An analysis of the dissolved oxygen and volume flow in Jilguero Stream, Cloudbridge Nature Reserve, Costa Rica

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Abstract

Jilguero Stream is a small, mid-altitude stream located in Cloudbridge Nature Reserve, Costa Rica. In order to assess water quality and hydrology, measures of dissolved oxygen and volume flow were made. The results indicated that water quality increases along the stream, and so do not show any degradation of water quality. In addition, it was found that runoff contributed most of the water in the lower parts of the stream, and that spring water was a fairly minor component of the volume flow.

Introduction

Cloudbridge is a private nature reserve located in San Gerardo de Rivas, Costa Rica. Bordering the Chirripo National Park, Cloudbridge is a middle-elevation (approximately 1500 to 2400m) cloud forest (Tingerthal 2006). Numerous small streams run through the park, originating from small streams and draining into the Chirripo River.

Water quality is an essential part of ecosystem health. Understanding waterways is therefore important to assessing the quality of an environment. One frequently measured parameter is dissolved oxygen (DO). DO measures the saturation of oxygen in water, which is important as aquatic organisms depend on DO for respiration. Low DO levels can indicate organic contamination or high nutrient inputs, as these cause spikes in bacteria, which consume the oxygen as they metabolize the nutrients. A previous study done in the Cloudbridge area found low (37-44% saturation) DO levels, indicating a polluted system (Souers 2004).

Cloudbridge reserve experiences high levels of precipitation (approximately 172 inches of rain per year), which falls mostly in the wet season (Giddy 2006). Most of that precipitation falls on the land, where it becomes runoff. As it travels downhill, it gathers nutrients and other chemicals from the land which it passes through. When the water collects into streams, the accumulated nutrients are also added to the stream. Land use is thus very important to the inflow of nutrients to streams. Loss of vegetation can promote leaching of nutrients from the soil. In addition, manure in pasture can add not only nutrients but also bacteria to water.

The present study will consider both dissolved oxygen and water volume at three sites along a small middle-altitude stream in Cloudbridge Nature Reserve to determine the importance of runoff to the streams, and to estimate stream degredation.

Methods

Three sample sites were selected along the Jilguero stream. Site one was the stream spring, a concentrated outflowing of water from a rocky patch located in secondary forest. Site two was approximately 150 meters lower on the slope, where the stream left secondary forest and began to traverse cattle pasture. Site three was located only slightly lower than site two in terms of elevation, and was where the stream hit the main road. Between sites two and three, the stream passed through both cattle pasture and coffee plantation.

Water volume was measured using a standard tape measurer. Width and depth at three equally spaced intervals across the stream were recorded. These measurements were used to calculate cross sectional area. Velocity was measured by using a stop watch and tape measurer to determine the time for a small floating object, such as a leaf, to travel 50 cm downstream. The cross sectional area and velocity were then multiplied to determine the flow rate of the stream in cm^3/s.

Dissolved oxygen was recorded using a Sper Scientific Dissolved Oxygen Meter and Probe. The probe was calibrated to 100% air saturation and adjusted for approximate elevation.

Each site was sampled three times during the months of October and November, which are part of the rainy season.

Results

Three DO measurements were taken at each site, at each time, and used to determine a mean value. Velocity was calculated over a 50cm distance. Area was calculated using stream width and three depth readings. Flow is the product of area and velocity. Results are giving in Table 1, with standard deviations where appropriate.

Date	Site	DO (% saturation)	Velocity (cm/s)	Area (cm^2)	Flow (cm^3/s)
19 Oct	1	93.0±0.265	51.2±12.1	240	11111
1 Nov	1	90.5±0.351	39.2±12.9	151	5903
16 Nov	1	93.1±0.200	35.6±5.32	221	8979
5 Nov	2	95.1±0.709	72.0±15.0	1628	145313
8 Nov	2	94.6±1.01	82.7±19.6	2525	203589
16 Nov	2	95.0±0.656	57.6±8.06	2940	186076
5 Nov	3	95.7±1.05	63.1±21.4	2064	104242
8 Nov	3	96.2±0.351	43.0±1.17	2401	105318
16 Nov	3	95.5±0.551	57.5±4.15	2160	112500

Table 1: Summary of measurements and calculated values taken from three sites along the Jilguero Stream in Cloudbridge. DO values are based on the mean of three readings, velocity is based on 3-4 measurements, and area and flow were calculated based on stream dimensions (flow calculations used the mean velocity in given in the table, not the raw data).

A one-way ANOVA indicated that DO saturation was significantly different at the three sites ($p=0.006$, $F=13.329$). Subsequent ANOVA tests of individual pairs indicated that each site was significantly different from the other two sites ($p<0.05$).

A one-way ANOVA indicated that volume flow was significantly different at the three sites ($p<0.001$, $F=70.941$). Subsequent ANOVA tests of individual pairs indicated that each site was significantly different from the other two sites ($p<0.05$).

Mean volume flow values indicate that the most water was present at site two, while the least was present at site 1. Based on these values, spring water can account for approximately 4.86% of the water at site two. Since the volume decreased between sites 2 and 3, a percentage of spring water present at site 3 cannot be estimated.

Discussion

Dissolved oxygen was significantly different between the three sites. Site 1 had the lowest DO, while site 3 has the highest. DO therefore increased along the length of the river. Oxygen is dissolved in streams by turbulence, so the constantly turbulent mountain stream caused a gradual increase in oxygen saturation. These results seem to indicate that there is no nutrient pollution occurring in this stream, however the high turbulence may be masking pollution effect. Souers (2004) showed that while nitrates did not increase along the length of the Chirripo river, phosphates did, indicating that there is some nutrient input to the river. The same study showed low (37-44%) oxygen saturation in the water. These values differ drastically from those found in the current study. This may be due to the fact that the previous study used a standard water quality test kit that did not account for the effects of elevation on dissolved oxygen.

Flow was different at all three sites. As expected, site 1 had the lowest volume of water, as it contained only spring water and lacked the accumulated runoff contributing to the other sites. Site 3, however, was expected to have the highest flow, but was in fact second to site 2. This result may be due to the type of land found between sites 2 and 3. The open pasture would encourage a higher evaporation rate than found in the forest further up the slope. Also, some of the water may have been lost in the swampy ground of the cattle pasture, as the soil absorbed the water and diverted it away from the stream. Further investigation is needed to determine the exact cause for this result.

Between sites 1 and 2, the volume flow increased drastically. Spring water accounted for as little as 4.86% of the flow at site 2. This indicates that rain water is a much more important water source for the stream than spring water. As a result, land use that may contaminate runoff will have greater effects than if the spring made a higher contribution.

At all sites, there was a high variation among volume flow estimates. At sites 2 and 3, this can largely be explained by changes in rainfall between the sampling days. Site 1, however, experienced high and unexpected variation, with the highest flow estimate almost double the lowest. This also may be due to variations in rainfall if the rainfall controls water levels in the aquifer feeding the spring (Taylor and Greene 2008).

Conclusion

Cloudbridge's Jilguero Stream is dominated by runoff from rainwater, with a relatively small contribution from spring water. Volume flow increases as the stream runs through forest, but decreases once it hits cleared land. Volume flow is also highly variable at all sections of the stream, which is likely due to variations in rainfall. Dissolved oxygen saturation increased along the length of the stream due to high turbulence. While it does not show any water quality degradation, it also cannot rule it out. Further studies should investigate the correlation of volume flow to rainfall, as well as attempt to measure evaporation and other aspects of the water budget.

References

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