# RECREATION IN NATURAL WATER RESOURCES

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## Summary

Water is the most valuable resource on this planet and is used for drinking, food supply, community development (industries) and recreational purposes. Population growth around the world, particularly near the coastlines has increased the demand for water and the services associated. Despite the technological and social advances in water engineering and management, there is currently an inadequate infrastructure to protect the coastal and recreational waters of the world from increasing pressures of pollution, overuse and climate change.

Anthropogenic activities have been instrumental in changing the climate and animal behavior; average seasonal temperatures and precipitation have shown different trends in recent years. Climate change can alter water quantity and quality, shoreline structure, wildlife habitat and waterfowl behavior. Existing waste treatment facilities may no longer be able to handle the increasing waste load which subsequently is released into recreational waters, causing eutrophication and algal blooms. In addition to water, sediments are now being recognized as a reservoir for pathogens and toxic metals. Once re-suspended, these organisms and materials can enter the water column and lead to illness in recreational users and aquatic animals.

Monitoring recreational waters is important in identifying the risk to recreational waters and public health. Research is being done to develop faster and more accurate measures for water quality testing. The need for these tools to be cost effective and accessible for monitoring agencies facing funding shortages is imperative. More effort needs to be undertaken for recreational water management and clean-up programs for already polluted waters. Educational programs can inform people of the risks associated with recreational waters and pollution prevention strategies. Inaccessible and polluted waters can affect local and national economies that rely on tourism. With increased public awareness and technology, recreational waters can be protected, maintained and restored for use by future generations.

## 1. Introduction

Hundreds of millions of people visit “recreational venues” such as lakes, rivers and ocean beaches each year. In the United States it is estimated that more than 180 million people visit the shoreline of the annually, including 60 million people who visit the international Great Lakes (Table 1). The quality and health of natural aquatic systems around the world are increasingly affected by population growth, over use, climate changes and large scale events such as algal blooms and oil spills. Water quality degradation is caused by numerous sources of pollution but particularly, fecal pathogens from human and animal waste associated with public health risks. Human waste inputs come from septic tank systems, waste water treatment plants and combined sewer overflows while animal waste inputs include wildlife, pets and agricultural and domestic animal feeding operations. It is also now known that sand and sediments are associated with reservoirs of these pollutants which can lead to increased physical and biological threats to those recreating in these waters. Water quality studies, monitoring and standards are common global approaches for protecting and restoring recreational waters of the world.

## 2. Recreational Waters

Recreational areas including water are defined by the United Nations as: “Recreational land and associated surface water consist of land that is used as privately owned amenity land, parklands and pleasure grounds and publicly owned parks and recreational areas, together with associated surface waters.”

About 70% of the Earth’s surface is covered in water. 96.5 % of this water is contained in saline water (oceans). 1.74% is contained in glaciers and icecaps. 1.7% is groundwater and only 0.008% is freshwater lakes, rivers or swamp water. The remaining fraction of a percent of water is in saline lakes, soil moisture, permafrost and the atmosphere. Only freshwater can readily be used for consumption, however both salt and freshwater can be used for recreation (glaciers may be used for recreational activities such as hiking and viewing). However, most natural water recreation takes place along the coastlines of the world.

The total length of the world’s coastlines is 1,634,700.7 km (Table 2). There are also 19 great lakes (those that have a surface area >10,000 km$^2$) in the world, representing a total surface area of 997,000 km$^2$. In terms of surface area, the Caspian Sea is the largest with 374, 000 km$^2$, followed by lakes Superior (82,100 km$^2$), Aral (43,000 km$^2$), Victoria (62,940 km$^2$) and Huron (59,500 km$^2$). In terms of volume, the Caspian Sea is the largest with 78,000 km$^3$, followed by lakes Baikal (22,995 km$^3$), Tanganyika (17,827 km$^3$), Superior (12,230 km$^3$) and Malawi (6,140 km$^3$). Some of the most famous recreational waters include the Caspian Sea which has 7,000 km of shoreline (including islands), the Great Lakes which have a total of 17,017 km of shoreline (including the connecting channels and excluding the St. Lawrence River) and Lake Victoria which has 3,440 km of shoreline. (Table 3)

