Korean Water Quality Standards for the Protection of Human Health and Aquatic Life

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Abstract

The Korean water quality standards (WQS) for the protection of human health have recently been expanded. The main reason for the expansion was to address the concern of increasing hazardous pollutants in water environments. A risk-based approach was used to derive the WQS for eight toxic substances including antimony, benzene, carbon tetrachloride, chloroform 1,2-dichloroethane, dichlromethane, diethylhexylphtalate, and tetrachloroethylene. Same methodology has been applied to revise the existing substances, and the WQS for lead and cadmium were reinforced. The method for deriving water quality criteria was revised from the US EPA's equation for deriving ambient water quality criteria. The Korean standard values were used for the input parameters where possible. The water quality monitoring data from four major rivers in Korea were used as an exposure data. Priority chemicals for the consideration of WQS expansion were determined based on the human health risk assessment. Subsequent to the current WQS, Korean ministry of environment plans to expand WQS up to thirty substances by the Year 2015. Ecological risk criteria were also derived and they will be incorporated in the WQC in the near future. *This work was conducted as a part of the project entitled 'Development of integrated methodology for evaluation of water environment'.*

Introduction

Approximately 40,000 kinds of chemicals have been distributed in Korea, and about 400 new substances have been added to the Korean market annually (MOE, 2006). The increasing usage of various chemicals indicates the greater emission of those chemicals to water environments, and the subsequent deterioration of water quality.

The first Korean water quality standards were issued in 1991. Previously, Korean WQS for the protection of human health included nine substances (As, Cd, Cr^{6+}, CN, Pb, Hg, ABS, Organophosphorus compounds, and PCBs), and they were not efficiently reflect a range of water contaminants that increase continuously with time. Human being and aquatic life are vulnerable to various chemicals, and they are supposed to expose to those substances via several exposure routes. Korean Ministry of Environment (MOE) has established a policy goal of "human and environment-centered chemical substance management." Therefore, there is an urgent need to establish additional WQS for new chemical substances to protect the health of the Korean people and aquatic life.

As a part of the project entitled 'Development of integrated methodology for evaluation of water environment' conducted for the three years (2004-2006), forty-three candidate chemicals were evaluated in terms of human risk and ecological risk, and priority substnaces were selected for the consideration of WQS expansion. The purpose of this paper is to

introduce the current status of Korean WQS based on the risk assessment and road map of progressive expansion plan for additional WQS in the near future.

Framework of the Derivation of Korean WQS for Human Health Protection

Figure 1 shows the overall procedure to derive the Korean water quality standards for the protection of human health. Tiered approach was employed. The Korean water quality standards for the protection of human health were suggested after considering current analytical technique, best available treatment technology, economic aspects and relations with current drinking water standard.

