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Waste Water Treatment in Geneva, New York:

The consequences on human life and the environment

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Our fresh water supplies are rapidly becoming damaged and yet our practices have not significantly changed in years. Wastewater treatment, while a necessary for everyday life, is a process that has yet to be perfected. While we need clean water, the process which provides us with this resource is actually polluting the water body from which the water was initially taken. Looking specifically at Seneca Lake in Geneva, New York, this paper will examine, in detail, the wastewater treatment process, the consequences, and evaluate some alternative methods.

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Introduction

Wastewater treatment is a key process in providing cities and the surrounding areas with safe, sanitary water for municipal uses. The contents of wastewater, also known as sewage, are “99.94 percent water with only 0.06 percent of the wastewater being dissolved and suspended solid material.”[1] Despite our need for clean water, this process is far from perfect. Many chemicals go untreated and some are even created from the treatment of waste water. Even with these imperfections there remains a lot of controversy over the inconsistent regulation of the wastewater treatment process. Often times there are large disparities between funding of plants in different areas. While the government does regulate the chemicals released, the restrictions sometimes do not take into account the effects that even minor changes in concentrations can have on ecosystems. Aquatic ecosystems such as Seneca Lake and the surrounding streams are subject to any change in chemical concentrations from anthropogenic sources, which can cause immense damage to these fragile ecosystems. Constant monitoring is extremely important because we utilize these water bodies for drinking purposes as well as many other vital activities. Our goal is to determine whether or not phosphates being released from wastewater treatment plants within the Seneca Lake watershed have a direct affect on the aquatic ecosystem and the source of drinking water for the local population.

[1] http://ohioline.osu.edu/aex-fact/0768.html

Background Information

Until the early 1700's, waste was being dumped uncontrollably into local waterways, fields, and virtually anywhere people felt compelled to dispose of their effluent. In the mid-1700's Benjamin Franklin and others began to urge the Pennsylvania Assembly to regulate the disposal of waste to prevent the contamination of local waterways. By the late 1800's the concept of sewer systems was beginning to emerge leading to some major U.S. cities enacting plans to control the release of municipal waste. Finally in the early 1900's, U.S. cities, generally with populations over 4,000 persons, began establishing basic sewer systems. After this Federal involvement began to increase with the establishment of pollution surveys of streams and harbors in 1914. These surveys revealed the damages from the dumping of oil, untreated municipal waste, industrial waste, and mine runoff. It took nearly twenty years before the first sewage treatment plant was mandated; in 1933 the government declared that wastewater must be treated prior to its release into the Mississippi River.

Wastewater "is released by residences, businesses, and industries in a community."[1] Our study of the wastewater treatment process is based upon the treatment system utilized at the Marsh Creek Treatment Plant in Geneva, New York. The waste water treatment process varies from between different plants but it can be generalized into a few main processes. (Image) Treatment begins when water from a sink, toilet, sewer, or any other source enters a vast pipe system that leads to a specified treatment center. Primary wastewater treatment begins with water entering the plant where the water velocity is reduced to promote the separation of the dense materials from the light materials. Within the first aeration tank the dense materials sink to the bottom as sludge and the lighter materials float to the surface and are skimmed off. It is estimated that this step alone removes approximately 40 percent to 60 percent of the suspended solids.[2] Secondary treatment begins with water flowing into large tanks known aeration basins. Inside of these tanks the organic matter within the wastewater is consumed by numerous microorganisms. Along with the consumption of organic matter, chemicals are added to the water. Air bubbles are then pumped into the water to help evenly distribute these chemicals which help to remove phosphorus.

At the Marsh Creek Treatment Plant these chemicals include iron salts and polymer, which help to precipitate out the phosphorus from the wastewater. Water then is pumped into a second clarifier tank, which helps to separate more solids from the water. These steps are necessary because there are federal and state regulations that determine the amount of phosphorus that can be released into any water body. The Marsh Creek Plant is mandated to reduce phosphorus levels to less than 1 ppm prior to release into the lake. Phosphorus is an important element because it is a major portion of the limiting nutrient phosphate. Phosphates, or PO_4^{-3}, generally come from the breakdown of organic matter by bacteria. An excess of phosphates can lead to the eutrophication, or overloading of nutrients in a water body. This can result in uncontrollable algal growth. Not only does this hurt the aesthetic value of the lake, but it can also destroy or alter the fragile ecosystem present within the lake.

