



ΧΑΡΟΚΟΠΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟ
HAROKOPIO UNIVERSITY

Preliminary environmental assessment for a pilot-scale bioplastic production unit

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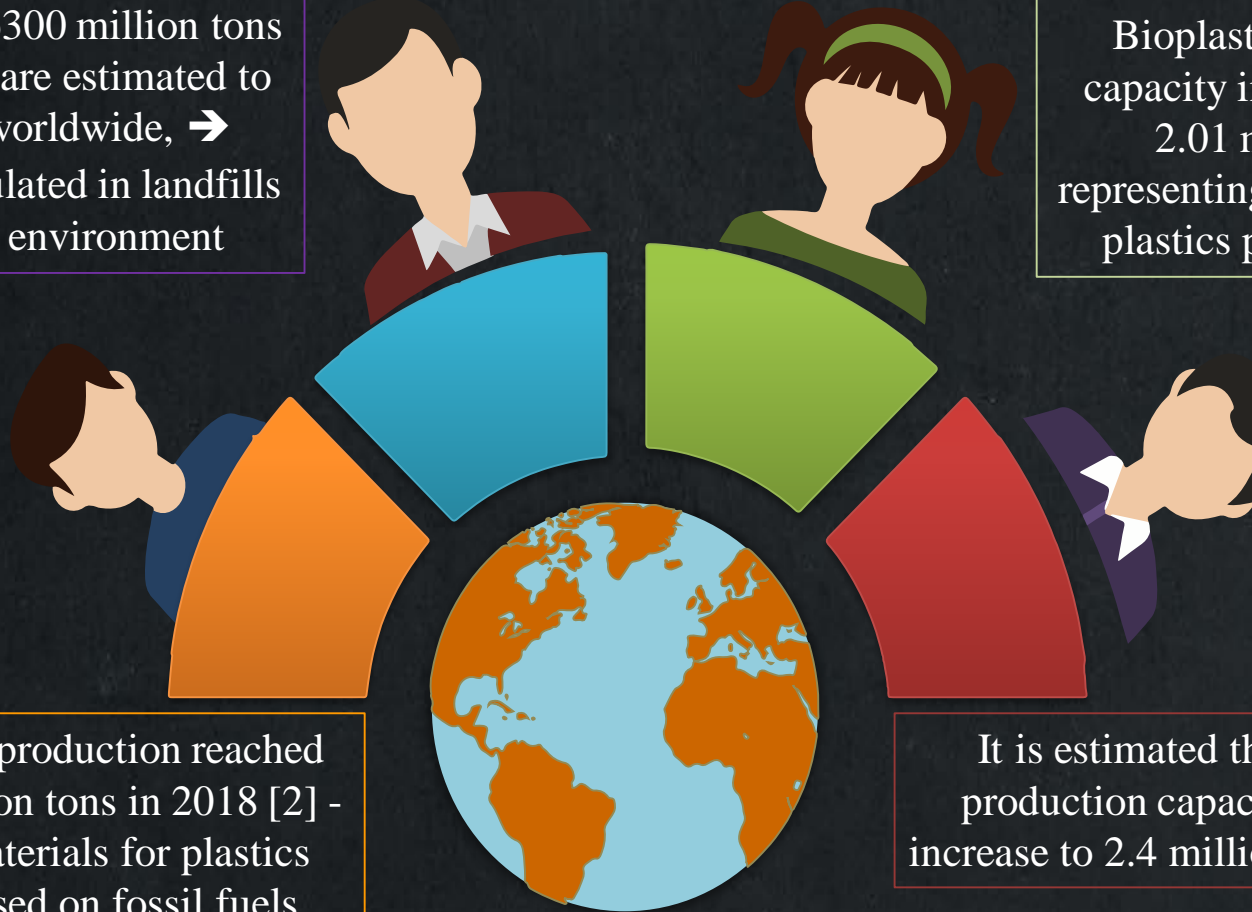
General info



About 80% of all plastics produced worldwide are not recycled or reused in other ways [7]

Approximately 6300 million tons of plastic waste are estimated to be produced worldwide, → **79%** is accumulated in landfills or the natural environment

Bioplastics production capacity in 2018 was only 2.01 million tons, representing 0.56% of global plastics production [10]



Global plastics production reached almost 360 million tons in 2018 [2] - 99% of raw materials for plastics production based on fossil fuels

It is estimated that bioplastics production capacity will tend to increase to 2.4 million tn by 2023 [10]

about 8-9% of world oil and gas consumption [3]




Raw materials for the production of bioplastics

Are generally divided into first, second and third generation


1

Raw materials are usually plants rich in carbohydrates that are also suitable for food or feed.