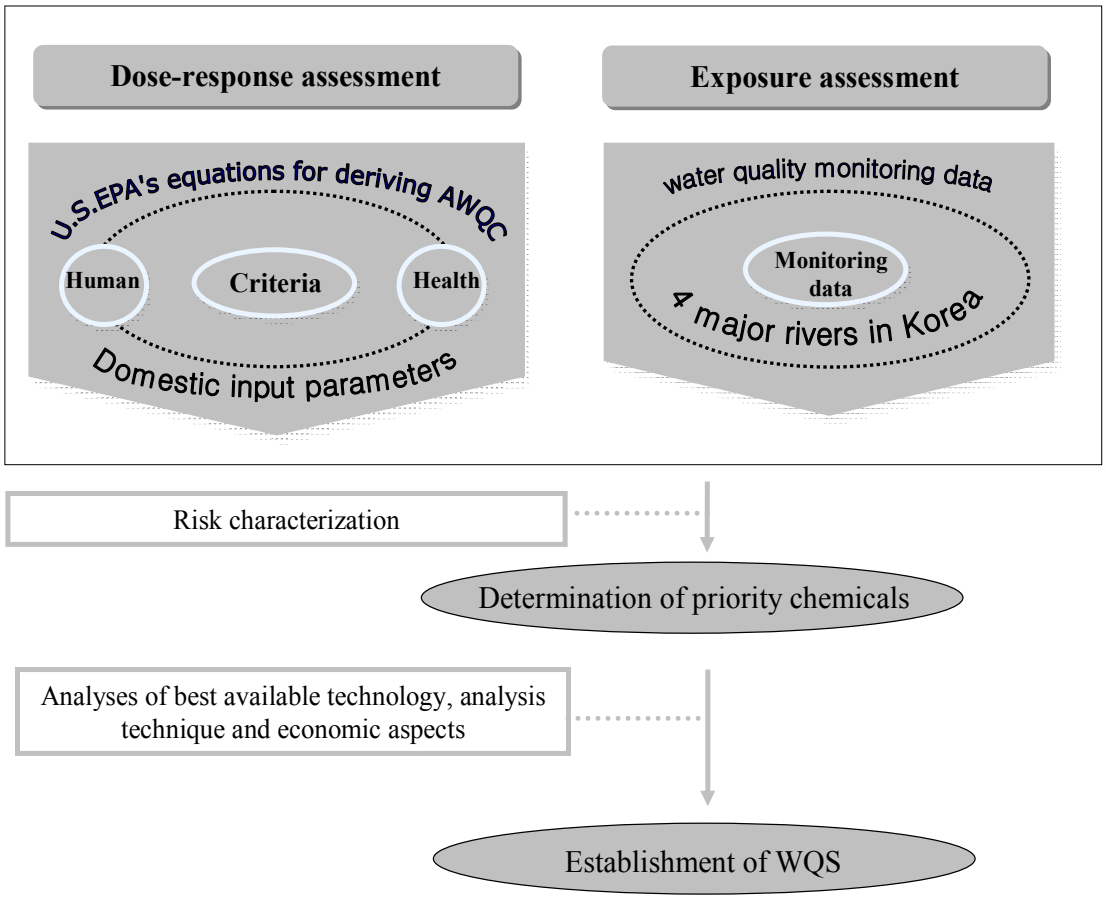

Figure 1. Framework of deriving Korean water quality standards for the protection of human health.

Toxicity database that was related to WQS derivation were US EPA's Integrated Risk Information System (IRIS, US EPA), "National Recommended Water Quality Criteria: Human Health criteria Calculation Matrix" (US EPA, 2002), "Report on 2001 National Health and Nutrition Survey" (Korean Ministry of Health and Welfare, 2002), and "Establishment of Environmental Risk Assessment Methodology and Transfer of Environmental Toxicity Evaluation Technology" (Korean Ministry of Environment, 1999).

The method for deriving water quality criteria was revised from the US EPA's equation for deriving ambient water quality criteria. Cancer and noncancer effects were estimated by the

equation (1) and (2), respectively (US EPA, 2000).

$$AWQC = \frac{10^{-6}}{SF} \times \left[\frac{BW}{DI + \sum_{i=2}^{4} (FIi \times BAFi)} \right] \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{ Equation (1)}$$

$$AWQC = RfD \times RSC \times \left[\frac{BW}{DI + \sum_{i=2}^{4} (FIi \times BAFi)} \right] \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{ Equation (2)}$$

where, AWQC is ambient water quality criterion (mg/L), RfD is reference dose for noncancer effects (mg/kg-day), RSC is relative source contribution factor, BW is body weight (kg), DI is drinking water intake (L/day), FI is fish intake (kg/day), and BAF bioaccumulation factor (L/kg). The Korean standard values were used for the input parameters such as fish intake, drinking water intake, and human body weight.

The water quality monitoring data from four major rivers (Han River, Youngsan River, Geum River, and Nakdong River) in Korea were used as an exposure data. Eight three to 113 sites were monitored during 2004-2005. Fourty three chemicals were monitored as candidate substances. Table 1 lists the candidate substances considered for the WQS expansion along with nine existing substances for the protection of human health.

Derivation of Ecological Risk Criteria

Ecological criteria was derived based on the "Australian and New Zealand Guidelines for Fresh and Marine Water Quality"(ANZECC&ARMCANZ, 2000). Based on the existing ecotoxicity database such as US EPA ECOTOX, European Union IUCLID, Australian and New Zealand TOX-2000, acute and chronic ecological criteria were calculated. Depending on the availability of necessary ecotoxicity data, three levels of ecological risk criteria were derived. Species sensitivity distribution was employed to derive high reliable criteria and medium reliable criteria for the protection of aquatic life. When sufficient ecotoxicity data was unavailable, assessment factor was used to obtain low reliable criteria. Although ecological criteria were developed as the part of the project, they are not implemented to the Korean WQS at this moment. The main reason for exclusion is the limitations of using the species that are not native to Korea. The toxicity data produced by Korean test species are significantly needed to reflect the Korean situation. Korean government are developing the Korean ecotoxicity test species and producing aquatic toxicity data using those species.

Table 1. The 9 existing and 43 candidate substances for Korean WQS expansion.

