Plastic in Freshwater Ecosytems: A looming crisis in the Philippines

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The problem on plastic pollution is on a global scale. The ubiquity of plastic debris is transforming the planet's surface by accumulation through time on land, ocean surfaces, sea beds, and even in abyssal depths (Barnes et al. 2009). Thus, it is considered as one of today's main environmental problems (Blettler et al. 2018, United Nations Environment Programme Yearbook 2005; UNEP Yearbook 2014; UNEP Yearbook 2016). While they are mostly used and disposed on land, plastic debris usually find their way to bodies of water where they pile up and cause heavy pollution as a result of human littering (Horton et al. 2017). Hence, their presence in aquatic environments, both freshwater and marine (Eriksen et al. 2013; Kooi et al. 2018) have received increased attention over the past years in the scientific community (Ryan 2015; Eerkes-Medrano et al., 2015). This is because of the potential risks they pose to human health (Wright and Kelly 2017), wildlife (Gall and Thompson 2015), and the environment (Thompson 2009).

Most available literature on plastics are focused on marine ecosystems, their impact on the marine biome, and the subsequent changes plastic debris are doing to marine habitats (Eriksen et al. 2013; Law 2017; Rochman et al. 2016). These also include encounters of marine wildlife and plastics such as incidence reports of ingestions and entanglement (e.g. de Stephanis et al. 2013; Schuyler et al. 2014), with intensive literature on charismatic megafauna and microplastic accumulation in economically important fish species (e.g. de Sá et al. 2018; Smith et al. 2018). In comparison, studies focusing on the effects of plastic on freshwater ecosystems and its biota remain limited (Blettler et al. 2018; Wagner et al. 2014). On a global scale, the literature on plastic pollution related to marine versus freshwater systems has a ratio of 41:7, with published marine pollution-related studies exhibiting a growth rate five times higher than freshwater studies (Blettler et al. 2018).

In the Philippines, particularly, there are almost no publications on freshwater plastic pollution. This is concerning since pollution in river, streams, and lakes are almost comparable to marine pollution levels (Peng et al. 2017). Additionally, Philippines is suggested to be one of the potential largest contributors of plastic in the oceans, mostly via rivers and streams (Jambeck et al. 2015; Lebreton et al. 2017). According to a global study, Pasig River in the Philippines is one of the largest contributors of plastics with an estimated 3.21×10^4 to 3.88×10^4 tons of debris emitted per year (Lebreton et al. 2017). While a call for research on marine plastics in the Philippines has been done (Abreo 2018), the little to almost no existing publications for freshwater plastics is concerning. The occurrence of plastics in freshwater ecosystems is an increasingly critical environmental issue. Even with the few available studies, the information highly suggests heavy contamination worldwide (Dris et al. 2015). Similar to marine ecosystems, plastic pollution come mostly from mismanaged wastes or improper disposal from residential, industrial, and agricultural activities, eventually finding its way to rivers, streams, and lakes. This makes the problem on plastics pollution in freshwater ecosystems as equally important and relevant as marine plastic pollution.

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Figure 1: Plastic accumulation in a shallow freshwater stream located under Matina Bridge, part of Matina River in Davao City. Accumulation may alter waterflow and deposition of substrate.

In addition to the scarcity of studies or lack thereof in freshwater ecosystems in the Philippines, other implications of plastic wastes warrant enough reasons to conduct assessments of the impact of plastic in rivers, streams, and lakes. For example, the effects of macroplastics and the incidence of ingestion and/or entanglement of marine species are documented (e.g. Abreo et al. 2016a; 2016b; 2019a; 2019b). However, no studies of this nature have been conducted for freshwater bodies in the country. Additionally, lakes can possibly have higher concentration of plastic because of its enclosed nature but remains little understood because of the lack of research in these ecosystems. The hydrodynamics of rivers is also a subject of many studies because of how it affects riverine plastic emissions in large rivers (e.g. Lebreton et al 2017; van Emmerik et al. 2018). On the other hand, shallow freshwater ecosystems may experience change in hydrodynamics; macroplastics and the consequent accumulation can affect ephemeral ponds and shallow streams (Figure 1) by channel alteration and deposition of substrate, ultimately disturbing and changing the dynamics of these habitats.

