Dilution and pollution: effects of wastewater reuse on water quality in the Los Angeles River

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Highlights

- A calibrated water quality model coupled with a hydrologic model was used to quantify the impacts of water reuse on water quality in the Los Angeles River.
- Treated wastewater effluent was found to be a major pollution source in dry weather for copper, zinc, and TDS, but not a large source for lead or TSS.
- Reductions in wastewater discharge led to a decrease in in-stream copper and zinc concentrations, but an increase in lead and TSS concentrations.

Introduction

The process of urbanization alters hydrologic flow regimes in innumerable ways. Replacing permeable surfaces with impermeable ones decreases the amount of water that can infiltrate and results in a corresponding increase in runoff for a given rainfall (Dunne & Leopold, 1968). This runoff carries a range of contaminants that degrade water quality receiving bodies of water, causing risk to human health and aquatic life. Water resources are further stressed by groundwater and surface water extracted for human consumption and use, which alters flow regimes and limits water available to support ecology. Historically, aspects of water resources (e.g., stormwater, water quality, drinking water, and wastewater) have been managed separately. Today, however, many cities are turning towards integrated water management approaches that aim integrate and weigh the various goals of water resources system, and conjunctively manage these resources (Bouwer, 2002).

Los Angeles, California illustrates one such case of integrated water management. Currently, treated wastewater is discharged into the Los Angeles (LA) River, contributing to both wet-weather and dry-weather flows. In the future, LA plans to use treated wastewater for non-potable uses or to recharge the groundwater basins (Water IRP, 2006). This reduction in effluent has the potential to greatly impact river flows and water quality in conflicting ways. Firstly, since treated wastewater discharge contributes a large portion of total pollutant loads, a reduction in WRP discharge may significantly reduce pollutant loads to the LA River. Secondly, however, since WRP discharge accounts for a large portion river flows, the same reduction in WRP discharge could reduce the dilution capacity of the river (i.e., increase pollutant concentrations).

This study aims to quantify impacts of water reuse on water quality in the LA River by applying water reuse scenarios to a calibrated water quality model in EPA SWMM. Specifically, we ask: (1) How do pollutant loads and concentrations vary, both spatially and temporally, along the LA River; and (2) How will pollutant loads and concentrations in the LA River vary with reduction of treated wastewater discharge?

Methodology

Study site

The LA River watershed, located in LA County, California, has an area of 2,165 square kilometers. The river is divided into six reaches on the mainstem and six tributary reaches based on regulatory compliance; most notably Burbank Western Channel, Compton Creek, and Rio Hondo. Three Water Reclamation Plants (WRPs)—named the Los Angeles-Glendale WRP (Glendale WRP), Burbank WRP, and Donald C. Tillman WRP (Tillman WRP)— contribute to flows in the LA River.

Hydrological model

A hydrologic model was previously created and calibrated, with detailed methods found in Stein et al. (2021). Briefly, physical data was collected to characterize 77 explicitly modelled catchments, including average slope, imperviousness, and soils data. Precipitation data was retrieved from Los Angeles County Automatic Local Evaluation in Real Time rain gauges.

Water quality model

A water quality module was added to a calibrated hydrologic model with an hourly time step in SWMM to simulate water quality in the LA River. The model was set up to account for three types of pollutant sources: stormwater runoff, dry weather discharge, and WRP effluent discharge. Five pollutants were simulated: total copper, zinc, and lead; total dissolved solids (TDS); and total suspended solids (TSS). Steps to simulate water quality associated with dry weather discharge and stormwater runoff include establishing pollutants to be simulated, defining land use types that generate pollution, assigning the percentage of each land use type to each catchment area, and setting the pollutant concentration and event mean concentration for urban baseflow and stormflow, respectively. The water quality model was calibrated manually for daily pollutant loads using observed data at four gauges.

Water reuse scenarios

Water reuse scenarios were applied to the calibrated hydrologic and water quality model by scaling the historical WRP discharge data in the modelled period. All three WRP discharges were scaled by 100%, 75%, 50%, 25%, and 0%. The 100% scenario represents all WRP discharge flowing into the LAR and no water reuse. The 0% scenario represents 100% reduction in WRP discharge in the river (i.e., WRP discharge is 0).

