Water Quality in Courtland Creek, East Oakland, California

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Introduction

Courtland Creek is a stream in East Oakland, California that is partly exposed in urban residential areas. The creek's waters flow southwestward from the Oakland Hills toward the East Creek Slough where they enter the San Leandro Bay. Like many of the creeks in Oakland, urban development over the years has altered both its natural course and the occurrence and habits of associated plants and animals. The stream is culverted for much of its course and is only exposed intermittently. We studied exposed sections in a residential neighborhood where its waters flowed through private properties and swaths of City of Oakland designated parkland. At four sites located in these locations we conducted a series of tests over the span of two years to determine the overall health of the stream using chemical and ecological assessment tools. In carrying out this study our intention was to determine whether its waters meet health requirements for both human and aquatic life, and also to examine the overall health of the creek ecosystem.

Over the two-year period of our study we have measured both dissolved oxygen and nitrate concentration levels. Beginning in 2012, we observed that nitrate levels reached 50 ppm in samples collected at each site where measurements were made. The presence of such unusually high nitrate levels lead us to broaden our testing procedure. Thus, in current year (2013) we extended our research to include the measurement of the following concentration levels: Chlorine, Nitrate, Nitrite, Phosphate, Dissolved oxygen, and Ammonia. In addition, late in 2013 we collected samples that were later analyzed to determine the presence of Escherichia Coli (E. coli).

Methods

Ammonia, Nitrate, Nitrite, and Phosphate
Aquarium Pharmaceuticals (API) test kits were used to measure Ammonia, Nitrate, Nitrite, and Phosphate concentrations in the water samples collected at Courtland Creek. The following procedure was followed to determine concentration levels of these species: Five ml of water were collected from each of four sites. These samples were placed in a test tube, to which reagents were added. After mixing and a brief reaction period, concentration levels were determined by comparing the resulting solution color with colors contained on standardized scale.

Dissolved Oxygen
A CHEMets Kit was used to determine the levels of dissolved oxygen in Courtland Creek waters. After collecting samples from all four sites, 25 mL of water was used for testing dissolved oxygen. An ampoule containing a reagent was placed and snapped inside the 25 ml beaker of water. The broken ampoule was mixed end to end several times. The reaction was left alone for 2 minutes until a color began to develop. The resulting color then was compared with a standardized color chart to determine concentration levels.

Chlorine
We used a test kit manufactured by the HACH company to determine chlorine concentration levels. Similar to the API test kit procedures, a 5ml sample was added to a test-tube, to which chemical reagents were added. Following a period for mixing and reaction, the color of the resulting solution was compared with colors on a standardized chart, which in this case is in the form of a color wheel.

E. Coli
Four separate 50 ml water samples were collected specifically for E. coli. analysis. One blank and one additional sample were collected from a given location, and two additional samples were collected from a total of three sites along the creek during the Fall of 2013. Following refrigeration, these samples were transported to a nearby EPA laboratory in Richmond, CA for analysis using the Membrane Filtration (MF) procedure. The MF procedure is a single step process that provides a direct count of E. coli colonies that grow on the surface of a membrane filter.

