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Article

# Effects of airport runoff pollution on water quality in bay area sites near San Francisco and Oakland airports

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## SUMMARY
**Airports contribute to pollution through point source and non-point source pollution, which can have negative effects on water quality and aquatic life. The purpose of our study was to determine if runoff pollution from the San Francisco airport (SFO) and Oakland airport (OAK) impacts water quality in the San Francisco Bay Area. We tested water quality at 12 sites surrounding these two airports, specifically testing for pH and the presence of specific metals and nitrates. From our results, we found that the presence of zinc, copper, chromium and nitrate increased as we got closer to the airports. The pH remained constant throughout the sites. We concluded that airport pollution is a likely source of elevated concentrations of some heavy metals and nitrates in the San Francisco Bay Area.**

## INTRODUCTION
Unrestricted pollutants from airport runoff can contaminate nearby waters and have a negative impact on the local ecosystems. The Environmental Protection Agency (EPA) controls and authorizes airport discharge into water through point sources of pollution in an attempt to diminish negative effects on water quality (1). Pollutants in water surrounding airports can kill fish, cause algae blooms, and contaminate the waters (2). Pollutants from jet fuel and construction, for example, can gather on runways and other surfaces and be washed into surrounding bodies of water by storms (1). Runoff pollutants may include oils, greases, de-icing chemical, jet fuel excess, nitrates, and metals including chromium, zinc and copper (1). Nitrates and metals including zinc and chromium are also all found in de-icing chemicals (3). Increased chromium, zinc, and copper in bodies of water can cause harm to organs and systems and can even cause death in aquatic species, particularly fish (4, 5, 6). An excess presence of nitrate in a body of water can cause excessive growth of algae that results in unstable amounts of dissolved oxygen, which causes stressful conditions for fish and other aquatic species and may cause them to die off (7). Airport runoff can also affect the pH of surrounding waters. When the pH of a body of water is either too high or too low, the aquatic organisms living in that water will die (8).

To determine whether airports in the bay area actively contribute pollution to nearby waters, we tested the relationship between vicinity to SFO and OAK airports and the water quality. Areas near the San Francisco International (SFO) Airport and Oakland International (OAK) Airport were studied to see how airports might impact water pollution. We tested three sites north of each airport and three sites south of each airport. We measured pH and sampled for the presence of metals and nitrates to test the hypothesis that water quality would decrease as proximity to an airport increased. Data from both airports showed that the water quality decreased as we got closer to the airport, with the amount of zinc, copper, and chromium increasing closer to the airport.

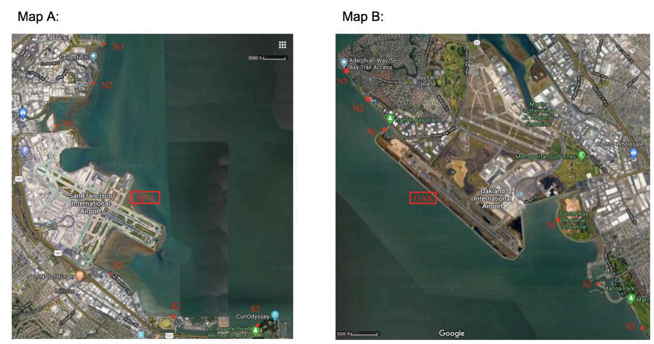



**Figure 1:** Sample location maps. Map A is of San Francisco Airport and surrounding testing sites. Map B is of Oakland Airport and surrounding testing sites.

## RESULTS
The purpose of our study was to determine if runoff pollution from San Francisco International (SFO) Airport and Oakland International (OAK) impacts water quality in the San Francisco Bay Area. The effect of airport pollution on water quality was tested by measuring parameters of water quality in sites surrounding SFO and OAK. We tested three sites north and three sites south of two airports, San Francisco International (SFO) Airport and Oakland International (OAK) Airport (**Figure 1**).