After the phosphorus removal process, the final treatment process is known as the "final clarification" stage. In this stage, the wastewater is pumped through pipes into two basins known as clarifiers. At the Marsh Creek Treatment Plant, these clarifiers are sixty feet in diameter. Within these clarifiers, it has been shown that approximately 89 percent of the biological oxygen demand of the remaining waste was removed during this step. BOD, or biological oxygen demand, is the measurement of the amount of oxygen utilized by the

[2] http://www.geneva.ny.us/WWTP/WWTP-Treatmen-Process.html

microorganisms in the breakdown of organic waste.[3] A higher BOD results in an increased amount of pollution because it means there are fewer microorganisms breaking down the organic waste. While the Marsh Creek Treatment Plant ends the process with the clarifier process, a tertiary treatment is available but not mandated at many wastewater treatment plants. Tertiary wastewater treatment is only used "where it is needed to protect the receiving water from excess nutrients."[4] The tertiary treatment involves either a biological or chemical processes in order to reduce the nitrogen or phosphorus levels reaming in the wastewater.

The effluent that separates out within the primary wastewater treatment process is commonly referred to as sludge. Primary sludge, or the sediments that settle out during the primary treatment process are commonly too toxic to dispose of without further treatment. The biological treatment process creates a secondary sludge which consists of excess microorganisms. Upon removal from the separation tanks, both the primary and secondary sludge contain mostly water which need to be removed prior to disposal. The water removal process can utilize using a number of different techniques which all help to decrease the volume of the material needing disposal. Furthermore, aerobic and anaerobic methods are utilized to decompose any remaining organic matter within the sludge as well as to help decrease the odor that the sludge emits.[5] Following proper treatment, the sludge is often spread onto agricultural lands to help recycle nutrients into the soil.

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[3] http://water.epa.gov/type/rsl/monitoring/vms52.cfm
[4] http://ei.cornell.edu/biodeg/wastewater/index.html
[5] http://ohioline.osu.edu/aex-fact/0768.html

Data Analysis

Water quality data has been compiled from Seneca Lake and the many streams that feed into it for over a decade now. The collection of this data has helped to monitor, maintain, and protect the health of our lake. Phosphate concentrations in Seneca Lake have been a focal point for discussion on the health of the lake for many years now. Upon the breakdown of organic material by bacteria, phosphates are formed and thus released into the water as result of this process. Most decomposition occurs along the lake floor, the sediments can thus pose a serious threat to the health of a lake. In an oligotrophic or healthy lake, there is a layer of oxygen that acts as a cap and traps most of the phosphates within the sediments. Eutrophic lakes are anoxic and thus there is no oxygen layer to cap the sediment based phosphates so they can openly enter the water column. This loading from the sediments is known as internal loading. Once phosphates enter the water column they are extremely difficult to disperse because algae rapidly take in the excess nutrients. Phosphates never become toxic in excess levels, so algae can freely consume and store phosphates until they need it for various life functions. Algal ability to consume infinite amounts of phosphates is known as luxury consumption.

The ability for algae to practice luxury consumption with phosphates makes the dangers of phosphate loading even more pertinent. Over the past decade, water quality in Seneca Lake and its surrounding streams has been monitored to help protect this valuable resource. One aspect of water quality, total phosphate concentration, is a measure of the amount of phosphorus dissolved in the water added to the amount consumed within biomass. This is a more accurate measurement of how phosphates are affecting the lake. It considers the phosphates absorbed within the water column as well as the phosphates within the biomass of the lake, rather than just the soluble phosphates. Having analyzed the data collected from Seneca Lake over the past four years on total phosphate concentrations it is evident that there is little to no significant change. Figure 1 shows, it is clear that the stream levels are much higher than the lake levels. Never the less, one would assume that the lake levels would be higher given the extremely high total phosphate levels in some streams. The lack of a significant increase within Seneca Lake despite the high total phosphate levels entering the water column is concerning; it suggests that the total phosphates are immediately being converted to biomass. When the phosphates entering the lake are converted immediately to biomass it is dangerous because it mirrors a phosphate loading trend, which can eventually lead to the eutrophication of a lake.

