Water Quality in the Abangares Watershed

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Abstract

Yo continué con el trabajo de estudiantes pasados en la medición de los efectos de la minería, la ganadería, y la utilización de la tierra en la calidad de agua, tan yo miró a las químicas en el agua de la cuenca del Abangares. Yo busqué los tipos de químicas y los cantidades de químicas en el agua. Para hacer esto, yo usó el equipo de CHEMets® y la sonda de YSI®. La calidad de la agua se encontró ser muy bueno; pero, las industrias locales están teniendo un impacto pequeño en la química de agua.

I continued with the work of past students in the measurement of the effects of mining, cattle ranching, and land use on the quality of water, so I looked at the chemicals in the water of the Abangares watershed. I searched for the kinds of chemicals and the quantities of chemicals in the water. To do this, I used CHEMets® equipment and the YSI® probe. The quality of the water was found to be very good; but, the local industries are having a small impact on the water chemistry.

Introduction

"Water is the liquid on which everything depends," Joaquin, a local educator and environmental preservationist, simply stated (Appendix 1). However, the water flowing through the streams of the Abangares watershed and ultimately into the houses of the people of Las Juntas, Costa Rica has been subjected to abuse by miners and cattle ranchers. Six years ago in an effort to retain the water purity, new rules and regulations (primarily for the ranchers) were developed by a team of researchers, which included Joaquin. Since that time, he says he has seen an overall improvement in the water quality, biodiversity, and the health of the people of Las Juntas.

Biodiversity has enormous economic and aesthetic value and is largely responsible for maintaining and supporting overall environmental health. Humans have long depended on aquatic resources for food, medicines, and materials as well as for recreational and commercial purposes. Aquatic organisms also rely upon the great diversity of aquatic habitats and resources for food, materials, and breeding grounds. Pollution from urban, industrial, and agricultural areas is a major contributor to the declining levels of aquatic biodiversity in freshwater environments (EPA). As a result of this pollution, valuable aquatic resources are becoming increasingly susceptible to environmental changes. Thus, conservation strategies to protect and conserve aquatic life are necessary to maintain the balance of nature and support the availability of resources for future generations.

Chemical bioindicators can be used to determine the significance of the impact made by mining, deforestation, and cattle ranching on the Abangares watershed. Various chemical tests identify impurities and other dissolved substances that affect water used for domestic purposes include: pH, water temperature, conductivity, turbidity, nitrate, phosphate, dissolved oxygen, and ammonia.

pH drastically affects aquatic life - a slight change in pH can mean the difference between life and death for most aquatic organisms. A pH range of 6.5 to 8.5 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates (Colorado State). Runoff from agricultural, domestic, and industrial areas may contain iron, aluminum, ammonia, mercury or other elements. The pH of the water will determine the toxic effects, if any, of these substances (Cooke).

The Federal Water Pollution Control Administration (1967) referred to temperature as "a catalyst, a depressant, an activator, a restrictor, a stimulator, a controller, a killer, one of the most important and most influential water quality characteristics to life in water (Division)." Often summer heat can kill aquatic animals because high temperatures reduce available oxygen in the water. Simply put, the warmer the water, the less dissolved oxygen, and vice versa.

Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current. It can be used to measure total dissolved solids, which indirectly affects the elimination of desirable food plants and habitat-forming plant species. Agricultural uses of water for livestock watering are limited by excessive dissolved solids and high dissolved solids can be a problem in water used for irrigation. It is recommended that the level does not exceed 257 mics (Strollo).

Turbidity is a measure of the cloudiness or amount of suspended solids in water, and higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria (EPA). The sediment accumulation comes from accelerated erosion of the riparian buffer zone from agriculture, logging operations (especially where clear-cutting is practiced), surface mining, and construction sites (Division). In a thriving riparian buffer zone, tree roots and grasses help to physically trap sediment by slowing down the water runoff from the surrounding area. But, in a stream in which the riparian zone has been cleared lacks roots and does not trap the sediment, nor does it hold together the stream banks.

A stream with a riparian buffer zone is able to maintain more natural inputs of nitrogen and phosphorous from municipal and industrial wastewater, septic tanks, feed lot discharges, and animal wastes into the stream because riparian zone plants have denitrifying bacteria on the rhizomes of their roots (Cooke). In the case of phosphorous, the riparian vegetation sequesters the nutrient in their roots or vascular tissue, thus controlling its entrance to the stream water (Hayes-Conroy). In a stream lacking a riparian buffer, most of these nutrients will flow into the stream during floods or through agricultural runoff. This influx of nitrates and phosphates serves to promote eutrophication, which can cause over-production of plankton. The resultant increase in turbidity depletes the dissolved oxygen levels as the necessary light for photosynthetic processes cannot reach the aquatic plants, which in turn causes other oxygen-dependent organism to die. Nitrate in excess of 45 mg/l is of health significance to pregnant women and infants under 6 months (Colorado State).

