Stream characterization of the Limón River in Puerto Rico during 2015 drought

CENTER FOR ENVIRONMENTAL INVESTIGATIONS
JUAN PONCE DE LEON HS
FLORIDA, PUERTO RICO

Keisha M. Mestey-Rivera, Kristofer J. Santa-Archilla and Prof. Elliot López-Machado
Juan Ponce de León ll High School - Florida, Puerto Rico

Funding provided by NSF Grant EPS-1101317

Introduction

❖ Site location

❖ Our research site was in the Limón River (Figure 1), located in the municipality of Utuado, in the north-central part of Puerto Rico (18°18' 57.50''N, 66° 36' 29.64''W), at an elevation of 406 feet above sea level. The basin provides water to Lake Dos Bocas for domestic consumption. The site code is RGA_RLmn_406.

❖ Geology and vegetation

❖ This region is part of the Montebello Limestone Member of the Cibao Formation. The site is surrounded by a secondary forest. According to the Holdridge life zone classification, it is a sub-tropical wet forest. There is no evidence of residential uses, roads or development. This place is used only for recreation. There is a very small area near the research site that has been used for agriculture purposes.

❖ Climate

❖ The climate regime resembles that of the north coast of Puerto Rico, but the region is wetter. In this area most of the rain falls between May and October, with less rainfall in June and July. Annual rainfall average is 1936 mm. Average annual temperature is 22 ºC.

❖ Drought

❖ Drought conditions in Puerto Rico are perceived initially following a deficiency in precipitation, in absolute amounts, for a given period (Figure 2). The National Oceanographic and Atmospheric Administration (NOAA) expresses the deficiency in precipitation, usually within a 12-month period, using three distinct statistical methods. Hydrologic, stream flow, lake or reservoir storage reduction, and lowering of ground-water levels.

Methodology

❖ Establish our research site location

- Coordinates were determined using Google Earth.

❖ Monitor Stream Physical and Chemical Parameters

- Samples where taken four times during a two month from October to November, 2015.
- Flow speed was calculated measuring the time of a tennis ball to traverse 6 m. The starting point was the line of the upstream transect and the finish line was the middle point (Figure 3).
- Channel geomorphology was described using two transects, one upstream and one downstream, and averaging depth and cross-sectional area. Each transect was divided into four sections and depth was measured at each point. Cross-sectional area was calculated using equation:

Cross-Sectional Area = Total width (m) X Avg. depth (m)

Considering that the stream bottom was rocky, we used a coefficient of 0.8 to calculate the flow using the equation:

$$\text{Flow} = \frac{A\,L\,C}{T}$$ where A=Area, L=Length, C=Coefficient, & T=Time

- Three water temperature and three pH measurements were taken at 0.5m depth in the sampling point on each visit. Temperature and pH were measured using a Martini pH 55 meter.
- Twelve water samples for Total Nitrogen and Total Phosphorus were taken at 0.5 m depth in the middle of the channel. Analyte - specific screw-top bottles were used. Following collection, samples were kept cool and sent to Saint Michael's College VT- RACC Program to be analyzed and determine the concentrations of phosphorus and nitrogen.

Figure 1. Study site at the Limón River. Left: upstream view of river. Right: location of research site within sub-tropical wet forest zone of Utuado, Puerto Rico.