| **Location** | **Total Beaches** | **# Freshwater Beaches** | **# Marine Beaches** | **# Visitors/ year** |
|---|---|---|---|---|
| United States | 6,099 coastal beaches | No Data | No Data | >180 million |
| United States Great Lakes | No Data | 582 | None | 60 million |
| European Union | 21,094 | 6,749 | 14,345 | No Data |
| Africa | No data | 677 lakes | No Data | No Data |
| Australia | No data | No Data | ~11,000 | 80 million |

Table 1. Numbers of beaches and visitors World-wide

These shorelines around the world are host to thousands of public recreational beaches. In the United States there are 6,099 coastal beaches and Australia has approximately 11,000 beaches. The European Union has 14,345 coastal beaches and 6,749 freshwater bathing areas. This does not include the number of rivers, streams, and ponds that people visit each year that are not formally labelled as public recreational areas though. (Table 1)

| Location | Total Coastline (km) |
|---|---|
| World | 1,634,700.7 |
| North America | 398,835.2 |
| Europe | 325,892.3 |
| Asia (excluding the Middle East) | 288,459.0 |
| South America | 144,566.8 |
| Oceania | 137,772.4 |
| Central America and Caribbean | 73,703.0 |
| Sub-Saharan Africa | 63,124.4 |
| Middle East and North Africa | 47,281.9 |

Table 2. Coastlines of the World

| Name of Lake | Surface Area ($km^2$) | Name of Lake | Volume ($km^2$) |
|---|---|---|---|
| Caspian (Russia) | 374,000 | Caspian (Russia) | 78,200 |
| Superior (Canada & US) | 82,100 | Baikal (Russia) | 22,995 |
| Aral (Kazakhstan & Uzbekistan) | 43,000 | Tanganika (Burundi, Dem. Rep. Congo, Tanzania, & Zambia) | 17,827 |
| Victoria (Kenya, Tanzania & Uganda) | 62,940 | Superior (Canada & US) | 12,230 |
| Huron (Canada & US) | 59,500 | Malawi (Malawi, Mozambique & Tanganika) | 6140 |
| Michigan (US) | 57,750 | Michigan (US) | 4920 |
| Tanganika (Burundi, Dem. Rep. Congo, Tanzania, & Zambia) | 32,000 | Huron (Canada & US) | 3537 |
| Baikal (Russia) | 31,500 | Victoria (Kenya, Tanzania & Uganda) | 2518 |
| Great Bear (Canada) | 31,326 | Great Bear (Canada) | 2292 |
| Tonle Sap (Cambodia) | 30,000 | Great Slave (Canada) | 2088 |

Table 3. Ten largest lakes of the World

## 3. Risks while Recreating

Recreational activities that take place in natural waters, such as swimming, boating and rafting, are popular across the world. However these activities are not always safe as there are both physical and biological risks involved.

### 3.1. Physical Risks

Physical risks at natural waters are usually associated with running and falling and diving in areas that are too shallow and contain rocks and other debris, which can cause cuts, bone breakage and head injuries. Drowning is also a risk at beaches, particularly where large waves may submerse swimmers heads and/or undertows occur (also known as rip currents and run-outs). These undertows can carry swimmers out away from the shore and into deeper, more dangerous waters quickly. Drowning is also a possibility when rafting, boating, tubing or water and jet skiing. During participation in these activities people can end up in deep or fast moving waters that are unsafe. In addition, exposure to the sun can cause damage to people's skin, with long term exposure associated with cancer. Heat stroke may occur where temperatures become too high. People who are most susceptible and should take extra precaution when exposed to the effects of the sun and heat include young children and elderly people.