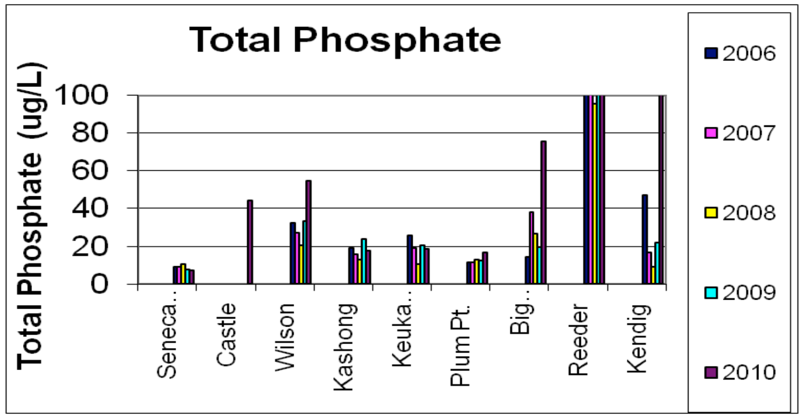

Figure 1 Courtesy of Prof. John D. Halfman

In order to confirm the idea that phosphates entering Seneca Lake were being converted immediately to biomass, the total soluble phosphate data was analyzed. If the soluble phosphate levels within Seneca Lake show an increasing trend over time, it would contradict the conclusion drawn from the total phosphate graph because it would mean that phosphates entering the lake are dissolving in the water column rather than being consumed by biomass. Figure 2 shows the total soluble phosphates have shown a decreasing trend over the past decade which coincides with the previous

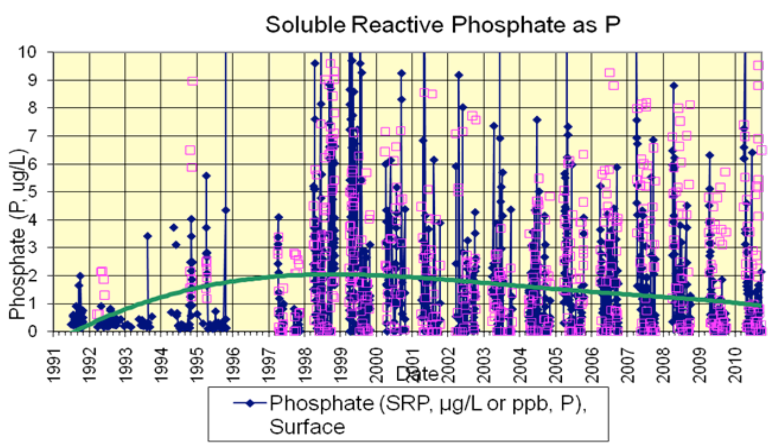

Figure 2 Courtesy of Prof. John D. Halfman

conclusion drawn. The decreasing levels of soluble phosphates in Seneca Lake suggest that the amount of algae is increasing, thus being able to consume more phosphates within the lake. Throughout the 1990's the soluble reactive phosphate levels showed a gentle, but noticeable increase; this is likely due to the increased use of phosphorus based fertilizers on agricultural fields in the area. These fertilizers have since been banned because their impact on the lake was realized; however, phosphates have continued to impact Seneca Lake. In order to analyze whether an increase in biomass was occurring the historic Secchi disk depth data was analyzed.

Secchi disk depths are relevant because an increase in biomass means more algae within the water column and this would thus decrease water clarity in the lake. From looking at image 3 we can see that clearly over the past decade water clarity is decreasing as demonstrated by the decreasing Secchi disk depth measurements. During the 1990's, the zebra mussel populations were expanding rapidly and thus able to filter a larger amount of the water within Seneca Lake. The increased amount of filtration caused an increase in water clarity as demonstrated by the increasing Secchi disk depths shown from 1991 until 1999. There would be lower algal populations in the lake as well as lower total suspended sediment concentrations due to the larger number of zebra mussels. While zebra mussels kept the phosphate problem within the lake in check, they still remained an unwanted and invasive species. When populations began to die off,

