Non-Point Source Pollution and Water Quality Impairment of Michigan Inland Lakes

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Introduction of Non-Point Source (NPS) Pollution

Michigan has over 35,000 lakes and ponds with many of them being developed and thus vulnerable to water quality degradation. Inland waterways are protected under state law through Public Act 451 of 1994, the Michigan Natural Resources and Environmental Protection Act (NREPA), and under federal law from the U.S. Environmental Protection Agency (EPA) under the federal Clean Water Act.

Non-point source pollution (NPS) is the pollution caused when climatic events carry pollutants off of the land and into lakes, streams, wetlands, and other water bodies (Michigan Department of Environmental Quality). Unlike point source pollution which is derived from distinctive discharge pipes, NPS pollution is often diffused in nature. The diffusivity of NPS pollution creates challenges in determining the location of pollution sources which makes mitigation (treatments) a difficult and sometimes impossible task. NPS pollution is regulated by statute and includes categories such as agricultural source runoff (*Figure 1*) and confined animal feed operations (CAFO's), small urban runoff (populations with less than 100,000 residents), urban storm water runoff from unsewered areas, septic tanks, runoff from abandoned mines, land disturbing activities, and atmospheric deposition. Although regulation exists, it is difficult to regulate NPS pollution at both the federal and local levels. There has been considerable debate among scientists, engineers, and other stakeholders regarding the most effective scale for reduction of NPS pollutants. The NPS pollutants of greatest concern to local waterways include nutrients such as nitrogen and phosphorus, sediment, toxic compounds, and pathogens (E. coli, among many others). The Water National Quality Inventory (1994) ranked the leading sources of water quality impairment to lakes as primarily agriculture, secondarily municipal point sources, and thirdly, urban runoff.

Figure 1. Ponded water on a farm that is likely to enter a nearby stream that flows into a lake.

Impacts of NPS Pollution on Inland Waters

Beginning in 2007 and continuing to the present day, the USEPA Office of Water and Office of Research and Development has partnered with multiple stakeholders at both the state and federal levels to derive comparisons among the nation's aquatic resources which include lakes, wadeable streams, large rivers, coastal estuaries, and wetlands. During the assessment, 1,028 lakes have been sampled along with 124 reference lakes and 100 lakes which were re-sampled. Lakes were selected from the National Hydrography Data Set (NHD) using a set of criteria that addressed trophic status, locale, and physical characteristics. Water quality indicators such as biological integrity, habitat quality, trophic status, chemical stressors, pathogens, and paleolimnological changes were measured. Although 56% of the nation's lakes possessed healthy biological communities, approximately 30% of lakes had the toxin Microcystin, which is produced by the blue-green algae Microcystis. Approximately 49% of the lakes had mercury concentrations in fish tissues that exceeded healthy limits. The key stressors of the lakes were determined to be poor shoreline habitat and excessive nutrients. A favorable outcome of the inventory revealed that half of the lakes exhibited declines in phosphorus levels compared to levels noted in the early 1970's. Despite this observed decline, many of our inland lakes continue to experience degradations in water quality. One reason for this problem is that many lakes have properties that utilize septic systems. Since riparians have little control over local pollutant loading from agriculture to inland lakes, the maintenance of septic systems is critical for water quality protection

Septic Systems and Groundwater

It is estimated that Michigan has over 1.2 million septic systems currently installed with many of them occurring in rural areas around inland lakes. Currently, only seven counties in Michigan (Benzie, Grand Traverse, Macomb, Ottawa, Shiawassee, Washtenaw, and Wayne) require a septic system inspection prior to a property being sold. The number of septic systems

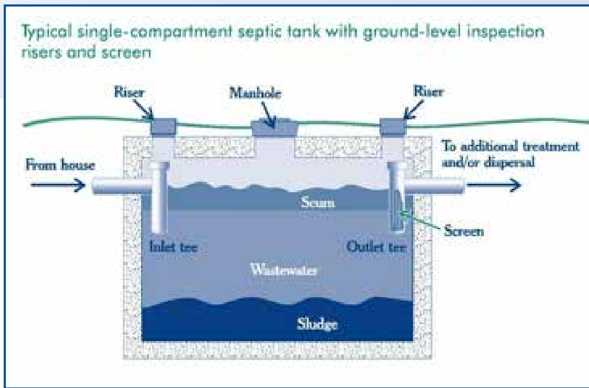

Figure 2. A diagram showing the basic components of a septic tank system (courtesy of the US EPA)

that are a risk to the aquatic environment is unknown which makes riparian awareness of these systems critical for protection of lake water. Construction of new septic tanks require notification and application by the homeowner to the county Department of Public Health and soils must be tested to determine suitability of the system for human health and the environment. It is recommended that each septic tank be inspected every three years and pumped every 3-5 years depending upon usage. The drain field should be inspected as well, and only grasses should be planted in the vicinity of the system since tree roots can cause the drain field to malfunction. Additionally, toxins should not be added to the tank since this would kill beneficial microbes needed to digest septic waste. Areas that contain large amounts of peat or muck soils may not be conducive to septic tank placement due to the ability of these soils to retain septic material and cause ponding in the drain field. Other soils that contain excessive sands or gravels may also not be favorable due to excessive transfer of septage into underlying groundwater. Many sandy soils do not have a strong adsorption capacity for phosphorus and thus the nutrient is easily transported to groundwater. Nitrates however, are even more mobile and travel quickly with the groundwater and thus are also a threat to water quality.

