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New ecological health assessment approaches of an urban stream using molecular and physiological level biomarkers and bioindicators

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This study evaluated ecological health, using various biomarkers and bioindicators, of pale chub (*Zacco platypus*) as a sentinel species, in Daejeon Stream, South Korea, during April–May 2011. The biomarkers and bioindicators were compared among three sites of control: Reference (C_z), transition (T_z), and the urban zones (U_z); and the 7-Ethoxyresorufin-*O*-deethylase (EROD) activity, DNA damage, acetylcholinesterase (AChE) activity, and vitellogenin (VTG) concentrations were more significantly increased in the U_z than in the C_z. Also, physiological markers such as condition factor, liver somatic index, visceral somatic index, and gonad somatic index were significantly increased in the U_z than in the C_z. For the health assessments, three categorized parameters of blood chemistry, molecular biomarkers, and physiological bioindicators were standardized and calculated as a star-plot, representing values of Integrated Health Response (IHR). Values of IHR had more significant ($P<0.05$) increases in the U_z than any other zones, indicating an impairment of ecological health by organic matter, nutrients (N, P), and toxic chemicals. This study is based on low levels of biological organization approach of molecular and physiological biomarkers and bioindicators, so further study of high-levels of biological organization approach such as community and population is required for overall range of health assessments. The approach of IHR values, however, may be useful in providing early warning of future impacts on ecological health.

Keywords: ecological health; biomarker; bioindicator; blood chemistry; multi-metric model

Introduction

The ecological health of urban streams and rivers are rapidly impaired by industrialization, urbanization, and high population density within the watershed (Finkenbine et al. 2000; Miserendino et al. 2008). Especially, urban stream ecosystems are more frequently disturbed by point-sources such as wastewater disposal plants as well as non-point sources (Kim and Yeom 2009; Yeom et al. 2009), and also by habitat modifications of channel structures and dredging by massive urban developments (Finkenbine et al. 2000). This phenomenon will increase toxic pollutions and eutrophication in urban streams. Such rapid urbanization may result in channelization of natural streams, which cause decreases of habitat diversity (Nolan and Guthrie 1998), increases of organic matters and nutrients (Meyer et al. 2005), and rapid sedimentations of heavy metal with organic matters from the water column (Finkenbine et al. 2000), resulting in modifications of biological functions by energy flow, material cycling, and trophic competition (Karr and Chu 2000).

Numerous studies of health assessments in lotic ecosystems (Barbour et al. 1999; Miserendino et al. 2008) pointed out that ecosystem health analysis and diagnosis were mainly based on high-levels of biological organization (H-LBO) approach, such as population to community studies. This phenomenon is well demonstrated in ecological health assessments, based on multi-metric fish models in North American, European waterbodies (Barbour et al. 1999; Karr and Chu 2000). The representative model is Rapid Bioassessment Protocol (RBP), which was developed by Barbour et al. (1999) and based on the H-LBO approach of fish community. This approach has been widely applied in many developed countries of USA, Canada, France, United Kingdom, Australia, and Japan in assessing modifications of physical habitat, biological health, and chemical impacts. This approach, however, could not detect the potential impacts on physiological, cellular, and molecular levels of individuals (organisms), and the assessments diagnosed just community or population levels. Adams and Greeley (2000) pointed out such disadvantages in conventional health assessments of aquatic ecosystems. In fact, inputs of industrial and domestic wastewater to urban streams influence wide-range biological responses from low-levels of biological organization

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