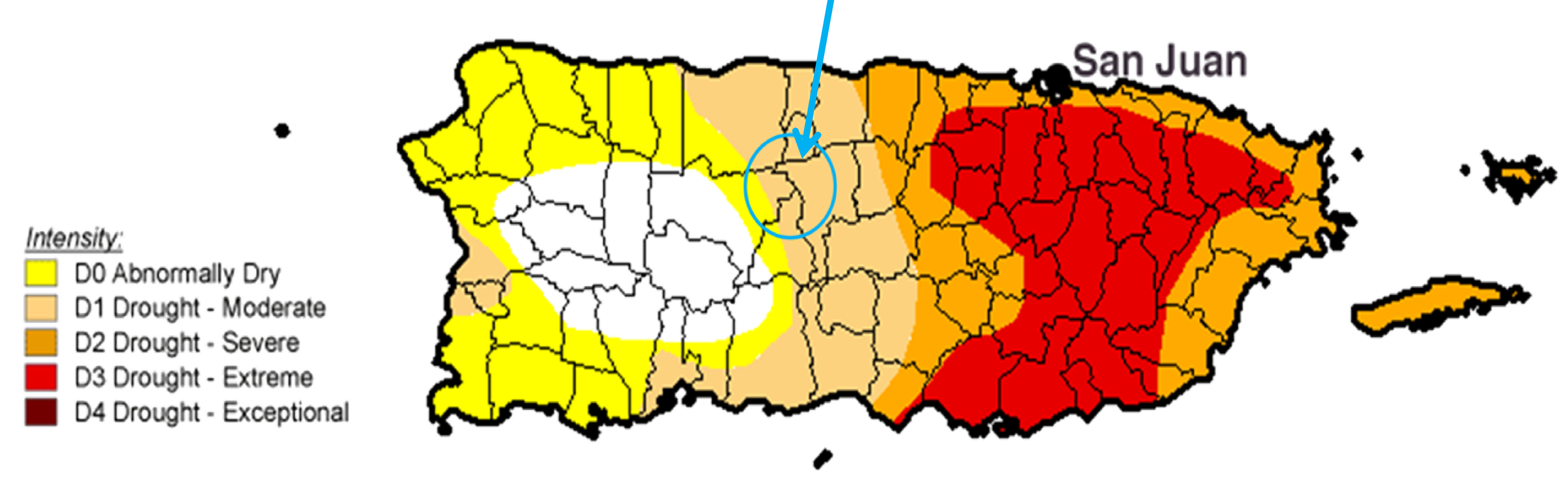


Figure 2: Map showing the areas affected by drought according to the intensity. Map from August 18, 2015. Blue circle shows the area where research was conducted.

