GOING WITH THE FLOW: DOES RECREATIONAL ACTIVITY IN THE SAN MARCOS RIVER LEAD TO NUTRIENT CHANGES?

by

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Abstract

The San Marcos River is a physico-chemically consistent spring-fed river with exceptionally high water clarity and serves as the home for numerous endemic and threatened species, such as Texas wild rice (*Zizania texana*) and the San Marcos salamander (*Eurycea nana*). Excess nitrogenous compounds like ammonia can be toxic, while increased nitrates and phosphates can cause increased algal growth and loss of water quality. In addition, increased suspended sediment (and associated turbidity) can lead to decreased light penetration, reducing light for photosynthetic requirements and the ability for animals to see prey. In this study, I collected data at Pyramid Park, which is adjacent to a common tube-embarking spot over an 8-week period. For an hour each day of data collection, people on the shoreline and in the water were counted at 15-minute intervals. A continuous count was also kept of all tubers, kayakers, and similar vessels that passed by during the hour. During this hour interval, I also collected a surface water sample. Lastly, I deployed two water quality sondes in the upper river: immediately downstream from the activity observation point, and the other in a major spring opening in Spring Lake to serve as a measure of the groundwater water quality. Sondes continuously logged temperature, conductivity, and turbidity at 15-minute intervals. I then assessed if there was a correlation between the number of people on the river and changes in water quality (nitrates, phosphates, and ammonium) and turbidity. Results from this study have implications for the relationship between the environmental effects of recreational activities and conservation efforts, city planning, and habitat restoration efforts.

Introduction

Texas State University is located right next to and even stewards a portion of land surrounding the San Marcos River, which is a main channel for the San Marcos River watershed (Saunders et al., 2001). Its main input of water comes from the Edwards Aquifer. The San Marcos River is home to its own endemic species, which have been listed as imperiled, such as the San Marcos salamander, *Eurycea nana,* and Texas wild rice, *Zizania texana* (Safi and Hashmi, 2021). The greatest obstacle against the survival of these species is the overdrawing of water from the Edward's Aquifer (Safi and Hashmi, 2021). Numerous pollutants, such as herbicides, pesticides, plastic litter, cigarette butts, beer bottles/cans, and many others, can also have adverse effects on wildlife (Safi and Hashmi, 2021). One experiment that was conducted (Crow et al., 2017) tested how the survival of Barton Springs salamanders, *Eurycea sosorum,* an endangered species, changed in response to different concentrations of nitrogenous wastes. As the concentrations increased, the salamanders died, with ammonia being the most toxic, followed by nitrite, and finally nitrate still being toxic at a higher concentration (Crow et al., 2017). Both being salamanders within 2 similar habitats, the San Marcos salamander likely faces the same issues that the Barton Springs salamander does. Not only can an abundance of nitrogen in the water be harmful to some species, but an input of excess nutrients can also cause harmful algal blooms (Sellner et al., 2003). These blooms are often dangerous, toxic microorganisms that increase turbidity, cutting of production for other algae (Sellner et al., 2003). When the nutrients are used up, they die off and decompose, which can deplete dissolved oxygen in the water. These nutrients can come from both natural and anthropogenic sources (Sellner et al., 2003). While most anthropogenic inputs are from wide-scale agricultural and industrial operations, we cannot discount the possibility that the average populace has an impact (Sellner et al., 2003). And, with a thriving young student body, the San Marcos River is a prime spot for recreational tubing. As people float for hours, often bringing things to drink and smoke, they tend to litter and urinate in the river. Foreign substances can possibly change the pH of the water, while urination can increase the total nitrogen concentration of the water. Lastly, swimmers can stir up sediments, which releases nutrients like phosphates, nitrates, and ammonium into the water. If these changes in water quality are detectable, further actions may need to be taken to ensure the survival of these endemic species.

The purpose of this experiment is to discover if there are any correlations between the activity of recreationalists on the San Marcos River and changes in water chemistry.

