Your Health, The Degradation of Water Supplies, and Seneca Lake

The Finger Lake region is filled with sparling farmland, pastoral views of the country side, small quaint towns, and beautiful lakes. Seneca Lake, the largest of all the Finger Lakes, maintains a very similar surroundings described above. While on the surface this may seem ideal, the Seneca Lake watershed is starting to fall to the grips of industrialization. Erosion of farm lands, increased productivity of the lake and landfill activity has added to the stress of Seneca Lake's environment. Seneca Lake's current nutrient budget is not at equilibrium, there are significantly more nutrients coming into the lake than being taken out through the outlet or sediments. This not only affects the quality of the water and the animals that live in it, but it also affects those living in the watershed as Seneca Lake is their main source of drinking water. Currently, Seneca Lake provides Class AA drinking water to a population of about 100,000 people (some cities include Geneva, Waterloo, and Watkins Glen). With very little treatment necessary to comply with drinking water standards, the lake provides us with a minimal cost drinking supply[i]. This is a luxury that we are putting in danger as the productivity of the lake increases going from slightly mesotrophic towards eutrophic conditions.

Two sources that contribute to the increase in productivity are Fertilizer and CAFO (concentrated animal feeding operations) runoff. These not only add to the productivity, but are the two major sources of the pollutants that are degrading the drinking water within the Seneca Lake Watershed. While some of the pollutants are minor and will not have much effect on humans, some of the pollutants can have serious medical side effects. Toxins such as

arsenic, cadmium, and mercury are found in chemical fertilizers while pharmaceuticals like antibiotics and hormones are found in CAFO runoff. All of these, if not handled properly, end up in the water system and into our bodies. In this paper, I will speak about these different toxins, how they get into our water system, what affects they have on humans, and best management practices to avoid contamination of our beautiful water source.

Originally, in the mid-1600's, a scientist by the name of John Rudolph Glauber created the first chemical fertilizer using a combination of saltpeter, phosphoric acid and potash. Since then, chemical fertilizers have been manipulated and are still used today in great quantities[ii]. Some ingredients now found in chemical fertilizers are: phosphates, nitrates, aluminum, barium, beryllium, copper, iron, lead, manganese, nickel, uranium, and zinc. Most chemical fertilizers are made from recycled materials such as hazardous waste. Between the years 1995 and 2000, 600 companies from 44 states (including NY) sent 270 million pounds of toxic waste to farms and fertilizer producers across the United States[iii]. While the use of chemical fertilizers has slowly decreased since the 1970's, they are still being used at high rates and the damage done to the water system years ago is still relevant due to the residence time, which is the rate at which the lake recycles its water, and the persistence of some of the pollutants. With Seneca Lake maintaining a residence time of about 18 years and maintains an 42.2% agricultural land use this is an extremely important topic.

Arsenic is one example of a chemical (semi-metallic) found among the ingredients of chemical fertilizers. This semi-metallic chemical typically occurs naturally in the environment

within the earth's crust, water, and smoke from volcanoes[iv]. In many cases people become exposed to arsenic by eating or drinking it, breathing it in, and even touching it, in these cases with small exposers the body is typically able to metabolize it without any health issues. However, when exposed over time, more frequent and life threatening health issues may occur. The largest concern about arsenic is that it is colorless, tasteless, and odorless (depending on its form) making it very hard to detect. Some of the health issues that may be caused by an exposure to arsenic are skin and lung cancer and serious damage to the liver or nerves causing numbness throughout the body[v]. Arsenic also attacks the DNA of the body, which causes a different reaction between people, this makes it very difficult to pin point the damage or where it the toxin comes from. If two people are exposed to the same levels of arsenic from the same contaminant, one person may show no symptoms and be fine, while the other person may develop sever nerve dysfunction or even cancer. Currently the United States is the largest importer of arsenic and arsenic compound in the word, and while the use of arsenic is decreasing due to the awareness of the health effects, it is still being used in larger quantities[vi].

