Dylan O'Ryan
ENVS 120 – Class Project Paper

Turbidity and Diatom Diversity: A look into human effects on water quality and the environment

Have you ever wondered what kind of influence you could have on your local environment? Have you thought about whether the way you live could influence water quality? Human impacts can have drastic effects on ecosystem health, water quality, and the environment.

First, we must define some terms that will be important in understanding the effects on water quality.

Water quality describes the overall condition and health of a waterbody. Some examples of water quality parameters are Dissolved Oxygen (DO), pH, Electrical Conductivity (EC), bacteria levels, and turbidity.

Turbidity is the "measure of relative clarity of a liquid" (USGS, Turbidity and Water). If a water sample contains more particles – such as dirt, soil, and algae – the less transparent and more turbid the water. Higher turbidity levels have been associated with overall water quality deterioration; therefore, turbidity can affect oxygen levels, dramatically reduce aquatic life populations, and degrade overall water quality. Turbidity is measured using probed handheld meters, Secchi discs, or a standard turbidity meter. The general measurement of turbidity is in NTUs or Nephelometric Turbidity Units. "The nephelometric method compares how light is scattered in a water sample against the amount of light scattered in a reference solution" (Department of Environmental Conservation – State of Alaska). A standard turbidity meter uses a collected sample of water and then this meter shines a light into the sample, the reflected light is the amount of particles in the water.

Diatoms, single-celled algae, are treated as an indicator of water quality in freshwater lakes, streams, and rivers. Researchers suggests that there is a correlation between diatoms and overall water quality. According to Otto (2016), high nutrient levels can result in eutrophication caused by pollutants in the water (Otto, 2016).

As part of an Environmental Protection Agency (EPA) study on the "ability of diatom abundance to predict levels of pollutants in samples from freshwater lakes, streams, and rivers," water quality data was collected in various freshwater bodies. Variables collected during this study include diatom diversity, known water pollutants (aluminum, potassium, ammonia, silica, sulfate), other general water quality parameters (pH, nitrate, turbidity), as well as characteristics of the sampling locations (shade and mean annual flow). The focus of the data analysis is on the associations between diatom diversity and turbidity.

Natural causes can contribute to overall turbidity in a water system; for example, natural litter (e.g., dead plant material) can decrease the clarity of the water. When the natural litter breaks down this can result in higher amounts of particulates in the water. Human-caused sources of turbidity are often avoidable. Examples of human-caused turbidity are stormwater runoff, industrial discharges, and land-use disturbances (Denby et al., 1987). Increased turbidity can have significant effects on ecosystems. For example, Lake Erie has seen water quality

disturbances over the past 50 years. At Lake Erie, there have been continual problems with algal blooms. The higher occurrence of algal blooms has been attributed to an excess of nutrients entering the water system. The nutrients are believed to come from the agricultural industry and personal use of fertilizers (which contain high levels of nutrients).

These algal blooms can have significant effects on the environment, economy, and human health. Harmful algal blooms can "produce extremely dangerous toxins that can sicken or kill people and animals, create dead zones in the water, raise treatment costs for drinking water, and hurt industries that depend on clean water" (EPA, Harmful Algal Blooms). Diatoms, along with other algae, are known to cause algal blooms. Therefore, the connection of diatoms and overall water quality is further shown with algal bloom occurrence.

With the EPA dataset ("diatom_richness_data"), I am focusing on turbidity and diversity. We already know that diatoms can cause algal blooms; therefore, using this data, we will see if turbidity is related to diatom diversity. The first step to begin analyzing the dataset is to use RStudio, an open-source statistical software, to determine the summary statistics of the two variables (mean, median, quartiles, minimum, and maximum). For the diatom richness data, the mean was more significant than the median. Therefore, this difference shows that the data has a skewed right distribution. Therefore, outliers may be increasing/drawing the average diatom diversity larger than the distribution of the data points. Similarly, for turbidity, the mean is significantly larger than the median. Therefore, outliers are skewing the mean higher.