Methods

I picked 1 site along the San Marcos River to collect my count data and water samples. The site chosen was the first bridge just downstream of Pyramid Park. For a total of 30 days over the span of February through March, I counted the number of swimmers in the water at Pyramid Park in 15-minute intervals for an hour as well as kept a continuous count of tubes, kayaks, and paddleboards that passed underneath the bridge over the hour. During this hour, I would also collect a surface water sample to be preserved in lab and later assayed for dissolved phosphates, nitrates, and ammonium. Preservation included filtering particulates, acid preserving, and refrigerating samples at the end of each week. Then, to determine concentrations, I spectrophotometrically analyzed the absorbance of the water samples, which was then converted to concentration using the determined standard curve. 2 sondes were deployed—1 downstream of the sample site, and the other at Spring Lake to serve as a baseline—to collect data in 15-minute intervals on dissolved oxygen, pH, and turbidity. Instead of using the 15-minute intervals directly, I opted to take the average of 4 intervals every hour of sonde data to compare to my counts. Similarly, I averaged my swimmer counts over each hour to avoid double counting. Then, for every hour of data, I added the average number of swimmers per hour and the number of tubes and kayaks per hour to get total recreational activity, which I used as the main independent variable for comparisons. For significance testing, I did a linear regression analysis using ANOVA with α at 0.05.

Results

Total recreational activity showed a statistically significant correlation with turbidity, but not any of the other variables, such as dissolved phosphates, dissolved nitrates, total ammonium, dissolved oxygen, and pH. Tubes and kayaks were the better predictor for changes in turbidity than swimmers.

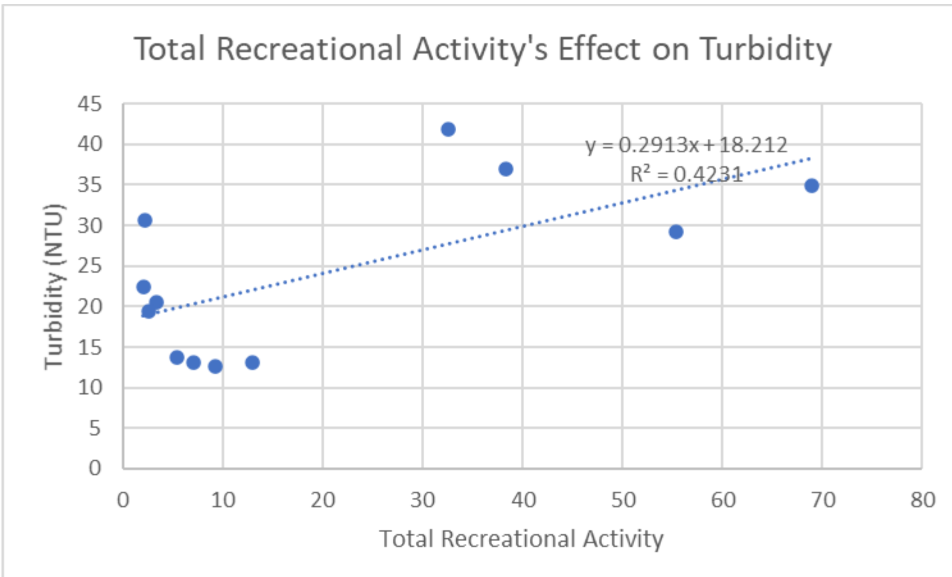

Figure 1. This figure shows the relationship between Total Recreational Activity and Turbidity. The data suggests a correlation. p=.022

