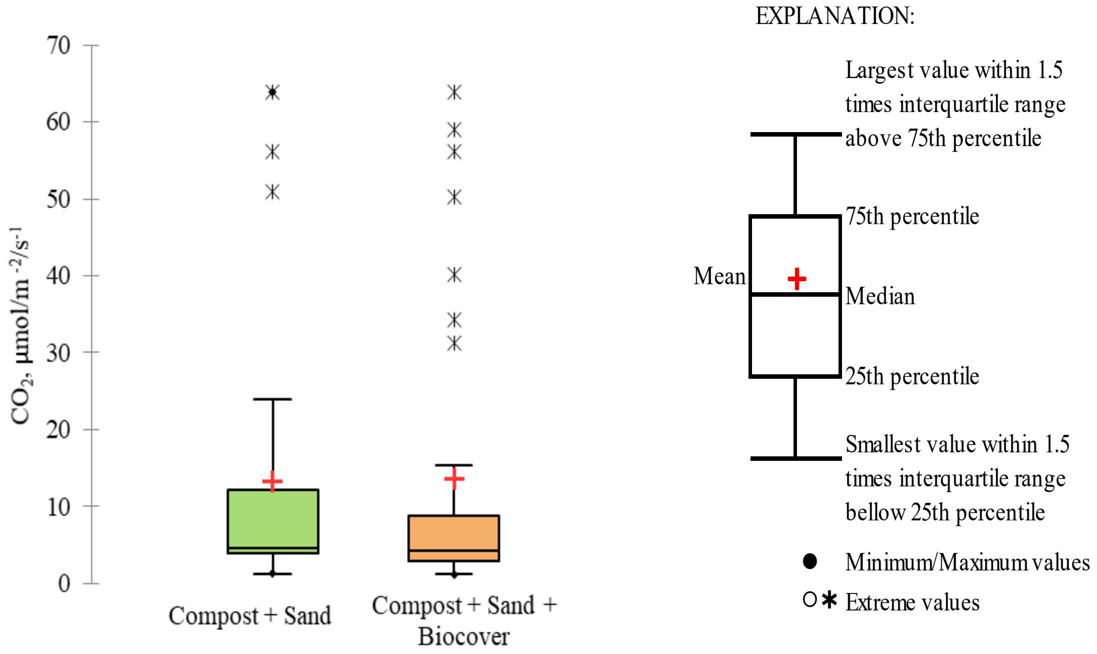

Figure 9. CO_2 emissions by experimental tube columns (CO_2, µmol m^{-2} s^{-1}).

N2O emission concentrations were analysed below. When looking at the created chart (Figure 10), it can be noticed that the tube column with biocover has slightly more extreme values than without. In contrast, the median of the data is significantly less precisely biocover. Other acquired values are relatively similar.

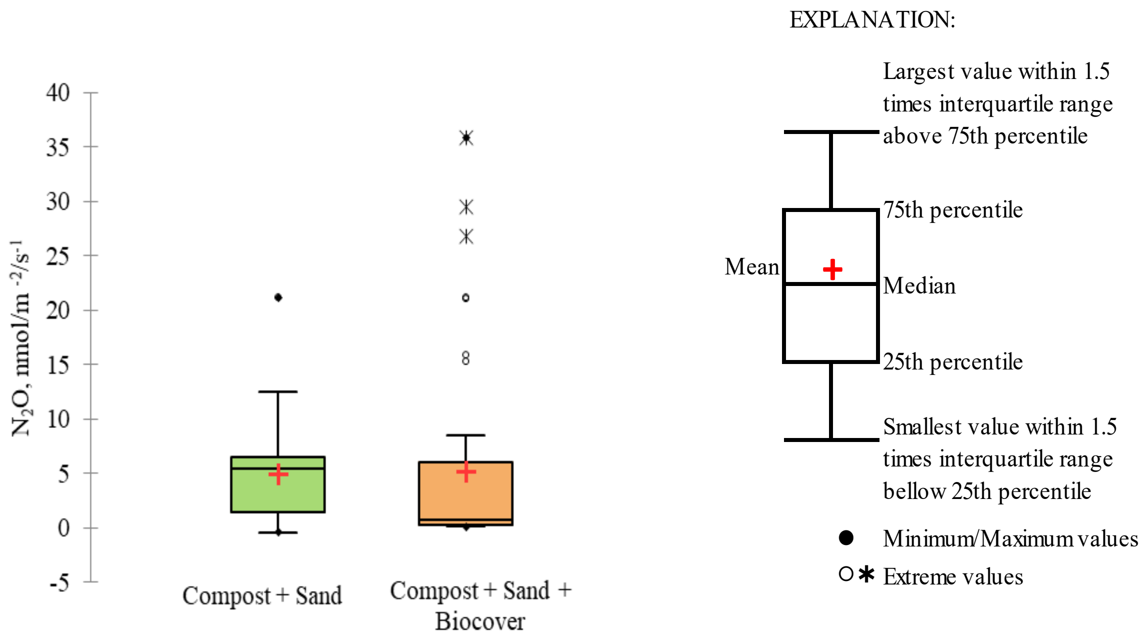

Figure 10. N_2O emissions by experimental tube columns (N_2O, nmol m^{-2} s^{-1}).

