THE IMPACT OF TREATED WASTEWATER AND BIOSOLIDS FROM THE MUNICIPAL WASTEWATER TREATMENT PLANT ON A CO_2 EMISSION FROM SOILS

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Introduction:

Emission of CO_2 from various sources into the atmosphere is one of the factors affecting the climate change. Plant and soils are important carbon pools. Soil can store a large amount of carbon. However, due to management practices can become also a significant source of CO_2 in the atmosphere. The microbial activity and consequently the CO_2 emission can be influenced by many amendments including contaminants that can occur in soils environment. Recently, treated wastewater is due to a water scarcity used for irrigation. Sewage sludge or farm biosolids are used as fertilizers. These sources contain a large amount of nutrients, which can enhance conditions for plants' growth, but also can increase a CO_2 emission from soils. In addition, it has been found that these sources also include variety of micropollutants including the human and veterinary pharmaceuticals that can contaminate soils and plants (e.g., Golovko et al., 2016; Klement et al., 2020; Kodešová et al., 2019a,b) and can also stimulate a CO_2 emission from soils (e.g., Fér et al. 2020). The aim of this study was to compare the CO_2 efflux from two soils under different treatments, i.e., soils irrigated with tap (drinking) water and treated wastewater from the municipal wastewater treated plant, and soils emended with two types of biosolids (stabilized sewage sludge or composted sewage sludge). In addition, two types of crops were assumed.

Material and mehods

Experiment was carried out in the wastewater treatment plant (WWTP) in České Budějovice, where 9 raised beds were installed during the March 2021. The area of each bed is 1 x 1.5 m, and the height is 0.8 m. The bed consists of a wooden frame and impermeable foil inside the frame. The bottom of the bed is inclined to one side, to the opening connected to the container for collecting seeping water. At the bottom of the bed there is an 8 cm layer of gravel covered by a geotextile, 3 cm layer of sand and a 60 cm layer of soil. Two beds were filled with an Arenosol and seven beds were filled with a Cambisol (Table 1). This year, either maize or a mixture of different vegetables was grown in these beds. Of the seven beds with the Cambisol, one of the beds containing either maize or vegetables was irrigated with tap water and other pair of beds (maize or vegetables) was irrigated with treated wastewater (i.e., WWTP effluent). In another pair of beds (maize or vegetables), composted sewage sludge from WWTP (marked here as C – composted biosolid) was mixed in the soil. The applied dose corresponded to 133 tons per hectare. In one bed, in which maize was grown, soil was amended with stabilized sewage sludge from WWTP (marked here as B - biosolid). The applied amount corresponded to 44 tons per hectare. Three beds containing both types of biosolids were irrigated with tap water. Only vegetables were grown in beds with the Arenosol, which were irrigated with either tap water or treated wastewater. All beds were irrigated twice a day 20 minutes in the morning and 20 minutes in the evening. The net CO_2 efflux (NCER) and the net H_2O efflux (W_{flux}) were measured using the LCi-SD portable photosynthesis system with a Soil Respiration Chamber (Figure 1.), according to Instruction Manual to Soil Respiration Hood V2 (ADC, BioScientific, 2011). The data was recorded in one-minute intervals (50 records). The first measurement was performed after the installation of the raised beds and application of both types of biosolids at the beginning of the April (i.e., on soils without plants and not affected by different irrigation treatments). Next measurements were carried out in April, May, June, July and September (i.e., on soils with plants in different stages of growth and under irrigation with treated wastewater or tap water). The average CO_2 efflux was calculated from the recorded data.

Table 1. Designation of the raised beds in WWTP

code	soil	crop	amendment	irrigation
AVE	Arenosol	Vegetable		(WWTP) Effluent
CVE	Cambisol	Vegetable		(WWTP) Effluent
CME	Cambisol	Maize		(WWTP) Effluent
CMB	Cambisol	Maize	Biosolid (stabilized WWTP sludge)	(tap) Water
CMC	Cambisol	Maize	Compost (composted WWTP sludge)	(tap) Water
CVC	Cambisol	Vegetable	Compost (composted WWTP sludge)	(tap) Water
CMW	Cambisol	Maize		(tap) Water
CVW	Cambisol	Vegetable		(tap) Water
AVW	Arenosol	Vegetable		(tap) Water

