Usage of effective microbe-modified organic fraction of MSW as fertilizer under winter conditions

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The green areas in cities and urban areas are becoming a higher concern for city planners, urbanists and local authorities as progressing climate change induces new actions towards better rainwater infiltration, circulation as well as the comfort of the local city climate. In parallel the quantity of solid biowaste remains at a high level. In Poland, in 2018 approximately 3.5 million tonnes of biowaste is available for novel management techniques, one of which may be Effective Microbes (EM) modification of the organic fraction of municipal solid waste (OF-MSW) and production of fertiliser for urban green areas. Returning nutrients, contained in OF-MSW, back into soil close to the nutrients loop, is an environmentally friendly solution for its utilisation. The story below shows that such a scenario works even under winter conditions.

This proposal is in line with the objectives of the Circular Economy Action Plan, which focuses on the sectors using a high amount of resources, where the potential for improvement is high, like water and nutrients. The proposal is also coherent with the EU Green Deal, namely it replaces the inorganic fertilisers (currently produced by heavy chemical industry) with organic ones derived from waste. This contributes to the aim of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. Moreover, clean water, healthy soil and biodiversity would be maintained. This action is in line with the Waste Framework Directive, where EU countries are obliged among others: for re-use and the recycling of municipal waste to a minimum of 55 %, 60% and 65% by weight by 2025, 2030 and 2035, respectively. The Directive also requires that waste will be managed without endangering human health or harming the environment, without risk to water, air, soil, plants or animals. The Directive criteria also specify when certain wastes cease to be waste and become a product, or a secondary raw material.

The study was undertaken by IMP-PAN. The OF-MSW was treated with effective microorganisms on-site, pelletized and dried for use as an organic fertilizer. The goal of later studies was: (1) to verify the fertilizing value of the OF-MSW modified by Effective Microorganisms (EM), (2) to compare its efficiency under winter conditions (October – April) to that of market accessible NPK mineral fertilizer, (3) to evaluate the residual effect on soil after OF-MSW fertilizer application. The dosages were carefully planned: (1) normal dose (the one recommended by the mineral fertilizer supplier - 20 kgN/ ha), (2) maximum allowable dose (according to the Polish legislation - 170 kg N/ ha), (3) an overdose in order to prove the effect of overfertilization.

The verification methodology was as follows: soil for each out of 39 pots (presented at the photo above) was prepared by mixing pre-sieved sand with peat in 5:1 gravimetric (?w/w) ratio. Then the prepared micronutrients (salts of K, Ca, Mg, Mn, Zn, Cu, S, B, Na, Mo) were added. Subsequently, fertilizers were added according to amounts ranging from 20 to 370 kg N/ha; then 80 seeds (ca. 0.5 g) of grass were placed on top and covered with the topsoil. Soil moisture was maintained at Field Capacity (ca. 35% cm^3 H_2O/cm^3 soil eg. 22% w/w) by watering with deionised water. Harvesting was performed after 30, 90 and 180 days of growth in a greenhouse for biomass yield and NK uptake analysis. Finally, the residual soil properties (NK, pH, EC) were analysed.

In general, the findings after 180 days of growth (3 harvests) indicate slower mobilization of nutrients from the organic waste-based fertilizer and subsequent gradual growth of grass biomass over time (with maximum after Harvest 2) and across the application rates (maximum at 170 kg N/ha). Cumulatively for the dose higher than 170 kg N/ha, the EM-modified OF-MSW resulted in ca. 50% higher growths and up to 80% higher N uptakes than for mineral fertilizer – no overfertilization effect was found for OF-MSW fertilizer! This is in sharp contrast to the mineral fertilizer, which resulted in fast growth of grass in the very beginning and only up to 70 kg N/ha (Harvest 1 and 2), after which the response curve shows a slow decline (the grass does not react to doses larger than 70 kg N/ha). Overfertilization was observed only for the mineral fertilizer.

Ryegrass responses to mineral fertilizer (up) and EM-MSW-OF fertilizer (down). Harvest 2.

Nitrogen utilization: the N content in grass samples was increasing linearly with growing fertilizer dose. When applying mineral fertilizer 70 ÷ 200 kg N/ha, ca. 20% more N was determined in plants in relation to the ones grown on the organic fertilizer. However, the total N uptake per area for both fertilizers provided equal N uptake (12 kg N/ ha) at 120 kg N/ ha application rate (ca. 10% of the input). The positive, noticeable effect of organic waste-based fertilizer was reflected in up to two times better N utilization at higher dosages as compared to the mineral one. This proves that OF-MSW based fertilizer would cause less nutrients leaching and more retention in plants, preventing eutrophication of water bodies.

The residual Nitrogen content in the soil was slightly (20%) higher after the EM-modified OF-MSW application than for the mineral one. The more fertilizer is applied, the more N is left in the soil. The residual N in soils treated with the mineral fertilizer is rather stable over the whole spectrum of fertilizer application rates, which is the result of its fast mineralization, uptake, water and air emissions. Even though this is not reflected in better grass growths in the whole range of dosages.

In general, the calculated total N amount in soil per area is more noticeable after organic fertilizer application. This indicates that this substantial bank of probably organically bound N, remaining in the soil, still results in increased growths at very high application rates for the organic fertilizer.

The TRL(?) of the EM-modified OF-MSW fertiliser production and application is assessed to be at the level of 7; it is rather easy to apply on land but it still requires the development of efficient high-scale equipment for pelleting or granulation of the pre-dried solid waste and its subsequent final drying. The required input energy could be for instance harvested from the nearby biogas plant.

ISWM Framework Positioning of the Case Story

Stakeholders: Citizens, Local Authorities

Waste System Elements: Waste treatment, Reuse, Recycling, Recovery

Aspects: Technical, Environmental, Financial, Socio-cultural, Institutional, Policy/legal

Management of OF-MSW by means of fertilization of urban green areas is closely related to the ISWM(?) framework. As the intended use is for urban green areas, local authorities are responsible for decision-making and citizens are the final users. The covered Waste System Elements are: Treatment with effective microorganisms on-site, pelletizing and drying (waste collection plant), then **Recycling** of nutrients in a form of fertiliser and organic matter into the soil and subsequent Recovery of nitrogen, potassium, phosphorus and other microelements by grass.

“Financial/ Economic” benefits are expected due to savings in reduced mineral fertilizer usage. Whereas “Sociocultural”, “Institutional”, “Policy/ legal/ political” factors need to be considered if scaled out and applied in real life.

Lessons learned:

1. Fertilizers based on separated at source OF-MSW are a good candidate for bringing back the nutrients to the environment,
2. Using OF-MSW as organic fertilisers even at higher dosages does not limit grass growth unlike mineral fertilisers.
3. OF-MSW fertilisers provided up to two times better N utilization at higher dosages as compared to mineral fertilisers. This proves its lower vulnerability to nutrient losses via leaching, thereby reducing the risk of eutrophication of water bodies.
4. The verification was done under winter conditions, so analogical experiment carried out in spring and summer are required (planned),
5. Further investigation to compare the effect of real-scale OF-MSW (sorted at a plant, not at the source), possibly anaerobically digested, on grass growth to check for any inhibiting effects (microplastic, heavy metals, organic pollutants effect on grass growth and its uptake), is required.