Dissolved oxygen analysis measures the amount of gaseous oxygen dissolved in an aqueous solution. Adequate dissolved oxygen is necessary for good water quality because natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. In fact, oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills (Division).

About three-fourths of the ammonia produced in the United States is used in fertilizers either as the compound itself or as ammonium salts such as sulfate and nitrate. It has been reported toxic to fresh water organisms at concentrations ranging from 0.53 to 22.8 mg/L. Toxic levels are both pH and temperature dependent. Toxicity increases as pH decreases and as temperature decreases. Plants are more tolerant of ammonia than animals, and invertebrates are more tolerant than fish. Hatching and growth rates of fishes may be affected. In the structural development, changes in tissues of gills, liver, and kidneys may also occur. Toxic concentrations of ammonia in humans may cause loss of equilibrium, convulsions, coma, and death (Division).

In order to better understand the relationship between water quality and mining, cattle ranching, and deforestation in the Abangares watershed, levels of dissolved oxygen, pH, conductivity, and temperature were quantified with the YSI® 556 Water

Quality Meter Multi-Probe System, while ammonia, phosphate, and nitrate levels were measured with CHEMets® Kits at seven predetermined locations. These included: High School Bridge, Agua Caliente, Gloria, Puente, Second Crossing, Aguas Claras, and Rio Boston. These sites represent locations that have been exposed to mining, cattle ranching, or both industries, and are accessible to people for drinking, playing, and waste disposal.

Based strictly on prior research, I had hypothesized that the chemicals indicative of these industries will be present in large quantities downstream from the work place. It was expected that downstream from a mine, there would be high turbidity, conductivity, and pH, and that deforestation would also cause higher turbidity and conductivity as well as increased temperature and decreased dissolved oxygen. Ranching was expected to raise pH, turbidity, conductivity, nitrates, phosphates, and ammonia and lower dissolved oxygen. However, Jessica Tanis (2000) and Christen Strollo (2003) found relatively normal levels of these chemical indicators. Tanis found low dissolved oxygen levels below the town of Las Juntas, and Strollo noted high concentrations of ammonia at Puente, high pH in the Rio Boston, and high conductivity at the first four sites possibly due to metal objects in the water. It may be that mining, cattle ranching, and deforestation have not had an immediate impact on the water chemistry, but that their effects may be accumulating over time. The long-term database compilation may someday show the damage that these industries have caused over the years.

Materials and Methods

To measure temperature, conductivity, percent dissolved oxygen, and pH, the YSI® 556 Water Quality Meter Multi-probe System was used. To take a reading, first the instrument was powered on. The 'Run' command was selected from the Main Menu, and the probe was inserted into the water. Continuous stirring was necessary throughout the reading. The ‘Log One Sample’ command was selected next, and the instrument could then measure the chosen parameters. Turbidity was also measured, but by observation alone.

To measure ammonia, phosphate, and nitrate, the corresponding CHEMets® kits were used. To measure ammonia (Kit 1510), the sample cup was filled to the 25 mL mark with sample. Two drops of A-1500 Stabilizer Solution was added and briefly stirred with the tip of the ampoule. The CHEMets® ampoule was placed in the sample cup and its tip was snapped by pressing against the side of the cup. The ampoule filled, leaving a small bubble to facilitate mixing, which was done via inversion. The color developed in one minute, and the ampoule was placed in the appropriate color comparator to determine the level of ammonia-nitrogen (NH_3-N) in the water. The comparator was held toward a source of bright light and rotated until the color standard that best matched the color of the sample was in the position directly below the ampoule. To measure phosphate (Kit 8530), the sample cup was filled to the 25 mL mark with sample. The CHEMets® ampoule was placed in the sample cup and snapped, allowing the sample to enter the ampoule leaving a small bubble. The contents were mixed by inversion several times and sat undisturbed for five minutes as the color developed. Then, the ampoule was placed in the comparator to make the reading. To measure nitrate (Kit 6902), the sample cup was filled to the 15 mL mark with sample and treated with the contents of one A-6900 Cadmium Foil Pack. The cup was capped and shaken vigorously for three minutes, upon which time it was allowed to sit undisturbed for thirty seconds. The ampoule was then placed in the cup and snapped, allowing the sample to enter the ampoule. Mixing was again done by inversion, and the ampoule was left alone for ten minutes for color development. The ampoule was then placed in the color comparator to determine the level of nitrate-nitrogen (NO_3-N) in the water.

Results

Table 1. Results of all chemical analyses performed at the seven pre-selected sites.