Macroplastics deteriorate into microplastics (fragments <5mm) via physical and chemical weathering (e.g., UV radiation) (Carbery et al. 2018). While this deterioration process is studied extensively in marine habitats, little is known about the rate and mechanism of fragmentation in freshwater environments (Free et al. 2014). Needless to say, microplastics pose more problems in both marine and freshwater habitats since they are more pervasive (Rios-Mendoza & Jones 2015) and have longer-lasting effects than macroplastics. The deterioration process increases the availability of plastics and exposes a wider range of organisms in aquatic habitats. This is supported by the increasing number of reports on microplastics incidence in different trophic levels including zooplankton (Desforges et al. 2015), mollusks (van Cauwenberghe & Janssen 2014; van Cauwenberghe et al. 2015), crustaceans (Goldstein et al. 2013), and fishes (Neves et al. 2015; Bellas et al. 2016). The incidence of ingestion also increased because of biofouling, a process where biofilms form on plastic surfaces transforming the debris or particle into a material, which trophic consumers mistake for food (Kooi et al. 2017).

Plastics have the potential to increase the concentration of toxic substance in the water by adsorbing chemical pollutants (e.g. bisphenol A, polychlorinated biphenyls, polycyclic hydrocarbons, polybromodiphenyl ethers) which affect the intermediate biota. For example, Avio et al. (2015) showed that pyrene, a polycyclic hydrocarbon adsorbs to polyethylene and polystyrene microplastics, which then accumulates in the tissues of the exposed mussels. It was also reported that the high concentration of pyrene affected the mussels' molecular and cellular pathways including altered immunological response and changes in gene expression profiles. In another study, the growth of marine microalgae was inhibited due to blockage of photosynthetic pathway via algal surface adsorption and aggregation (Zhang et al. 2015). These studies support that all trophic levels are adversely affected by microplastics. Hence, it is important to determine the degree of effect plastic has on biotic factors in freshwater ecosystems.

It is also important to note that microplastics can be distributed via atmospheric pathways (Dris et al. 2016) through wind transport into aquatic environments. This means that even lakes and springs high in the mountain can be possibly contaminated by plastic. In addition, it was found out that plastics pollution was present even in remote areas where human activities are limited, which could be attributed to a lack of proper waste management (Free et al. 2014), also affecting potable underground water sources (World Health Organization 1996). Plastics contain phthalates, a softener used to increase the flexibility of the material (Giam et al. 1978). During plastics production or its disposal after use, phthalates become partially dissolved in water in the form of residues and escapes into the atmosphere via evaporation where they are washed backed into the ground by precipitation (i.e. rain, snow) (Peakall, 1975; Atlas & Giam 1981). Upon entering the soil, they are partially but strongly adsorbed by organic substances and reach underground water even with continuous soil filtration (Brooke et al. 1991). The contaminated underground water can then be drawn out via wells or springs for consumption, making humans in rural areas dependent on underground tap water highly exposed to the carcinogenic effects of the compound used in plastic manufacturing.

Furthermore, freshwater ecosystems are substantial sources of fish and other organisms that are potential protein source of inland communities, thus, studying plastics is also important in ensuring food security (Macusi et al. 2015). The toxicology of microplastics show that the toxins they release eventually accumulate in tissues of living organisms when consumed (Rochman et al. 2013; Avio et al. 2015). Increased biomagnification of plastics and toxins released by plastics through trophic transfer is also possible (Farrel and Nelson 2013; Ziccardi et al., 2016), which could render freshwater organisms unsafe for human consumption. Although research in this area is still in its infancy, this can have severe negative implications on future food security since a significant portion of fisheries supply (i.e., tilapia) of the country comes from freshwater bodies.

Research on this field of plastic pollution is of utmost importance because of its potential adverse effects on the ecosystem and biodiversity of the country. Freshwater environments significantly differ from the marine ecosystems, such as in the amount of sunlight, pH, and hydrodynamics. These abiotic factors can affect the rate of deterioration and fate of plastics and should be included when studying plastics in these ecosystems. Freshwaters systems are also in close proximity to plastic sources since production, commercial, and residential facilities in inland communities are concentrated around main rivers and tributaries. Hence, the effects of plastic on freshwater environment should be studied, especially their abundance, fate, and various interactions in these ecosystems. Additionally, the development of standard protocols for the sampling and collection of plastics in these environments should also be done as they are needed for their proper quantification and identification. The Philippines is highly dependent on the ecosystem services provided by freshwater environments (e.g. tourism, food) and thus needs to focus on the proper management and conservation of these resources. With the rate at which plastics is currently manufactured, used, and disposed, and with the prevailing waste mismanagement (as shown in Figure 1) and its obvious impacts to the aquatic environments of the Philippines, it is evident that appropriate policies and guidelines should be implemented to reduce the usage, and possibly the production of plastic materials. However, the lack of knowledge and data can hinder our understanding of the problem, resulting in our inability to provide sound solutions. There is scarcity of studies on plastics in freshwater bodies in the Philippines and with the growing literature on their negative effects, plastic research and its impacts to freshwater ecosystems are highly needed.

CONFLICTS OF INTEREST

The authors declare no conflicts of interests.

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