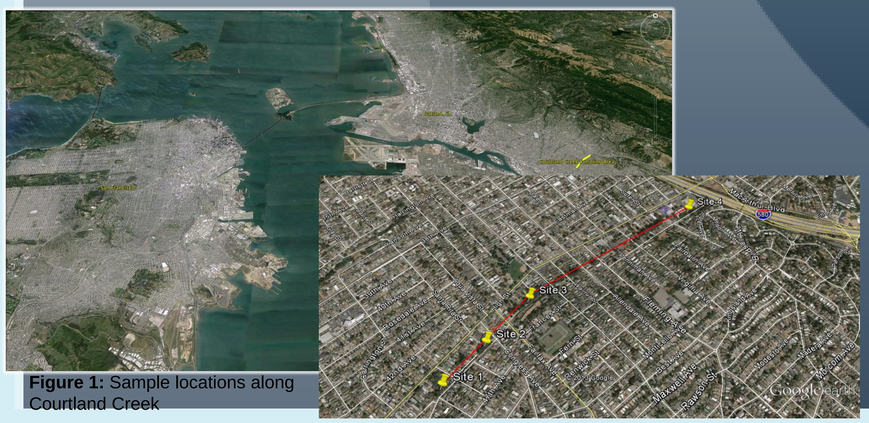

Figure 1: Sample locations along Courtland Creek

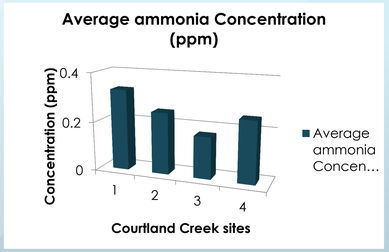

Figure 2 All sites at Courtland creek have levels of ammonia that are relatively low. However, 0.02 ppm is the minimum concentration that can be toxic for some aquatic organisms.

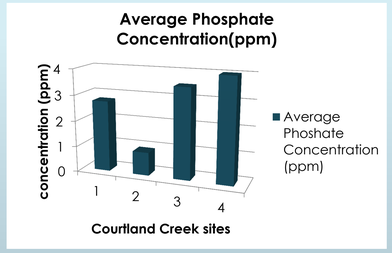

Figure 3 The desired levels of phosphate are 0.3 ppm or lower, however the data collected at all four sites indicates high levels of phosphate.

Figure 4 *Research group performing API Kit tests, dissolved oxygen CHEMets Test, and chlorine HACH Test.*

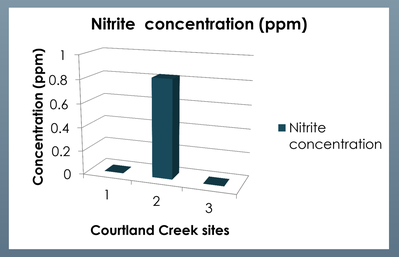

Figure 5 Concentration levels at site 2 indicate significant concentration of nitrites. At 0.83 ppm, it is near the maximum contamination level (MCL) of 1ppm, as established by the EPA.

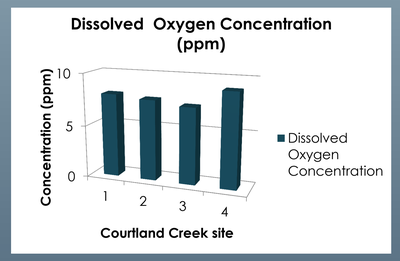

Figure 6 The levels of dissolved oxygen are above 5 ppm, which is sufficient for maintaining the aerobic conditions in the creek. Levels between 7-10ppm will create a healthy environment for aquatic life.

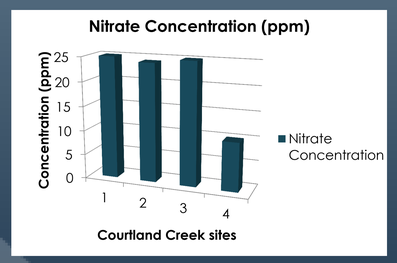

Figure 7 Courtland Creek has high levels of nitrates, an average of 25 ppm in sites 1 through 3. It can be assumed that site 4 has lower levels of nitrate because it is located up stream. These levels of nitrate would be toxic to vertebrates and stressful for many invertebrates.

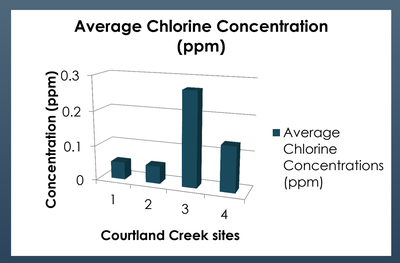

Figure 8 According to EPA criteria of chlorine levels, 0.01 ppm is the minimum concentration that for the viability of fish. At all four site the concentration of chlorine is above the 0.01ppm, further indicating the lack of fish or other aquatic organism in Courtland creek.

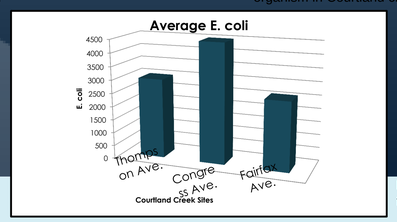

Figure 9 The large amounts of E. coli found at sites of Courtland Creek.