2

Raw materials that **are not** suitable for **food or feed**. These can be either non-edible crops (eg cellulose), such as the "body" of corn or cane molasses.



3

Includes biomass from algae, industrial or municipal waste





The goal of this study

LCA of pilot scale bioplastic unit production

- to find food waste categories with the major contribution
- to make an environmental evaluation of the production process into pilot unit





Methodology



Raw material was food waste collected from selected hotel units in the study area.



The power supply of the unit, is the electricity mix of Crete in the year 2019.



One of the actions of the A2U Food project is the production of bioplastics from raw materials belonging to the third generation.



One pilot scale bioplastic production unit.
11 operating cycles (batches)



The initially required amount of food waste for each cycle is 65 kg of which is produced → 9 kg of pure poly-L-lactic acid (PLLA).



Pilot scale Bioplastic production unit



UIA

**URBAN
INNOVATIVE
ACTIONS
A2UFood**

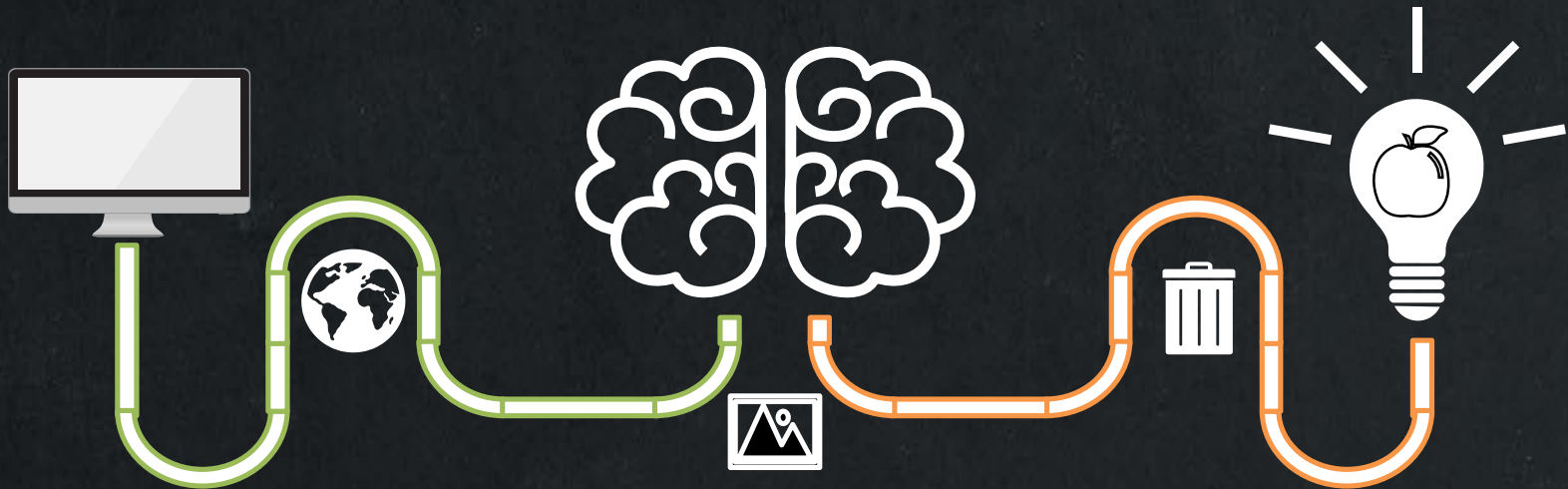


Environmental assessment

The selected method of evaluation is the **ILCD 2011 Midpoint + V1.11 / EC-JRC Global**, equal weighting, which is included in the Simapro software

It includes the following sixteen impact categories:

- climate change
- ozone depletion (ODP)
- human toxicity with or without cancer effect
- particulate matter
- ionizing radiation HH and E
- photochemical oxidation
- acidification
- terrestrial eutrophication,
- marine eutrophication
- freshwater ecotoxicity
- land use
- depletion of water resources





Functional Unit



Each operating cycle

requires 5 working days in a single shift per working day (total operation of the unit for 55 days).

was the raw material for the production of bioplastic, which amounts to 1365 Kg, Excepted meat and fish products

The total amount of food waste



the limits of the system include the transfer to the pilot bioplastic unit by the special vehicle, which is on average a route of 14 Km.