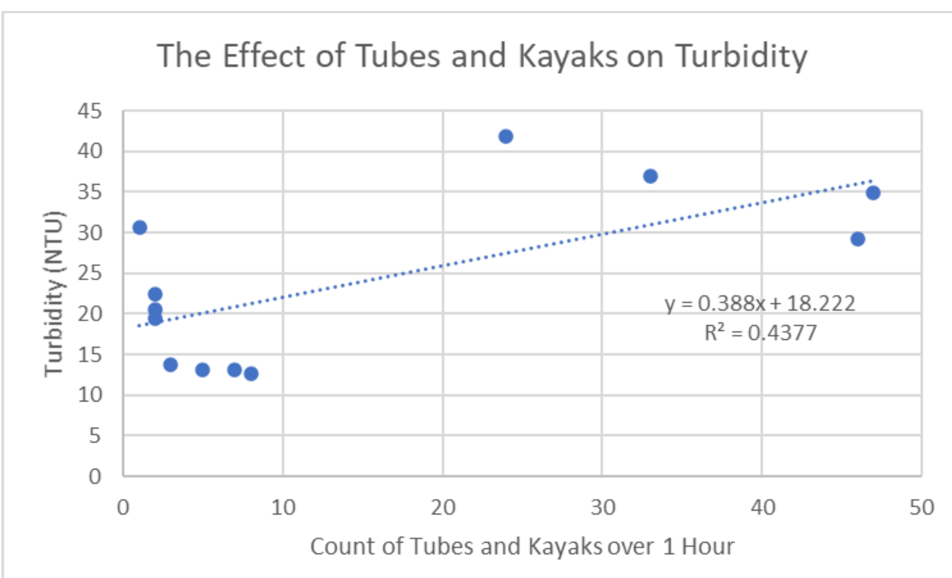

Figure 2. This figure shows the relationship between Count of Tubes over 1 Hour and Turbidity. The data suggests a correlation. p=.019

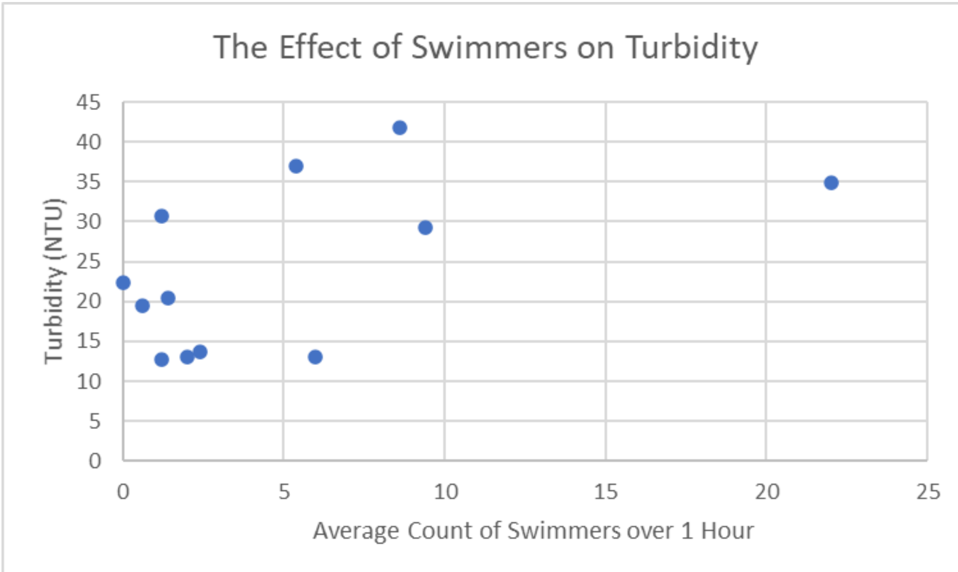

Figure 3. This figure shows the relationship between Average Count of Swimmers over 1 Hour and Turbidity. Unlike Figures 1 and 2, Figure 3 does not suggest a correlation. p=.068