Results and Discussion

In a continuation of our Courtland Creek ecological quality assessment that began in 2012, water quality testing was conducted again in 2013 to further investigate the overall health of Courtland Creek. This work has resulted in the detection of high concentration levels of ammonia, chlorine, nitrate, phosphate, and coliform bacteria at all four sites where samples were collected.

Ammonia in stream waters is primarily found in two states, the un-ioinized (NH3) and ionized (NH4+) forms. Waters with high levels of un-ionized ammonia, with a minimum being 0.02 ppm are toxic to fish and other aquatic organisms. Ammonia levels measured in collected samples varied from 0.17 ppm to 0.33 ppm, which is well above that considered toxic for many aquatic organisms (0.02 ppm). The concentration of ammonia found at Courtland Creek correlates well with the fact that little to no macroinvertebrate or other aquatic organisms observed within the creek environment studied. The presence of ammonia is usually associated with fish waste, however the lack of aquatic life present indicates that the high levels of nitrogenous waste may be due to discharge of raw sewage or industrial waste.

Chlorine was detected in samples collected from each of our sample sites. Extremely high chlorine concentration levels were measured in samples collected from one site in particular. Natural creek systems should have no measureable amounts of chlorine. The high levels of chlorine detected may be attributed to the presence of small amounts of treated water from a private residence. The presence of chlorine at all sites indicates that there are other sources of treated water entering Courtland Creek.

Nitrate and nitrite are found naturally in soil and water but usually at relatively low concentration levels. High levels of nitrate in streams are often attributed to agriculture, industry and municipal sewage facilities. Because both nitrate and nitrite are highly soluble, they can easily be transported when contamination sources come into contact with water. According to EPA, nitrate concentration levels above 10ppm and nitrite levels above 1ppm can be detrimental to water quality and the viability of aquatic organisms.

High concentration levels of nitrate were measured in samples obtained from all sites, at an average of 25 ppm. and nitrite levels were measured in samples collected from one site (1ppm). The presence of high nitrate and nitrite levels in samples collected at various sites along the creek is indicative of pathogenic bacterial contamination, and in this case is supported by the presence of large amounts of E. coli found in the creek. This suggests that there is a likelihood of raw sewage contamination.

High levels of phosphate were detected in samples collected from each site. Such values are indicative of poor water quality in the creek that can affect the viability of organisms. Probable sources of contamination include human and/or animal waste entering the creek as untreated sewage and urban run-off.

The average dissolved oxygen concentration level measured was above 5ppm. The lowest value obtained was 7.1ppm while the highest recorded was 9ppm. These results indicate that dissolved oxygen concentrations are not a limiting factor for aquatic life in Courtland Creek.

Conclusions

With high levels of phosphate, nitrate, ammonia, and measurable levels of chlorine found in all sites tested, it is very possible that treated water, as well as raw sewage drainage is contaminating the creek. The results from chemical analysis of collected water samples combined with field observations indicate that poor water quality of the creek has been detrimental to aquatic and surrounding life. Such a circumstance also can result in incidences of health problems in the surrounding residential community, especially with the presence of E. coli. The City of Oakland Public Works and Sewer Division has been notified about the high concentrations of various chemical species that we have measured in Courtland Creek. As a result, they have initiated their own sampling of the sites that this research group studied.

Inspired by the results of our work over the past two years, this research group also has begun leading a Courtland Creek restoration effort that includes the participation of local community members. As part of this effort we have engaged in the removal of all invasive plant species surrounding the exposed areas of the creek, and the replacement of them with native species. By doing this, the ecosystem of this creek can slowly begin to be restored to a much healthier condition, allowing for native wildlife to also return. Although the restoration project does not address the specific concerns regarding contamination of the creek waters, it provides an opportunity to share data, draw attention to Courtland Creek ecosystem in general, and to create awareness regarding the maintenance of the creek environment. As such, our team plans on continuing creek quality research and restoration/education efforts, and to demonstrate how systematic creek studies can contribute to addressing potential health risks that communities may face.