Results and discussion

Water quality spatial and temporal trends

Median daily loads decrease slightly in drier months compared to wetter months. Median daily concentrations stay relatively constant or increase in the drier months, due to lack of dilution capacities. Every constituent shows a pattern of increasing *load* as pollutants are transported downstream after Burbank and Glendale WRPs discharge into the LAR. On the other hand, the median and data distribution of daily *concentrations* for each constituent except TDS decrease slightly or stay relatively constant directly after Burbank and Glendale WRPs. Together, these results suggest that, for most constituents, the WRP discharge increases pollutant loading downstream but also dilutes pollutant concentrations overall.

While TSS and lead *concentrations* at each WRP are consistently low or non-detect every month, copper, zinc, and TDS from WRPs contribute significantly to dry weather pollutant loads (Figure 1a). Wet weather sources (i.e., stormwater runoff) comprise most of the copper, zinc, TSS, and lead loads, while dry weather sources (i.e., WRP discharge) comprise the majority of TDS loads (Figure 1b).

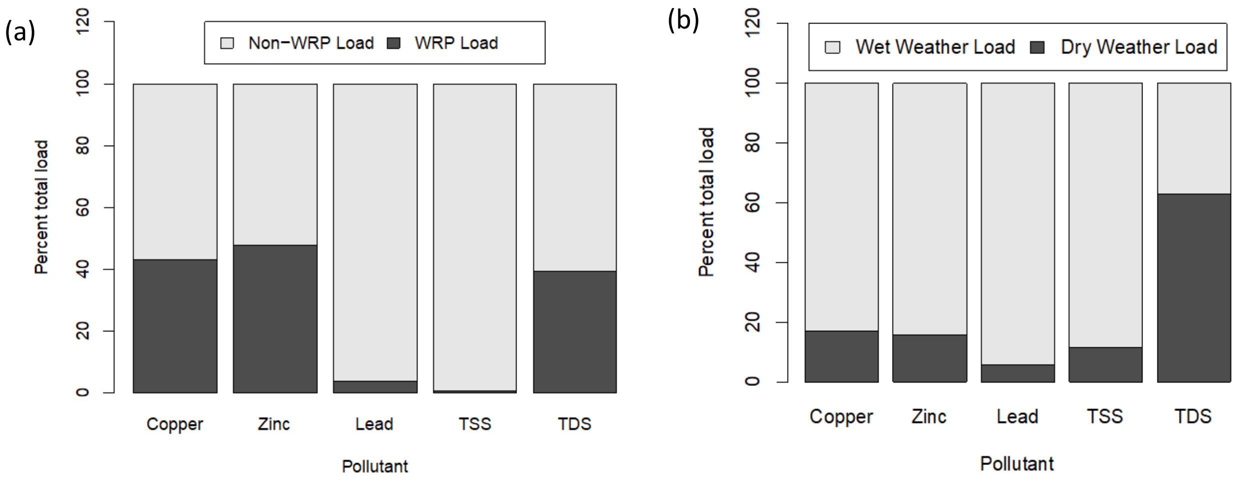

Figure 1. Load source contribution (percent) during dry weather (panel a), and percent of dry and wet weather loads in the LAR (panel b). (WRP = Wastewater Reclamation Plant)

Water reuse impacts

Pollutant loads are flow-dependent; reduction in flows leads to a corresponding reduction in pollutant loads. Predictably, therefore, flow reductions led to load reductions for copper, lead, zinc, TSS and TDS in the LA River. Unlike pollutant loads, the response of pollutant *concentrations* to reductions in WRP discharge depends on the pollutant: for example, reductions in WRP discharge led to a decrease copper and zinc concentrations, while the same reductions led to an increase in lead and TSS concentrations. Overall, these findings suggest that WRP water reuse corresponds to a reduction in copper and zinc concentrations (i.e., higher WRP reuse leads to lower copper and zinc concentrations), but to an increase in lead and TSS concentrations (i.e., higher WRP reuse leads to higher lead and TSS concentrations). Additionally, across the different WRP scenarios, median pollutant concentrations converge as pollutants travel downstream. This finding suggests that flow increases downstream (due to growing contributing area) dampens the impact that flow reduction from WRPs has on pollutant concentrations.

Conclusions and future work

This research conducted a water quality assessment to quantify the impacts of water reuse on water quality in the LAR. WRPs were found to be a major pollution source in dry weather for copper, zinc, and TDS, but not a large source for lead or TSS. These results suggest that decisions regarding water reuse must consider impacts to water quality: while water reuse will diversify water portfolio of the city, it has complex implications for surface water quality. Depending on the pollutant and its pollution source, water reuse could serve to improve or degrade water quality in the LAR.

References

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