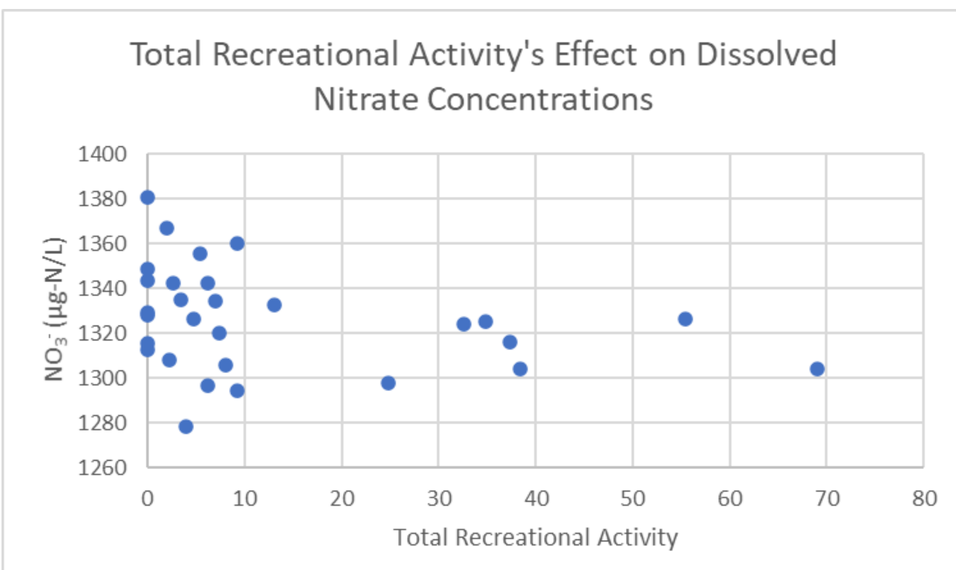

Figure 4. This figure shows the relationship between Total Recreational Activity and Dissolved Nitrates. There is no correlation. p=.131

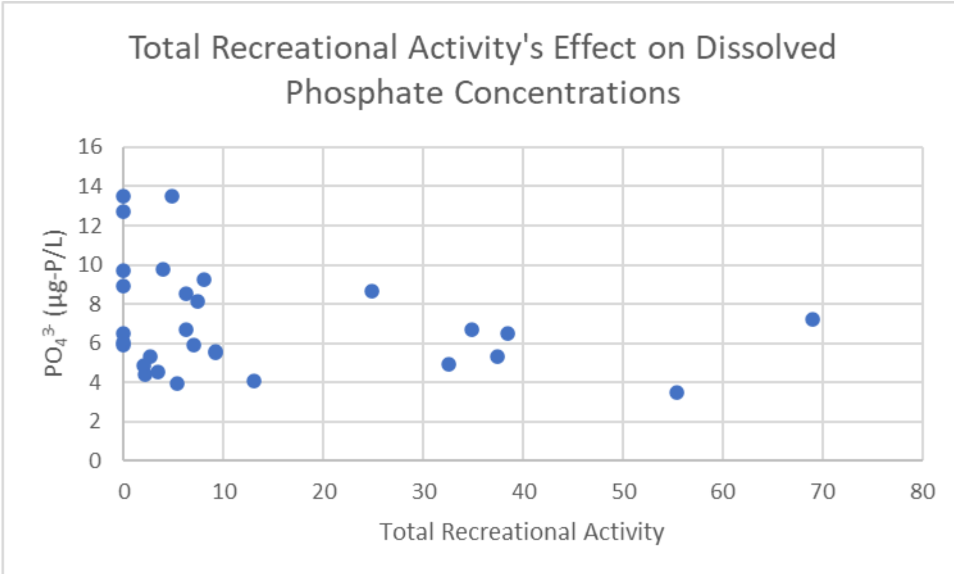

Figure 5. This figure shows the relationship between Total Recreational Activity and Dissolved Phosphates. There is no correlation. p=.127