To begin analyzing the dataset, you must create a linear model regression analysis. Since the two areas of interest are continuous variables, we must conduct a linear model regression analysis. "A linear regression model describes the relationship between a dependent variable" and an independent variable (Mathworks, What is a Linear…). I utilized RStudio to perform a linear regression model for turbidity and diatom diversity. From this test, a regression coefficient (R-squared) was determined to be 0.9818. Therefore, with an R-squared of 0.9818, 98.19% if the data fits the linear model for turbidity and diatom diversity. With a high R-squared, this regression model fits the relationship of turbidity and diatom diversity very closely.

Additional information from this test was the p-value, which was less than (<) 2e-16. Therefore, this p-value is an extremely small number (<0.0000000000000002)! With the p-value being significantly less than 0.05, there is strong evidence to reject the null hypothesis. The null hypothesis is that there is no statistical difference between the means of diversity and turbidity. Therefore, we can conclude that there is a statistical difference between diversity and turbidity; thus, allowing for us to analyze the dataset with visualizations.

Now that we know that the two variables are statistically different, we can graph the correlation between these two variables. The graph of these two variables looks extremely skewed, with high outliers (on both x and y values) not allowing us to see a clear trend within the areas of interest.

Diatom Diversity vs Turbidity
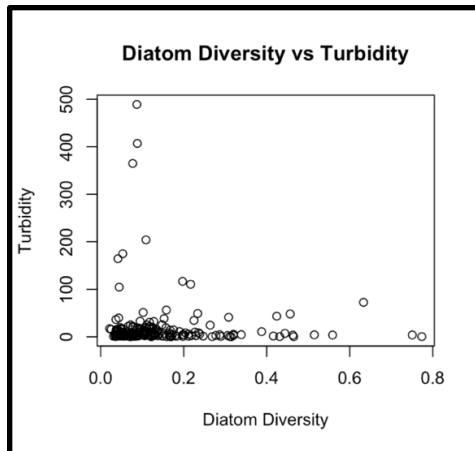
A question of removing outliers is introduced with this highly-skewed visualization between turbidity and diatom diversity. Critics of removing datapoints argue that this can remove essential data characteristics and data inflections in the dataset. For example, removing high turbidity points can remove significant fluxes in turbidity readings. This can be said for diatom diversity in removing diatom diversity values higher than the statistically determined outlier range. Removing these outliers can remove essential values within the dataset. Those who argue for removing outliers convey that removing outliers may increase the relationship between two variables.

For the sake of visualizing the relationship between the two areas of interest (turbidity and diatom diversity), I removed the statistically determined outliers for the curation of a graph of the relationship. A total of 33 outliers were removed from the dataset. The newly created graph conveys the strong relationship between turbidity and diatom diversity. As turbidity increases, the diatom diversity increases.

Diatom Diversity vs Turbidity
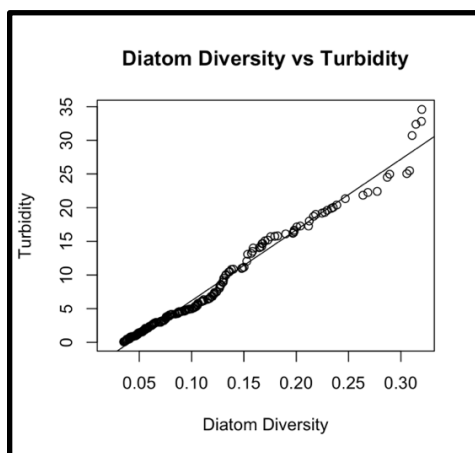
We now know diatoms and turbidity are strongly correlated; we can further connect this to real-life applications. Diatom diversity is associated with human effects, where excess nutrients from industries enter into the water system. Influencers, such as agricultural industries and personal effects, are increasing the nutrient level of water systems. This was shown in the Lake Erie example, where sediment run-off (higher turbidity) carried excess nutrients and caused

eutrophication. Eutrophication is caused when there are decreased oxygen levels allowing for algae to thrive. It is the industry's responsibility to ensure that water quality degradation is not happening, and it is the general public's responsibility to hold the industries responsible.

Some personal effects of turbidity are sediment and dirt run-off in the stormwater. People often dig up a front lawn and do not properly dispose of the sediment; therefore, it enters the stormwater system. We, as responsible citizens, should ensure that our practices are not affecting the environment. Additional human effects of turbidity include construction site sediment run-off and other related effects. To reduce turbidity and sediment run-off, we must hold the construction industry responsible for its environmental effects. To reduce pollutants, we should ensure that construction sites have proper stormwater pollution prevention practices, such as Best Management Practices (BMPs). Additional ways to limit and lower turbidity is to "address its source. This includes reducing stormwater run-off, restoring eroding stream and lake shorelines, and applying industry-specific [BMPs]" (Department of Environmental Conservation – State of Alaska).