Transportation

for the operation of the bioplastic unit amounting to 5703,4kWh of electricity.

The energy needs



were based on the production of an equal amount of plastic raw material, both from conventional materials (LDPE ETH) and from bioplastics of industrial production. The module is defined as "Production and processing of 99 kg of raw material (bioplastic from food waste, bioplastic from corn, LDPE)".



The scenarios to be compared



Raw material LCA

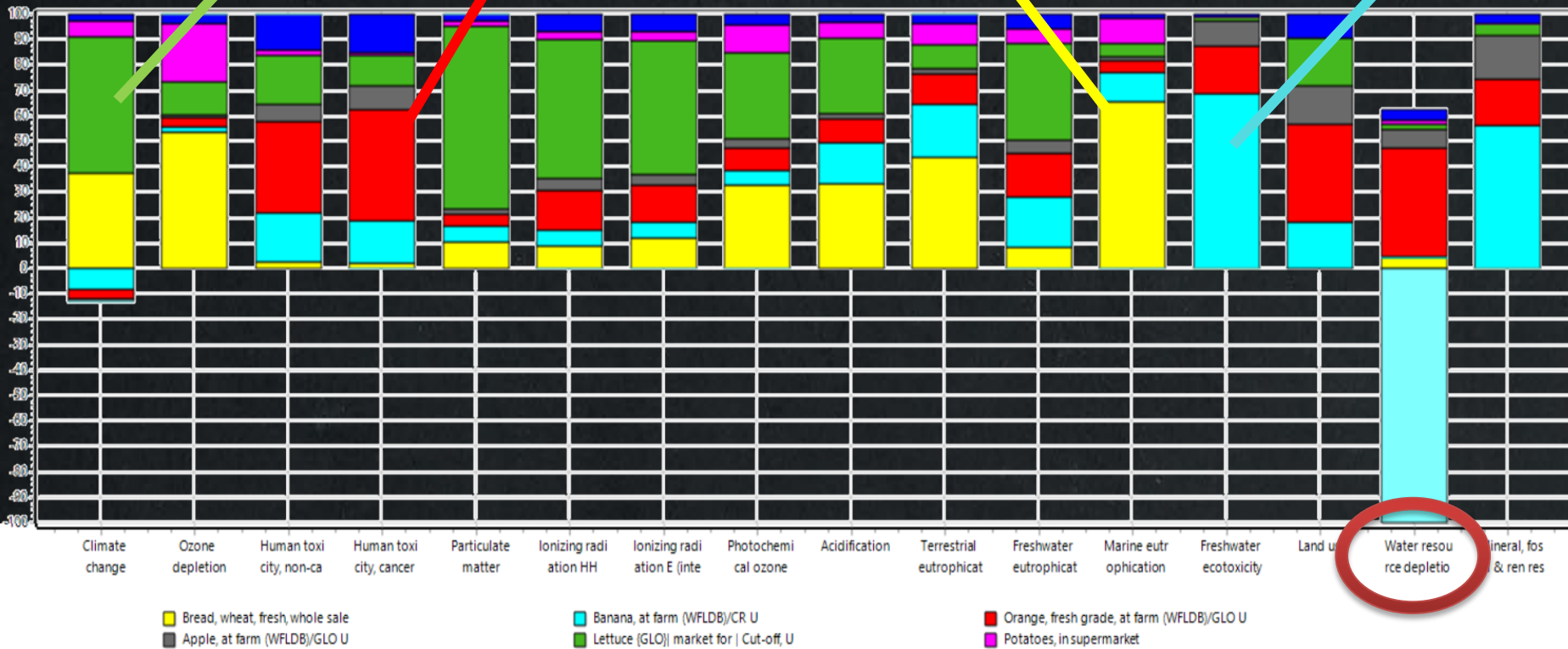
Characterization about food waste categories