We tested for pH and the presence of zinc, copper,

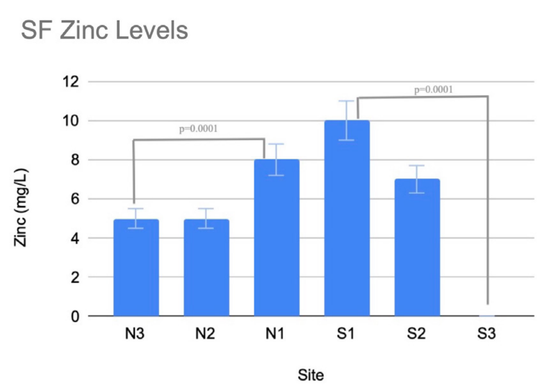



**Figure 2:** Zinc levels near the SFO airport and surrounding areas.

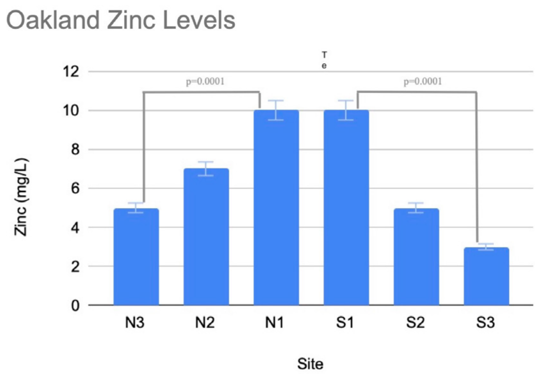



**Figure 3:** Zinc levels near the OAK airport and surrounding areas.

chromium, and nitrate using test strips and a meter. The levels of zinc in the water increased as we got closer to the airport (**Figures 2 and 3**); the zinc levels were highest at the sites closest to the airport (N1 and S1) ($p$ = 0.0001), ranging from 8.0 to 10.0 ± 0.500 mg/L, and lowest at the sites farthest from the airport (N3 and S3), ranging from 3.0 to 5.0 ± 0.50 mg/L ($p$ = 0.0001). I did unpaired t tests for our sets of data and found the $p$ values of the sites closest to the airports compared to the sites farthest away from the airports. The levels of copper and chromium also increased near the airport (**Figures 4, 5, 6, and 7**). The copper levels were highest at the sites closest to the airport (N1 and S1) ($p$ = 0.0001), at 0.10 ± 0.01 mg/L; they were lowest at the sites farthest from the airport (N3 and S3), with average values at 0.50 ± 0.01 mg/L ($p$ = 0.0001). The levels of chromium were highest at the sites closest to the

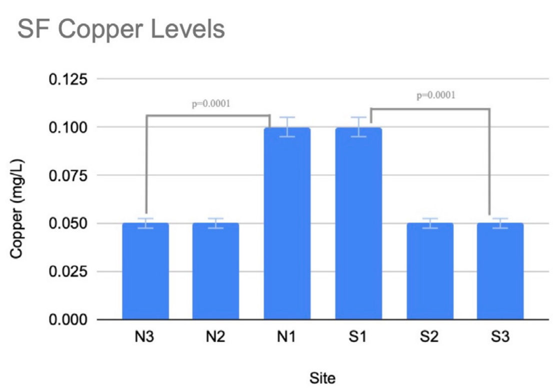



**Figure 4:** Copper levels near the SFO airport and surrounding areas.

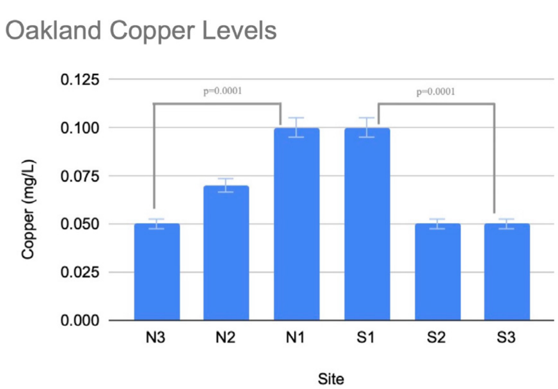
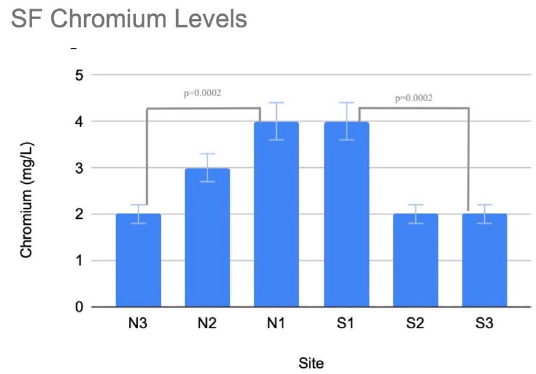



