Plastik sa Kapaligiran: Addressing Mismanaged Single-Use Plastics

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Note: The views expressed are those of the author and do not necessarily reflect those of the DOST, its attached agencies, or its senior management.

Abstract

The Philippines annually consumes about 2.15 million tons of plastics, with 35% (0.76 million tons) ending up in the environment, primarily comprised of single-use plastics (SUPs). One solution is to switch to biodegradable alternatives like polyhydroxyalkanoate-based (PHA) bioplastics derived from biomass such as agricultural residues. With the country's abundant biomass resources, there's potential to replace SUPs with PHA-based bioplastics. Approximately 1.9 million tons of PHA could theoretically be derived from ~11.3 million tons of sugarcane and corn residues, effectively preventing plastic leakage into the environment.

Plastic Litter in the Philippines

The Philippines has been recognized as a significant source of marine plastic pollution, with approximately 0.75 million tons of plastic waste discharged to the open ocean each year; accounting to about 6% of the global total of marine plastic pollution (Jambeck et al., 2015). With an annual plastics consumption profile of around 2.15 million tons, 0.76 million tons or 35% are leaked into the open environment while 0.71 million tons or 33% are disposed to dumpsites and landfills. With around 0.35 million tons or 16% are stored or in-use, and around 0.18 million tons are recycled.[1] Delving deeper, it was found out in waste assessments and brand audits conducted across the country that the plastics utilized in a year are around: 59.7 billion pieces of sachets, 17.5 billion pieces of shopping bags, and 16.5 billion pieces of plastic labo bags.[2] It can be inferred from such data that the plastic litter leaked into the open environment is mainly comprised of said single-use plastics (SUPs). The presence of plastic litter (both macro and micro plastics) in the environment has already been characterized and reported for beaches, rivers, and mangrove forests. Moreover, microplastics presence in marine biota such as oysters & selected fish species, whalesharks, and rabbitfish have been reported and constitute as part of the local baseline data that we have on the presence of plastics in the open environment and its corresponding ecosystems. (Tabañag et al., 2022)

The insufficiency of the nation's waste management infrastructure, coupled with human carelessness, is frequently pinpointed as the primary factors behind plastic pollution seeping into both land and sea environments. Despite several cities or local government units (LGUs) endeavoring to enact sustainable zero waste strategies, the persistent growth and use of SUPs undermine these efforts in strategy implementation.[3] While national adoption of the action plan on marine litter[4], along with the enhanced producer responsibility (EPR) scheme[5], aims to manage and minimize plastic leakage into the environment, particularly the open sea, these coordinated measures ultimately emphasize waste avoidance and reduction as the optimal solution.

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[1] EPR Scheme Assessment for Plastic Packaging Waste in the Philippines, 2020. Published by WWF-Philippines. https://wwfph.awsassets.panda.org/downloads/epr-scheme-assessment-for-plastic-packaging-waste-in-the-philippines--stakeholder-rep.pdf

[2] Plastics exposed: How waste assessments and brand audits are helping Philippine cities fight plastic pollution, 2019. Published by Global Alliance for Incinerator Alternatives. https://www.no-burn.org/wp-content/uploads/Plastics-Exposed-2nd-Edition-Online-Version.pdf

[3] In accordance with the Ecological Solid Waste Management Act of 2001 (RA 9003) which is the primary accountability of LGUs within their respective jurisdictions.

[4] In reference to the following memorandum circulars and resolutions of the Department of Natural Resources (DENR) that adopted the National Plan of Action for the Prevention, Reduction, and Management of Marine Litter (NPOA-ML): DENR Memorandum Circular 2021-10 and NSWMC Resolution No. 1441, Series of 2021

[5] Extended Producer Responsibility Act of 2022. http://legacy.senate.gov.ph/republic_acts/ra%2011898.pdf.

Bioplastics as Alternative Packaging Solutions

As the country's direction on preventing plastic litter leaking into the environment emphasize waste avoidance and reduction, one of the means to reduce this leakage is to replace SUPs with 'biodegradable bio-based packaging materials (or referred as bioplastic/s throughout the succeeding discussions).' The advantage of bioplastic packaging materials is that they are considered as sustainable alternatives such that they completely degrade into non-toxic derivatives hence reducing their accumulation in the environment and they have lower carbon emissions (as derived from bio-based feedstocks). In other words, bioplastics have significantly reduced environmental impact than the petroleum-based SUPs. (Choe et al., 2021; Kim et al., 2023)

