INTEGRATED LIFE CYCLE ASSESMENT IN THE ENVIRONMENTAL CHEMICAL RISK ASSESSMENT - APPLICATION TO COMMON PLASTICISERS

D. Sarigiannis[1,2,3*], S. Karakitsios[1,2]

[1] Aristotle University of Thessaloniki, Department of Chemical Engineering, Environmental Engineering Laboratory, University Campus, Thessaloniki 54124, Greece

[2] HERACLES Research Center on the Exposome and Health, Center for Interdisciplinary Research and Innovation, Balkan Center, Bldg. B, 10th km Thessaloniki-Thermi Road, 57001, Greece

[3] School for Advanced Study (IUSS), Science, Technology and Society Department, Environmental Health Engineering, Piazza della Vittoria 15, Pavia 27100, Italy

*(*denis@eng.auth.gr)*

ABSTRACT

Plastic waste management and the associated risks to human and ecosystem health are recognized as key issues in sustainable waste and resource management worldwide. The plastic crisis, has induced a number of jurisdictions to pose bans on use of plastic bags and enhance plastic recycling in the respective municipal waste management systems. Still to date, however, landfilling remains the most common waste management practice in Greece in spite of enforced regulations aimed at increasing recycling, pre-selection of waste and energy and material recovery. As yet, there is a much more limited number of studies focusing on the adverse human health effects of plastic products and waste, the ubiquitous nature of plastic material notwithstanding. Thus, in this study we have developed an innovative tool for integrated health risk assessment of plastic waste. The INTEGRA LCA software couples the integrated external and internal exposure assessment capabilities of the INTEGRA computational platform with life cycle impact assessment. The integrated software platform allowed us to perform a first-of-its-kind analysis of adverse health outcomes attributable to chronic exposure to persistent organic pollutants associated with plastic material use and disposal. Our analysis focused on plastic waste generated in the two main metropolitan centers in Greece, Athens and Thessaloniki. A comprehensive review of up-to-date information on plastic products and plasticizers used by the urban population was performed in order to build up the application-specific release/emissions inventory. Compounds of interest in this regard include bisphenol A, phthalates such as DEHP and its metabolites, DINCH, di-(2-ethylhexyl)adipate. The environmental fate analysis performed, included both multi-media contamination found in plastic waste and contamination of the food web including seafood. Integration of all human exposure routes and pathways to the toxic compounds contained in plastic was done at the level of systemic internal dose using the intake fraction methodology. We then parameterized properly the state-of-the-art generic physiology-based biokinetic (PBBK) model in the INTEGRA platform for these compounds and used it to reckon the biologically effective dose (BED) at the target tissues more closely associated with the putative adverse health outcomes considered in our study. Thus, we estimated the level of homeostatic perturbation induced by the BED at the target tissues.

Our analysis highlighted that landfilling is the worst waste management strategy on a global scale. At the same time, the investigated options for waste treatment coupled with energy and material recovery would result in very important benefits in terms of greenhouse gas emission reduction. However, not all options are equally benign to the local environment and to the health of the local population, since both the former and the latter are still affected by non-negligible local emissions. With regard to public health impacts, adverse effects on the endocrine system with cascade impacts on human reproduction, metabolic syndrome and, even, neurotoxicity after chronic exposure to the persistent organic chemicals found in plastic products and waste were estimated.

The estimated risks of the plasticizers investigated above seem to be relatively low, with the exception of DEHP, where the estimated intake is in the same order of magnitude with the respective TDI. Beyond that, the cumulative effect of these compounds has to be taken into account. Among the various steps of the respective life cycle, waste remaining in the environment is expected to be particles/fragments abraded from end-use products during their service life and during disposal. These particles are primarily released to the urban/industrial soil compartment in landfills. However, the smallest fraction may also be distributed to the air compartment or to the surface water environment ending up in the sediment. Overall, the comprehensive

analysis of the waste management options indicated that incineration contributes significantly to increased levels of exposure through inhalation for the population living close to the incinerator facility, while on the other hand recycling results in lower exposure from all environmental exposure pathways.