	Substance
Existing substances for human health protection(9)	Arsenic(As), Cadmium(Cd), Chromium(Cr^{6+}), Cyanide(CN), Lead(Pb), Mercury(Hg), ABS, Organophosphorus compound, Polychlorinated biphenyls(PCBs)
Candidate substances (43)	Iron(Fe), Zinc(Zn), Manganese(Mn), Fluorine(F), Trichloroethylene(TCE), Tetrachloroethylene(PCE), Dichloromethane(DCM), 1,1-dichloroethylene(1,1-DCE), Benzene, Carbon tetrachloride, Phenol, Copper(Cu), Selenium(Se), Total organic carbon(TOC), Ammonia nitrogen(NH_3-N), Nitrite nitrogen(NO_3-N), Boron(B), Diazinon, parathion, Fenitrothion, Carbaryl, 1,1,1-trichloroethane, Toluene, Ethylbenzene, Xylenes, 1,2-dibromo-3-chloropropane(DBCP), 1,2-dichloroethane, Chloroform, Vinyl chloride, Chloroethane, Styrene, Chlorophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol, Pentachlorophenol(PCP), Alachlor, Bis(2-ethylhexyl)adipate(DEHA), Bis(2-ethylhexyl)phthalate(DEHP), Benzo(*a*)pyrene(BaP), 2,4-dichlorophenoxyacetic acid(2,4-D), Dichloroacetic acid, Trichloroacetic acid, Antimony(Sb)

Future Plan for WQS Expansion in Korea

New WQS for freshwater are derived for benzene, carbon tetrachloride, chloroform, 1,2-dichloroethane, dichlromethane, tetrachloroethylene, diethylhexylphtalate and antimony. Subsequent to the existing WQS, Korean Ministry of Environment issues the additional six and two WQS by 2007 and 2009, respectively, and plans to finally expand WQS up to thirty substances by 2015 (Figure 2).

Korean MOE has incorporated risk assessment polity in legal framework of water quality management. In addition to chemical toxicity assessment, national wide monitoring program for hazardous pollutants is going on in the major Korean rivers to collect exposure data that will be used for risk assessment in the near future. The exposure data for hazardous pollutants will be related to update the water quality criteria. Furthermore, current efforts include implementing ecological risk criteria as legal standards.

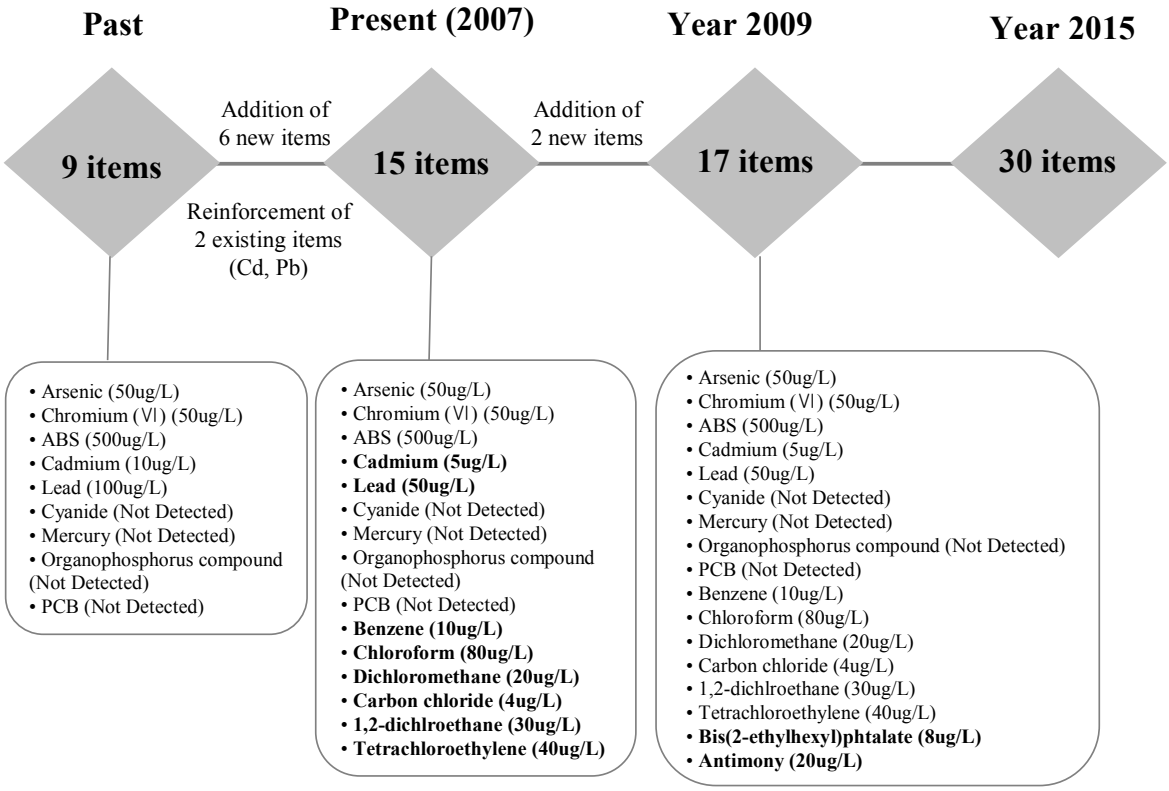

Figure 2. Road map for extension of Korean WQS (WQS values are in parenthesis).

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