**Figure 5:** Copper levels near the OAK airport and surrounding areas.




**Figures 6:** Chromium levels near the SFO airport and surrounding areas.

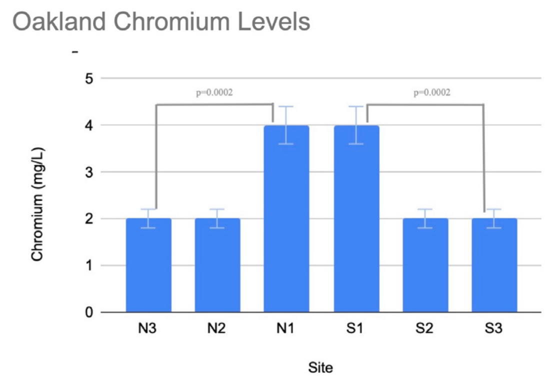
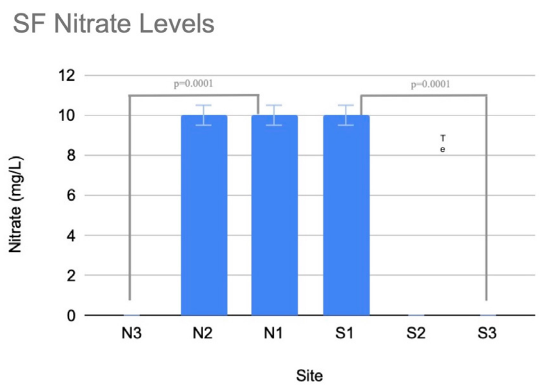



**Figure 7:** Chromium levels near the OAK airport and surrounding areas.

airport (N1 and S1) ($p$ = 0.0002), at 4.0 ± 0.2 mg/; the levels were lowest at the sites farthest from the airport (N3 and S3), set at 2.0 ± 0.2 mg/L ($p$ = 0.0002). Nitrate was detected at the sites closest to the airport (N1 and S1) at 10 ± 1.0 mg/L, but was not detected at the sites farthest from the airport (N3 and S3) ($p$ = 0.0001) (**Figures 8 and 9**). The pH levels remained fairly consistent throughout the sites, with a slight increase as we got closer to the airport at about 8±1 ($p$ = 0.0004). The Oakland sites had a slightly higher pH, at around 9 ± 1 than the corresponding San Francisco sites, at around 8 ± 1 ($p$ = 0.0004) (**Figures 10 and 11**).

## DISCUSSION

Our experiment demonstrated an increase in levels of zinc, copper, and chromium as proximity to an airport increased, suggesting that airport pollution impacts water quality. Based on the results of the *t*-test, the findings for the difference in zinc, copper, chromium, nitrate, and pH levels from the sites closest to the sites farthest away from the airport were all statistically significant. The findings presented in this study support our hypothesis that water quality will decrease as proximity to an airport increases. The EPA does not report standard levels for chromium or nitrate in saltwater, but for copper, the healthy amount is less than 0.0031 mg/L (9). Near the airport, the average level of copper in the surrounding waters was 0.10 ± 0.01 mg/L, which is well above the healthy level. A safe amount of zinc in saltwater is less than 0.081 mg/L. Near the airports, the average level of zinc ranged from 8-10 ± 0.5 g/L, all higher than the safe amount in unpolluted