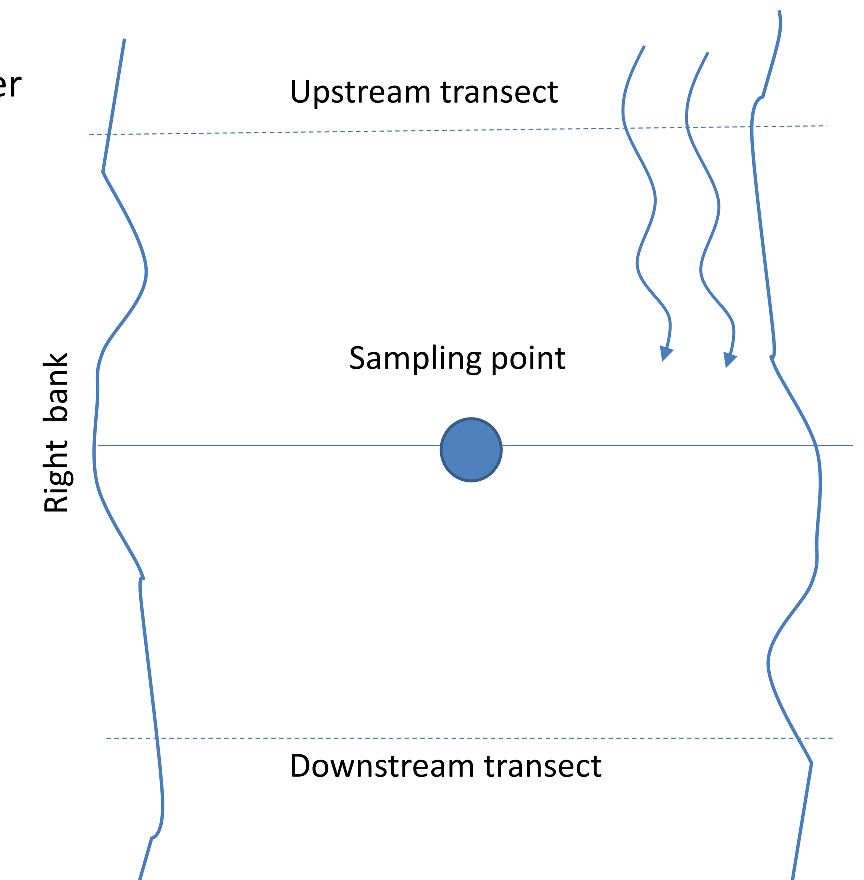


Figure 3: Stream diagram

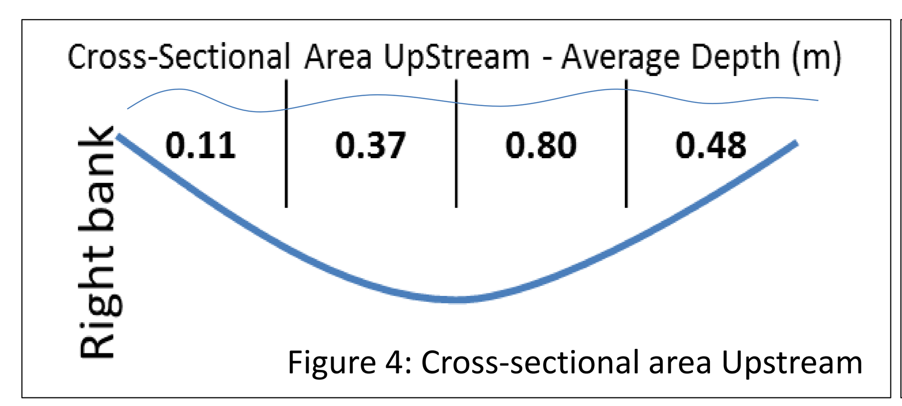


Figure 4: Cross-sectional area Upstream

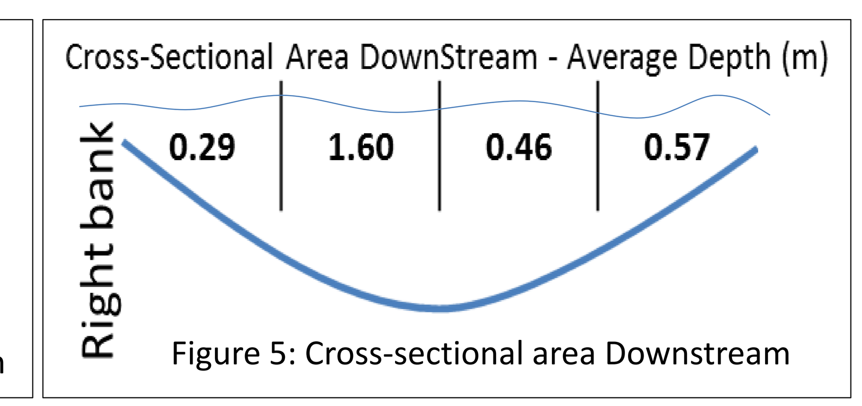


Figure 5: Cross-sectional area Downstream

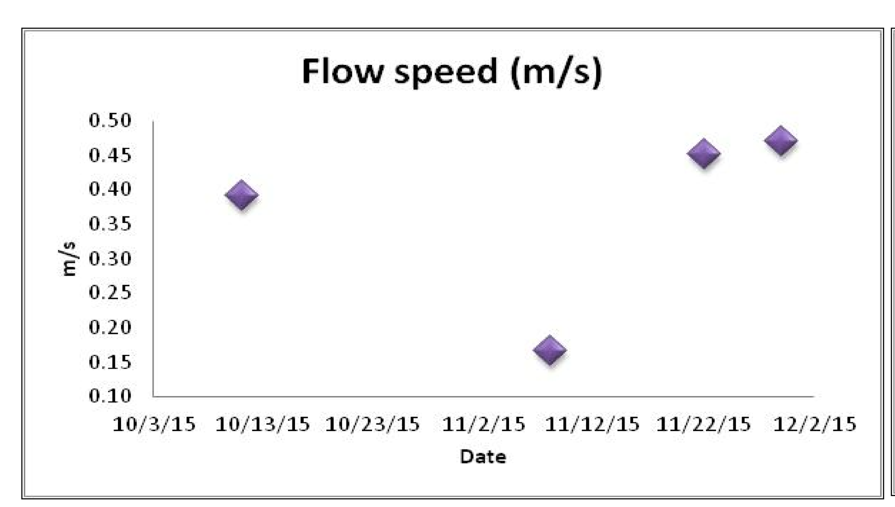


Figure 6: Flow speed

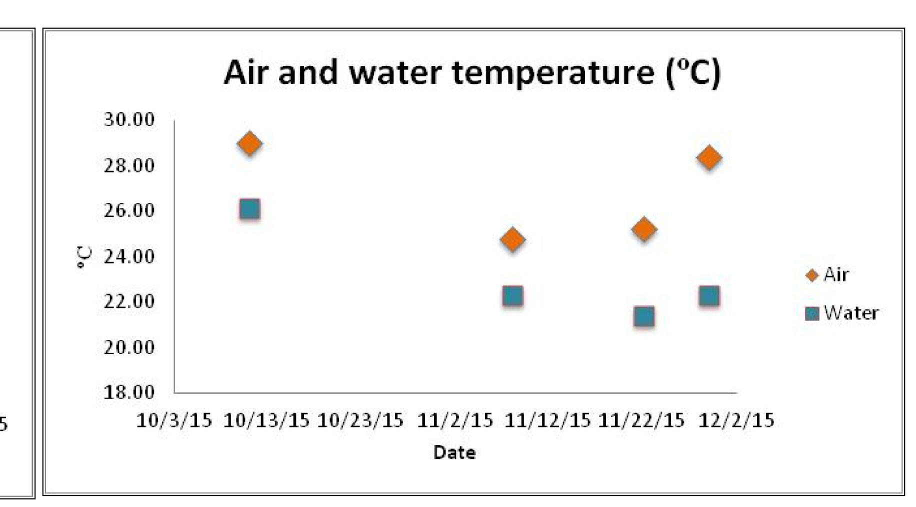


Figure 7: Changes in air and water temperature

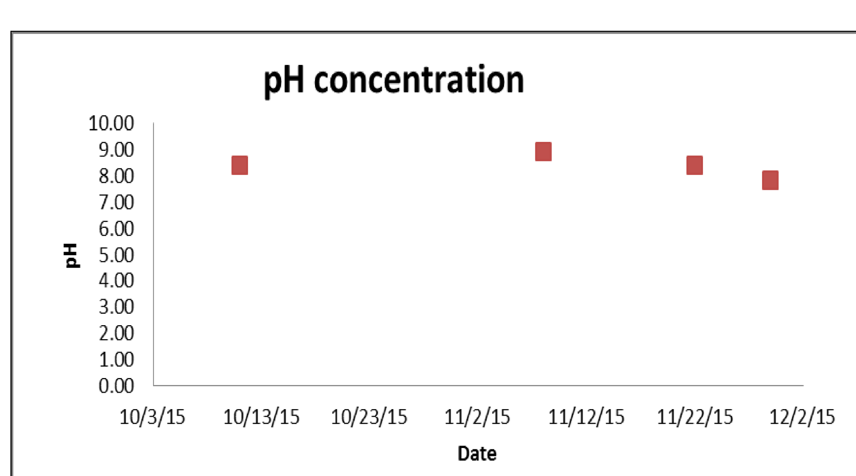


Figure 8: Stream pH concentration

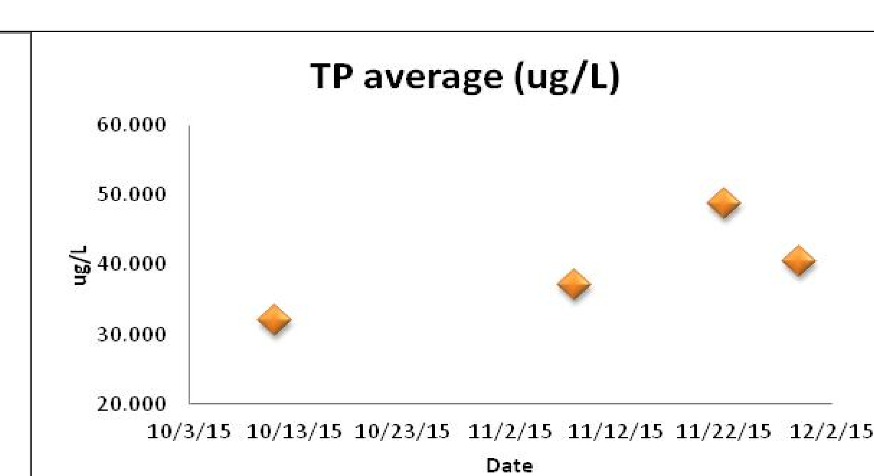


Figure 9: Total phosphorus concentration

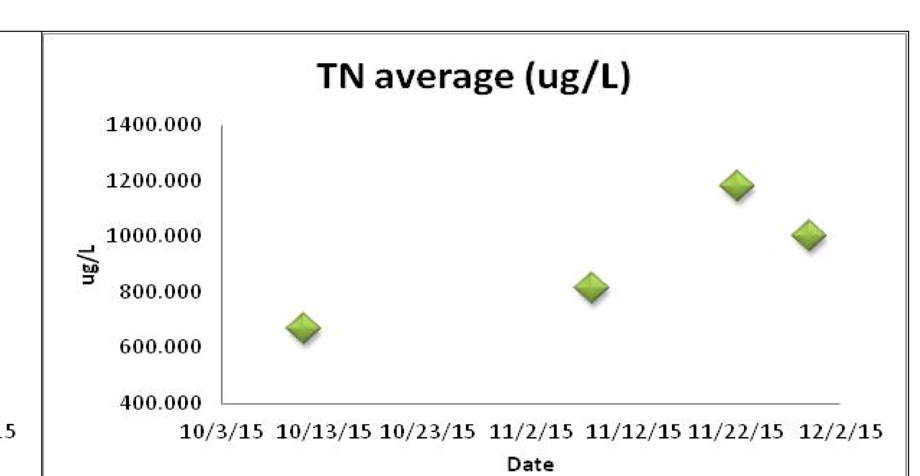


Figure 10: Total nitrogen concentration

Results/Discussion

❖ Physical parameters

❖ Average depths for upstream and downstream did not exceed 1.0 m. Only one place in the downstream transect measured 1.60 m (Figures 4 and 5). The presence of rocks in the stream bed, and lack of rains caused low depth levels.

❖ Average flow speed (Figure 6) was 0.37m/s. The lowest speed occurred in first week of November 2015, caused by tree branch debris upstream. Maximum speeds around 0.45 m/s is evidence of minimal change during the study period, owing to the lack of rain in the basin.