In Seneca Lake, arsenic has breached the water system through chemical fertilizer runoff from the surrounding farm lands. A study from 1999 revealed an increased amount of arsenic taken from the sediment core. While still below the drinking water regulation of 0.010 milligrams per liter (µg/L), it was much higher than the lakes that maintained fish consumption advisory. The sediment core indicated that there were arsenic levels that were close to or

slightly above the permissible exposure limit. Since then, there has not been an updated testing of the sediment core, however, the levels of arsenic are still an alarming indicator and need to be addressed[vii].

Cadmium is another example of a toxin used in chemical fertilizers. Cadmium was first discovered in Germany in 1817 as a by-product of the zinc refining process and is now found in many products in the United States such as in canned foods, drinking water, batteries, cigarette smoke, motor oil, exhaust, tires, plastics and some paints[viii]. While cadmium levels are typically highest in urban areas where there are large quantities of vehicle exhaust, it is also found in areas with large agricultural land use patterns, like those surrounding Seneca Lake. Similar to arsenic, cadmium in our water system is also a result of chemical fertilizer runoff into surrounding river and streams that feed into the lake. Small cadmium exposers can lead to headaches, fevers, nausea, salivation, vomiting, or abdominal cramping and diarrhea, while larger exposers or small exposers over a long period of time can cause prostate and kidney cancer, permanent kidney and liver damage, loss of sense of smell, and may cause anemia[ix]. Cadmium poisoning is a serious issue that occurs all around the world causing many deaths and illnesses. Having an increase of levels of cadmium in our drinking water will have drastic consequences for the homes that are located within the Seneca Lake watershed.

The last toxin of this focus is mercury. Similar to the other toxins, mercury can get into the Seneca Lake watershed from chemical fertilizer runoff. Mercury can be especially

dangerous due to its ability to bio accumulate, or pass on the toxins throughout the food chain, at greater levels as it travels up the food chain. This process of bioaccumulation typically leaves humans at the highest rates of toxic intake. Some side effects of mercury exposure are kidney damage and spontaneous miscarriages in women. A large exposure or low levels of exposure over time can lead to mercury poisoning (also known as Minamata disease) which can cause tremors, memory issues, gum and salivation problems, and hallucinations and psychosis[x].

In New York State, since 2001, sixty-three lakes, reservoirs, and ponds have been added to the Department of Health's fish consumption advisory list due to elevated levels of mercury. In 2009 the average concentration of mercury was .127 ppm which exceeds the national drinking water standard of .002 ppm. While these levels were found within the sediment and not in the water itself, it is still extremely alarming as Seneca Lake tested much higher than the surrounding lakes[xi]. When observing the history of Seneca Lake's surrounding it's no surprise that there were such elevated levels of mercury (figure 6[xii]). During the 1890's, Seneca Lake had booming farms where mercury was used as a key ingredient in pesticides causing much of the runoff to find its way to the lake. Mercury was not only found in the agricultural scene but in the industrials as well. Coal plants and chemical manufacturers played a key role in these high levels of

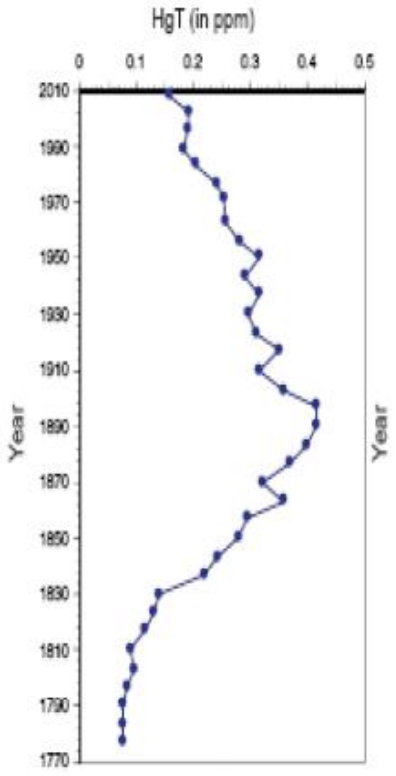
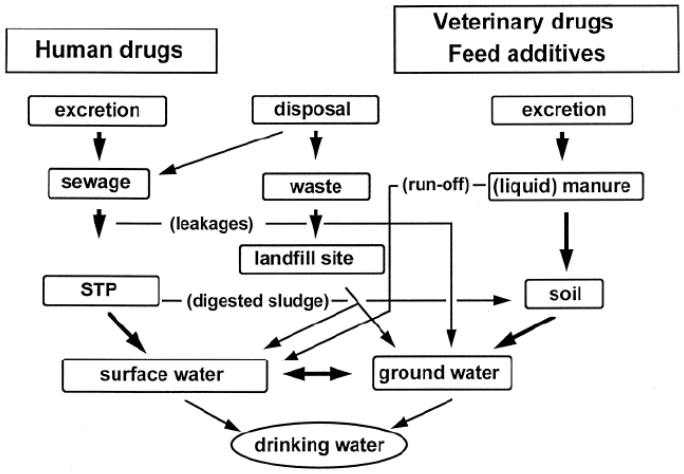