**Figures 8:** Nitrate levels near the SFO airport and surrounding areas.

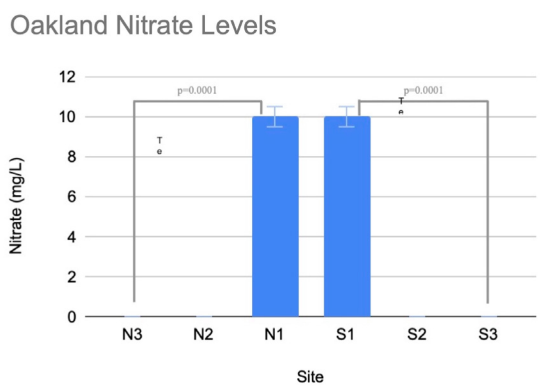



**Figure 9:** Nitrate levels near the OAK airport and surrounding areas.

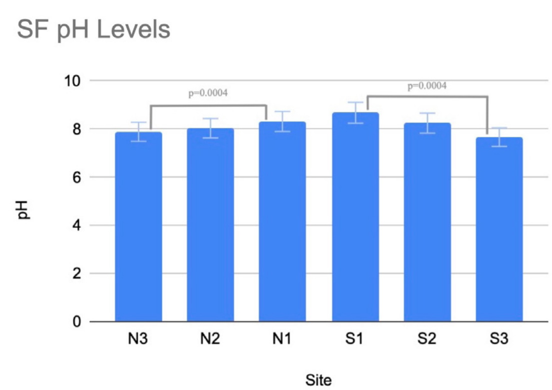
bodies of water. The expected pH of saltwater is anywhere within the range of 6.5-8.5 (9), which is mostly consistent with my data, although some sites had a slightly higher pH. Comparing the reported safe levels of pollutants with the levels determined in our samples reinforces that there is an unhealthy concentration of pollutants near the airport. As previously illustrated, contaminated waters with high amounts of metals can cause damage to aquatic species and excessive growth of algae. I chose to examine these metals because they are commonly used in de-icing chemicals, which are found around airports. In addition to metals, the pH also can impact aquatic species. Although it was not large, I did observe a decrease in pH further away from the airport. It might be that airport pollutant runoff is not acidic, so it does not affect the pH, or that it is acidic but buffered within the surrounding bodies of water.

Runoff pollution, unlike other sources of pollution originating from airports, cannot be fully controlled and brings harmful chemicals into surrounding waters. Although there are attempts to manage runoff pollution from airports, such as preparing for a scenario of large scale oil contamination and requiring the development of solutions to reduce pollution in waters, some runoff pollution still makes it into the surrounding waters (1). The San Francisco Bay Area has regular water quality monitoring and assessment from the EPA. The EPA controls point sources of pollution by issuing NPDES permits and conducting inspections. The NPDES permit affirms a facility knows where to discharge pollutants from point sources, such as putting some amount of a pollutant into surrounding waters, process it, or put it in a landfill. (10) However, other potential sources of pollution, such as shipping traffic, human pollution or litter, input from streams or canals, or storm runoff, could also influence the water quality. Additional testing on specific types of airport pollution and parameters of water quality would help us better understand how airport runoff affects water quality.

Further research could include sampling more sites in the San Francisco Bay Area and different canals that flow into the San Francisco Bay, testing more parameters, testing during different seasons and at different times of day. This experiment should be repeated at sites surrounding different airports in diverse cities and countries to see if the same results would appear and remain consistent. Further testing on the appearance of specific metals and other parameters of water quality, as well as other types of chemicals found in airport pollution, could help further clarify how airport pollution affects surrounding bodies of water. Taking data at times when there is more airport traffic, as opposed to less airport travel, would also be important to test. These suggestions for future research would help us further understand how airports affect water quality and aquatic life, and would help the communities who depend on these bodies of water.

## METHODS

Twelve sites were selected by two airports, San Francisco International Airport and Oakland International Airport, during July 4-5, 2020. I tested for pH and the presence of specific metals in three sites north of each airport and three sites south of each airport. To tell how the levels of pollutants changed, the selected sites were not close to each other. Using a map, sites were selected that were approximately two




