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Opinion

Emerging Concerns about Microplastic Pollution on Groundwater in South Korea

Heejung Kim and Jin-Yong Lee *

Department of Geology, Kangwon National University, Chuncheon 24341, Korea; hydroqueen@kangwon.ac.kr
* Correspondence: hydrolee@kangwon.ac.kr; Tel.: +82-33-250-8560

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If human history has thus far been divided into the Stone Age, Bronze Age, and Iron Age, then modern times can be considered the Plastic Age [1]. Without plastics, it would be impossible to manufacture the innovative products created by modern civilization. The word "plastic" originates from the Greek word *plastikos* and the Latin word *plasticus*, meaning "formable or moldable in a cast". It is often used interchangeably with the term *resin*. Plastics are organic polymer materials or compounds that can be shaped by heat or pressure. Plastics, considered a miracle gift in the 20th century, have been part of humans' lives for more than 150 years; daily lives inevitably involve using plastics in some form. Plastic use has soared worldwide since the 1960s; more than 335 million tons of plastics were produced in 2016 [2–4]. Plastics, which do not decompose and thus harm the ecosystem, are recognized as among the main contributors to environmental pollution worldwide. Furthermore, vast amounts of synthetic plastic remain non degradable and natural decomposition takes a long time [5,6].

The situation in South Korea is bad. According to the 2016 National Statistical Office survey, South Korea's annual plastic consumption per capita was 98.2 kg in 2016, the highest in the world [7,8]. International discussions regarding the regulation of plastic use are being conducted to address this situation [9]. At the 4th United Nations Environment Assembly in 2019, an environmental policy resolution was adopted that includes a significant reduction in the use of disposable plastics by 2030 [10]. A policy to ban all or some disposable plastics was also announced in South Korea [11]. MP (microplastic) is defined as plastic particles >100 nm and <5 mm in size [9,12]. Plastic that is intentionally produced with a microscopic size are called primary MPs. Such plastics are generally used in cosmetics, cleansers, shampoos, and fabric softeners. Secondary MPs are small plastic pieces that are generated from clothes, bags, wrapping paper, cups, bottles, and plastic products for industrial and fishery uses when they are crushed or decomposed by physical, chemical, and biological processes over time [10]. In addition, MPs released into the environment can adsorb toxic pollutants, thereby increasing the risk of exposure to pollutants [13–15]. Considering these serious problems posed by MPs, research on MPs has been actively focused on the marine environment in South Korea and other countries [11]. A few recent studies have been conducted on freshwater environments in other countries and the presence of MPs in wastewater treatment facilities and streams has been reported [12]. However, because there are no case studies on the research methods and occurrences of MPs in surface water and groundwater environments in South Korea, investigations on MPs in these environments have to be accorded a high priority. MPs are a new type of pollutant in the groundwater environment. They have been found in many parts of the world and are drawing great public attention [16].

They became a major concern mainly after the discovery of the North Pacific Central gyre garbage patch by C.J Moore [17], and The Guardian revealed that MPs were detected in 83% of tap water in 14 countries in 2017 and in 93% of 260 drinking water sources in 11 countries in 2018 [18]. There has been an increasing interest in MP contamination in recent years. MPs are difficult to decompose due to their physicochemical properties [19]. Contaminants can easily spread into the environmental system because of MPs remaining in the terrestrial or aquatic environment and organisms (Figure 1) Awareness around the severity of the pollution has been increasing [20], especially considering that the bioconcentration of MP contamination can cause ecosystem disturbances [21]. In South Korea, as MPs were detected in tap water in 2017, investigations into the distribution of MPs in industrial and sewage treatment facility discharge water were initiated [22]. Unlike the freshwater environment, it is difficult to use a single method to qualify and quantify MPs in the groundwater environment.

