**INTERNATIONAL WATER QUALITY GUIDELINES TO PROTECT AQUATIC LIFE

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Freshwater is a very limited resource. It makes up only about 3% of the estimated total water on earth and, of this, 68.7% is presently frozen, 30.1% is groundwater and 0.9% is surface water (USGS, water.usgs.gov/edu/watercyclefreshstorage.html). Most (87%) of the available freshwater is utilized for agricultural purposes (IPPC 2007), leaving just 13% of the worlds’ available freshwater for drinking, industrial and other uses, including aquatic life.

Conflict concerning the distribution of surface water has arisen in many parts of the world (including the US), especially as a result of drought conditions. Further, as the surface water supply decreases, its capacity for dilution of point and non-point pollution decreases. Because human uses (especially agriculture) turn to groundwater sources when surface water supplies decline, the ambient quality of the remaining surface water is reduced, as pollution sources usually do not decrease in a commensurate manner. Climate change may expand the conflict over the distribution of surface water and further strain our ability to maintain its quality for aquatic life.

The relative scarcity of surface water underscores the need to maintain its quality suitable for aquatic life. This need is recognized in many countries throughout the world, especially in those that are economically developed. Although some countries undergoing economic development have also established water quality criteria for the protection of aquatic life, others have not made provision for that purpose. We provide a short overview describing the state of surface water quality guidelines (recommendations), criteria (not enforceable by law) and standards (enforceable by law) in various parts of the world, with a focus on efforts to maintain water quality for aquatic life. Additionally, the guidelines to protect aquatic life for several common water quality parameters in selected countries are presented as illustrations of the variations in those guidelines.

Globally, water quality standards, criteria and guidelines for surface waters have focused primarily on human consumption and agricultural use (irrigation) rather than on aquatic life protection. Nearly all countries have drinking water quality standards, and many have also developed criteria for other human uses, such as agriculture. However, water quality guidelines to protect aquatic life, where present, vary by country. For example, utilizing section 304(a) of the Clean Water Act of 1972, the US developed tiered aquatic life use criteria. Canada’s aquatic use guidelines attempt to protect all forms of aquatic life and aspects of life cycles (CCME 1999). Other countries have also developed such guidelines, including the European Union (WFD, 2000/60/EC), Vietnam (ESCAP 1990), China (MEPPRC 1990) and Nigeria (FEPA 1991), as examples. In the case of the European Water Framework Directive, achieving a good ecological status or potential of water bodies has been defined as the primary target with biological communities serving as important bioindicators (Geist 2014 and references therein). We illustrate the challenge of a unified criteria by illustrating guidelines from countries from different continents, under a gradient of economic development status, and retrievable/available data. The guidelines for common parameters in these selected countries are provided in Table 1.

Water quality guidelines to protect aquatic life feature prominently in evaluating water resource development projects. Such projects are frequently part of the infrastructure planning in many developing countries around the world. This is especially true in newly industrialized countries, where irrigation and hydropower projects provide the basis for economic growth. Such projects impact the fisheries resources of the waters under development in numerous ways, including changes in water quality. Most noticeable are changes in water temperature, levels of dissolved oxygen and suspended sediments (e.g. Mueller et al. 2011). Other, less noticeable changes are no less significant, including release of mercury into the water column from newly inundated soils (Bodaly et al 1997). An Environmental Assessment (EA) is usually prepared as part of the country's permitting process, and is a requirement for funding by an international lending institution, such as the World Bank (World Bank 1999). An assessment of the project's impact on water uses and water quality is required in the EA, including resultant impacts on affected aquatic biological resources. In countries having water quality guidelines to protect aquatic life, those guidelines are used for the EA. However, in countries that do not have such guidelines, their absence poses a challenge when assessing and mitigating the impact on affected fisheries resources.

Several alternative approaches to water quality evaluation can be used when no guidelines exist to protect aquatic life. If no provisional guidelines exist, the guidelines developed in a neighboring country having the same fish fauna and sharing river systems may prove most relevant and useful. Professional judgment, based on the affected fish fauna, using the guidelines of other countries in which the same species of the affected fauna are present, may also be used (based on the assumption that water quality guidelines that protect the species in one country will protect them in another, no matter how distant). Finally, the United Nations Environmental Programme in collaboration with the United Nations University Institute for Environment and Human Security and the Global Water Systems Project (2014) is developing international water quality guidelines for aquatic ecosystems. When available, they may be of use when a country has no specific water quality guidelines to protect its fisheries resources.

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