Finally, the concentration of CH_4 emissions was analysed. When examining the created chart (Figure 11), it can be seen that methane emissions from the biocover tube columns are significantly lower than without it. Lower is the median, mean of the data, data amplitude, as is the majority of the data in a lower amplitude.

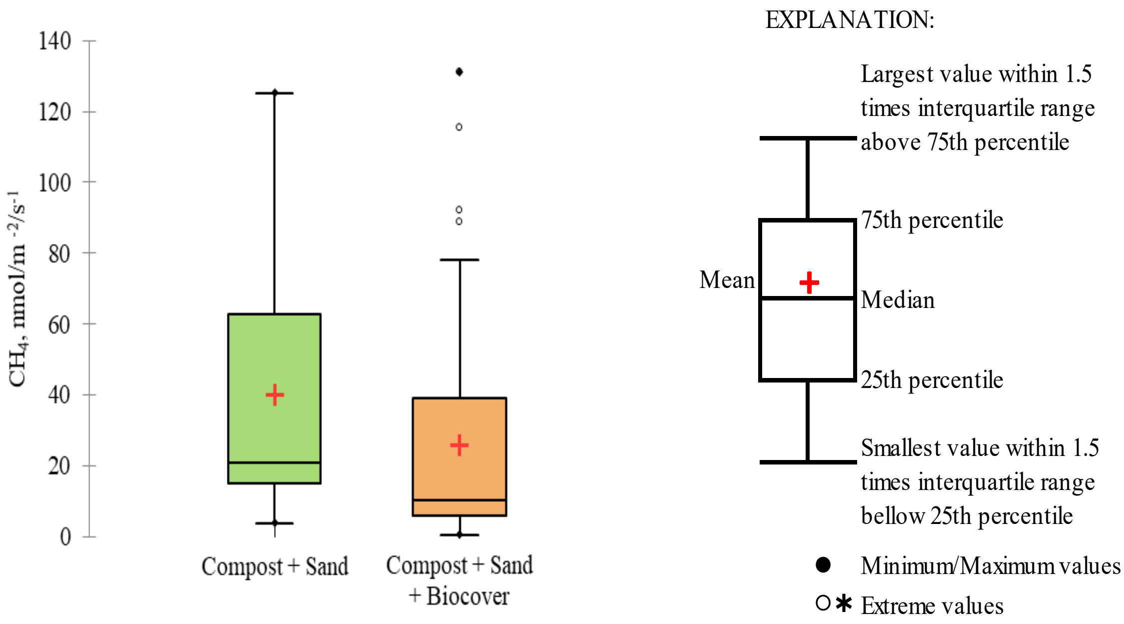

Figure 11. CH_4 emissions by experimental tube columns (CH_4 nmol m^{-2} s^{-1}).

Emissions from greenhouse gases (GHG) have been and will be a topical theme that has been supported by its escalation in recent years. In addition, landfills have a wide focus on air pollution. The results obtained are very positive as biocover was expected to have a positive impact on emissions of methane. However, it also appears to have a positive impact on other GHG emissions as well as on NH_3 emissions. Looking at other similar studies (Bogner *et al.*, 2005; Huber-Humer, 2004; Perdikea, Mehrota, & Patrick, 2008; Siltumens *et al.*, 2022), it may be observed that they place emphasis on methane emissions, which is in some way understandable because methane is the most hazardous GHG emission. After this, it can be considered that the results obtained are unique, covering all greenhouse and NH_3 gases for the materials concerned. Continuing the experiment and obtaining long-term results will be able to judge the use of this material already in landfill pilot sites.

Conclusions

The laboratory biocover experiments play a very important role with a future potential. This enables examination of the created biocover and to study the benefits and disadvantages of it in detail. Following the results, it is possible to identify the weaknesses and improve the composition of biocover. Continuing the study will make it possible to determine its effectiveness and predict the extent of the reduction in GHG emissions of the material in question.

This biocover experiment demonstrates that the created biocover is effective. The highest efficiency is observed directly on CH_4 emissions. This is a very good indicator because methane gas is the most hazardous of GHG emissions to our surrounding air and climate.

The study also shows that a largely existing material, which is a fine fraction of waste and compost, can be used to reduce GHG emissions. Biocover landfills have great potential in the future because all the ingredients used are available around the landfill site.

The experiment will be continued and further studied in order to develop more promising approaches to reduce GHG emissions from landfill in the future.

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