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SI 305
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Evaluating Ann Arbor Drinking Water Quality and PFA Presence

Summary

Ann Arbor drinking water contains high levels of harmful chemicals, which could lead to long-term physical effects and affect the health of residents. The amount of PFAs present have been measured and recorded over the course of several years, which can be used to examine the drinking water quality and evaluate if PFA presence is increasing. This warrants changes to water infrastructure to promote water quality and control the amount of PFAs, especially PFPeA, present in Ann Arbor's drinking water.

Problem Diagnosis

The Environmental Working Group (EWG) conducted a water quality report on Michigan tap water and found that, while the first quarter of 2021 had water that followed federal standards, the water did not always meet the health guidelines outlined by the EWG, as shown next to the first graphic on their 2021 update[1]. The same report found that legal guidelines for water contamination have not been updated in 20 years, leading to a high likelihood of long-term effects from tap water contamination that are not currently considered.

The Drinking_Water_Intake_PFAs data set shows the prevalence of different PFAs, or perfluoroalkoxy alkanes, in Ann Arbor drinking water, observed over several years. They measure PFPeA, or perfluoropentanoic acid, along with other PFAs. The presence of these chemicals in high amounts can lead to disastrous health effects for residents consuming the water. An article by the Michigan Water Stewardship Program finds that effects of consuming contaminated water include pregnancy-induced hypertension, liver damage, increased LDL cholesterol and thyroid disease, and a greater risk of decreased fertility[2]. These health risks can become prevalent for Ann Arbor residents if PFA risks are not addressed. Residents need to be made aware of these risks and even the presence of PFAs in their water, as these effects may only present themselves once they are no longer preventable and the water is unsavable for residents. Property and population values in Ann Arbor may also begin to decline if PFA amounts continue to rise, more information about them spreads, and people living in Ann Arbor may be harmed. This poses risks to city officials concerned about the quality and well-being of Ann Arbor residents.

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[1] Environmental Working Group conducted a water quality report on Michigan and found some PFA and chemical amounts that were under the legal limit, but above their safety guidelines https://www.ewg.org/tapwater/system.php?pws=MI0000220
[2] Article about possible side effects of PFA exposure https://miwaterstewardship.org/michigan-water-issues/

The 2022 Ann Arbor Water Quality Report lists many likely causes of PFA contamination in water[3]. These include firefighting foam, waste from industrial facilities, and stain-removing treatments that run into the water supply. The report also finds that PFAs do not break down in the environment and build up over time in blood and organs, suggesting more severe health effects for residents ingesting them. These causes can be reevaluated to decrease future PFA contamination in drinking water for residents.

Due to these reasons, high levels of PFAs in drinking water indicate that it is dangerous for residents to consume. Ann Arbor drinking water must be evaluated to determine the amount of concern and resources that city officials should put towards eliminating PFA-causing chemicals and having safer drinking water.

Research Questions
1. Does the drinking water have increasing levels of PFAs over the observation period?
2. Are there high amounts of PFPeA in Ann Arbor drinking water?

RQ1 Findings
Each PFA in the "Drinking_Water_Intake_PFAs" data set was analyzed to determine whether or not their values increased throughout their observation periods. Each PFA's values over time are plotted in Figure 1. Many PFAs had significant fluctuations in values, with most values staying relatively low. Each PFA was then plotted using a scatter plot with a linear regression line to look for increasing or decreasing trends in the overall data. PFHpA had the only definite, though weak, positive trend, as shown in Figure 2. A large portion of data included "Not measured" or "Not detected" values, so more concrete data observations could show different trends. More data and collection over an extended period would be needed to continue monitoring drinking water quality and get a more detailed picture of PFA presence. Observations were not taken at consistent time intervals, so visualizations may not show an accurate relationship between PFA values and time. The PFAs were also plotted independently from each other, so there could be relationships between them that affect each other's presence that are not currently apparent.