Additional good stewardship practices to ensure that water quality in your area is not being affected by personal effects are innumerous. Some examples of good stewardship practices are properly utilizing fertilizers, only allowing "rain down the drain," participating in trash cleanup, picking up natural litter (such as leaf litter), and many more practices.

The importance of reducing turbidity it's extremely important to overall environmental health. Turbidity can have numerous ramifications, from subtle effects and significant effects. Visual effects of turbidity can affect tourism and the simple enjoyment of a water source. If lakes, streams, and rivers aren't as visually appealing, tourism might decrease because of that. The visual of a water body can have a drastic effect on the experience. Below are two images of Lodi Lake, a lake located in Lodi, CA.

Which would you rather swim in? Which would you rather sit by and eat lunch? Which would you rather drink from? Through this depiction, turbidity can have a drastic effect on the visuals of a water body.

Image 1: Clear, low turbidity   Image 2: Murky, high turbidity

Effects on aquatic habitat and life can be hugely affected by turbidity. With increased turbidity, oxygen levels can decrease, and access to food for animals can be affected. Ecosystem diversity, similar to diatom diversity, can reflect water quality. If species migrate to other places due to degraded water quality, this can reflect un-suitable conditions for various species. For example, high turbidity "is known to clog the gills of fish, interfere with their ability to find food, and bury bottom dwelling creatures and eggs" (Department of Environmental Conservation – State of Alaska).

Turbidity can decrease the look of a water body, kill aquatic species, decrease economic development, and affect personal health. Therefore, turbidity is exceptionally vital to water quality. The City of Lodi pulls water from Lodi Lake (depicted above) for drinking water for the City of Lodi residents. With high turbidity in drinking water, the water treatment process can become more complex. According to the Department of Environmental Conservation – the State of Alaska, chlorine used in drinking water treatment is affected by high turbidity by not allowing for proper treatment. Therefore, "some organisms found in water with high turbidity can cause symptoms such as nausea, cramps, and headaches" (Department of Environmental Conservation – State of Alaska).

Are you wondering how to ensure that you're not affecting your environment? Be sure to follow proper stewardship practices from Council for Watershed Health:
1. Pick up after your dog – "pet waste washes into our rivers and streams after a storm… Not cleaning up after your pet threatens human health because [this] contains harmful bacteria and other pathogens that can make you sick"
2. "Let it flow" – "building rock dams may seem like fun, but it alters the habitat of animals living in our streams through sediment buildup and increased turbidity of water and can block passageways for fish"
3. Don't litter in waterways – "trash in our streams causes major problems for wildlife… plastic can look like a lot like food to fish and birds and when swallowed, can suffocate or starve wildlife"
4. Pick up cigarettes – "cigarette filters are one of the most common pollutant found in waterways and are toxic to wildlife"; (5) food waste, "eating outdoors is a great way to enjoy nature, but your lunch can impact our rivers and streams… [this] introduces nutrients and depletes the water of dissolved oxygen as it decomposes… lack of water leads to agal blooms and fish deaths" (CWH Science, 2017).

Additional suggestions for limiting and decreasing your personal effect on water quality are listed below (Arcadia, 2017):
1. "Dispose of toxic chemicals and medical waste properly
2. Shop with water pollution in mind
3. Do not pour fat and grease down the drain
4. Use phosphate-free detergent and dish cleaner
5. Report water polluters
6. Avoid plastic containers
7. Help clean up beaches and rivers"

Ensuring that you are not influencing the environment is extremely important if you want to enjoy the environment. With increases in pollution, climate change, and environmental effects, limiting your personal effects on the environment are extremely important. You can decrease turbidity by ensuring that you don't allow dirt and other natural litter down the storm drain, you can decrease water quality effects by properly disposing of chemicals, and you can follow the good stewardship practices outlined above. If you've ever enjoyed being out in nature, being at the beach, or enjoying a hike in the redwoods – you are responsible for protecting the environment.

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