While bioplastics are promising alternatives to SUPs, it should be noted that the Philippines has already been using imported bioplastics for the 3D-printing and packaging industries, and local compounding. Examples of bioplastics are starch, poly-lactic acid (PLA), polyhydroxyalkanoates (PHA), and blends. Also, bio-based non-biodegradable polymers have reached the local market including bio-polyethylene terephthalate (bio-PET), bio-polyethylene (bio-PE), bio-polypropylene (bio-PP).[6]

Through extensive involvement with stakeholders nationwide, it has become evident that the bio-based polymers under discussion hold significant promise as emerging technologies crucial for the Philippines in the foreseeable future. These polymers, specifically the bioplastics, offer a sustainable solution to combat the problem of poorly managed SUPs. The engagement activities have highlighted the urgency of addressing SUPs and have underscored the potential of as a viable alternative. This recognition suggests that embracing such technologies could play a pivotal role in mitigating environmental challenges posed by SUPs. By fostering dialogue and collaboration among various stakeholders, including government bodies, industries, and environmental groups, the Philippines can proactively adopt and integrate these innovative solutions into its waste management strategies.[7]

In the context of bioplastics R&D landscape (Figure 1), there have been efforts to produce the following bioplastics or biopolymers derived from local biomass feedstocks such as: starch, cellulose, chitin, carrageenan, gelatin, PLA, and PHA. In this landscape, the challenges in R&D implementation mostly stem from the establishment of collaborations with research institutions and respective industry partners along with the limited channel for promotion of the developed technologies. On the other hand, it is significant to note that among the government-funded R&D initiatives, there is an on-going thrust in the pilot-scale production of PHA. As such, PHA shows a promising pathway as a commodity that will eventually be utilized for a wide range of applications, specifically in alternative packaging solutions for SUPs.

PHA is locally produced from the fermentation of sugars derived from lignocellulosic biomass of agricultural residues (i.e., corn stover, sugarcane residues), as these types of biomass feedstocks do not have any implications on food security.(Perez et al., 2023; Tantoco et al., 2023) In the context of agricultural residues, in the sugarcane processing industry, it has been estimated that there are approximately 6.6 million tons per year of sugarcane trash (bagasse and leaves) generated from the 15.5 million tons per year of sugarcane harvested in the Visayas region.(Go et al., 2020) Moreover, for the corn industry, approximately 4.7 million tons per year of corn stover is generated from 6.1 million tons per year of corn harvested all over the country.(Go et al., 2019) From the fermentable sugars present in the highlighted agricultural residues, around 1.1 and 0.79 million tons per year of PHA can be produced respectively from sugarcane trash and corn stover.[8] As such, 1.9 million tons per year of PHA can be potentially produced from sugarcane and corn processing residues and this is more than twice the quantity of plastics being leaked into the open environment (Figure 2). Tapping the potential of

