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Overview of Vol.5, No.1 – Aquatic Ecosystems

Reclamation of Aquatic Systems: Counteracting Contamination, Eutrophication, and Impoundment

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Clean water is a necessary component of life on earth and presumably a prerequisite for unhindered ecosystem functioning, yet humans have been and continue to be somewhat careless in our treatment of aquatic systems. Agricultural runoff, leaks and spills of toxic compounds during transportation and storage, and intentional and accidental release of industrial wastewater are all-too-common examples of the many pathways by which pollution enters aquatic systems. In the United States, at least, regulations that limit the levels of certain pollutants in industrial effluents are in place, while other chemicals and by-products have been banned entirely. Nonetheless, much damage has already been done. Dams on rivers also drastically alter the upstream and downstream ecosystems, yet the removal of dams is a challenge because the sediment that accumulates behind them is often a repository for toxic compounds that may have been banned decades ago. The five papers discussed in this overview cover a wide range of topics, yet the common theme concerns the tremendous effort humans are now expending to reverse the degradation of aquatic systems and to ensure that such extensive pollution never occurs again.

One source of aquatic pollution that will be difficult to ever fully eliminate is accidental oil spills during oceanic transport and from offshore drilling facilities. Methods for dealing with these spills are fairly refined: to some extent, oil on the water surface can be contained with booms and then picked up by skimmers. However, when oil meets the land/water interface it adheres to the surfaces of the rocks and sediment particles and becomes fairly difficult to remove (Laws 1993). The 1989 *Exxon Valdez* spill in Prince William Sound, Alaska, provided the opportunity to compare beach and rocky shore cleanup techniques along the 1,100 miles of affected shoreline. A. Hilla reports that workers attempted to clean about one-third of the shoreline by spraying the oil-covered rocks and sand with high-pressure hot water. As the oil drained into the water it was recovered with skimmers. While this method made the beaches look cleaner, it appears to have stalled long-term recovery of these areas. The 60° C water actually killed many of the organisms that had survived the influx of oil, including oil-degrading microbes that naturally occur in marine habitats. Recolonization of these "sterilized" areas has been slow, and as a result, oil that was pushed deeper into the sediment by the high pressure has been slow to degrade and continues to contaminate the ecosystem. Bioremediation was successfully implemented on other parts of the shoreline (Pritchard 1991), and Hilla points out that low-pressure cold water cleaning probably should have been explored more thoroughly. Despite the tragic nature of the situation and the failure of high-pressure hot water cleaning, the lessons learned from the *Exxon Valdez* cleanup will ensure more efficient and successful oil spill response in the future.

As opposed to oil spills, many aquatic pollutants slowly but continuously enter the environment over long periods of time. Between 1954 and 1976, pulp and paper mills along the banks of the Lower Fox River (northeastern Wisconsin) dumped approximately 125 tons of polychlorinated biphenyls (PCBs) into the river as a component of their wastewater effluent. PCBs were banned in the US in 1976 after it was found that they can cause developmental and reproductive problems in humans and other wildlife and are probably carcinogenic. As of 1995, no organisms capable of biodegrading PCBs have been found (Barlow and Tzotzos 1995), so standard reclamation procedures consist of removing, de-watering, and safely storing the contaminated sediment. According to K. Thering, 5% of the total PCBs have been successfully removed from the Lower Fox River by way of these expensive methods. Special landfills have been constructed specifically to receive PCB-laden sediments, but their containment of this breakdown-resistant toxin remains in question.

Acid mine drainage (AMD) is another example of slow and continuous pollution. AMD occurs when water and oxygen react with pyrite, a component of many coal mine tailings, to form sulfuric acid and ferrous hydroxide. When this enters the waterways, size and species diversity of fish and macroinvertebrate communities are often diminished. Unlike PCB's, AMD can be detoxified through chemical treatment, which is currently the most common means of remediation. Certain chemicals will react with various compounds in the runoff to raise the pH and precipitate metals, but C. H. Reinhardt warns that misuse of these dangerous chemicals can actually lead to excessively alkaline discharge.

Recently, attempts to passively treat AMD have proven quite successful. Shunting mine runoff through constructed limestone channels or drains is effective at raising pH, and some labs have even combined limestone treatment with microbial conversion of AMD to non-acidic and non-toxic compounds. Additionally, certain types of wetlands are capable of receiving AMD and improving water quality over time by means of inactivation of metal compounds by microbes that inhabit them. Wetlands can even be constructed directly in the path of mine runoff, yet highly acidic effluent may need to be buffered with alkalinity additions in order for the microorganisms to function efficiently.

Constructed wetlands have proven to be an effective means of remediation for other forms of pollution as well. Excess nitrogen in the form of nitrate can lead to dinoflagellate and algal blooms, fishkills, eutrophication of waterways, and other serious problems in aquatic habitats. In addition, it has contributed to the formation of "dead zones" in the Gulf of Mexico and the mid-Atlantic. J. H. Hornbeck reports that wetlands and riparian buffers greatly reduce the impact of both nitrogen (N) and phosphorous (P) runoff from agricultural fields. Success of a constructed wetland or riparian zone is determined by the extent to which the vegetation intercepts and takes up the excess nutrients. Hornbeck also makes it clear that, for the same purpose, management of existing wetlands in agricultural areas is of great importance.

If agricultural runoff of N and P is not intercepted by vegetation, it often ends up in lakes. Since P is usually the limiting factor for aquatic plant growth, lake restoration programs tend to focus on reducing P levels. However, if the external sources of P (which include urban runoff, sewage treatment plant effluent, and many others in addition to fertilizer runoff) cannot be reduced, lakes must be managed for internal P loading, or the movement of P from the sediment back into the water column. Certain chemicals can be added that cause excess P to precipitate from the water column and fall to the lake bed. In addition, these chemicals serve to inactivate the P once it gets to the lake bed by forming a "floc blanket" over the sediment, which prevents re-release of P from the sediment to the water column. The chemicals in common use are said to be non-toxic and long lasting, in one case maintaining P reduction twelve years after the initial treatment. Even so, D. Charboneau warns that the use of alum as a precipitant can lead to aluminum toxicity in acidic, basic, and soft water lakes.

Efforts to reduce excess P in lakes are motivated by issues of human use as well as ecological functioning. This is also the case with the removal of dams across the US. Currently, over 75,000 dams impede about half a million miles of previously free-flowing rivers, but many of these dams are deteriorating or are no longer needed for their initial purpose. Even though this presents opportunities to return riverine ecosystems to what they once were, the prospect of removing a dam is daunting. Huge volumes of sediment are trapped behind many dams, the result of decades of deposition, and the uncontrolled release of this sediment load would be devastating to the downstream habitat. In addition, in many areas of the US and certainly other parts of the world, the sediment is contaminated with toxic compounds, in some cases long-since banned. E. M. Quinn reviews sediment management strategies and points out that the ecologically sound and cost-effective process of reclaiming rivers through dam removal must be done mindfully.

While pollution cleanup attempts are not always successful, efforts are being made to reclaim many different kinds of aquatic systems. Spill response procedures continue to be refined, as do methods for dealing with toxic sediments, reducing levels of water-borne toxins, and correcting nutrient imbalances in the water column. With the exception of Hilla, each of the authors discusses reclamation success stories that have arisen from persistent labor and good research. Each author also issues a warning against being careless in the task of aquatic reclamation lest efforts to help result in further harm.

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