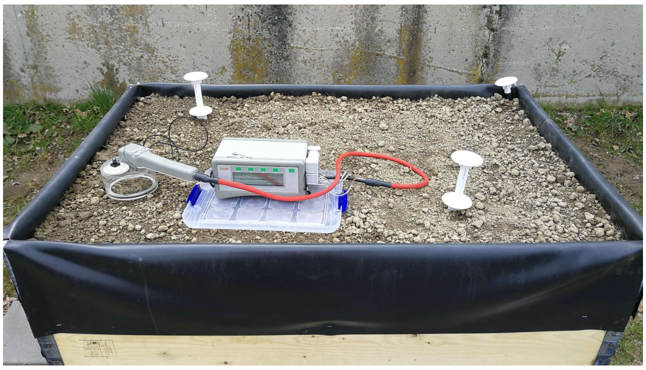

Fig. 1. Measurement of the net CO_2 efflux in in April 2021

Results and discusion:

The average CO_2 effluxes from all beds during the entire growing season are shown in Figure 2. The average values measured in early April ranged from -0.05 to 0.62 µmol^{-1} s^{-1} m^{-2}. The similar values were observed for both beds with the Arenosol. These values were considerably higher than values obtained for beds with the Cambisol without any biosolid, which were even negative. The reason can be a faster mineralization in the Arenosol due to higher warming of the sand compared to the Cambisol, and therefore higher activity of soil microbes. However, both types of biosolids considerably increased the CO_2 efflux from the amended Cambisol. The higher values of the CO_2 effluxes from soil mixed with stabilized and composted sewage sludge is caused by a higher amount of organic carbon and other nutrients affecting a soil microbial activity (Raich and Schlesinger, 1992) and perhaps also by presents of various organic contaminants (Fér et al., 2020). This affect almost disappeared at the end the vegetation season (in September) likely due to mineralization of the organic matter, uptake nutrients and other compounds by plants and percolation of dissolved substances into the drainage water. Interestingly there is no evident trend indicating any effect of treated wastewater on the measured CO_2 effluxes. Values for CMW, CVW and AVW, and for AVE, CVE and CME do not mostly differ except values measure in July for AVE and AVW, and values measured in September for AVE and CVE, and AVW and CVW. One of the reasons can be that this year, there were often rich atmospheric precipitations that could dilute applied wastewater. Our results also do not show any influence of the planted crops. Almost in all cases the average CO_2 efflux increased during the vegetation season and then declined (i.e., lower values measured from the beginning of September). The highest CO_2 effluxes were achieved in July (values varied between 1.23 and 3.32 µmol^{-1} s^{-1} m^{-2}). The CO_2 efflux was higher during the warmer months because the soil CO_2 efflux increases with increasing temperature (Schaufler et al., 2010).

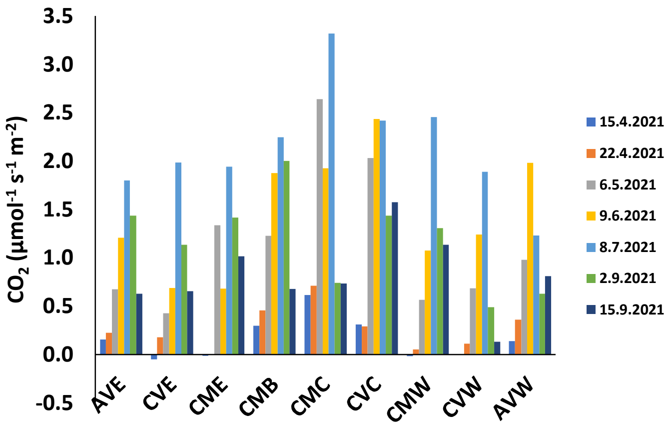

Fig. 2. Average values of the net CO_2 efflux for all beds during the entire vegetation season 2021, where the first letters A and C denote the Arenosol and Cambisol soil type, respectively, the second letters V and M imply vegetable and maize, respectively, and the last letters indicate treatments: E – irrigation with treated wastewater, W - irrigation with tap water, B - biosolid, C – composted biosolids.

Conclusion:

This study attempted to describe how different treatments and plants influence the CO_2 efflux from two types of soil. While stabilized and composted sewage sludge positively affected the CO_2 emission, the effect of treated wastewater or plant was not confirmed.

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