Location*	Temp (°C)	Conductivity (µs/cm)	DO %**	pH	Amm. (mg/L)	Phos. (ppm)	Nit. (ppm)
1	27.14	362	129.5	7.88	0	0	0.1
2	30.15	1772	124.2	7.53	0.2	0	0.1
3	25.18	225	146.0	7.89	0.1	0	0
4	23.90	214	157.5	7.67	0.4	0	0.15
5	24.40	213	155.5	7.65	0	0	0
6	24.36	240	154.1	7.91	0.1	0	0.1
7	24.03	149	151.1	7.60	0	0	0.2

**Not calibrated.

*Location name and notes about the site (see Appendix 2 for pictures and map):
1 – High School Bridge – downstream of Las Juntas, very polluted, turbid on edges, clear in current
2 – Agua Caliente – downstream of Tres Hermanos goldmine, some pollution, turbid on edges, clear in current, noted some standing pools
3 – Gloria – manmade waterfall, upstream of San Antonio, little to no pollution, very turbid
4 – Puente – downstream of large ranch, downstream of joining of Rio Boston and Aguas Claras, no pollution, very turbid due to recent rainstorm
5 – Second Crossing – downstream of joining of Rio Boston and Aguas Claras, upstream of Puente, no pollution, very turbid due to recent rainstorm (high sediment levels affected readings at this site)
6 – Aguas Claras – no pollution, smallest stream, no turbidity in spite of recent rainstorm, where drinking water is taken from
7 – Rio Boston – downstream of Boston goldmine, no pollution, very turbid due to recent rainstorm, highest flow rate

The highest temperature and conductivity levels were found at the High School Bridge and Agua Caliente, which were also the sites of the lowest dissolved oxygen readings. pH varied little with in group, and no traceable levels of phosphate were found at any site. Ammonia and nitrate were found in highest quantity at Puente, but the overall range of these two indicators was very narrow.

Discussion

Water is essential to life. If water quality is poor, the quality of life is adversely affected. Overall, the quality of the water in the Abangares watershed is very good. Any unusually turbid water was due to rain; only High School Bridge and Agua Caliente exceeded the conductivity standard of 257 mics; all pH, ammonia, and nitrate levels were within the respective ranges; and no phosphate was found at all. However, some evidence does support the hypothesized impact of mining, cattle ranching, and deforestation on the water quality.

It was expected that the effects of mining would appear in high turbidity, conductivity, and pH. Agua Caliente and Rio Boston, the two sites most directly affected by the mining industry yielded mixed results. The turbidity of the Rio Boston was high at the time of my visit due to a recent rainstorm; the conductivity tests showed Rio Boston as the lowest with 149 µs/cm and Agua Caliente as the highest with 1772 µs/cm; and Agua Caliente yielded the lowest pH (7.53) with Rio Boston falling in the middle of the group (see Table 1). The extremely high conductivity found at Agua Caliente could have been a summation of heavy metals in the water from mining and of metal objects thrown into the water by the townspeople. So, because of the rain and pollution, it is hard to say whether or not mining is having a definitive impact on the water quality or not.

Exposure to a cattle ranching was expected to raise pH, turbidity, conductivity, nitrates, phosphates, and ammonia and lower dissolved oxygen. It is nearly impossible to find a river in the Abangares watershed that has not been affected by cattle ranching. However, the site most abruptly downstream of a cattle ranch was Puente, which, as seen in Table 1, does show elevated nitrate and ammonia levels of 0.4 mg/L and 0.15 ppm, respectively. These two indicators strongly suggest that ranching is having a negative impact on the quality of the water; but, without elevated pH, conductivity, and phosphate levels, no absolute judgments can be made. Also, it is sure that the recent rainstorm increased the amount of land runoff. Because the land was deforested to establish the ranch, there is no riparian buffer zone to hinder the entrance of nitrates and ammonia into the river in the event of a storm. Hence, these elevated levels may only be representative of chemistry of this location after a flooding, not at all times.

The strongest argument can be made for the negative impact of land development on water quality. Increased temperature, turbidity, and conductivity and decreased dissolved oxygen were anticipated to result from deforestation. The areas most affected by deforestation are residential areas, downstream of which are High School Bridge and Agua Caliente. These sites showed the highest temperatures (27.14°C and 30.15°C), highest conductivity (362 µs/cm and 1772 µs/cm), and also the lowest dissolved oxygen levels (129.5% and 124.2%) (see Table 1). This data fully represents the inverse relationship of temperature and dissolved oxygen levels. With high temperatures and low dissolved oxygen, it is hard for aquatic organisms to thrive and the overall biodiversity of the ecosystem will decline. The eroded riparian buffer zone at these sites may one day cause the ammonia, nitrate, phosphate, and turbidity levels to rise. The amount of pollution found at these sites is another hindrance to aquatic plant growth, which will further deprive the river of oxygen.

While mining and ranching may not have a significant impact on the water quality, there is strong evidence for the negative impact of deforestation and land development. Although the growth of the towns in the Abangares watershed cannot be stopped, the continuation of reforestation and preservation efforts can help to maintain the improvement of the water quality. Proper trash disposal in the towns could also help to prevent any adverse effects of the excessive pollution. Ultimately, the most valuable preventative measure is education. High awareness among the people is essential to protect this natural resource. It is the beliefs held by the inhabitants of the Abangares watershed that will ensure the exceptional water quality that we see there today.

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