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Introduction

Water is essential to the planet and its societies, yet, it is one of the scarcest resources globally today (Klessing, 2000; Jöbgen *et al.*, 2004; Babou and Callot, 2007). According to the World Resources Institute (WRI, 2008), global water consumption increased sixfold in the last century and over 40% of the world's population lives in water poverty today. It is estimated that if present water use trends continue, two of every three humans will live in conditions of water stress worldwide by 2025. Water use affects all economic sectors including tourism, and the lack of it represents a major impediment to development (Rahm *et al.*, 2006). In Québec, water quality rather than water availability is of greater concern particularly in lake regions. Lakes are complex and fragile ecosystems that form an important part of Québec's heritage and they are part of the quintessential tourism experience in some regions (Hade, 2002; Tourisme Québec, 2007). For some years now, many of the lakes heavily used by tourism and recreation have been suffering from algal outbreaks in Québec. In 2007, the propagation of blue-green algae resulted in over 200 lakes being declared off-limits to bathers, because of risks associated with eutrophication. In this context, the aim of this chronicle is to highlight how tourism and recreation are a part of the eutrophication problem in Québec, and outline some of the solutions that could be implemented to address this growing issue.

Some Impacts of Eutrophication and Algal Blooms

It is well accepted that tourism can exert particular pressure on water in all seasons at all destinations (Clivaz and Reynard, 2008). However, total water use by tourism is difficult to ascertain because the sector is diffuse and fragmented and, consequently, total impact is also hard to estimate. The average urban citizen in Québec uses 90 to 180 litres of water a day, while the average global use per tourist ranges from 100 to 2000 litres per day (Gössling, 2006). Water use by tourism is directly linked to operations of facilities and maintenance, as well as use by visitors for various activities such as to shower, swim in pools, and so on. For some activities and facilities, water use may even be much higher, for example ski stations that draw heavily on water for artificial snowmaking. Much of water consumption in tourism is also associated with chemical use such as detergents and soaps, which can be a significant source of pollution.

Furthermore, besides their damaging physical impacts, motorized activities on lakes also introduce various hydrocarbon compounds from fuels and anti-fouling paints (Mosisch and Arthington, 2004). The use of synthetic fertilizers and various chemical products by the tourism sector is common to maintain green spaces around establishments. For example, in Québec, 307 golf courses contribute approximately 40 000 kilograms of active ingredients through fungicides, herbicides, and insecticides to ecosystems and the most severely impacted areas occur in the Montréal, Laurentides, and Lanaudière regions, which are all places of high lake concentration (Lavardière *et al.*, 2007). Sewage outflow from diffuse small-scale tourism and recreation can be a singularly important source of bacteria and algae in freshwater systems in remote areas (Lukavsky *et al.*, 2006), although their contribution has not been established in Québec, especially around outfitter camps and resorts.

The impact of pollution such as eutrophication on water quality is dependent on lake characteristics, intensity and type of pollution, as well as management regimes, amongst other factors. Furthermore, eutrophication is partially a natural process as lakes age and become nutrient rich. This transformation process is affected by the biophysical and chemical characteristics of an individual lake, as well as by the hydrogeology and land use pattern of its watershed (Salmaso, 2000; Davies and Koop, 2006). An excessive introduction of nutrients by humans has led to severe eutrophication of certain freshwater systems worldwide (Gössling, 2006; Davis, 2007; WRI, 2008). Impacts of eutrophication often mean excessive growth of phytoplankton and algae, changes in species abundance and composition, biomass production and dissolved oxygen content. Some lakes can become eutrophic to the point of hypoxia because their ecosystem gets completely depleted of oxygen. Eutrophication is also associated with various health risks to humans and a general loss of lake amenity caused by unpleasant smells and reduced water clarity (Larkin and Adams, 2007; Health Canada, 2008).

In Europe and in North America, agricultural sources are generally the primary contributors to eutrophication, while sewage and industrial sources are secondary (Cronberg, 1999; McGarrigle and Champ, 1999). In Québec, agriculture, deforestation, human sewage, urban and industrial run-off are common sources, but it varies in different regions. In certain lake areas of Europe and North America, visitors and secondary residential users are known to be the most

important contributors to lake eutrophication (Jöbgen *et al.*, 2004; Weible, 2007). However, in Québec there is not sufficient information to date to determine exact contributions of this sector. Certainly the high proportion of secondary homes present in lakeshore areas of the Province that have septic tanks is an important contributor, because these retain only a percentage of their waste volume (Hade, 2002). Up to 25% of waste from septic tanks seep into the soil and the groundwater, and, depending on its location, eventually enter a lake.

Algal blooms can also be natural, but once a lake becomes eutrophic, it can trigger rapid growth of certain harmful algae types (Cronberg, 1999; Salmaso, 2000; Larkin and Adams, 2007). Blue-green algae or cyanobacteria are known as the most common harmful algae in freshwater lakes, reservoirs, and slow-flowing rivers. In many cases they remain dormant, unless conditions for their reproduction become favourable. Algae can increase for many reasons, and nutrient-loading change is but one mechanism (Anderson *et al.*, 2002). There can be a significant time lag between waste production and eventual groundwater or lake water contamination. In some places, the observed algal areas have been linked to heavy fertilizer use up to 10 to 20 years prior to the outbreak (Anderson *et al.*, 2002; Shear, 2006).