**Figures 10:** pH levels near the SFO airport and surrounding areas.

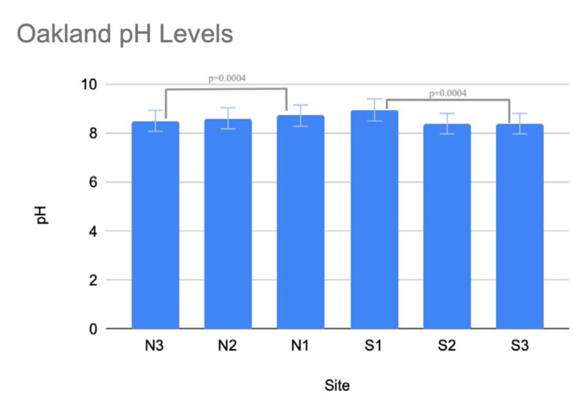



**Figure 11:** pH levels near the OAK airport and surrounding areas.

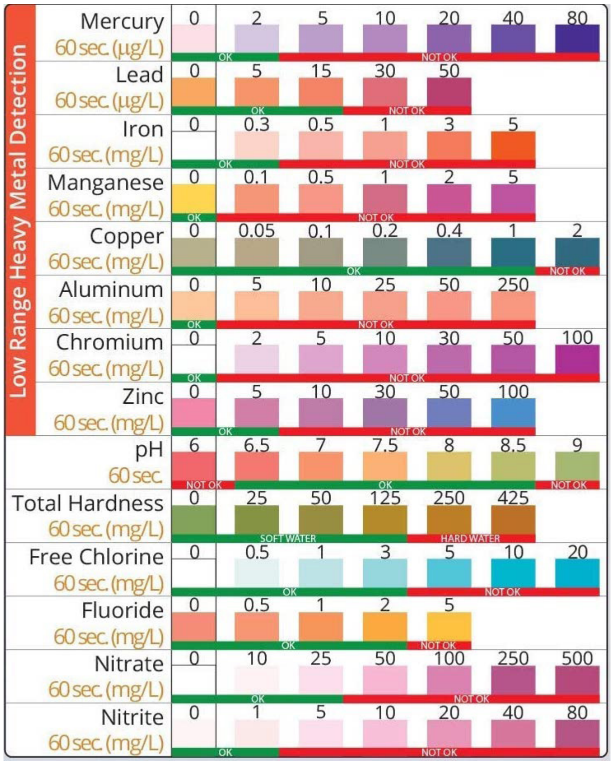



**Figure 12:** Resolution on the guide for zinc, copper, chromium, nitrate, and other metals for the water quality tests used.

miles apart. The VIVOSUN pH meter was used to determine the pH of all samples. This meter was selected because of its high ratings on Amazon and because of how easy it is to calibrate. To test pH, the VIVOSUN pH meter was immersed into the bay until the reading stabilized. The reading was then recorded, and the pH meter was cleared through cleaning with pure water and drying it. This process was repeated two more times to ensure the precision of my results. The Ultimate Drinking Water Test Strips (life2O) were chosen to test for the presence of metals. These test strips were specifically chosen because the kit came with many tests, which allowed for accurate measurements. To test the presence of specific metals, a test strip was taken from the Ultimate Drinking Water Test Strips (life2O) and immersed in the bay for two seconds. It was then removed from the water and left for 60 seconds before the results were recorded. All of the results fell within the acceptable range for the test strips. The testing range of the strips for zinc was from 0 to 100 mg/L and the range for copper was from 0 to 2 mg/L. The range for chromium was from 0 to 100 mg/L and the range for nitrate was from 0 to 500 mg/L. This process was repeated once and the results were compared to measure precision of the test strips. When these strips are immersed in the water, they turn a certain color. The strips come with a guide that shows the different colors and matches them to the quantity of the metal present. If a test strip color appeared to be in between two of the colors on the guide, the value was recorded as in between the two values on the guide. The resolution of the colors of metals varies (**Figure 12**), and since the guide was used o determine the value, the accuracy is limited by the resolution of the colors.

To assess the significance of my results, I did a student's unpaired *t*-test and used $p = 0.05$ as a significance cutoff. I used GraphPad's t-test calculator to get the results. All of my data yielded *p*-values less than 0.05, which indicates statistical significance. The values for expected error were calculated by finding the standard deviation of all my trials for a pollutant.

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## REFERENCES

1. "Environmental Desk Reference for Airport Actions." *Federal Aviation Administration*, www.faa.gov/airports/environmental/environmental_desk_ref/media/desk-ref-chap20.pdf
2. "Environmental Impacts of Airport Operations, Maintenance, and Expansion." *EveryCRSReport*, Congressional Research Service, 31 Mar. 2008, www.everycrsreport.com/reports/RL33949.html.
3. "Airport Deicing Operations (Revised)." *Environmental Protection Agency,* https://www.epa.gov/sites/production/files/2015-06/documents/airport-deicing-pds-2000.pdf
4. Eisler, Ronald, "Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review", U.S. Fish and Wildlife Service Biological Report 85, *USGS,* 1986, www.pwrc.usgs.gov/eisler/CHR_6_Chromium.pdf.
5. Li, X. F., et al. "Acute Toxicity and Hazardous Concentrations of Zinc to Native Freshwater Organisms Under Different pH Values in China." 24 Sept. 2018. *Springer Link*, link.springer.com/article/10.1007/s00128-018-2441-2.
6. Yanong, Roy P.E., "Use of Copper in Marine Aquaculture and Aquarium Systems", *EDIS,* 2010, edis.ifas.ufl.edu/fa165.
7. "Nitrates and Their Effect on Water Quality – A Quick Study." *Wheatley River Improvement Group*, www.wheatleyriver.ca/media/nitrates-and-their-effect-on-water-quality-a-quick-study/.
8. "PH of Water." *Environmental Measurement Systems*, Fondriest Environmental, Inc, 19 Nov. 2013, www.fondriest.com/environmental-measurements/parameters/water-quality/ph/.
9. "National Recommended Water Quality Criteria – Aquatic Life Criteria Table." *Environmental Protection Agency,* https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table.
10. "National Pollutant Discharge Elimination Systems (NPDES)." *Environmental Protection Agency*, https://www.epa.gov/npdes/about-npdes.