❖ Differences between air and water temperature showed an average of 3.8ºC (Figure 7). Water temperature fluctuated between 21 ºC and 26 ºC. Air temperature fluctuated between 25 ºC and 29 ºC . According to Puerto Rico Department of Natural and Environmental Resources, the annual average air temperature for the zone is 22 ºC (DRNA, 2007) . Those air temperatures increase with the evapotranspiration of the forest.

❖ Chemical parameters

❖ Stream pH concentration fluctuated between 7.8 and 8.9 (Figure 8). Those results are very near the range for surface streams in Puerto Rico. According to the Environmental Protection Agency, waters in Puerto Rico should not fall outside the range of 7.5 to 8.5 (EPA, 2014).

❖ Total phosphorus (TP) is a measure of all the forms of phosphorus, dissolved or particulate, that are found in a sample. The standard values for TP in streams in Puerto Rico should not exceed 160ug/L (EPA, 2014). Our result shows values below the standard (Figure 9). Each sample revealed concentrations equal or below 60ug/L.

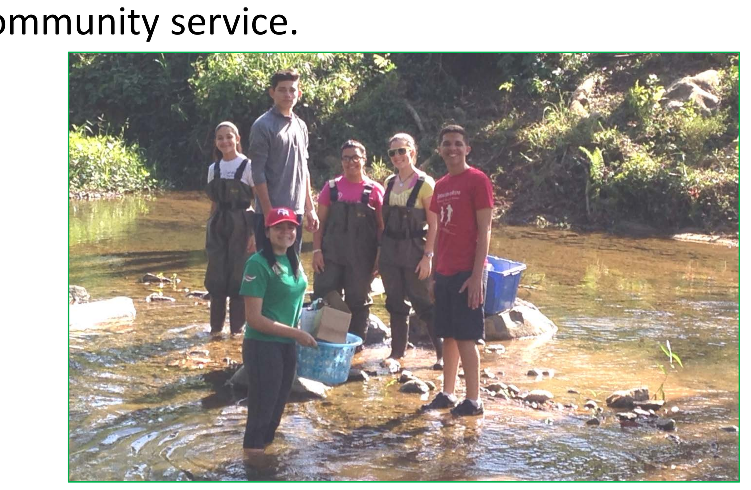
❖ Nitrogen, in the forms of nitrate, nitrite, or ammonia, is a nutrient needed for plant growth. It is used in the crop fields and farms. Runoff water can introduce it into streams . The EPA only establish standards for nitrates and ammonia in Puerto Rico. Total ammonia should not exceed 1000ug/L. Our results for total nitrogen concentrations indicated values between 600ug/L and 1000ug/L (Figure 10). No farms or crop land are near the site; as a result small amount of nitrogen is present.

❖ Conclusion

❖ Average concentrations of chemical parameters are near the acceptable range. Measure that exceed the parameter may carry errors or is affected by alkaline soil or input from surface runoff. The cross-sectional area looks stable. The drought has not adversely affected these. Flow speed was affected by the lack of rain. As speed is low the depth remains similar.

❖ This characterization establishes baseline data during drought conditions to perform comparative research in the future.

❖ Students enhanced their research skills and practiced monitoring techniques. This experience allowed opportunities to understand the importance of team work to promote science for community service.



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RACC Reference Manual 2015-2-16

Acknowledgements:

•Lindsay Wieland - CWDD Director
•EPSCoR Science Mentors
•Noelia Báez - LUQLTER Schoolyard Program Coordinator
•Dr. Omar Pérez – UPR, Río Piedras Campus
•Land owners