

EGU2020-18272

<https://doi.org/10.5194/egusphere-egu2020-18272>

EGU General Assembly 2020

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## Plastics in Agriculture: Sources, mass balance and transport to local aquatic environments

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The properties of plastic products have become important features in everyday lives, including in Norwegian agriculture. According to Grønn Punkt Norway's statistics, agriculture is the third largest sector for plastic consumption, after domestic use and industry. Most of the plastic used by agriculture is used for production of round hay bales and as agricultural films to protect and improve crops, known as mulching. The films may be subjected to weathering through mechanical stress, oxidation and photodegradation, leading to fragmentation. These plastic particles can be dispersed into the soil and pass via drainage networks from agricultural soil into local aquatic environments. Additional agricultural plastic sources may come from fertilisers, pesticides, and sewage sludge application to land. This preliminary study investigated soil and runoff-water from agricultural fields in Morsa catchment. Concentrations of plastic (number of plastic particles) and types of plastic were determined in the soil and water samples. The selected sites had berries, grass, and cereal crops. Several fields were selected to represent sludge application: two fields selected had sludge applied recently in 2018, and two had received historical application, 7-8 years ago. In one area, plastic film was used to cover berry crops, for protection and cover. Non-biobased PBAT biodegradable plastic was used as mulching film in one of the vegetable areas. A further type of mulching, which blocks solar insulation to adjust soil temperature and restrict the wavelengths that encourage weed growth, was used in a different vegetable field. One vegetable field that has not used plastic products (including sludge application) in the past and was considered as a reference field in this study.

Globally, there are only a few studies that have measured microplastics in agricultural soils, and none in Norway to date. The concentrations of plastics above 50  $\mu\text{m}$  found in the samples from Morsa were low, except from where mulching occurred with the plastic film PBAT. Microplastic PBAT concentrations were considered to be high, and the soil contamination was comparable with other values reported for soil undergoing intense agricultural production in other parts of the world. In runoff-water from a field where cereals and grass were grown, the concentrations of microplastics were considered high compared to other reported values from freshwater systems. This indicates that plastics can be mobilised from agricultural soils to the aquatic environment, and films from agricultural use may represent an important source. Polyethylene fragments were

the dominant particle type found in the runoff-water, which may have originated from the soil as they represent the most dominant particle type in the corresponding field. A total of 14 different plastic polymer types were found in the soil samples, but, there was little agreement between the use of plastics (e.g. agricultural film) and what type was found in the soil. Samples from areas where neither sludge nor film was used also contained microplastics. The overall dominant particle morphologies were fragments, fibres and films. These data represent the first baseline assessment of microplastic contamination in agricultural soils undergoing a range of different plastic application types in Norway.