Green salads

Citrus

Bread

Banana



Method: ILCD 2011 Midpoint+ V1.11 / EC-JRC Global, equal weighting / Characterisation / Excluding infrastructure processes / Excluding long-term emissions
Analysing 1 p 'Bioplastic Unit_Raw materials';

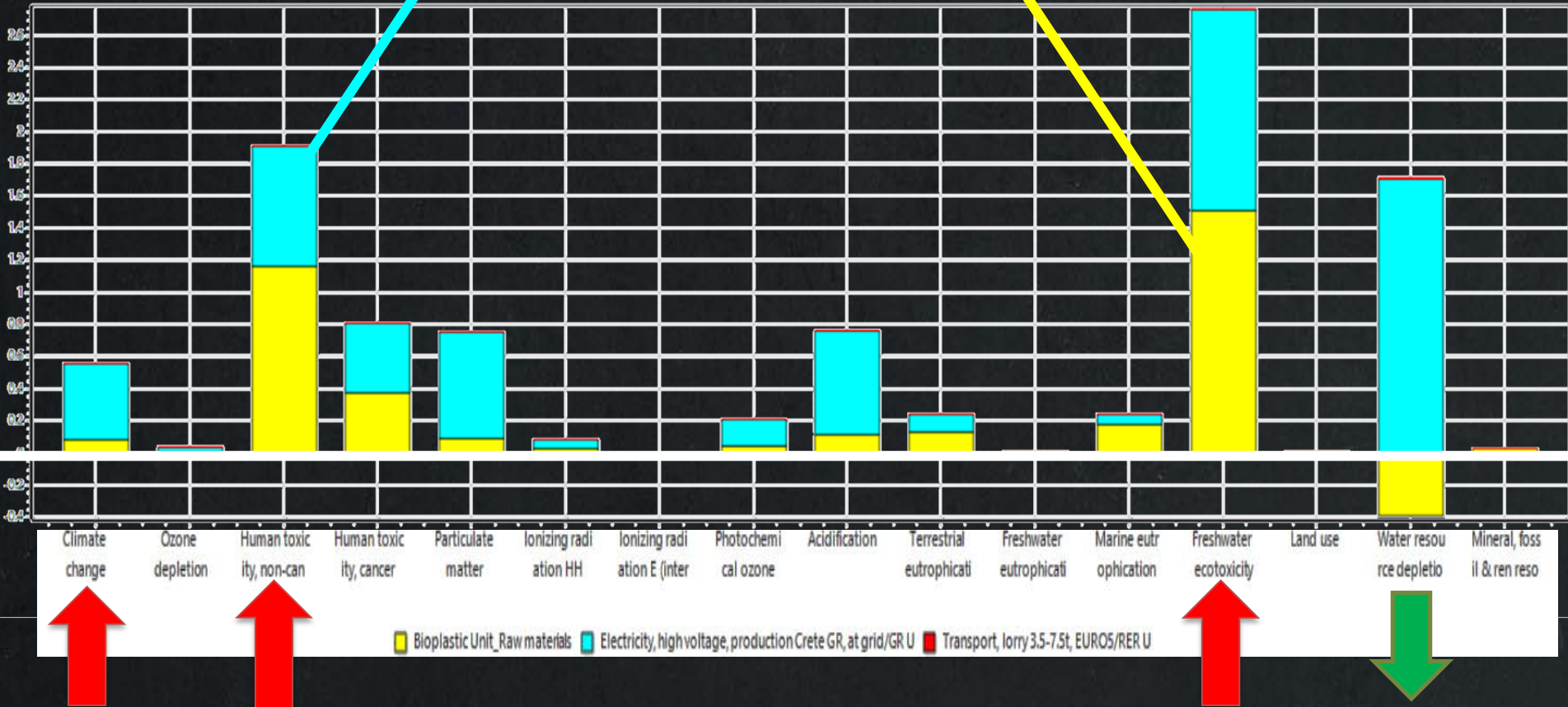


Total LCA

Normalized chart

Electricity

Food waste raw material