Figures

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[3] 2022 Water Quality report (2022 City of Ann Arbor Water Quality Report file) showing detected contaminants
https://drive.google.com/drive/u/0/folders/1VggYKg7FqMjjg8xfJ-c-GDQaBhJy7FTD
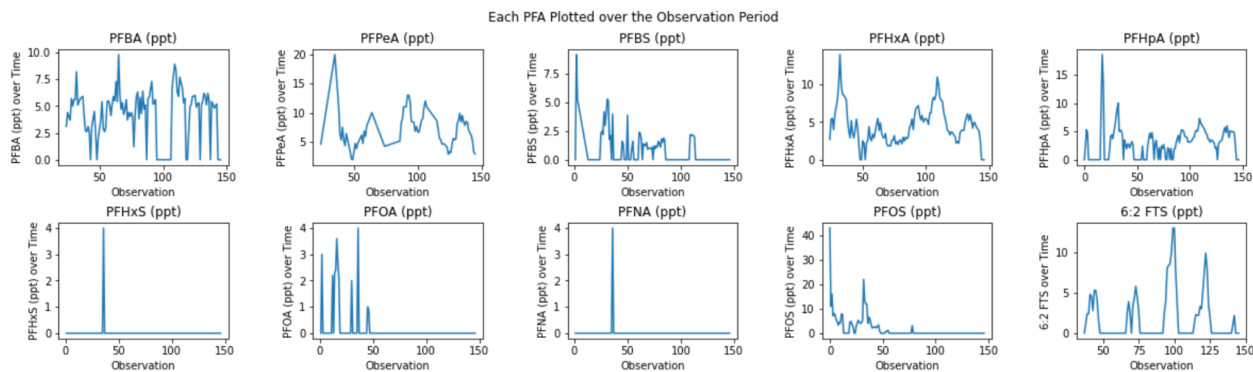
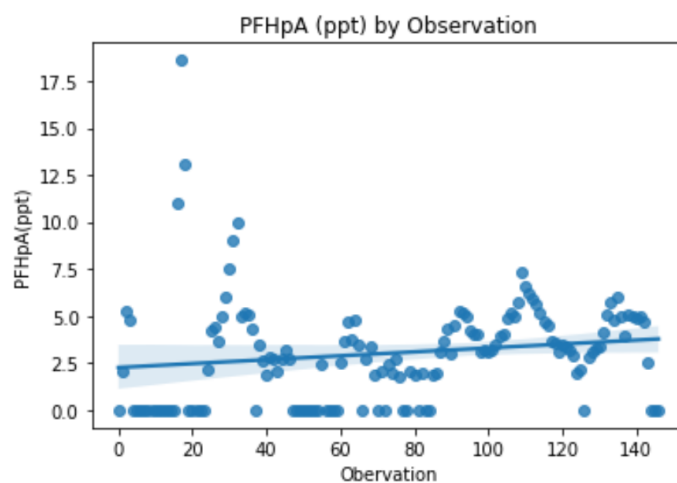Figure 1: Line graphs of each PFA value over the course of the observation period.

Figure 2: A scatter plot with a linear regression line showing PFHpA values over the course of the observation period with a slightly positive trend.
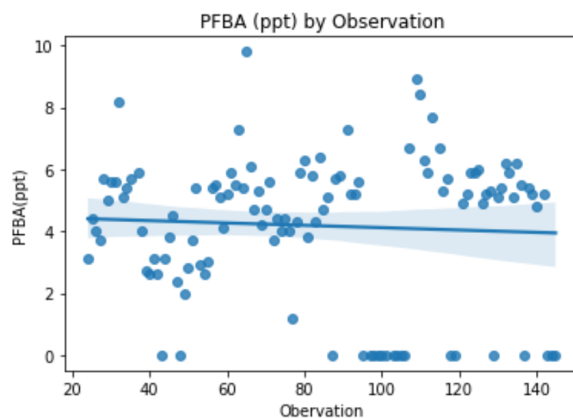

Figure 3: A scatter plot with a linear regression line showing PFBA values over the course of the observation period.

