Contributions of Sewage effluents to Nutrients, Discharge, and DOC in Streams in Puerto Rico

INTRODUCTION

Some waste water treatment plants (WWTP) in Puerto Rico continuously discharge their effluents directly to streams. With urbanization, generation of sewage effluents increases and fluvial export of nutrients are expected to increase above background levels. Excess nitrogen and phosphorus are of particular concern because eutrophication of inland reservoirs is limited by phosphorus inputs, and coral reefs are damaged by excessive nitrogen inputs.

Effluent discharges are regulated based on organic load contributed to the receiving water body. Stream communities rely on organic matter and the type of organic matter in the stream can be altered by changes in the landscape or human activities.

Economic development on the heavily populated island of Puerto Rico has resulted in increasing wastewater generation. Therefore, it is imperative to document the impacts of WWTP effluents on stream quality in order to devise better decision-making tools for stream management and restoration.

Research objective: Our goal was to examine the contribution of WWTP to stream nutrients, discharge and dissolved organic carbon (DOC).

METHODS

Four WWTP were sampled to determine the relative contributions to stream nutrients, river discharge, and river DOC concentrations during base flow conditions during 2007-2008. Two of these four WWTP were sampled intensively and the other two were used as synoptic sites. Three stations were established at each site: upstream from the sewage effluent, at the WWTP effluent, and downstream from the effluent. At each station, water samples were collected to analyze the effluent contribution to stream phosphate, nitrate, ammonium and DOC flux. Export of nutrients for the upstream and effluent station was calculated as the product of nutrient concentration and instantaneous stream flow and summed to obtain the downstream daily export. Analysis of the biodegradability of organic matter (BOD) and the specific UV absorbance (SUVA) were conducted to observe any contribution from the sewage effluent to the quality of organic matter in the stream .

RESULTS

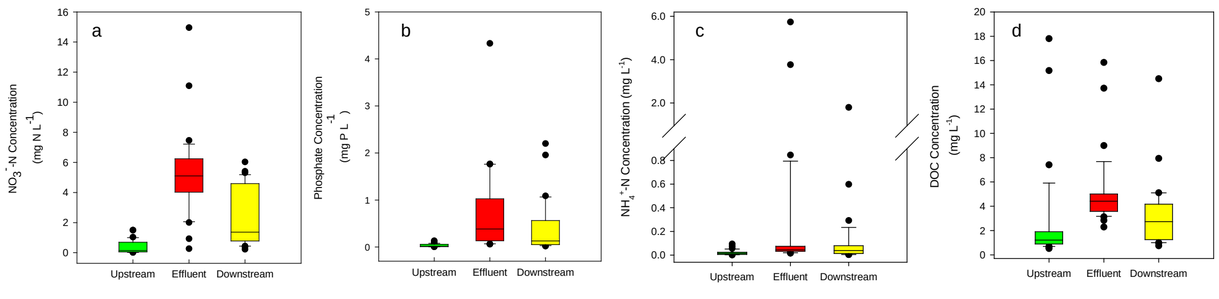

Figure 1. Mean a) nitrate, b) phosphate, c) ammonium, and d) DOC concentrations in milligrams per liter for the three stations: upstream, effluent and downstream at all the streams sampled during the study. Box plots display 10th, 25th, 50th, 75th and 90th percentiles, and individual data points outside the 10th and 90th percentiles.

Nitrate, phosphate, ammonium and DOC effluent concentrations highly increased background concentrations with a median of 5.0 mg L^{-1}, 0.4 mg L^{-1}, 0.04 mg L^{-1}, and 4.4 mg L^{-1}, respectively (Figure 1). At the downstream station nutrient concentrations were lower than the sewage effluent concentrations but higher than background levels indicating the change in stream water chemistry by the WWTP.