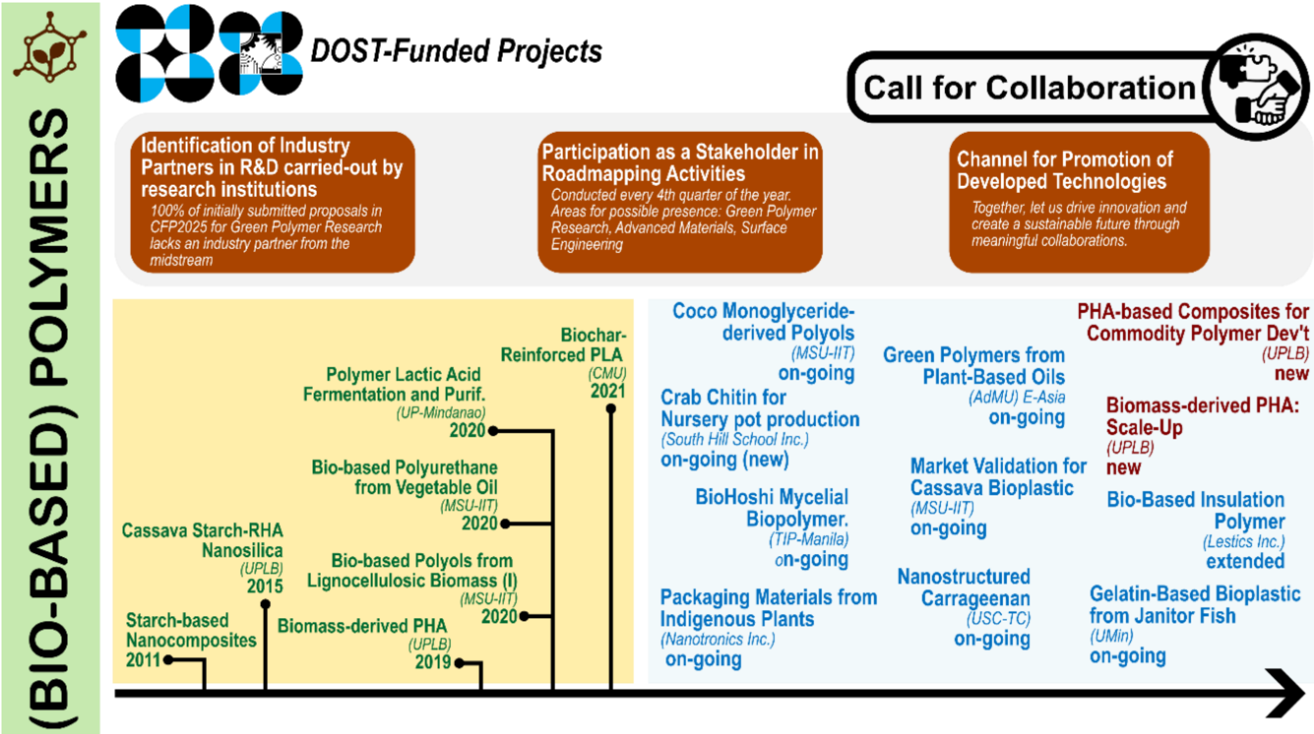
[6] An Industry Brief on the Philippine Bio-Based Economy. Batungbacal, B., Ventura, J.R.S., and Benjamin, M.F., 2023. https://drive.google.com/file/d/1CI89pD90Iy3sbFnk5JphU3WhrJ1p7nzD/view?usp=drive_link

[7] With respect to the "Trade and Industry Development (TID) Talks" organized by the Department of Trade and Industry – Board of Investments (DTI-BOI) last 13 November 2023. This provided an avenue for stakeholders to appreciate the significance of the bio-based economy (BBE) initiatives on biofertilizers, bioplastics, and sustainable aviation fuels to draw recommendations on development initiatives that could enhance trade and investments. See: https://boi.gov.ph/boi-partner-industries-academe-vow-whole-of-nation-collaboration-to-make-bio-based-economy-devt-happen-in-ph/

[8] Based on calculations from the theoretical yield of 0.38 g PHA per g glucose. See Perez et al., 2023; Tantoco et al., 2023

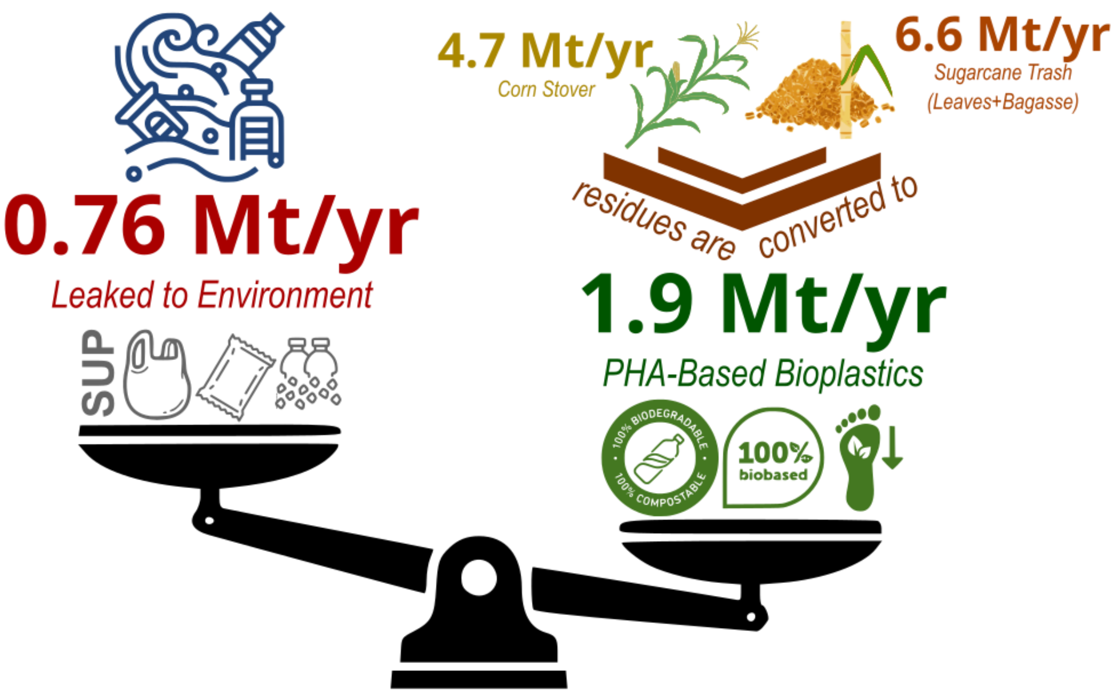
agricultural residues to produce bioplastics as an alternative to SUPs can possibly eliminate the plastics being leaked into the environment.