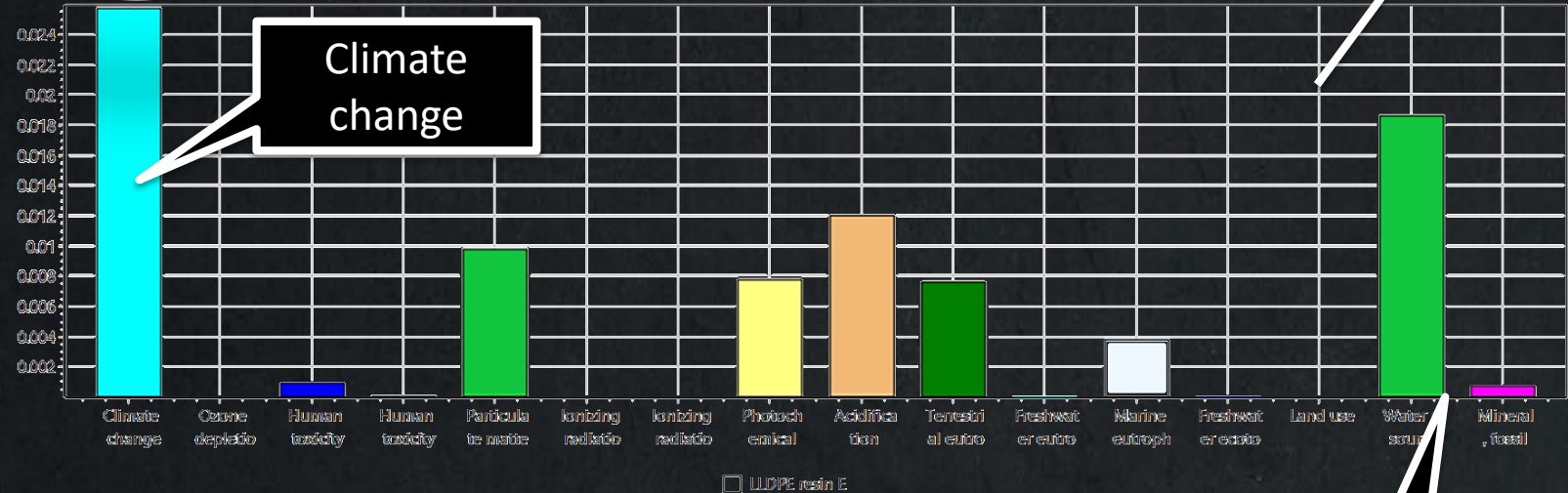




Compare

The two other ways of plastic material production

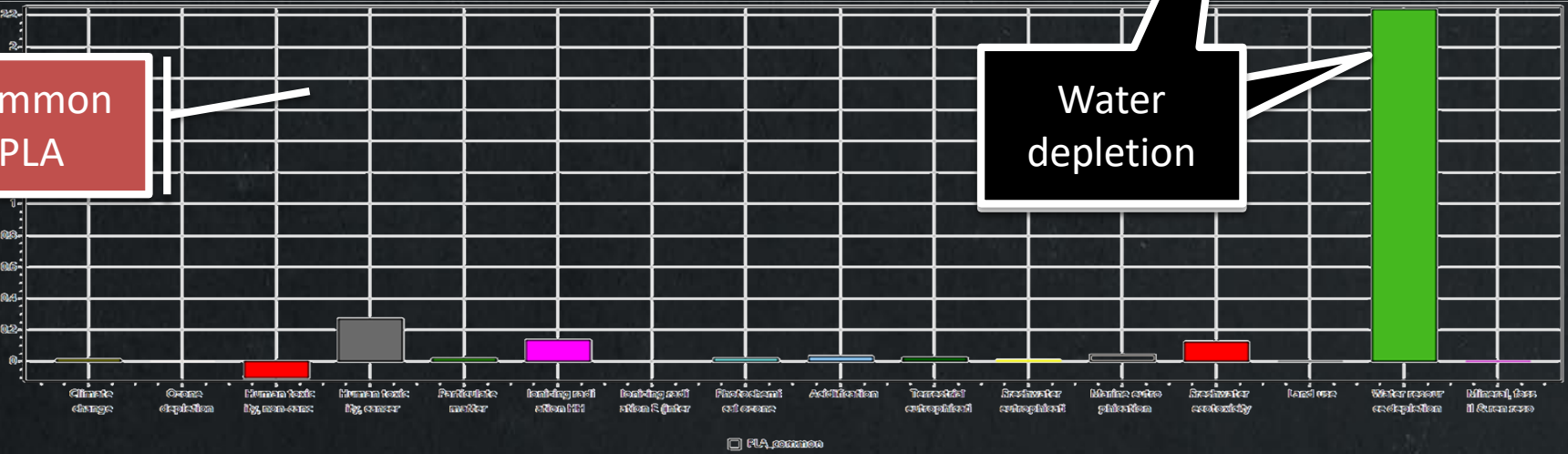
LDPE plastic



Method: ILCD 2011 Midpoint-V1.11 / EC-JRC Global, equal weighting / Normalization / Excluding infrastructure processes / Excluding long-term emissions
Analyzing 11 e "Plastic bags"

