Advances in quantifying marine litter to support waste management decision-making in local authorities of the Global South

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Plastics have become one of the most fundamental materials for industry and for everyday life. They offer great functional benefits at low cost. The use of plastics has increased 20-fold in the past 50 years and is expected to double in the next 20 years (PlasticsEurope, 2015). However, despite the many benefits that plastics bring to society, we also see that there are some drawbacks. As a majority of packaging items are used only once before being discarded, it is estimated that 95% of its value, USD 80-120 billion, is lost to the economy each year (The Ellen MacArthur Foundation, 2016). Additionally, plastic production emits global warming gasses, with it estimated that in a business as usual scenario, the entire plastics industry could be producing 15% of the annual carbon budget in 2050. An astounding 32% of plastic packaging also escapes collection systems, causing major environmental, social and economic loss by impacting natural systems such as the ocean (The Ellen MacArthur Foundation, 2016).

Much of the plastic leakage is expected in the Global South and as suggested in recent studies is mainly a result of mis-managed waste (Wilson *et al*. 2013;Velis, 2014; Jambeck *et al*. 2015). A typical solid waste management system in a developing country displays an array of problems, including low collection coverage, irregular collection services, illegal open dumping, open burning without pollution control, and the handling and control of informal waste picking or scavenging activities (Ogawa, 2018). These general characteristics of the Global South often relate to inadequacies of waste management sector due to lower municipal budgets compared to the Global North.

Expanding on the above, the Global South, with three quarters of the world populations, has access to one-fifth of the world income (Therien, 2010). Corruption and poor environmental enforcement are features of the Global South. There are fewer trained people, and the best people tend to be concentrated in capitals rather than in field posts; equipment for monitoring and data gathering is scarce, and the basic data is unreliable (Bell and Russell, 2002). Moreover, the Global South lacks appropriate technology, political stability and the economies are disarticulated (Therien, 2010).

These characteristics of the Global South, are compounded by the predictions of rapid urbanization rates and an increase in waste generation in the upcoming years. This makes the introduction of local decision-support tools as well as the implementation of locally adopted policy and engineering interventions to manage plastic pollution a great challenge.

Here we outline the progress towards developing a decision-support tool for waste management authorities that quantifies the degree of plastic leakage into the environment. The tool builds on the outcomes of the ISWA MLTF report “Prevent Marine Plastic Litter- Now!” (Velis *et*. *al*. 2017). It is applicable at the city district-level and takes into account sources, factors that affect the location and quantity of potential plastic pollution, and potential mitigation interventions. It has also the capability to expand to quantification of loss of ‘value’ present in waste plastics via the combination with the Complex Value Optimisation for Resource Recovery (CVORR) approach (Iacovidou *et*. *al*. 2017). This approach assesses how value is created and destroyed in resource recovery from waste systems. It achieves this by taking into account environmental, economic, social and technical positive and negative impacts within the socio-political context of the specific regions (Iacovidou, *et al*. 2017).

The decision-support tool estimates the quantity and type of plastic entering the environment from land-based sources under a variety of typical landscapes and conditions, using both a temporal and spatial approach. The principal of the model developed (Figure 1) is that the study region is split into different regions (modelling unit cells). These may be regular unit cells (i.e., 1 km^2 grid) or be related to geographical / political boundaries (i.e. constituencies, post codes etc.). Although the regular unit cells are likely to give a higher spatial resolution, the geographical / political modelling unit cells allow easier data collection / analysis as they provide more natural boundaries.

The characteristics of the area under study is defined according to a number of typologies related to the relative land use of the area, the waste management system in place and the geographical and social conditions. The total amount of plastic waste arising is then calculated for each land use based on predicted waste generation rates and waste compositions. The summation of these gives the overall plastic waste generation in that modelling unit cell. These calculations are performed accounting for any variations in waste generated with time (i.e. is the same amount of plastic waste generated each day or are daily / season variations expected) and the different types of plastic waste produced (i.e. plastic packaging, agricultural film etc.).

Following the determination of the plastic waste generated, the end-of-use disposal routes are addressed using Material Flow Analysis. Transfer coefficients are linked to the social, material and geographical conditions of the area in order to estimate the plastic waste that may enter the environment (e.g. waterways) for different locations and time.

After estimating sources and amounts of plastics escaping the defined system, the tool proposes to the users as list of prioritized locally adapted policy and engineering interventions to prevent and reduce plastic waste pollution. Emphasis is withdrawn on the actions that could be taken at the different stages of the waste management system in place and that could serve as solution to prevent plastic pollution.

Despite that many of the inputs within the model are likely to be highly uncertain, it could provide a first approximation and allow a more thorough understanding and visualisation of how plastic waste enters waterways. It is anticipated that further input from experts and practitioners would enable to confirm the validity of the transfer coefficients used throughout this work.

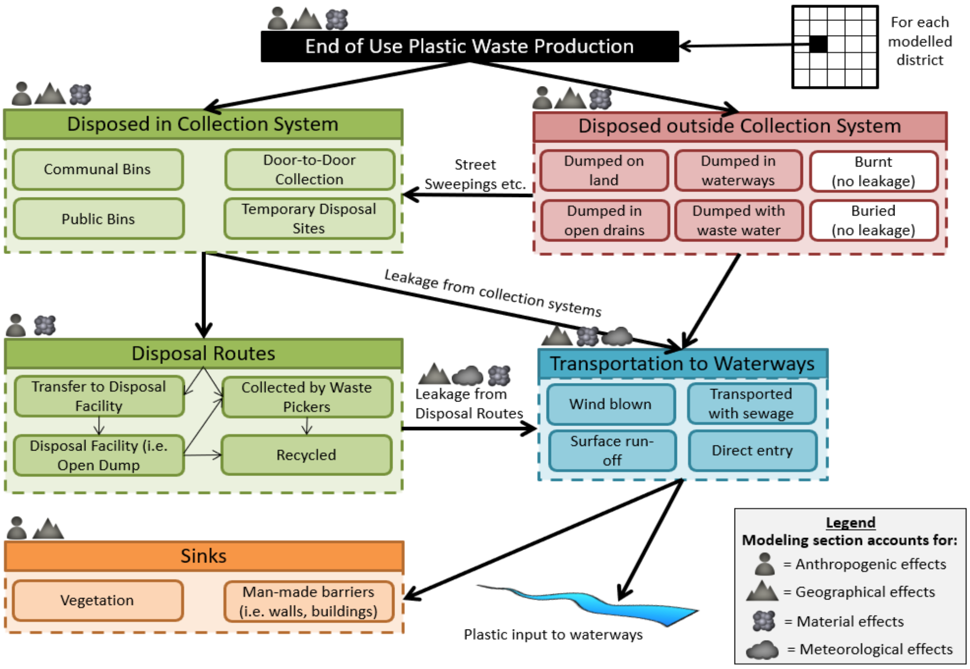

Figure 1: Conceptual model of plastic litter entering to environmental sinks (i.e. 'leakage').

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