### 3.2. Biological Risks

In addition to the physical risks of recreating in natural waters there are also biological risks, or risks which manifest as a recreational water illness caused by microbial pathogens. *[Note: biological risks associated with sharks and jellyfish for example are small in contrast to risks from microorganisms and are not included.]* Recreational water illnesses are acquired by swallowing, breathing or having physical contact with contaminated water. Contamination may be from anthropogenic waste materials produced from the activities of humans (e.g., sewage from cities) but can also occur from natural processes such as blooms of hazardous algae. Human and animal wastes are the most common sources of harmful pathogens which cause recreational water illnesses during recreational activities.

Humans and animals excrete microbes in their feces. Some of these microbes have the ability to survive for extended periods of time in the environment and are then transferred to other humans or animals through the oral route. The fecal-oral route refers to this pathway; excretion into the environment followed by ingestion by a susceptible individual, facilitating pathogen transfer between individuals and the environment. Microbes that are transferred from human to human by the fecal-oral route are referred to as human pathogens and include viruses and some specific bacteria such as *Shigella*. Microbes that are transferred from animal fecal material to humans are referred to as enteric zoonotic pathogens and include *Cryptosporidium* and *Escherichia coli (E. coli)* O157:H7. People come into contact with these microbes by swallowing contaminated recreational waters, breathing aerosols or touching contaminated surfaces (e.g., sand) and then through their hands, transfer microbes to self and others.

Skin, wound, ear, eye, respiratory, neurological and gastrointestinal infections are among the most common recreational water illnesses. According to the World Health Organization (WHO) the most frequent adverse health outcome associated with exposure to fecally contaminated recreational water is enteric illness. Enteric illnesses are associated with the gastrointestinal tract (stomach and intestines) and most commonly associated with diarrhea, often referred to as AGI, acute gastrointestinal illness. Diarrhea illnesses can be caused by microbes such as bacteria including some *E. coli* strains (including *E. coli* O157:H7), *Shigella* and *Campylobacter*. Protozoan parasites associated with recreational water illness include *Cryptosporidium* and *Giardia* and some viruses include Adenoviruses and Noroviruses. Young children, elderly and immuno-compromised people are most at risk for becoming ill due to exposure to these harmful microbes. Table 4 lists these microbes and Table 5 presents some of the outbreaks that have been documented from fecal or urine contamination of lakes or from other microbial risks.

An outbreak occurs when many people visiting the lake or river at a similar time become ill. Most outbreaks are documented at lakes and are caused by unidentified microbes in which the people become ill with AGI. It is suspected that most of the pathogens such as Norovirus are coming from human feces but others could come from human or animal wastes such as the parasites *Cryptosporidium* and *Giardia* and bacteria such as *E. coli* 0157:H7. The bacterium *Leptospira* comes from animal urine and causes Leptospirosis a disease associated with swimming, wading and whitewater rafting in contaminated lakes and rivers. It is found throughout the world but mostly in temperate or tropical climates. In addition to fecal pathogens, there are also widespread impacts due to the Schistisome parasites which are associated with snails and birds including ducks, which are part of the parasites normal life cycle. Exposure to these parasites, which are found in both marine and fresh waters, causes what is known as swimmers itch. In addition *Vibrio*, a naturally-occurring bacterium in marine systems, causes wound infections that can result in hospitalization and death.

| Microbe | Disease | Incubation time |
|---|---|---|
| Bacteria | | |
| *Escherichia coli* (O157:H7) from cattle and human feces | Gastrointestinal | 12 hours-3 days |
| *Campylobacter* spp. From animal, bird, cattle and human feces | Gastrointestinal | 2-5 days |
| Cyanobacteria, known as blue green algae, naturally-occurring associated with nutrients. | Gastrointestinal , respiratory and nervous system | 30 minutes – 2 days |
| *Leptospira* from animal urine | Fever, headache, vomiting. | 2 days- 4 weeks |
| *Salmonella* spp. from humans and animal feces | Gastrointestinal | 1-3 days |
| *Shigella* spp. from human feces only | Bacillary dysentery | 2-4 days |
| *Vibrio spp* naturally occurring in marine systems, | Gastrointestinal, liver involvement, wound infections | 2-4 days |
| Parasites | | |
| *Cryptosporidium parvum* from animal and human feces & *C. hominus* (oocysts) from human feces | Diarrhoea | 2-10 days |