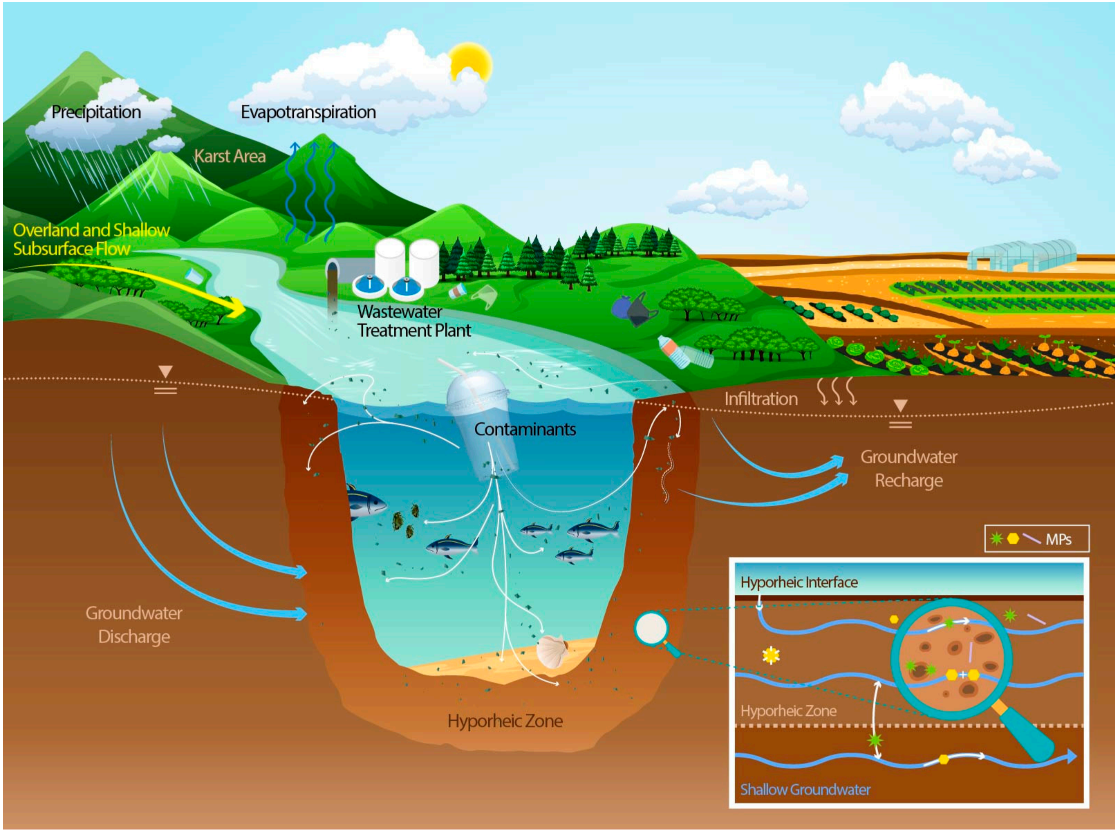

Figure 1. Fate of microplastics in aquatic and terrestrial environments and their link to hyporheic zones.

The U.S. National Oceanic and Atmospheric Administration supports a variety of studies related to MPs through collaborations with research institutes [23]. Recently, an Illinois University research team studied MPs that were discovered in a karst aquifer [24]. In addition, the Technologies for the Risk Assessment of MicroPlastics (TRAMP) research project was conducted in the Netherlands from 2015 to 2019, in which relevant ministries, research institutes, and universities participated. In this project, nanoplastic and MP detection technologies as well as technologies to evaluate the transport, risk, and impact of plastics were developed; further, the present and future risks of plastics in freshwater environments were predicted. In addition, the University of Bayreuth in Germany operates the Collaborative Research Center 1357 Microplastics Research Group (speaker: Prof. Dr. Christian Laforsch) with funding from the German Research Foundation (Deutsche Forschungsgemeinschaft). They have been studying the transport of MPs through ecosystems, biological impacts of MPs, and natural reduction of MPs for many years. In particular, the European Union is preparing institutional strategies for monitoring MPs in drinking water including spring water [25]. They are also considering diverse countermeasures such as the development of recycling technologies for plastics in a circular economy package, development of biodegradable plastics, technology development for the identification of harmful substances in plastics, and marine waste prevention [26–29].

In South Korea, ongoing studies focus on the biological effects and toxicity; environmental hazards; human hazards; analysis methods; and the current status, transport, movement mechanism, treatment, and reduction of MPs in the ocean, freshwater (surface water), soil, and wastewater treatment facilities [14]. However, thus far, research has mainly focused on the marine environment in South Korea and studies regarding the surface water and soil are very limited [30]. In particular, there is no research on the occurrence, fate, and transport of MPs in groundwater. Figure 1 conceptualizes the transport of MPs generated on the ground in the groundwater system and in the hyporheic zone (HZ), which contains a mixture of groundwater and surface water. The issues of marine pollution and bioaccumulation of MPs are of great concern and, hence, research interest worldwide. It has been estimated that 1.15 to 2.41 million tons of plastics flow through streams and rivers into the sea annually worldwide [31,32]. Because the majority of MPs in the ocean originate from land [21], the number of studies on MPs targeting marine ecosystems and freshwater, particularly surface water, has increased. In addition, because MPs have been recently detected in groundwater, technologies that can be used to measure MPs in groundwater and evaluate their transport must be developed. Groundwater contamination by MPs is of particular concern because the HZ, waterfront areas near wastewater treatment facilities, and karst areas have highly vulnerable hydrogeological properties for maintaining and managing groundwater resources (Figure 1). Therefore, the expansion of MPs research from marine ecosystems to underground environments, such as terrestrial groundwater, will have great social and academic value.

Currently, the exact status of groundwater contamination by MPs in Korea is unknown, and research related to groundwater is seldom carried out. Thus, as research on MPs progresses, our understanding of MPs will be enhanced through the accumulation of more reliable data. It is not clear as to exactly how MPs affect the human body. However, there is no doubt that MPs are increasing in the human environment. Therefore, efforts should be made to establish a basis for MPs detection systems for groundwater. It is also necessary to conduct MPs detection surveys frequently in groundwater, rivers, soil, drinking water, etc., in consideration of the consumption patterns in Korea, whose per capita plastic consumption is the highest in the world, and also to mitigate the hazards of MPs. However, domestic research on MPs remains very basic. In the future, various studies should be conducted to prepare the scientific basis. These studies should include investigating the sources and pollution status of MPs on land, identifying the behavior of MPs that have entered groundwater, determining the harmfulness of groundwater contaminated by MPs, and establishing the degree of infiltration of pollutants into groundwater.

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