Urban aquatic environments

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Introduction

Rivers, streams, lakes, wetlands and estuaries in urban environments can be a real asset to a city. They can also be depressing because they are no longer what we might call "natural". Perhaps they are very modified to fulfil some specific purpose, or full of rubbish, have heavy algal blooms or perhaps there is no water in them at all. What would they have been like before the urban environment became established around them?

Cities throughout the world, including New Zealand, have been built on rivers and often on the tidal reaches of these or on estuaries. Navigable rivers provided access to the hinterlands for early settlers along with a source of fresh water, food, useful plant materials and bird life. Highly productive estuaries would have benefited from the nutrients flowing down the river. A diversity of habitats for plants and animals would have existed in streams, lakes and wetlands associated with these rivers, some with gravel beds suitable for the larvae of stoneflies, mayflies and caddis flies and their fish predators, others with silty substrates more suitable for rooted plants and burrowing animals such as worms, snails, midge larvae and fish adapted to these conditions.

What have we done to our urban aquatic environments to change these conditions?

The main impact of urban development is a change in hydrology by altering the flow regimes. This has been done by drainage of wetlands, channelisation of rivers and streams, and covering the land with hard surfaces that reduce infiltration and increase runoff.

Wetlands have been drained to create towns and cities in many parts of the world, including Christchurch. Drainage alters the water table and therefore changes the habitat for plants and animals that are adapted to a particular water regime resulting in a change in species composition to those with lower water requirements.

Straightening and lining of river and stream channels with artificial substrates to remove the excess water also removes the complex three-dimensional habitat of natural streams. Meanders, bends, pools and riffles disappear thereby decreasing the range of microhabitats and the number of different types of bottom dwelling fauna that are able to survive.

Covering the urban area with hard surfaces from transport networks, factories and housing creates impervious ground that reduces the amount of water that can soak into it to replenish groundwater supplies. After rain events in urban catchments, the changes in stream flow show that floods peak earlier, the peak discharges are higher and the flood duration is shorter than in rural catchments (Auckland Regional Council 1995). The more impermeable a catchment becomes, the greater the number of drains the more quickly the floods strike, the higher they rise and the quicker they abate. It has been calculated that a rural lag time of two hours is reduced to 20 minutes when a catchment is 20% impervious (NWSCO 1981).

This increase in runoff can result in channel enlargement through natural widening, undercutting and erosion of stream banks. This can reduce stream depth in periods of dry weather and contribute to stream warming which can have marked effects on the stream biota by affecting habitat, distribution and migration of fish species, for example.

Klein (1979) has studied the relationship between urbanisation and fish diversity in 74 streams in Maryland, USA. As the percentage of impervious surface increases, fish species have been shown to decrease. This decline is probably due to a number of factors associated with impervious cover including an increase in instream pollutant loading with increased runoff, changes in baseflow, and alteration of riparian and instream habitat.

Clearing the riparian zone of vegetation is often associated with channel restructuring. The critical vegetation cover for biota is removed and the bare ground contributes to erosion of the banks and increased sediment loads in the water. Riparian vegetation also plays a role in preventing surface and subsurface nutrient runoff into the water by plant uptake.

Increased nutrient loading from fertilisers, industry, animal and garden wastes into aquatic systems can result in excessive plant growth such as sea lettuce in estuaries, filamentous algae and periphyton in gravel river beds, algal blooms in lakes, ponds and sluggish channels, and large aquatic plants in lakes and sediment loaded streams, rivers and lakes.

High sediment loads resulting from runoff from urban developments or bank erosion alters stony substrate habitats by infilling the spaces between the stones thereby smothering invertebrates and destroying fish habitat. Fish that hunt by sight may be affected by suspended sediment in the water, their gills may become clogged and their food supply smothered (Quinn *et al.*1991). Light penetration into the water is also reduced affecting photosynthesis and therefore the food chain. Increased sediment input may also affect fish populations by causing an increase in susceptibility to disease, reducing growth rates and modifying behaviour patterns (Collier 1989).

Fish spawning may also be affected by high sediment loads. The Styx River in Christchurch is showing changes in the distribution of trout redds and their viability which appear to be strongly correlated to sediment inputs from new developments in the catchment (Craig Dolphin, pers comm).

