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Impact of the degradation of plastics called "biodegradable" on soil ecology, by monitoring of Nitrifying Activity and Respirometry

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Résumé : The association RITTMO is a research and innovation institute, dealing with environment and agronomy.

In spring 2010, we conducted a survey, which aimed at understanding and quantifying the use of biodegradable plastics for vegetable production in Alsace. In July 2010, we completed this survey by experiments whose objectives were to study the biodegradation of these plastics, and to measure their impact on soils.

Soil were sampled on different sites, each time on two different horizons. Fragments of plastic soil were removed from soil after crushing and sieving, and weighed to know the ratios in soil. Then they were chopped finely (<2mm) to inoculate them again in soils at different doses.

Monitoring of nitrification activity

The objective is to measure the impact of the biodegradation of plastics on soil ecology, by monitoring of nitrification activity during 21 days, with sampling every 7 days.. The nitrification is the transformation of ammonia into nitrates leading to the supply of available nitrogen to plants. The hypothesis is that if plastics are truly biodegradable, they could stimulate bacterial activity, and this should result in higher production of nitrate in soils, compared to control soils.

For each horizon of each site, samples were prepared in aluminum cups. The addition of NH₄⁺ stimulates bacterial activity.

The table below presents the details for a single horizon:

Test soil	Modalities with or without addition of ammonium (100 mg N / kg dry soil)	Date of KCl 1M extractions (number of repetitions)			
		0 (3)	7 (3)	14 (3)	21 (3)
Soil with plastic	Without addition of NH ₄ ⁺	0 (3)	7 (3)	14 (3)	21 (3)
	With addition of NH ₄ ⁺	0 (3)	7 (3)	14 (3)	21 (3)
Control soil	Without addition of NH ₄ ⁺	0 (3)	7 (3)	14 (3)	21 (3)
	With addition of NH ₄ ⁺	0 (3)	7 (3)	14 (3)	21 (3)

Every 7 days, extractions with a solution of 1M KCl were realised, following the standard Afnor 14238. The extractions were sent to the Laboratoire départemental d'Analyses et de Recherche de l'Aisne (LDAR) to analyze and determine the amount of NH_4^+ , NO_2^- and NO_3^- present in the different modalities and their control soil.

The results showed that nitrification activity is lower in soils containing plastic than in control soils (for the modalities with addition of NH_4^+ , 54 % of NH_4^+ present at the beginning (t_0) were consumed in the soil with plastic versus 87 % in the control, at t_7). The analysis also showed an inhibition of nitrification activity gradually as the dose of plastic rises. These results contradict the initial hypothesis, because the biodegradation of plastic looks like slowing down the bacterial activity. It would appear as biodegradable plastics modify the quality and ecology of soils.

Respirometry measurements

The initial hypothesis of these experiments is that biodegradable plastics are a carbon source for microorganisms. The addition of these plastics in the environment should stimulate the metabolic activity of micro-organisms, manifested, among other, by the release of CO_2 .

The system (Oxitop) measures the volume of CO_2 emitted by respiratory activity, relative to a quantity of soil. The sample is placed in airtight environment, the CO_2 released is absorbed by hydroxide sodium. This creates a pressure difference which is measured and reported to a volume of gas produced.

We made these measurements during periods of 10 days, on different types of soil samples with different doses of plastics compared each time with control soils without plastic:

Mode 1: Site 1 top soil + 1219mg (per kg of dry soil), plastic (dose 1)

Mode 2: Site 1 soil low plastic + 486mg of plastic

Mode 3: Site 2 top soil + dose 1 + dose 5 (= dose 1 x 5)

Only the results of modes 2 and 3 have provided useful results. They show a decrease of microbial activity in the presence of plastic compared to control, and that the higher the dose of plastic, the greater the inhibition is. The inhibition appears to be stronger in the first 3 or 4 days than in the following days.

The plastics seem to have an inhibitory effect on metabolism and / or multiplication of microorganisms. However this experiment does not validate this last hypothesis. It has not been met by the initial hypothesis. Indeed, the inhibitory effect hides any possible increase in microbial activity due to biodegradation of plastics.

These experiments have shown a decrease in microbial activity related to ammonia oxidation in the presence of plastics. To test the hypothesis of an inhibitory effect on plant growth of these plastics, ecotoxicity tests should be implemented. It would be useful to test the effect of the dose of plastic, but also and especially the exposure time. Only one type of plastic, Bionov, composed of Mater-Bi has been tested, it would be worthwhile to extend these tests to other types of biodegradable plastics made of different polymers.