| | | |
|---|---|---|
| only.<br>*Entamoeba histolytica* (cysts) from human feces only.<br>*Giardia* (cysts) from animal and human feces<br>*Schistosomes* from bird feces and found in snails. | Amoebic dysentery<br><br>Diarrhoea<br><br>Swimmers Itch, cercarial dermatitis | 1-7 weeks<br><br>1-2 weeks<br><br>Minutes |
| Virus from human feces only<br>Adenovirus<br>Hepatitis A<br>Norwalk virus<br>Rotavirus | <br>Respiratory<br>Hepatitis<br>Diarrhoea, vomiting<br>Diarrhoea, vomiting | <br><10 days<br>15-50 days<br>1-2 days |

Table 4. Common bacteria, parasites and viruses which may cause recreational illnesses

| **Country/area** | **Years** | **Outbreaks/Cases** | **Pathogens** |
|---|---|---|---|
| USA<br>Lakes and rivers | 1999-2004 | 44 outbreaks<br>1091 cases | AGI (56%)<br>Norovirus (14%)<br>*Cryptosporidium* (10%)<br>*E.coli* (with 0157) (9%)<br>*Giardia* (5%)<br>*Shigella* (5%) |
| Sweden<br>Lake | 2004 | 2 lakes<br>163 cases | Norovirus |
| Australia<br>Lakes | 1990-06 | 6 studies<br>1326 cases | Cyanobacteria |
| US<br>Lakes/ponds | 1995 | Hundreds of cases | Shistosomiosis<br>Swimmers Itch |
| Gulf of Mexico | 2003-04 | 142 cases<br>70 hospitalizations<br>9 deaths | *Vibrio* wound infections |
| Australia | 1998-2004 | 883 cases | Leptosporosis |

Table 5. Select recreational outbreaks

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**Biographical Sketches**

**Rachel M. McNinch** recently graduated with her Masters degree from the Department of Fisheries and Wildlife at Michigan State University, after having earned her Bachelors degree from the same department. Her graduate research focused on waterfowl fecal bacteria content and waterfowl fecal bacteria loading effects on beach sand and water. She works for the Center for Water Sciences at Michigan State University and is currently using geographic information systems (GIS) to look at the state of Michigan's *Escherichia coli* database. Research interests include recreational water quality and human health.

**Shikha Singh** is a recent Masters graduate from Michigan State University in the department of Fisheries and Wildlife. Her research interests are focused upon water quality and environmental health. Currently, she is focused on identifying relationships with surface water and sediments near Lake Michigan using fecal indictor bacteria. She grew up in London, Ontario and graduated from the University of Western Ontario from the department of Biology before migrating to Michigan for further studies. When doing research, she has an interest in international aquatic issues and photography and can be seen trapezing though areas like Siberia, Russia, Portugal and India.

**Dr. Joan B. Rose** currently holds the Homer Nowlin Chair in Water Research at Michigan State University after receiving her PhD from the University of Arizona and spending 14 years at the University of South Florida. Dr. Rose is an international expert in water microbiology, water quality and public health safety publishing more than 250 manuscripts. She is considered one of the authorities on *Cryptosporidium*. She is currently co-director of the Center for Water Sciences which includes work with the Great Lakes and Human Health Center of NOAA. She is also Co-Director of the EPA/DHLS Center for Advancing Microbial Risk Assessment. She is currently the chair of the EPA Science Advisory Board Committee on Drinking Water and serves as an advisor to the US-Canada International Joint Commission.