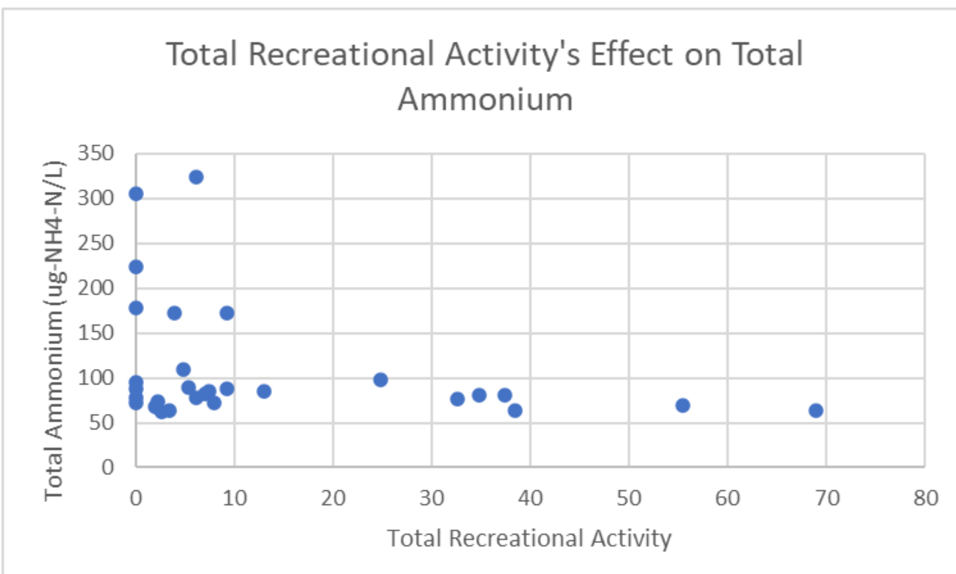

Figure 6. This figure shows the relationship between Total Recreational Activity and Total Ammonium. There is no correlation. p=.092

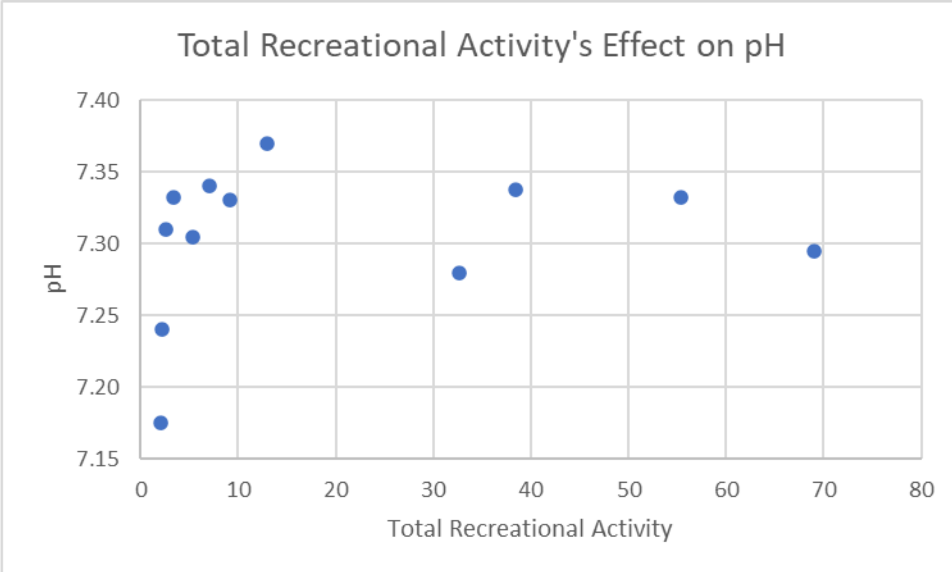

Figure 7. This figure shows the relationship between Total Recreational Activity and pH. There is no correlation.