Toxic contaminants are often associated with sediment in aquatic systems and may pass into the food chain or have more direct effects on invertebrates and fish, particularly if they are associated with oxygen depleting wastes. The toxicity of a pollutant often depends on the form in which it is present (e.g. hexavalent chromium is more toxic to aquatic organisms than trivalent chromium compounds, Katz and Salem 1994) and on other physical and chemical parameters present in the water such as flow rate, pH, and dissolved oxygen levels.

Overall, pollution tolerant aquatic invertebrates, such as oligochaete worms, snails and chironomid midge larvae, tend to dominate over pollution sensitive species, such as mayfly and caddisfly larvae, in urban ecosystems and therefore the food chain as a whole may be affected.

What can we do about all these problems?

Engineers, ecologists and planners need to work together to revert to more natural designs incorporating ecological principles. Habitat diversity can be created through pool and riffle systems, meanders and bends, changing box drains to swales.

The Christchurch City Council Water Services Unit has assessed the condition of Christchurch waterways according to their values in terms of drainage, landscape, heritage, ecology, recreation and culture (Watts and Greenaway 1999). Some cost options were compared between management for drainage only and management to achieve all values identified for a particular waterway. The cost of piping for drainage only was calculated at between $500 and $1300 per metre with replacement needed about every 150 years. The cost of "natural treatment" using an open channel or swale which had all the above values appreciating over time was calculated at $30 to $1000 per metre with replacement unlikely to be needed.

Sediment control is one of the big problems in urban areas although the incorporation of settlement ponds before discharge into waterways can be very efficient. The Wigram East Retention Basin was built in 1993 for flood retention and to improve water quality before it enters the Heathcote River. Early monitoring results for sediment, heavy metals and phosphorus attached to sediment showed that the pond was efficient as a settlement basin for these pollutants from industry before discharge into the Heathcote River entering (Ward and Meurk 1995, Gilsen and Mitchell 1999). However, monitoring after heavy rain suggests that the process can be reversed with export of material accumulated in the pond into the river exceeding inflows into the pond.

Dissolved reactive phosphorus (DRP) presents a different problem as it does not settle out. Initial monitoring in 1994 showed DRP entering the pond in pulses, particularly after rain events. Generally more DRP entered the pond than left it. However, since 1995 more DRP is leaving the pond than entering (Ward and Meurk 1995, Gilsen and Mitchell 1999). A 12 hour sampling during a rain event in 1995 shows that inflow of DRP to the pond increases during the event while outflows remain constant. i.e. same levels as before the event started. The pond seems to be processing or holding the phosphorus in some way when a pulse comes in and releases it at a fairly constant rate to the Heathcote River (M. Haines 1996 unpublished).

Care is needed therefore when assessing the design and efficiency of these systems to take into account the time of sampling and the long-term changes in the system.

Using plants to take up nutrients from aquatic environments depends on the removal of the vegetation seasonally or the nutrients will return to the water in winter dieback. Watercress, for example, is commonly found in rivers, streams and drains in New Zealand. Howard-Williams and co-workers (1982) have been shown this plant takes up nutrients from the water on a seasonal basis and in winter nutrients are released and will return to the system. In Europe, plants are harvested from the edges of lakes, rivers and wetlands as a source of fuel, roofing material and household goods.

Riparian management to provide stable banks, nutrient uptake, overhanging vegetation and shade improves water quality and creates habitat diversity and temperature control which in turn reduces instream plant growth. Some excellent examples of riparian restoration can be seen in urban areas over recent years, often by simply not mowing the riverbanks and allowing the native plants to regenerate.

Community involvement and education can greatly assist in planning, restoration, monitoring and management allowing stewardship over a part of the environment: "my patch". Some cities such as Christchurch are producing practical pamphlets for individuals and community groups to explain how to restore a waterway and how to monitor the changes occurring.

School water monitoring programmes are in place in many countries. Lincoln University's *Waterwatch Kaitaiki wai* (2000) allows students of all ages hands on monitoring of local waterways and an understanding of the ecosystem processes and the state of the environment.

Conclusion

Engineers, ecologists, planners and communities need to work together to enable improvement in our urban aquatic environments. With our increased understanding of natural systems and their function, we have the ability to design and restore our urban waterways so that industrial pollution, sediment and nutrient input are minimised. Habitat diversity can then be increased and therefore the species of plants and animals that require these microhabitats will increase. In addition, the waterways will be healthier environments for humans, whether purely aesthetic or for instream recreational uses.

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