Insights

PFNA and PFHxS each had a single observation that was not 0, so they caused no concern. PFHpA's values seem to be increasing over time, so more research should be done to observe it in drinking water to determine the extent to which it endangers Ann Arbor residents, as well as whether it has reached a threshold to become a health hazard. PFBA, PFPeA, PFHxA, and 6:2 FTS all had horizontal regression lines, showing neither a positive nor negative trend overall. An example of PFBA's horizontal trend line is shown in Figure 3. However, each plot had values fluctuating around the trend line, showing that these PFAs alternate between increasing and decreasing over time. These do not necessarily support the initial expectation that many PFA presences would increase over time, but more research should be done to observe them and determine how often their fluctuations exceed maximum contaminant levels for experts to determine how hazardous they are. PFPeA especially seems to have high fluctuations and values and will be further studied in RQ2. Overall, the fluctuations and frequency of high values should be utilized to inform water quality experts about what PFAs to put most resources towards.

RQ2 Findings

The Environmental Working Group has a health guideline set at 1 ppt in drinking water for PFPeA, which will be used to analyze this data set. A mean value of 7.12 ppt, a minimum of 1.9 ppt, and a maximum value of 20 ppt were found. Most PFPeA values were between 1.9 and 13.51 ppt, as shown in Figure 4. A linear regression plot between PFPeA values and observations within the observation period was created to better evaluate the correlation. As seen in Figure 5, PFPeA values fluctuated around a nearly horizontal trend line. Figure 6 shows the data's PFPeA values, excluding the 20 ppt observation to treat it as an outlier. There were many "Not measured" values, so it is possible that information could be gained from them with the help of the original researchers, who could give a concrete meaning to these values. Again, this analysis would benefit from more observations with consistent time intervals between recordings. More research can also be done to determine how the presence of PFPeA and other PFAs affect each other for future PFA reduction.

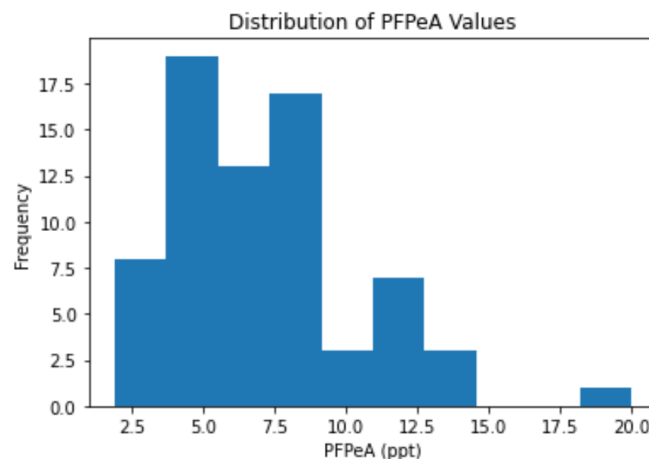Distribution of PFPeA Values

Figure 4: A histogram showing the distribution of PFPeA values in the data set.
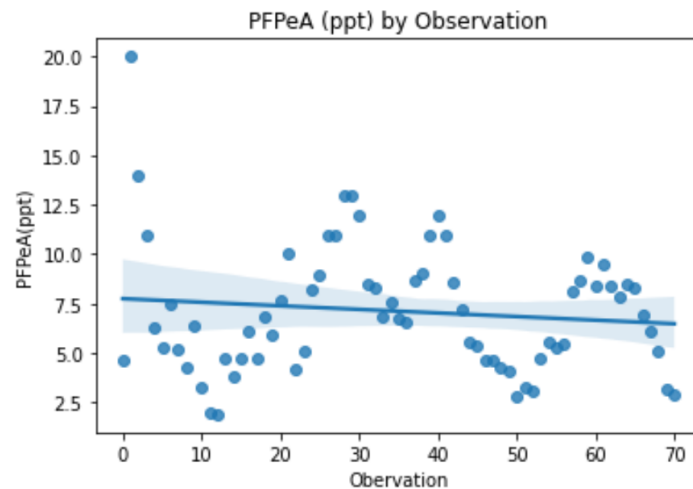

