Effects of biogas digestate and winter crops on dissolved organic carbon and nitrates fluxes in soil.

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The anaerobic digestion industry is currently in development and enables the energetic valorization of organic waste products (OWP) to generate biogas. A co-product of this process, digestate, is more and more produced and can be recycled on agricultural lands as a low-cost alternative to mineral fertilizers. Thus, the organic carbon (C) it contains could improve the soil quality and store C in subsoil through dissolved organic C (DOC) transfers. Biogas digestate is a recent OWP characterized by a chemical composition rich in recalcitrant molecules and little is known about its impacts on dissolved fluxes in the scientific literature.

In order to evaluate the impacts of biogas digestate and winter crop on DOC and nitrates fluxes in soil, the experimental site EFELE from the SOERE PRO network (https://www6.inra.fr/valor-pro) was followed. The long-term evolution of the repeated application of OWP since 2012 was assessed for three different treatments: pig slurry, biogas digestate from the anaerobic digestion of pig slurry and a mineral fertilizer as a control. Lysimeters were monitored from 2014 to 2022 (8 drainage seasons) with two replicates per modality and depth (40 and 90 cm) under winter cover of wheat or mustard. The drainage seasons lasted from November to April. The DOC and nitrates dynamics observed for the four years under wheat and the four years under mustard were repeatable. Nitrates leaching losses were low under mustard (2.7 ± 2.3 kg N.ha\textsuperscript{-1} at 40cm and 0.9 ± 0.8 at 90cm), which had fulfilled its role as a catch crop, and higher under wheat (30.5 ± 12.9 kg N.ha\textsuperscript{-1} at 40cm and 14.3 ± 10.1 at 90cm), regardless of treatment. Regarding the DOC fluxes at 40cm depth, there was a significant difference between mustard (34.0 ± 11.4 kg C.ha\textsuperscript{-1}) and wheat (20.6 ± 11.1 kg C.ha\textsuperscript{-1}). DOC fluxes under biogas digestate were significantly higher (36.3 ± 16.2 kg C.ha\textsuperscript{-1}) than under mineral fertilizer and pig slurry (21.4 ± 7.4 kg C.ha\textsuperscript{-1} on average). At the beginning of the drainage season, the DOC concentrations dynamics were already significantly different between digestate and the two other treatments under mustard, which was sown in September and already well developed. Under wheat, which was sown in November, there was no difference between treatments at the beginning of the season. It was only in the middle of winter, when the crop had more time to develop, that a difference could be observed. It seemed that the crop effect controlled the treatment effect. DOC fluxes to groundwater (90 cm) were not significantly different between treatments or crop (7.4 ± 6.0 kg C.ha\textsuperscript{-1} on average). Part of the C could be stored between 40cm and 90cm depth or mineralized.