Common PLA

Water depletion



Method: ILCD 2011 Midpoint-V1.11 / EC-JRC Global, equal weighting / Normalization / Excluding infrastructure processes / Excluding long-term emissions
Analyzing 3 p "Common PLA"



3 scenarios

Method: ILCD 2011 Midpoint+ V1.11 / EC-JRC Global, equal weighting

Impact category	Unit	Conventional plastic	Industrial PLA	Pilot production
Climate change	kg CO2 eq	222.8921	147.264	2753.51
Ozone depletion	kg CFC-11 eq	2.8E-06	3.29E-05	0.00047
Human toxicity, non-cancer effects	CTUh	1.92E-06	-1.4E-05	0.00029
Human toxicity, cancer effects	CTUh	2.25E-07	3.56E-06	1.01E-05
Particulate matter	kg PM2.5 eq	0.07033	0.108886	2.9065
Ionizing radiation HH	kBq U235 eq	9.572694	42.40612	5.1601
Ionizing radiation E (interim)	CTUe	8.66E-05	0.000382	0.00017
Photochemical ozone formation	kg NMVOC eq	0.450399	0.930479	5.55390
Acidification	molc H+ eq	0.900894	1.786151	30.1523
Terrestrial eutrophication	molc N eq	1.565028	4.688211	39.9591
Freshwater eutrophication	kg P eq	0.003771	0.06498	0.04393
Marine eutrophication	kg N eq	0.144183	1.266457	7.33759
Freshwater ecotoxicity	CTUe	17.86801	481.661	10329.4
Land use	kg C deficit	5.753346	241.001	992.269
Water resource depletion	m3 water eq	44.26494	197.166	91.0182
Mineral, fossil & ren resource depletion	kg Sb eq	0.000139	9.56E-08	0,0056



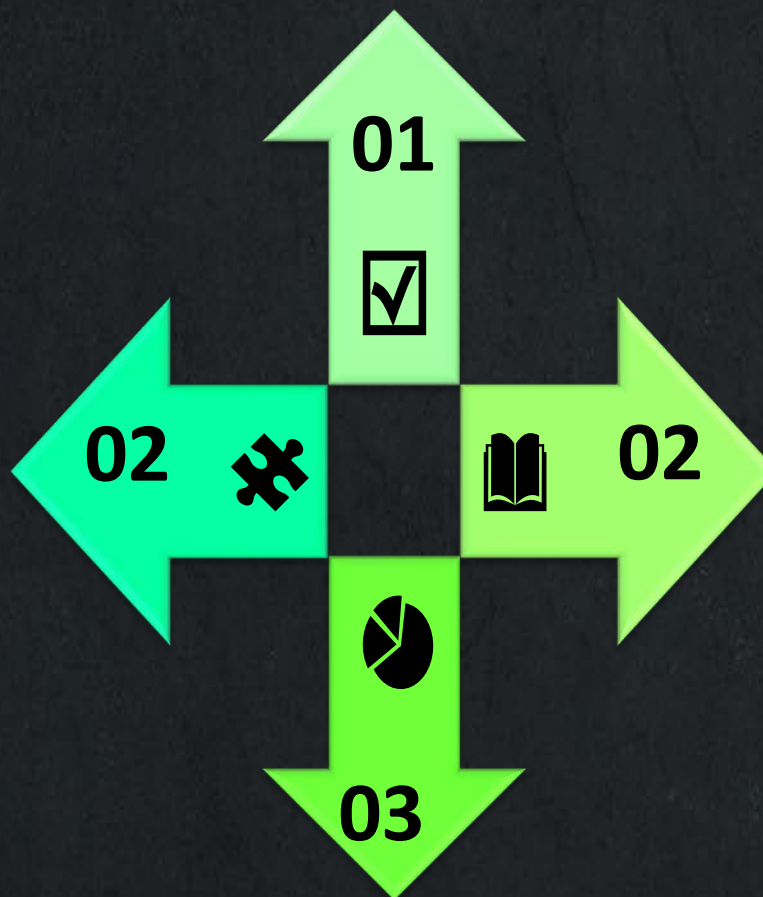
Conclusion

Food waste prevention

Sustainability

Electricity

contributes to the environmental footprint of the operation of the bioplastic unit. More specifically, it contributes to 14 of the 16 studied categories and mainly to human toxicity with and without carcinogenic effect, to depletion of water resources, to acidification and to climate change