Figure 5: A plot showing PFPeA values from the data set with a liner regression line.
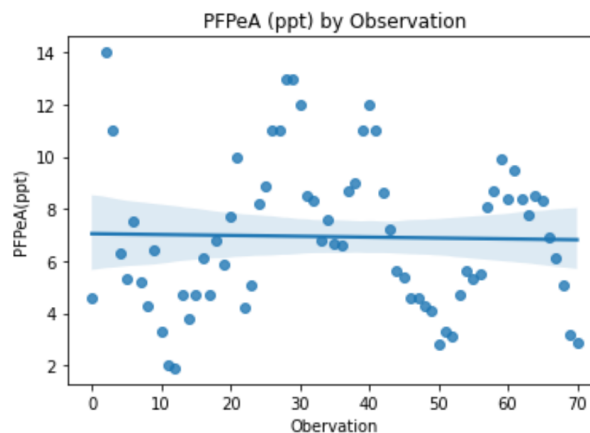

Figure 6: A plot showing a linear regression line of PFPeA values from the data set excluding the value of 20 ppt.

All valid PFPeA observations in the data set exceeded the EWG health guideline, which raises concerns for the health of Ann Arbor residents. The maximum value found in the data set was 20 times the health guideline, though it was from an early observation. The distribution of values also shows a slight right skew, so most values stay below roughly 12 ppt. Fluctuations around the linear regression line imply that factors are causing PFPeA concentrations to alternate between increasing and decreasing, which could be external, so more research should be done to study this phenomenon. There seems to be a slight decreasing trend when all values are graphed. Removing the possible outlier of 20 ppt shows a perfectly horizontal trend line, further demonstrating that PFPeA concentrations simply fluctuate around an average of 7.12 ppt. This means that there is a consistently concerning amount of PFPeA in drinking water, and city

officials need to prioritize cleaning it from Ann Arbor. However, the amount does not seem to be increasing, so residents do not need to raise further concerns to stop the increase of PFPeA presence. In order to prioritize the health and safety of Ann Arbor residents, water infrastructure must account for eliminating PFPeA from drinking water.

Conclusion: Recommendations

Recommendation 1: Continue observing PFA presences in Ann Arbor drinking water over several years with consistent, frequent, detailed observations.

Audience: Ann Arbor water quality experts and researchers

The data set utilized in this analysis had crucial information about how prominent many PFAs are in drinking water, affecting Ann Arbor residents' health. High amounts of different PFAs have been linked to several adverse health effects, as shown in the study above[4]. PFA observation should be prioritized to ensure the well-being of residents, who will be the most directly affected by high PFA presence in their drinking water. More long-term and frequent observations of drinking water quality will allow more usable data to analyze PFA presence and provide a more accurate representation of PFA trends in water. More detailed observations would include analysis of more PFAs than the chemicals shown in the data set to minimize harm from other previously unnoticed chemicals that could affect residents. Consistent observations would give the most accurate information on the relationship between water quality and time. Better water filtration systems to remove current PFAs would provide a short-term solution for harm reduction for residents. Water quality experts and researchers should be tasked with filtering and PFA elimination, as PFAs are a primary concern in drinking water, and the severity of adverse health effects from their exposure means that the presence of these chemicals is a time-sensitive issue that should be given priority.

Recommendation 2: Decrease amounts of PFPeA in Ann Arbor drinking water.

Audience: Ann Arbor city officials and water quality experts

This analysis has shown a concerningly high level of PFPeA in Ann Arbor drinking water. There has been as high as 20 times the EWG health guideline of PFPeA presence recorded, meaning PFPeA, in particular, has shown to be a highly priority concern. Experts should be concerned about decreasing its level immediately to ensure Ann Arbor residents' health and safety. More research should also be done to study the effects of PFPeA exposure in both the long-term and short-term to adequately address future health effects for residents. More research could be done to study the reasons behind the fluctuation of PFPeA in water to further understand this chemical and how to decrease it or reduce high fluctuations. Studies on the relationship between PFPeA and other PFAs in Ann Arbor drinking water could also be utilized to understand the reasons behind its fluctuations and high concentrations. Officials and water quality experts need to understand the reasons behind such high PFPeA presence in Ann Arbor and take action to decrease levels of PFPeA immediately to ensure resident health in the long term.

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[4] Article about possible side effects of PFA exposure https://miwaterstewardship.org/michigan-water-issues/