Fig. 6.

pollution. Since this time, the amounts of mercury being put into the lake have decreased drastically. However, due to its already heavy presence, any more mercury put into the lake can cause huge health issues for not only the wildlife in the lake but also the population of the Seneca lake watershed as well[xiii].

While the use of chemical fertilizers is slowly decreasing, the number of CAFOs or concentrated animal feeding operations has increased. CAFOs, if located in a close proximity to a body of water that flows into the lake or if they maintain improper handling of waste, can lead to animal excrement in the water (Figure ES1[xiv]). Reeder Creek, which flows into Seneca Lake, is in the vicinity of a larger CAFO which produces massive quantities of animal waste. Looking at the phosphate levels in each input to Seneca Lake, Reeder Creek is significantly higher at 160.4 mg/l, over double the amount of the next highest phosphate contributor (See Table 18)[xv]. From this we can conclude that animal waste is in fact getting into the water system. Animal waste not only carries nitrates and phosphates but it also carries



Note: STP is sewage treatment plant.

Figure ES1: Fate and transport of pharmaceuticals in the environment (Ternes, 1998)

Table 18. Average stream concentration and flux data 1999-2011 (Halfman, 2012).

Concentrations	Conductivity µS/cm	Discharge m^3/s	Nitrate mg/L, N	Total Phosphate µg/L, P	Phosphate (SRP) µg/L, P	Suspended Sediment mg/L, N
Seneca Lake	696	--	0.3	9.8	1.9	1.2
Castle	844	0.3	0.4	51.9	36.9	18.7
Wilson	629	0.4	1.0	40.8	32.7	5.7
Kashong	561	0.7	0.9	22.3	13.8	5.8
Keuka Outlet	359	3.2	0.7	21.7	15.4	8.7
Plum Pt.	580	0.1	0.9	13.0	8.5	2.3
Big Stream	400	0.6	0.5	34.9	48.6	3.9
Catharine	416	2.6	0.2	37.9	11.4	42.5
Reeder	589	0.2	0.7	160.4	109.5	2.5
Kendig	527	0.2	0.7	40.1	25.6	4.5

pharmaceuticals that have been fed to the animals such as hormones and or antibiotics. These substances get into the animal's systems from meat producer's need to increase milk production, keep them from getting sick, making them heftier, or for increasing reproduction rates. Without these drugs, animals that are kept in such confined and heavily populated spaces would get sick and die. Factory is something that is frowned upon for many reasons, but for environmentalists these large scale farms are not only terrible for the animals but for the environment as well, high uses of water, excess methane, and pollution of the surrounding environment are among those reasons.

For the past 8 years the topic of pharmaceuticals in our water systems has been gaining publicity. All over the United States different types of pharmaceuticals including narcotics, antibiotics, heart medication, hormones and treatment medicine for epilepsy, have been found in the drinking water. While in smaller quantities, these drugs can make a large impact. In the Chesapeake Bay for an example, medications (along with other pollutants) caused the fish in the area to have reproductive issues and threaten their very existence. This is an issue that we must avoid in Seneca Lake. Exposure to these types of pharmaceuticals can cause reproductive issues in women, heart problems, and even cancers if exposed for long periods of time. Similar to mercury, pharmaceuticals are extremely persistent in the water system and are very expensive and difficult to remove. Our current wastewater treatment systems do not have the infrastructure needed to filter out these pollutants[xvi]. Due to the difficulty of removal and the

persistent of the pollutants, it is necessary to stop these drugs from getting into our water system for our health, our environment, and our economy.

