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Occurrence of micropollutants in four major rivers in Korea

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HIGHLIGHTS

- The levels of micropollutants in rivers were reported across all of Korea.
- Industrial activity near sampling sites was related to chemicals found in rivers.
- Pollutants detected in rivers were the intermediates of other chemicals.
- The risks posed by the pollutants were not directly linked to their concentration.
- Data that are more appropriate are needed to improve the risk assessment method.

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ABSTRACT

There has been an increasing concern in recent years over the presence of numerous micropollutants in river water. Simultaneously, risk assessment of micropollutants has become increasingly important due to their high toxicity. Therefore, the aims of this study were to characterize the levels of micropollutants in rivers, to identify the sources of these pollutants, and to evaluate their risk quotients (RQ) to the ecological system. Monitoring data from 159 sites distributed across four major rivers in Korea were collected from the Ministry of the Environment (KME) reports. Tests were performed to check for the presence of 35 pollutants in river waters, from which 29 pollutants were detected. Organochlorine pesticides (OCPs) occurred most frequently, at low concentrations, whereas volatile organic compounds (VOCs) and phthalates were detected at higher concentrations. Based on this study, it was suggested that the factories near the sampling sites where pollutants were found represent one of the main sources of chemicals. After comparing the industrial activities with the measured pollutants, although the released amounts were not reported, representative intermediate chemicals were found in the river water. The RQs of most VOCs were below one, despite their concentration range being higher, compared with other pollutants. Methyl bromide and di-n-octyl phthalate occurred frequently in the Han River Basin and the Nakdong River Basin, respectively, and their RQs were consistently high, so further studies should focus on their exact emission source in order to reduce ecological risk. The results suggest that it will be necessary to develop methods of risk assessment that are more tailored to the various micropollutants present in river water, in addition to the implementation of water treatment systems to reduce ecological risk.

1. Introduction

Rivers are thought to be frequently exposed to large amounts of micropollutants originating from the discharge of effluent from wastewater treatment plants, which are one of the most significant sources of micropollutants in all aquatic environments. The micropollutants are toxic to the aquatic environment and remain within waters, without experiencing degradation by microorganisms or light. Thus, in recent years, there has been an increasing concern over the presence of numerous micropollutants in streams and rivers, including pesticides, solvents, and plasticizers (Claver et al., 2006; Ikem, 2010; Liu et al., 2013).

In Korea, it is especially important to monitor the concentrations of micropollutants in rivers. Around 87% of water destined for human use in Korea is derived from surface water sources, such as rivers, lakes and streams, with only 13% obtained from groundwater, compared to the average surface water use in OECD (Organization for Economic Co-operation and Development) member countries, of 78%

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(OECD, 2004). In addition, most urban and agricultural areas are located along rivers in Korea, meaning that water discharged to upstream regions is inevitably reused further downstream.

Ecological or environmental risk assessment is defined as a procedure by which the likely or actual adverse effects of pollutants and other anthropogenic activities on ecosystems and their components are estimated, to within a known degree of certainty, using scientific methodologies (Depledge and Fossi, 1994). Similarly, environmental risk management, which is more politically oriented, designs and implements regulatory measures based on the risk assessment (Van Leeuwen and Hermens, 1995). It is important to incorporate the risk assessment into future risk management strategies because even pollutants with low concentrations can have high toxicities, owing to the specific characteristics of the pollutants and receptors.

Assessment of micropollutants has been carried out, based on treatment processes and types of wastewater, such as industrial or municipal wastewater, in a limited area only, with the aim of investigating the behavior of micropollutants in an aquatic environment (Behera et al., 2011; Hwang et al., 2012). Therefore, it is necessary to extend this research by monitoring the levels of micropollutants in river water across the entire country. The aims of this study are to report the levels of micropollutants in river waters of Korea, alongside the activity of industrial complexes near the rivers, in order to identify the source of detected chemicals and to assess the individual risk each chemical poses to the ecological system, based on the number of compounds detected and their concentrations.