Eutrophic ecosystems and those affected by algae outbreaks have a diminished capacity to provide services to society and this can significantly influence communities that rely on water for their livelihoods (Selman *et al.*, 2008). In Australia, algal blooms in freshwater systems cost the community from 180 to 240 million AUD every year. Research from the United States suggest that this effect is not similar on every business and a study in Florida showed that algal blooms in coastal waters affected monthly revenues of waterfront businesses, resulting in 29% and 35% net reductions for the restaurant and lodging sectors respectively. The total net economic effect of diminished lake water quality in Québec has not been calculated, however it would be variable. This is likely to depend on many factors, including the relative size of the expenditures for tourism activities linked to lake use. The diversified nature of Québec's tourism industry may also mean that the loss of revenue in one area might result in a net gain in another, because tourists simply redirect their activities in a situation of available alternatives (Hoagland *et al.*, 2002). Given the proliferation of tourism products in Québec, and elsewhere, tourists will continue to have alternatives. However, residents and economic activities reliant on lakes will need to address the consequences of continued eutrophication.

Possible Mitigation Measures

It is not clearly established how either tourism or recreation contribute, compared to other land uses, to lake eutrophication in Québec. It is also not clear how much lakes contribute to tourism economics in different regions. Thus it would be important to understand the relationship between lakes and tourism to enable problem mitigation involving the tourism industry (McGarrigle and Champ, 1999; Davis and Koop, 2006). An adequate long-term preventative approach at the watershed scale and the use of appropriate management tools are therefore required (Jorgensen and Rast, 2007). Tourism is often

not included as a major land use when it comes to stakeholder management groups, because it is diffuse and it is often perceived to be harmless. Yet, tourism is an important water resources user amongst residents and other industry sectors. In this context it is thus important that the tourism industry adopts a sense of ownership over the natural resources it exploits (Sheppard *et al.*, 2006).

Environmental restoration of lakes is expensive and complex, given that several organizations may have legal jurisdiction over them (Bramwell and Pomfret, 2007). There are several examples of successful restoration projects in Québec involving collaborative work between the tourism industry, government, and non-government organizations (Tourisme Québec, 2000). Some of these projects include riparian vegetation planting and the development of recreation activities and infrastructures around lakes. Other management actions, such as planting aquatic species to increase natural filtering mechanisms, may also be pertinent in some lakes, because these absorb additional nutrient loads (Jöbgen *et al.*, 2004). While such interventions are considered effective to mitigate eutrophication, the physical presence of plants in lakes has been reported to be a nuisance to recreational swimmers and boating in the Netherlands (Coops *et al.*, 2002).

One of the most effective ways to address environmental management problems is to prevent them from occurring initially, and this can be achieved by raising awareness via education. Various public sector and non-government organizations recommend more efficient use of water resources for the tourism sector and the elimination of toxic substances. Awareness programs such as the *Charte des lacs* (MDDEP, 2008b) in Québec are important tools to help educate the population, improve water use, and reduce pollution (McGarrigle and Champ, 1999). Some tourism businesses have switched from using toxic substances in their operations and replaced polluting products with biodegradable alternatives. However, the extent of change across the whole sector has not been determined.

In order to involve the tourism industry and tourists more in environmental management programs, it would also be important to determine their perceptions and attitudes to lakes and water resources in Québec. General perceptions of environmental quality can be surprising, even when community livelihood is water dependent (Varkuti *et al.*, 2008). For example, in a study of permanent residents around an important lake tourism destination in Hungary, researchers found that only 43.3% considered water quality important to recreation and only 13.3% considered it important to the economic well-being of the region.

Regulation can also be an effective tool to address water quality problems around lakes and the Government of Québec has implemented a range of measures recently. The use of pesticides, herbicides, and insecticides is regulated, although various land uses are affected differently. Since 2006, legislation no longer permits pesticide use on lawns and public green spaces, including semi-public areas and places managed by municipalities (MDDEP, 2008a). Consequently, particular users in the tourism sector such as golf

courses are now required to submit a plan to reduce their use of pesticides by 2009 by 12.9% on average, fungicides by 9.4%, herbicides by 8.2%, and insecticides by 7.4%.

Conclusion

This chronicle briefly highlighted some of the relationships between tourism and lakes. Québec's tourism sector relies on lakes and continued eutrophication of these ecosystems may have negative impacts on this industry. The competition for freshwater resources will likely to intensify in the future and climate change will also affect lakes in Canada (Jones *et al.*, 2006). These may have important impacts for tourism in Québec and, consequently, some monitoring of key indicators would be useful to help adapt to changing resource conditions. Very limited knowledge is available presently about lake tourism in Québec; therefore, more research would be important to establish some basic facts aimed at more effective decision-making.

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