Figure 1. DOST-Funded R&D projects on Biopolymers as of 2023 along with the insights for collaboration efforts



Data Source: DOST-PCIEERD Project Database[9]

Figure 2. Offsetting the petroleum-based plastics with the benefits obtained by using bioplastics derived from agricultural residues.



[9] Information on these projects can be found in the following links: completed projects, https://pcieerd.dost.gov.ph/supported-programs-projects/supported-programs-and-projects/completed-projects; on-going projects, https://pcieerd.dost.gov.ph/supported-programs-projects/supported-programs-and-projects/on-going-projects

Policy recommendations

Tapping into the potential of biomass feedstocks. Biomass valorization for higher value products such as bioplastics should be incorporated in the bigger sustainable consumption and production, along with the circular economy, perspectives.

Piloting and Scale-Up Challenges. Enhanced support for local R&D, start-ups, and even private sector led initiatives especially in targeted government investments for pilot-scale demonstration facilities with respect to biopolymer production from local biomass feedstocks.

Product and Market Regulations. Establishment of local standards, specification, and product norms for biopolymers along with their subsidies and product tax policies. Development of mandates and bans on non-bio-based plastic products. IEC campaigns on sustainability labeling along with public awareness and acceptance of bioplastics. Procurement policies on bio-based materials.

References

Choe, S., Kim, Y., Won, Y., & Myung, J. (2021). Bridging Three Gaps in Biodegradable Plastics: Misconceptions and Truths About Biodegradation [Mini Review]. Frontiers in Chemistry, 9. https://doi.org/10.3389/fchem.2021.671750

Go, A. W., Conag, A. T., Igdon, R. M. B., Toledo, A. S., & Malila, J. S. (2019). Potentials of agricultural and agro-industrial crop residues for the displacement of fossil fuels: A Philippine context. Energy Strategy Reviews, 23, 100-113. https://doi.org/https://doi.org/10.1016/j.esr.2018.12.010

Go, A. W., Tabañag, I. D. F., Ju, Y.-H., Conag, A. T., Toledo, A. S., Orilla, J. W. A., & Angkawijaya, A. E. (2020). Sugarcane processing by-products for bioethanol production in the Philippines: a retrospective assessment from 2007 to 2017 and future challenges. Biofuels, 1-11. https://doi.org/10.1080/17597269.2020.1812999

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768-771. https://doi.org/10.1126/science.1260352

Kim, M. S., Chang, H., Zheng, L., Yan, Q., Pfleger, B. F., Klier, J., Nelson, K., Majumder, E. L. W., & Huber, G. W. (2023). A Review of Biodegradable Plastics: Chemistry, Applications, Properties, and Future Research Needs. Chemical Reviews, 123(16), 9915-9939. https://doi.org/10.1021/acs.chemrev.2c00876

Perez, N. A. D., Requiso, P. J., Alfafara, C. G., Capunitan, J. A., & Ventura, J.-R. (2023). Pretreatment Optimization of Corn Stover with Subsequent Enzymatic Hydrolysis for Polyhydroxybutyrate (PHB) Production. Philippine Journal of Science, 152(1).

Tabañag, I. D. F., Mendoza, M. L. G., Samimi, A. M., Saba, M. Y. S., Ignacio, P. S. P., & Onda, D. F. L. (2022). A Call for Digital Transformation in the Marine Environmental Protection Sector: A case for marine plastic litter pollution monitoring. Innovatus: A Journal on Computing Technology Innovations, 5(2), 21-29. https://doi.org/10.5281/zenodo.7363756

Tantoco, C. J. A., Requiso, P. J., Alfafara, C. G., Capunitan, J. A., Nayve Jr, F. R. P., & Ventura, J.-R. (2023). Response Surface Methodology and Artificial Neural Network Optimization and Modeling of the Saccharification and Fermentation Conditions of the Polyhydroxybutyrate from Corn Stover. Philippine Journal of Science, 152(1).