PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXIX cycle, 2023-26)

Project draft

1.Field of interest

AGR13

2.Project title

Bioplastic in the environment

3.Tutor (membro del Collegio dei Docenti)

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4. Relevance of the topic and state of the art:

High bioplastic contents in digestate/compost raises some questions that go beyond the qualitative aspect of the final products, and are related to biodegradation of these biopolymers' residues in soils (De Girolamo et al., 2019); if from a qualitative point of view of the final products (compost and digestate) they are still officially classified as "plastic", in reality they are bioplastic and so formally, completely biodegradable in soil. In recent decades investigation into the degradation of bioplastics in the soil is arousing interest in the scientific community, with reports showing for such biopolymers (e.g., PLA and starch blends), regardless of conditions tested, significantly faster degradation rates than the time required by petroleum-based plastics which severely accumulate in soil environments (Chamas et al., 2020). For instance, several studies have shown the importance of intrinsic biodegradability in reducing bioplastics' residual life and their persistence in soil environments (Degli Innocenti and Breton, 2020). Cucina et al., (2021) in a comparison study on biodegradation kinetics constants, reviewed the estimated times for complete degradation in soil, indicating half-life times with complete degradation in soil achieved in 591 ± 313 and 1,604 ± 1,010 days for starch-based and PLA bioplastics, respectively. possibly reaching concentrations of 8 –10% (on a weight basis) of OFMSW (Cucina et al., 2021b).
Despite the active investigations focused on elucidating the behavior of biodegradable bioplastics in AD and composting processing under the current industrial management systems and with different operating conditions, there is still much to understand, especially towards assessing the overall fate, the degree of degradation and the impact of applying such digested polymeric organic fragments to the soil. No information is yet available in the literature regarding the effect of waste management of bioplastics on the subsequent degradability in soil.

5. Layout of the project (draft)

5.1. Materials & Methods:

- Bioplastic analyzed will consist in polylactic acid (PLA) and starch-based bioplastics.
- Bioplastic will be chemical characterized by FTIR spectroscopy.
- At the same time natural polymer will be consider lignin, cellulose and hemicellulose.
- Anaerobic digestion of waste and bioplastic will be performed by using lab-scale reactor of 1-3 L.
- Bioplastic composting will be performed by using lab scale composter of 16 L.
- Microplastic will be investigate in the biomasses studied.
- Bioplastic pretreated will be incubated into agricultural soil and degradation kinetic studied.
- Absorption of xenobiotic compounds by microbioplatic and plastic ((PET, HDPE, LDPE)
- Molecular biologic will be applied studying soil microorganisms responsible for bioplastic degradation.

5.2. Schedule and major steps (3 years):

First year: reporting the state of the art. Bioplastic, plastic and natural polymer collection and characterization.
Bioplastic treatment by anaerobic digestion and composting

Second year: Digestate and compost obtained will be incubated into soils. Under aerobic condition studying their behavior vs. plastic and natural polymer. At the end for incubation microbioplatic, microplastic and micropolymers fibers will be detected

Third year: residual microfibers in soil will be studied for their ability adsorbing xenobiotic molecules and to form microbial cluster.
At least 6 months will be spent in a foreign research institute and at Bio repack consortium.

6. Available funds

Borsa di studio nell'ambito del D.M. 352 se reiterato peri l 2023 + 30.000 € di contratto di ricerca

Ente Finanziatore: BioRePack – Consorzio nazionale per il Riciclo organico degli Imballaggi in Plastica. Sede operativa: Corso Venezia, 12 – 20122 Milano, Sede legale: via Cola di Rienzo, 212 - 00192 Roma

7. Literature:

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2. Chamas, A., Moon, H., Zheng, J., Qiu, Y., Tabassum, T., Jang, J.H., Abu-Omar, M., Scott, S.L., Suh, S., 2020. Degradation Rates of Plastics in the Environment. ACS Sustain. Chem. Eng. 8, 3494–3511. https://doi.org/10.1021/ acssuschemeng.9b06635.

3. Cucina, M., Carlet, L., De Nisi, P., Somensi, C.A., Giordano, A., Adani, F., 2022a. Degradation of biodegradable bioplastics under thermophilic anaerobic digestion: A full-scale approach. J. Clean. Prod. In press, 133232. https://doi.org/10.1016/j. jclepro.2022.133232. Available online 21 July 2022.
4. Cucina, M., de Nisi, P., Tambone, F., Adani, F., 2021a. The role of waste management in reducing bioplastics' leakage into the environment: a review. Bioresour. Technol. 337, 125459 https://doi.org/10.1016/j.biortech.2021.125459.
5. Cucina, M., De Nisi, P., Trombino, L., Tambone, F., Adani, F., 2021b. Degradation of bioplastics in organic waste by mesophilic anaerobic digestion, composting and soil incubation. Waste Manag 134, 67–77. https://doi.org/10.1016/j. wasman.2021.08.016.
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8. Degli Innocenti, F., Breton, T., 2020. Intrinsic biodegradability of plastics and ecological risk in the case of leakage. ACS Sustain. Chem. Eng. 8, 9239–9249. https://doi.org/ 10.1021/acssuschemeng.0c01230.
9. Ebrahimzade, I., Ebrahimi-Nik, M., Rohani, A., Tedesco, S., 2022. Towards monitoring biodegradation of starch-based bioplastic in anaerobic condition: Finding a proper kinetic model. Bioresour.Technol. 347, 126661 https://doi.org/10.1016/j. biortech.2021.126661.
10. Urayama, H., Kanamori, T., Kimura, Y., 2002. Properties and biodegradability of polymer blends of poly(L-lactide)s with different optical purity of the lactate units. Macromol. Mater. Eng. 287, 116–121. https://doi.org/10.1002/1439-2054 (20020201)287, 2<116AID-MAME116>3.0.CO2-Z.