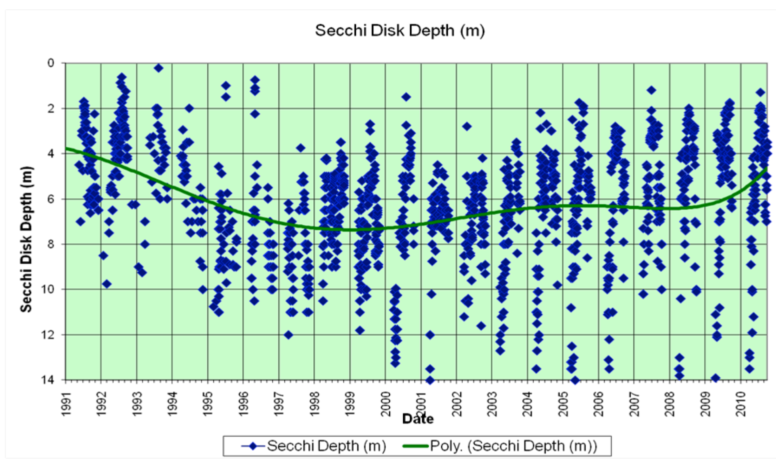

Figure 3 **Courtesy of Prof. John D. Halfman**

people began to notice the increase in algae populations in the lake and thus the phosphate loading problems garnered more attention. Although it is evident that wastewater treatment plants do introduce effluent with raised phosphate levels in to Seneca Lake, it is clear that these plants cannot be the only sources threatening the health of the lake.

Discussion

Fresh water; a resource vital for survival yet one that we take for granted every day and continue to abuse. It has become abundantly clear that fresh water is constantly overlooked when discussions about non-renewable resources occur and eventually we will enter a time when fresh water is no longer instantly available with the turn of a faucet. The wastewater treatment process, while necessary to provide clean water for numerous functions, also can lead to the detriment of water bodies into which effluent is released. While almost all technology brings with it detrimental consequence in one form or another, the wastewater treatment process is one in which we cannot afford such consequences. Currently the effluent from wastewater treatment is carrying elevated rates of phosphates into Seneca Lake and the amount of biomass, or algae, in the lake is increasing over time. Given the large nature of the Seneca Lake watershed, the area from which phosphate loading can occur is also larger. In figure 4 we can see that there are an increased number of wastewater treatment facilities within the watershed represented by red dots. Even though there are more treatment plants in the Seneca Lake watershed, it is evident that there must be other sources beyond wastewater treatment effluent. Land use within a watershed can also have major impacts on the pollutants or nutrients that are found within a water body. The unique topography and climate of the Finger Lakes region makes it ideal for agricultural production. Within the Seneca Lake watershed, the vast majority of the land is utilized for agricultural purposes including, but not limited to vineyards and other produce fields, as well as concentrated feed operations. A map of the land use within the entire watershed can be seen in image 5; note the large amount of yellow land coverage which represents agricultural land use. Produce fields, such as vineyards or corn fields, formerly caused phosphate loading because of phosphorus based fertilizers running into the streams and thus into the lake during rain events. Despite phosphorus based fertilizers being banned in recent years, animal excrement, which is spread on fields, causes phosphate loading in that it increases the organic material entering streams and lakes; organic material is broken down by bacteria, thus releasing phosphates into the water body. Similar to produce fields, concentrated feed operations or CAFO's, cause animal excrement to enter streams, get broken down, and thus cause increased phosphate levels within the lake.

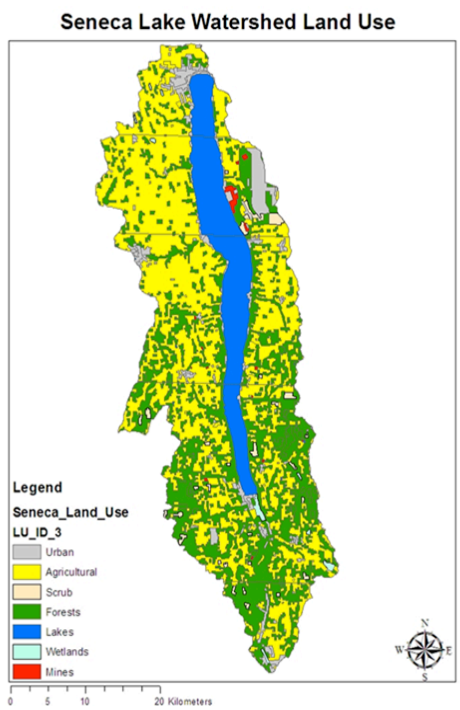

Figure 5

While it is likely that a combination of these alternative sources of phosphates along with imperfections within the wastewater treatment process cause the phosphate loading problem within Seneca Lake. Although a wholesale change of the wastewater treatment process is not feasible, a number of small scale changes could achieve a similar result. Some available technologies, while far from perfect, could be furthered with technologies available or developed in the coming years.