Finally, it should be noted that the raw material needed for the production of bioplastics in the case of the study, is the food waste produced at the municipal level, which is available at no additional cost. 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.

3339.35 Kg

of the equivalent carbon dioxide for electricity



References



- [1] Geyer, R., Jambeck, J.R., Law, K.I.L., Production, use, and fate of all plastics ever made *Sci. Adv.*, 3 (2017), Article e1700782, <https://doi.org/10.1126/sciadv.1700782>
- [2] Plastics Europe, Plastics Contribution to the Circular Economy, (2020), Available online:, <https://www.plasticseurope.org/en/focus-areas/circular-economy> (Accessed on 08.01.2022)
- [3] Nielsen, T.D., Hasselbalch, J., Holmberg, K., Stripple, J., Politics and the plastic crisis: a review throughout the plastic life cycle, *WIREs Energy Environ.*, 9 (2020), Article e360, <https://doi.org/10.1002/wene.360>
- [4] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J., Dunphy-Daly, M.M., Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution, *Environ. Int.* (2020), <https://doi.org/10.1016/j.envint.2020.106067>
- [5] Russo, I. Confente, I., Scarpi, D., Hazen, B.T., From trash to treasure: the impact of consumer perception of bio-waste products in closed-loop supply chains, *J. Clean. Prod.*, 218 (2019), pp. 966-974, <https://doi.org/10.1016/j.jclepro.2019.02.044>
- [6] Shogren, R., Wood, D., Orts, W., Glenn, G., Plant-based materials and transitioning to a circular economy, *Sustain. Prod. Consum.*, 19 (2019), pp. 194-215, <https://doi.org/10.1016/j.spc.2019.04.007>
- [7] Blank, L.M., Narancic, T., Mampel, J., Tiso, T., O'Connor, K., Biotechnological upcycling of plastic waste and other non-conventional feedstocks in a circular economy, *Curr. Opin. Biotechnol.*, 62 (2020), pp. 212-219, <https://doi.org/10.1016/j.copbio.2019.11.011>
- [8] European Commission, A European Strategy for Plastics in a Circular Economy, (2018), Available online: <http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf> (Accessed on 01.02.2022)
- [9] Sidek, I.S., Draman, S.F.S., Abdullah, S.R.S., Anuar, N., Current developments on bioplastics and its future prospects: an introductory review, *i TECH MAG*, 1 (2019), pp. 3-8, <https://doi.org/10.26480/itechmag.01.2019.03.08>
- [10] European Bioplastics, Bioplastics Market Data 2019, (2020), Available online: https://docs.european-bioplastics.org/publications/market_data/Report_Bioplastics_Market_Data_2019.pdf (Accessed on 12.12.2021)
- [11] Imre, B., Garcia, L., Puglia, D., Vilaplana, F., Reactive compatibilization of plant polysaccharides and biobased polymers: review on current strategies, expectations and reality, *Carbohydr. Polym.*, 209 (2019), pp. 20-37, <https://doi.org/10.1016/j.carbpol.2018.12.082>
- [12] Sindhu, R., Gnansounou, E., Rebello, S., Binod, P., Varjani, S., Thakur, I.S., Nair, R.B., Pandey, A., Conversion of food and kitchen waste to value-added products, *J. Environ. Manag.*, 241 (2019), pp. 619-630, <https://doi.org/10.1016/j.jenvman.2019.02.053>
- [13] Magdalena, R., Calvo, G., Valero, A., The Energy Cost of Extracting Critical Raw Materials from Tailings: The Case of Coltan. *Geosciences* 2022, 12, 214 <https://doi.org/10.3390/geosciences1205.02.14>



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Thanks for your attention!