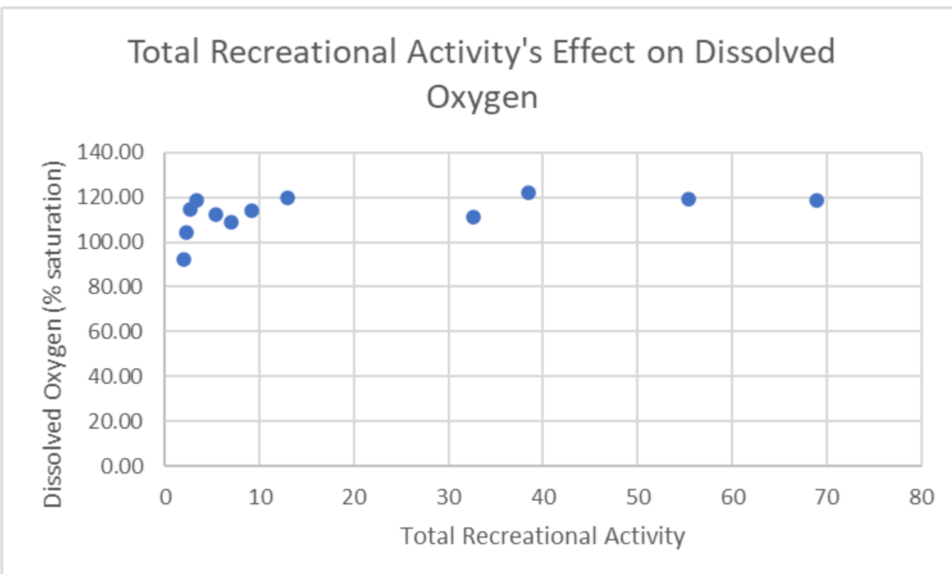

Figure 8. This figure shows the relationship between Total Recreational Activity and Dissolved Oxygen. There is no correlation.

Discussion

Based on the results, turbidity increased as the total recreational activity increased. Between tubers/kayaks and swimmers, however, the former was the better predictor for turbidity. This could be attributed to the observation that, during this study, some of the hours assayed were subjectively cold; the air temperature ranged between 0 and 27 degrees Celsius. Between 0-10 degrees, I recorded no activity at the river. Then, I noticed that around 10-15 degrees, kayakers began traversing the river, but swimmers were not present unless the air temperature was at least about 20 degrees. So, there would be increase in turbidity due to human activity (kayaking) but the air would be too cold for swimmers to be out, so increases in turbidity, in the context of swimmers as the dependent variable, were associated with 0-counts, reducing the correlation between swimmers and turbidity, while supporting the correlation between tubers/kayaks and turbidity. This does not mean, however, that swimmers are negligible and should be excluded from consideration.

Meanwhile, correlations between recreational activity and total ammonium, dissolved phosphates, and dissolved nitrates were not supported by this study's data. Phosphates varied naturally by about 10 µg/L, nitrates varied about 100 µg/L, and ammonium varied at most 300 µg/L. Variation for phosphates was particularly small, and variation for any of these 3 variables could not be explained by tubers/kayaks, swimmers, nor total recreational activity. Originally, this experiment was designed under the assumption that, if the benthic layer of the river is disturbed, it could release nutrients bound in the sediment into the water column. While this may still be occurring, it is occurring on a scale undetectable by statistics and by the environment itself. Because of the sheer volume of water that flows through the San Marcos River, it would take significantly more turbation to cause detectable nutrient changes, if any at all.

Large changes in nutrient concentrations could be detrimental to stream health, as massive increases can cause toxic algal blooms or allow more competitive plant species to overtake endemic Texas wild rice. Stable nutrient concentrations belie a stable environment. Lack of anthropogenically-caused changes in pH and dissolved oxygen also supports this seeming stability. The instability, then, comes from the varying turbidity, which ranged by 20-25 NTUs. This change is perceptible to the naked eye and, in aquatic environments, decreases the effective visual range of both foragers and predators, decreases the available light for photosynthesizers, and decreases the aesthetic value for humans.

For future studies following this one, the summer months should be assayed as well. With total recreational activity's upper bound being 69, this study just scratches the surface of the potential recreational traffic the San Marcos River can endure in a day. There are some days where the river is estimated to have hundreds of people pass through in an hour, which would likely cause further increases in turbidity. And, despite nutrient changes being established as unaffected in this study, it is possible that this study's highest datum for total recreational activity is lower than the threshold for nutrient concentrations to begin varying. Therefore, nutrient changes should not be neglected from consideration unless sufficient testing occurs on the San Marcos River during peak activity. Not only could nutrient changes be detected during these peak summer months, but the upper limits of recreation-driven turbidity could be established for the river as well. A clear relationship between activity and turbidity has already been elucidated, so the work remaining is determining the upper extremes of this relationship. Another concern tied to recreational activity in water is chemical pollutants caused by sunscreen. With hundreds of people tubing in the hot sun for hours, it is easy to imagine, if each person applied sunscreen, that sunscreen would be washed into the river system regularly and in great concentrations. However, this would require developing a system of testing for sunscreen in water, which can consist of any number or different chemicals. Perhaps this can be tested indirectly by assessing indicator species as a measure of stream health, though this method indicates stream health as whole and may denote other sources of pollution and habitat disruption.

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