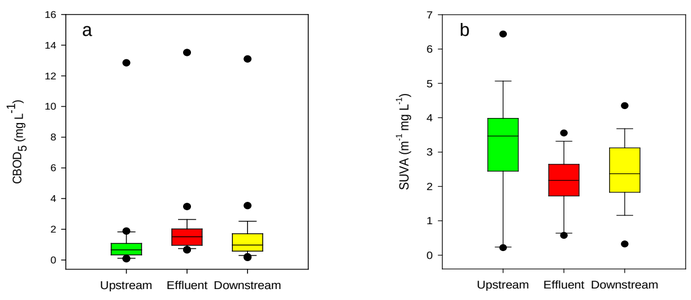

Figure 2. Mean a) biological oxygen demand ($CBOD_5$) and b) SUVA values for the three stations: upstream, effluent and downstream at all the streams sampled during the study. Box plots display 10th, 25th, 50th, 75th and 90th percentiles, and individual data points outside the 10th and 90th percentiles.

Incubations for BOD samples showed higher oxygen consumption by bacteria on the effluent in all sites compared to those samples collected in the upstream station (Figure 2a). Mean SUVA values were elevated at the upstream station indicating that the DOC in the stream contains high percentage of aromaticity (refractory organic matter) (Figure 2b). Low SUVA values were observed in the sewage effluent suggesting labile organic matter. According to our BOD and SUVA findings, sewage effluents are contributing labile organic matter to the stream changing the type of organic matter in downstream communities.

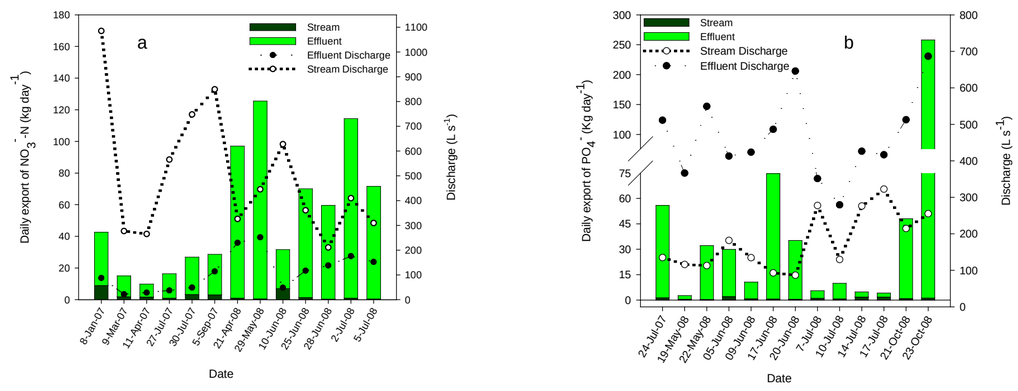

Figure 3. Daily export of a) nitrate and b) phosphate in kilograms per day and the daily discharge (in liters per seconds) from the stream and effluent during 2007-2008 for Río Fajardo and Río Bairoa at Caguas, respectively. Black bars represents the stream daily export and green bars are the effluent daily export. The dotted line with open circles represents the stream daily discharge and short-dashed lines with black circles represents the effluent daily discharge. Data shown are from the intensive streams sampled.

Sewage effluents contributed a substantial amount of the daily downstream export of phosphate and nitrate at the streams with loads up to ten times higher than before the effluent (Figure 3a and b). The daily downstream flux of ammonium and DOC at Río Fajardo was mainly contributed by the stream, however, at Río Bairoa the sewage effluent contributed all the ammonium and DOC (data not shown). The reason for this is due to the differences in discharge between the effluent and stream at both sites. Most of the discharge at Río Fajardo is contributed from the stream (61 to 94%) but the sewage effluent at Río Bairoa contributes about 56 to 88% of the downstream discharge dominating the downstream discharge of the stream. Our findings suggest the need to develop better strategies to control nutrient loading from WWTP to streams in order to reduce problems associated with eutrophication and hypoxia in downstream inland and coastal wasters.

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