Occurrence of Antibiotic Resistant *E. coli* in Surface Water: A Study in a Typical Urban Watershed, Korea

Ha Na Yoo[1], Seo Jin Ki[1], Joo-Hyon Kang[2], Young-Sik Ham[3], Sung Min Cha[1], Seung Won Lee[1], Seung Yoon Lee[4] and Joon Ha Kim[1, 5,*]

[1] Department of Environmental Science and Engineering, Gwangju Institute of Science and Technology (GIST), 261 Cheomdan-gwagiro, Buk-gu, Gwangju, 500-712, Korea
[2]Department of Civil and Environmental System Engineering, Dongguk University, Seoul 100-715, Korea
[3] The Council for Paldang Water Quality Policy, 559-21 Yangsu-ri, Yangseo-myeon, Yangpyeong-gun, Gyeonggi-do, 476-823, Korea
[4] K-water Research Institute (KRI), Korea Water Resources Corporation 462-1, Jeonmin-dong, Yuseonjg-gu, Daejon, 305-730, Korea
[5] Sustainable Water Resource Technology Center, Gwangju Institute of Science and Technology (GIST), 261 Cheomdan-gwagiro, Buk-gu, Gwangju 500-712, South Korea

Corresponding author E-mail*: joonkim@gist.ac.kr*

Abstract: Elevated levels of antibiotic-resistant (AR) bacteria are routinely detected in surface water, whereas the dissemination of such bacteria across tributaries, rivers, or watersheds is often unknown. In a present study, one year of water quality monitoring was conducted to assess the sources, occurrence, and distribution of AR bacteria in a typical urban watershed, the Gwangju Watershed, Korea. For this study, a total of 828 *Escherichia coli* (*E. coli*) isolates obtained from 8 sites in stream water were tested for their resistance against 15 different antibiotics. Results revealed that while antibiotic resistance of the *E. coli* isolates showed no significant difference among sites, resistance rates to one and more antibiotics were always higher than those of non-antibiotic (below 50%), representing a high incidence of antibiotic resistance in the surface water. Among the antibiotics tested, the isolates were most resistant to tetracycline (50%), followed by carbenicillin (33%) and ampicillin (32%). However, the resistance rates showed no measurable difference between the isolates from the wastewater treatment plants and those from downstream sites, except for streptomycin ($p < 0.05$), indicating that untreated sewage discharge was not a primary source of the resistance. In addition, no significant difference in resistance rates was observed between summer and winter seasons. When the relationship between resistance rates in 828 *E. coli* isolates to antibiotics and those of multiple antibiotic resistance was further examined, a high correlation was found in streptomycin, carbenicillin, piperacillin, tetracycline, and ampicillin, thus suggesting that these antibiotics could be used as potential indicators for representing the resistance rate of *E. coli* isolates in surface water.

Keywords: antibiotic, resistance rate, antibiotic indicators, *E. coli*, Gwangju Watershed

INTRODUCTION

Antibiotic-resistant (AR) bacteria, microorganisms that are resistant to specific antibiotics, have been an emerging issue under the global health agenda (Jack, 1996) due to their characteristics of fast transmission and wide distribution in the environment. The growing use of pharmaceutical chemicals such as antibiotics has caused, in particular, the widespread distribution of such compounds in aquatic environments, subsequently resulting in the prevalence of antibiotic resistance among aquatic bacterial populations (Yu *et al*., 2009).

To date, AR bacteria have been studied in aquatic systems such as rivers (Al-Ghazali *et al*., 1988), lakes (Ahmed *et al*., 2008), domestic sewage (Walter *et al*., 1985), treated wastewater (Silva *et al*., 2006), and drinking water (Walia *et al*., 2004). Among them, natural freshwater systems such as rivers or lakes, where bacteria naturally live, were found to be an effective media for AR bacteria to transfer their genes to neighboring microbial colonies (Al-Ghazali *et al*., 1988). Contaminated water with multiple antibiotic resistance in bacteria could be mainly explained by either bacterial conjugation (i.e., a process to transfer a genetic material between bacteria through direct contact) or other genetic mechanisms of change (i.e., from antibiotic resistant bacteria to antibiotic sensitive bacteria due to horizontal gene transfer; Silva *et al*., 2006).

In Korea, the occurrence of AR bacteria in aquatic environments has also markedly increased in recent years. Specifically, the excessive use of antibiotics has received considerable attention due to the increased frequency of antibiotic-associated bacterial diseases in response to the current use of antibiotics (see Table 2 below). To a limited degree, prevalence of AR bacteria across diverse waterbodies over time has been reported worldwide (Cherry *et al*., 1972; Kelch and Lee., 1978; Schaffter and Parriaux, 2002); yet, there are no national standards or specific guidelines to regulate bacterial resistance to antibiotics in Korea.