Improvements

There are many different alternatives to obtaining clean drinking water and potential additions to the wastewater treatment process. Many of the issues with wastewater treatment today are funding and a lack of money available to create wastewater treatment plants with all of the necessary cleaning processes. Nevertheless, even the most funded and sophisticated waste water plants have their faults and can cause harm to the environment. Many people do not realize how important it is to have clean drinking water. Fresh water is one of the major resources that we cannot live without, yet very few people recognize what life would be like without readily available clean water. We have spoiled ourselves here in the United States when it comes to how and where we utilize our water. We are constantly wasting a vast amount of clean water when it comes to showering, dish washing, brushing teeth, washing hands, and many more habitual activities. Many of these uses of water are important for daily practices; we need to come up with better methods to more effectively use and reuse this water so we do not waste this valuable resource.

Whether from underground aquifers, lakes, rivers, or springs, all of our fresh water comes from natural sources. Some of the ground water is naturally filtered by soil and rock layers, but further filtration and treatment generally occurs. Upland lakes and often reservoirs are located above human habitation and are sometimes protected by a protective zone to prevent contamination. This "buffer" zone is an extremely useful and natural way to protect clean drinking water from external contamination.[6] Rivers, canals, and lowland lakes are at lower elevations and are increasingly being affected by human populations. Water from these sources can have a high bacteria load and many contain a large amount of suspended solids. Our rivers,

[6] http://water.epa.gov/drink/index.cfm

canals, and lakes are at risk; almost all of this danger comes from anthropogenic sources. For this reason we need to act now to help improve these regions rather than acting after our water sources are altered beyond the point of repair.

Many countries that have low quality drinking water and few water sources in general must resort to alternative sources for their fresh water. Some of these techniques are simple, extremely cost effective, and could be implemented in the United States as a potential method to better our water quality further. Solar Water Disinfection or SODIS is a technique that uses UV-A radiation from the sun and heat to inactivate pathogens that may cause harm to the human body. In developing countries, they use old water bottles as a means to foster this technique. In many of these countries at least one-third of the population cannot find access to clean drinking water. This results in a high risk of water borne diseases which cause about 2.5 million deaths a year.[7] A simple and effective process, like SODIS, could easily be implemented in the United States in a more advanced form. When the water reaches the wastewater treatment plants, an initial tank could be created with a glass cover over the top. A glass cover would act as a magnifier which would increase the intensity of the sun as well as the temperature inside the tank. This process would be entirely energy free outside of creating the glass cover, but it also entirely natural resulting in no excess pollution. Relatively clear water is required to utilize SODIS so that the UV-A radiation and heat can penetrate the water killing harmful bacteria. Nevertheless, with any technology, there always seems to be some disadvantages. SODIS does not remove chemical or organic pollutants within the water so this method is not a replacement for our whole system; however it is effective in areas such as third world countries.

Another alternative to finding clean drinking water is atmospheric water generation. If there was a natural disaster that causes our drinking water sources to become unavailable this

[7] http://www.fredrinkingwater.com/water_quality/quality1/1-explain-solar -water-disinfection.htm

method could be a good alternative. As our water supply becomes increasingly damaged by our own means, such as drilling, hydro-fracking, and dumping, it is only a matter of time before it will no longer be available for our use. Atmospheric Water Generation is a relatively new technology and is used mostly in the desert; however, it could easily be implemented in areas that are not in a desert climate. Atmospheric water generation or AWG can provide high quality drinking water by extracting water from the air by cooling it and then condensing it. Most of the AWG's operate very similarly to a dehumidifier; air is first pulled through an electrostatic filter which removes approximately 93 percent of all airborne particles. The air is passed through a cool coil which causes water to condense; air temperature is reduced as it passes over this coil, which in turn reduces the air's capacity to carry the water vapor. Some more advanced AWG actually have a UV tank where the water sits for thirty minutes killing roughly 90 percent of all germs and bacteria in the water. The water is then passed through a sediment screen and more filters to remove volatile organic chemicals that may be in the water.[8] On the most advanced AWG the water is filtered through an ultra-filtration membrane where virtually all bacteria and common viruses are removed. Finally, water is pumped to a holding tank and cycled through the UV tank to ensure clean and fresh drinking water. The amount and rate water production from an AWG depends entirely on the temperature, humidity, and volume of air passing through the cooling coils as well as the capacity of the machine.

