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Characteristics of washed-off pollutants and dynamic EMCs in parking lots and bridges during a storm

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Abstract

Given the importance of water quality in drinking water sources, the Korean Ministry of Environment is designing and instigating the total maximum daily load (TMDL) program for major large rivers. For the successful implementation of this program, nonpoint pollutants resulting from various land uses should be controlled. Especially, paved areas such as parking lots and bridges are stormwater intensive land uses because of their high imperviousness and high pollutant mass emissions from vehicular activity. Vehicle emissions from these paved areas include various pollutants such as heavy metals, oil, grease and particulates. This research was conducted to investigate the magnitude and nature of the stormwater emissions with the goal of quantifying stormwater pollutant concentrations and mass emission rates from a parking lot and a bridge. Two monitoring sites in Kongju city were equipped with an automatic rainfall gauge and an automatic flow meter for measuring rainfall, water quality and runoff flow. This study presents the concentration changes during storm occurrence and event mean concentrations (EMCs) in the parking lot and bridge. The first flush criteria, a new concept explaining the relationship between EMC and the first flush effect, is also suggested using dynamic EMCs.

Keywords: Dynamic EMCs; Parking lot; Bridge; TMDL; Land use; Nonpoint sources

1. Introduction

Korea has made tremendous advances in the past 30 years to clean up its aquatic environment by controlling pollution from point sources. Although point source discharges have decreased in recent years, many water bodies or rivers are still impacted and are either eutrophic, with excess algae biomass and episodes of toxic algal blooms, or oxygen depletion. Nonpoint sources (NPSs) are the cause of many of the problems. NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from a large variety of sources and is so widespread because of its possible occurrence at any time in any type of land use (EPA, 1994, 1995, 1996; Saget et al., 1995; Smullen et al., 1999). In spite of the billions of dollars that have been spent on cleaning up point pollutant sources, many water bodies in Korea remain polluted. NPS pollution remains a major cause of the degradation of receiving waters and presents new challenges to the

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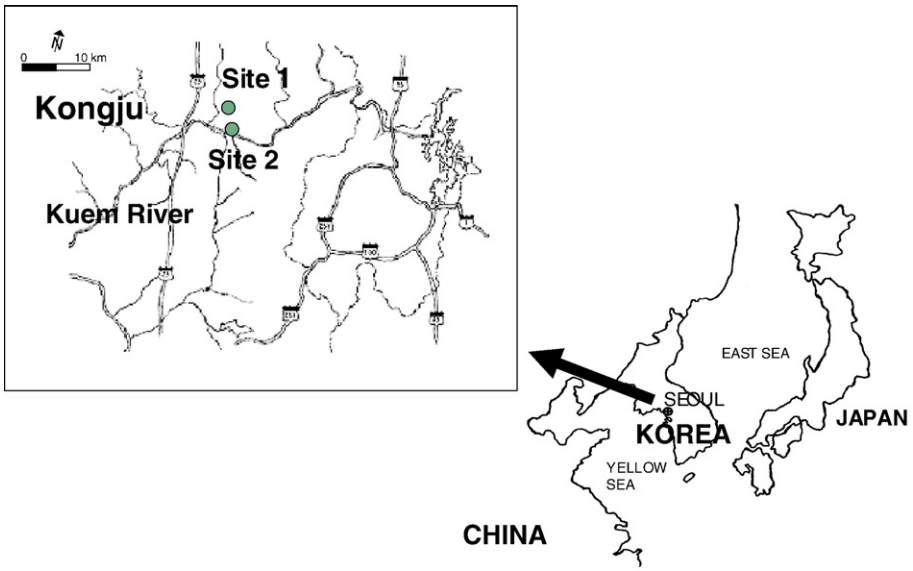

Fig. 1. Monitoring locations.

environmental and legal professions (Charbeneau and Barrett, 1998; Kim, 2003; Kim et al., 2004). The recent emphasis in Korea has been to manage NPS pollution. Therefore, the Ministry of Environment has developed a program of total maximum daily load (TMDL) to protect water bodies from possible pollutants. TMDL is the sum of the allowable loads of a single pollutant from all contributing point sources and NPSs (Corwin and Vaughan, 1997; Deletic and Mahsimivic, 1998; Driscoll et al., 1990). The calculation must include a margin of safety to ensure that the water body can be used for the designated purposes.

Generally, nonpoint pollutants are caused by various land uses. Paved areas such as parking lots and bridges are stormwater intensive land uses since they are highly impervious, and have high pollutant mass emission from vehicular activities (Stenstrom et al., 2001; Vorreiter and Hickey, 1994). Vehicle emissions have different pollutants such as heavy metals, oil, grease and particulates from sources such as fuels, brake pad wear and tire wear. A storm event usually leads to highly polluted runoff from parking lots and bridges which directly affects the water quality near the site (Gupta and Saul, 1996; Kim, 2003; Larsen et al., 1998). The washed-off pollutant concentrations from NPS, including parking lots and bridges, are quantified with the event mean concentration (EMC). This is defined as the total mass load of a pollutant from a site during a storm divided by the total runoff water volume discharged during the storm (Bertrand-Krajewski et al., 1998). EMCs are especially valuable for estimating pollutant loads. If the EMC is known, and a rational method for calculating runoff is assumed, it is easy to estimate loads. The load is the product of the rainfall, area and runoff coefficient. This approach is useful if the environment of the receiving water can be managed using average concentrations and loads. However, the EMC does not provide information on the time varying changes in pollutant concentration or mass emissions. In paved land uses, the first flush effect is an important phenomenon for selecting the best management practices (BMPs) by providing reasonable treatment criteria. Even though the EMC is concerned

Table 1
Event table in the parking lot and bridge

Events (parking lot/ bridge)	Event date	ADD (days)	Total rainfall (mm)	Storm duration (h)	Avgerage rainfall intensity (mm/h)	Runoff coefficient
E-1	2004-05-28	13	20.5	4.57/4.78	4.5/4.3	0.88/0.87
E-2	2004-06-17	18	45.3	9.73/10.77	4.7/4.2	0.90/0.92
E-3	2004-07-03	2	36.4	9.2/9.22	4.0/3.9	0.94/0.71
E-4	2004-07-11	3	9	7.02/8.73	1.3/1.0	0.64/0.68
E-5	2004-08-16	1.8	29.4	7.33/5.67	4.0/5.2	0.81/0.79
E-6	2004-08-22	2	8.1	5.55/6.23	1.5/1.3	0.85/0.83
E-7	2004-09-11	3	36.2	6.45/5.05	5.6/7.2	0.88/0.80