2. Materials and methods

2.1. Description of the data

In Korea, the Ministry of the Environment (KME, 2012) has monitored micropollutants from four major rivers nationally and has released a report that detail the monitored data of volatile and semi-volatile compounds in these rivers (KME, 2010). In this latest report, river water samples were collected from 159 sites, which were taken to represent diverse locations across South Korea, as shown in Fig. 1. The details of sampling sites in each river basin are shown in Fig. A.1, including the locations of industrial complexes alongside the sampling sites. Table A.1 presents information on each basin, such as the lengths of the main streams, the watershed area, human population, and the daily discharge of treated wastewater. The samples were collected during three separate periods in 2010: July, September, and November, and were tested for 35 volatile and semi-volatile compounds.

Data from the Pollutant Release and Transfer Registers (PRTR) of Korea were used to identify the source of the chemicals reported in

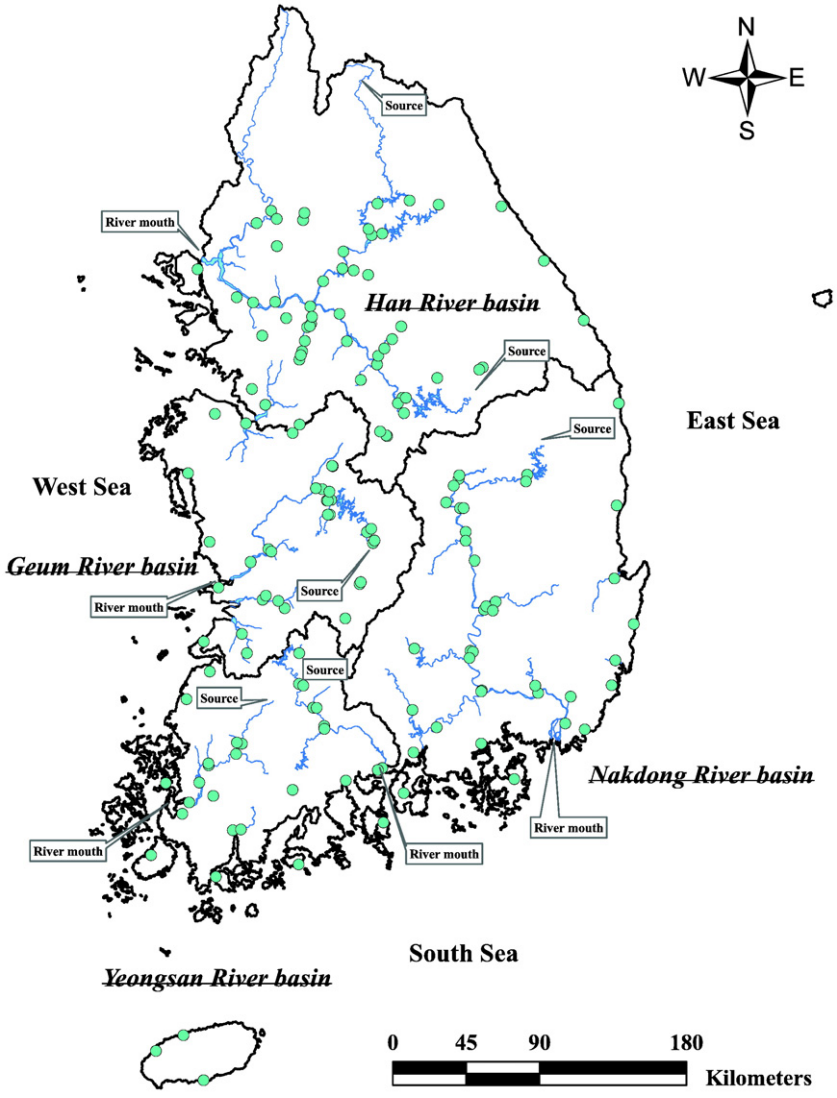

Fig. 1. Map of sampling sites in South Korea. River water sampling sites are depicted as blue circles.