In the Seneca Lake area, cancer rates are on the rise, during 2003-2005 24% of all the deaths in the area were cancer related. This number is 10.2% higher than the state average and 8.25% higher than the national average[xvii]. While these numbers cannot be directly correlated with environmental exposures, it brings the possibility into question. Even if only 1% of the cancers are environmentally related, that is a large number of potentially preventable deaths. The areas surrounding Seneca Lake are not as economically prosperous as other surrounding areas in Western New York. The average household income for the counties in the Seneca Lake watershed is about $10,000 under the New York state average[xviii]. With economic challenges and medical costs on the rise, in the long run it will not only be beneficial for our health but for the areas economic status as well to put in place best management practices.

Best management practices (BMPs) for these pollutants and toxins can be anything from planting bushes to building new infrastructure in our waste water treatment plants. The best balance for best management practices is to a find a line between effectiveness and economically sustainable/ reasonable. For the toxins that come from chemical fertilizers there are numerous cost and environmentally beneficial solutions. One solution is the switch from chemical to organic fertilizers. This switch will not only decrease pollutants but is also less expensive. Since organic fertilizers have more organic material, they remain loose and airy which better allow them to hold moisture and nutrients. All of these factors allow healthier soil

and promotes healthier root development, which will help decrease runoff and topsoil erosion. Chemical fertilizer, while fast acting, quickly depletes the soil of nutrients and dries it out which requires more fertilizer and water. When the soil is dry and depleted of nutrients it becomes very vulnerable for erosion and runoff. This change will also be beneficial to the people who eat the crops grown in non-toxic fertilizers, allowing fewer chemicals to reach the consumer through the chemical absorption in their food. By eliminating the toxins from the soil and preventing the contamination of the actual crop will prevent chemical contamination in our produce. [xix]

Another potential BMP is crop rotation, which consists of planting different crops next to each other and planting them in different plots each year. This will also help prevent single nutrients from being depleted from the soil. For an example if you only pant corn, it would deplete a large amount of nitrogen while leaving other essential nutrients behind. If this was cross cropped then one crop could take the nitrogen while maybe you plant a crop that excretes nitrogen back into the soil while taking other nutrients. This process keeps the soil rich with nutrients and healthy which will prevent both runoff and erosion.

The last best management practice for farming is planting buffer strips. Buffer strips are trees or bushes planted along the boundaries of the farm to absorb the nutrient runoff from the farm. This provides a great environment for this greenery to prosper and it decreases the amounts of nutrients that run off due to the trees ability to absorb the runoff. The healthy

roots of these plants also help prevent erosion and runoff by creating a solid base for the soil structure.

The best management practices to prevent pharmaceuticals from getting in the water can be very complex but very simple at the same time. Since the drugs are so difficult and expensive to remove, it is in our interest that we act to prevent rather than act in response. Simple things like creating a program to educate about this issue and collect unused medication may make a huge and lasting impact. A sign at pharmacies in town is a simple and cost effective way to spreading this knowledge.

The proper removal of animal excrements is also a large player in these best management practices. If the waste is properly removed then we will have less waste runoff into our streams making Seneca Lake less of a concern for pharmaceutical waste runoff. The most simple of all the BMPs is simply just keeping the animals away from the streams. Preventing them from walking into the streams will also decrease the exposure of waste to the streams. This is cost free and surprisingly effective.

Seneca Lake not only brings natural beauty and clean drinking water but high amounts of revenue due to the tourist industry. The loss of any of those elements would be catastrophic for the Seneca Lake watershed. Most people in the watershed take clean drinking water for granted because of the luxury of having such a large and clean body of water readily accessible. However, if we continue to take the lake for granted, we may end up in a situation where our

main water source is gone, or the lake is too hazardous to swim in, all which steer tourists away. In order to maintain the integrity of the water, we need to change our actions, if we don't, the future is very unclear for the Seneca Lake's waters.

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