The utilization of septic systems by riparians is still quite common around inland lake shorelines. A basic septic system typically consists of a pipe leading from the home to the septic tank, the septic tank

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Figure 3. A bloom of the blue-green alga, Microcystis on an Ottawa County Lake.

itself *(Figure 2)*, the drain field, and the soil. The tank is usually an impermeable substance such as concrete or polyethylene and delivers the waste from the home to the drain field. The sludge settles out at the tank bottom and the oils and buoyant materials float to the surface. Ultimately the drain field receives the contents of the septic tank and disperses the materials into the surrounding soils. The problem arises when this material enters the zone of water near the water table and gradually seeps into the lake bottom. This phenomenon has been noted by many scholars on inland waterways as it contributes sizeable loads of nutrients and pathogens to lake water. Lake bed seepage is highly dependent upon water table characteristics such as slope (Winter 1981). The higher the rainfall the more likely seepage will occur and allow groundwater nutrients to enter waterways. Seepage velocities will differ greatly among sites and thus failing septic systems will have varying impacts on the water quality of specific lakes. Lee (1977) studied seepage in lake systems and found that seepage occurs as far as 80 meters from the shore. This finding may help explain the observed increases in submersed aquatic plant growth near areas with abundant septic tank systems that may not be adequately maintained. Loeb and Goldman (1978) found that groundwater contributes approximately 44% of the total soluble reactive phosphorus (SRP) and 49% of total nitrates to Lake Tahoe from the Ward Valley watershed. Additionally, Canter (1981) determined that man-made (anthropogenic) activities such as the use of septic systems can greatly contribute nutrients to groundwater.

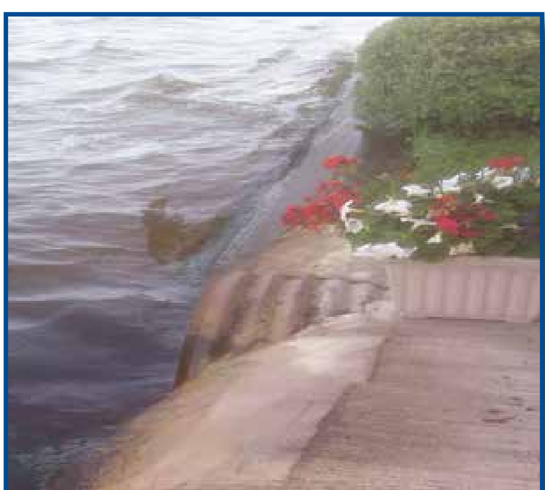

Figure 4. The inlet to Indian Lake, Cass County, Michigan as an example of a CSA.

Poorly maintained septic systems may also lead to increases in toxin-producing blue-green algae such as Microcystis. This alga is indicative of highly nutrient-rich waters and forms an unsightly green scum on the surface of a water body *(Figure 3)*. Toxins are released from the algal cells and may be dangerous to animals and humans in elevated concentrations. Furthermore, the alga may shade light from underlying native aquatic plants and create a sharp decline in biomass which leads to lower dissolved oxygen levels in the water column. Repeated algae treatments are often not enough to compensate for this algal growth and the problem persists.

Critical Source Areas

A specific area within a watershed that contributes any NPS pollutant is referred to as a Critical Source Area (CSA). CSA's can contribute high loads of nutrients and sediments to inland waterways and often escape detection during lake management programs. In vulnerable areas, these pollutants enter lakes after a climatic event such as heavy rainfall or snowmelt. The surrounding landscape is critical for the determination of CSA's as some areas contain high slopes which increase the probability of erosion, while others contain soils that pond and contribute pollutants to the lake via runoff from the land. This information is critical to include in a watershed management program since Best Management Practices (BMP's) should be site-specific and address the pollutant loads at the site-level. Many BMP's will follow recommendations from Low Impact Development (LID) which aims to reduce the amount of imperviousness in developed areas. Since so many lake shorelines are already developed or are being further developed, the use of LID practices will help reduce runoff and protect water quality. An example of an LID practice would be the installation of vegetation buffers along lake shorelines, especially in front of recently constructed homes with impervious surfaces. Inherently, following this protocol will allow for improvements to water quality at the regional scale. An example of this approach is being studied on Indian Lake in Cass County, Michigan. A prominent CSA in the immediate watershed surrounding Indian Lake would include the inlet to the lake (Figure 4) and the areas upstream that contribute loads to the inlet and eventually to the lake. The surrounding watershed is being dissected for each CSA and corresponding BMP's for each area are being offered to improve the overall water quality of the lake. The lake currently experiences extensive blue-green algae blooms along with heavy submersed aquatic plant growth and loss of dissolved oxygen with depth during stratified periods. An abundance of software exists to determine the location of CSA's and to predict nutrient and sediment loads from these areas to inland waterways.

Concluding Statement

Although NPS pollution is regulated, it is often diffuse and difficult to determine the origin and thus prescribe site-specific solutions. Riparians can begin with improvements to their shorelines with vegetation buffers and also with regular maintenance of septic systems. Since the use of lawn fertilizers that contain phosphorus is already regulated, these other nutrient sources become more critical to address. The improvement of some lakes since the inception of the Clean Water Act of the 1970's is evidence that regulation has helped clean up our waters. However, there are still many impaired lakes throughout the U.S. and in Michigan that require cooperation from stakeholders at all jurisdictional levels.

References

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