A couple of techniques that could help improve our wastewater treatment process and help prevent contaminated waters include settling ponds and constructed wetlands. Settling ponds are areas that are used to treat contaminated waste water; typically these can be found on or near farms. Water will sit in a constructed pond allowing some of the suspended pollutants in the water to settle to the bottom. The water then likely enters a stream and runs into a lake or

[8] http://www.air2water.biz

larger stream. Another potential process to help better our current wastewater treatment process is creating constructed wetlands. Constructed wetlands are artificial marsh or swamp areas that are created for the discharge of waste water, storm water runoff, or sewage treatment[9]. This wetland acts as a habitat to wildlife and naturally filters out many contaminants. These constructed wetlands can also be used for land reclamation after mining or other disturbances that can be extremely detrimental to the environment. A feasible way to implement a constructed wetland into our current wastewater treatment process would be to build a wetland down stream of where the wastewater effluent release. Placing a wetland here would allow the released effluent from the wastewater plant to be further filtered before entering a major water body. Both of these techniques use little energy after their initial creation and can be cost effective ways to improve contaminated water both before and after our current wastewater treatment process.

Ethical Issues

There has been much controversy when it comes to the placement of wastewater treatment plants or any sort of waste treatment facility in general. Many of these plants and landfills appear to be conveniently placed in areas where the populations generally have lower income levels. It seems that the local residents are taken advantage of due to their low level of education and lack of understanding of local laws and rights. For instance, in the Geneva area, the Marsh Creek Wastewater Treatment Plant is located in an area of low income minorities. When constructing a waste facility, city planners and companies will always follow the path of least resistance. More often than not, this path leads directly through these low income communities. The lesser resistance put forth by these communities towards the placement of a

[9] Jansson, H; Et. Al., *Buffer Zones and Constructed Wetlands as Filters for Agricultural Phosphorus,* Journal of Environmental Quality, v. 29, 2000

facility means that legal issues are not likely to be raised. Another example can be seen in the Skaneateles watershed. Wastewater from the Skaneateles wastewater treatment plant is pumped into the neighboring Onondaga watershed and therefore into Onondaga Lake. The average income for the city of Skaneateles is approximately $70,000, while the average income for Onondaga County is only $50,000. It is clear that given the higher income in the Skaneateles community, they can afford to ship their effluent to a lower income area and thus protect the quality of their lake.[10] This relationship might be met with more resistance if the citizens of Onondaga County were more educated on the state of their lake and the effects of excess wastewater effluent.

Nevertheless, there are ways to prevent this sort of unfair placement of wastewater treatment plants. For example, if information was made readily available to these communities about what is being placed nearby, they would be able to better put up resistance if deemed necessary. Pamphlets could be distributed to local communities and community meetings should be held to discuss the proper placement of a plant. Community leaders need to be held responsible when it comes to informing the general public about waste facility installation by holding town meetings to make sure that all residents are properly informed. Plants should also be put in areas away from homes and areas where children may be. School locations should also be considered in the discussion about the placement of plants. Clearly, there are many issues when it comes to the placement of wastewater treatment or any other waste facility. These issues can be addressed with the proper information being given to the local communities in forms that are easy to understand and read. Laws then need to be enforced, regardless of whether there is a civilian call for justice. The voice of those affected by the construction of the waste facility needs to be heard.

[10] http://www.city-data.com/city/Skaneateles-New-York.html

Conclusion

Throughout history, the human race as a whole has experienced disaster after disaster. However, there appears to be a troubling trend: people generally do react to a situation rather than acting to prevent it. This trend has shown itself throughout history and is truly something that can be prevented. For instance, when it comes to fresh water for drinking or any other purpose, people fail to recognize how important and fragile this resource is. Despite this fact, we continually use practices that further damage our fresh water bodies and the fragile ecosystems within them. An example of this is our wastewater treatment process. While we need this process to provide us with drinking water and clean water for a number of vital processes, it is actually causing excess nutrients to return to our water bodies. Whether it is from lax legal regulations, a lack of knowledge, or a lack of caring, action must be taken to start making changes to this process for the sake of our fresh water supplies. Being a community with a front row seat to any changes in Seneca Lake, Geneva needs to jump start a movement within the Seneca Lake watershed. The movement needs to better protect the lake from wastewater effluent run off and any source of nutrient loading or the citizens of Geneva will witness a devastating result.

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