Preliminary environmental assessment for a pilot-scale bioplastic production unit

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The accumulation of plastic waste in the environment is a top concern worldwide. It is estimated that approximately 6300 million tons of plastic waste are being generated, while more than 2/3 of them end up in landfills or the natural environment. According to the context of the circular economy, resources are used as much as possible, while the materials are recovered and regenerated. The diversion of biowaste from landfills to innovative treatment methods, to be converted back into a usable product or raw material, has many alternatives. The raw materials for the production of bioplastics are divided into first, second, and third generations, depending on their stage of development. The first generation includes raw materials that are usually plants, rich in carbohydrates, and also suitable for human consumption. The second generation raw materials includes materials that are unsuitable for consumption (non-food crops e.g. cellulose) or by-products of first-generation ones. The third-generation includes the most innovative raw materials, which are still in the early stages of development (biomass from algae, industrial or municipal waste).

One of the actions of the A2UFood project is the production of bioplastic from raw materials belonging to the third generation. More specifically, the raw material was food waste collected from selected hotel units in the study area. The raw material was then converted to bioplastic. This process took place on a pilot scale in the bioplastic production unit that was built to meet the needs of this project. The action of bioplastic production from food waste is part of the axis of reduction of food waste produced by the Municipality of Heraklion (in the island of Crete) and their conversion in the context of the circular economy and a product of added value. The production, within the project, concerns the amount of bioplastic that will be produced by 11 operating cycles (batches) of the unit. The required amount of food waste for each cycle was 65 kg, from which 9 kg of pure poly-L-lactic acid (PLLA) was produced. In total the unit operated for 55 days and the incoming amount of food waste was 65 kg food waste * 11 batches = 1,365 kg and the final product was 99kg PLLA. For this process, the environmental assessment was performed using the life cycle assessment methodology for 16 impact categories. In addition, a comparison was made with the same amount of plastic production from the industrial raw materials (EDR) used in the manufacture of household waste bags and packaging. The limits of the system include the transfer to the pilot bioplastic unit with the special vehicle, which is on average a route of 14 Km. In addition, the energy required for the operation of the bioplastic unit amounting to 6840 kWh of electricity, based on the energy mix of Greece, was taken into account. The grouped food categories were examined: "Fresh vegetables and salads", "bakery products" and "fresh fruits". Initially, the group of food products that have the greatest environmental impact if discarded was identified. Citrus fruits and bread have been found to make a significant contribution to several categories of impacts and more specifically citrus fruits to 13 out of 16 and bread to 10 out of 16. However, as expected, the use of electricity for the operation of the pilot bioplastic production unit, contributes significantly to the environmental footprint of the action. This is due to two main reasons: At first, the fact that the energy mix of Greece is not largely supported by renewable resources and fossil fuels occupy the most important

percentage and the supply of electricity and secondly that the pilot application for the production of bioplastic has a small scale and does not incorporate any price adjustments. That is, the fact that the limited capacity for input and processing of raw materials as well as the low production capacity of the unit's bioreactors, limit the environmental benefit. It is therefore established that the use of the pilot unit would be environmentally sustainable, if over time the supply of its energy needs was made exclusively from renewable energy resources, especially when the raw materials needed for the production of bioplastic, is food waste produced at the municipal level, available at no additional cost.