A Tale of Two Wetlands: Using Constructed Wetlands to Mitigate Pesticides in Urban Runoff

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INTRODUCTION

Pesticides transported with urban runoff often reach concentrations toxic to aquatic invertebrates[1]. Constructed wetlands have proven an effective best management strategy in agricultural areas[2,3]. This study is part of a long term monitoring program conducted by the Department of Pesticide Regulation evaluating the efficiency of two small constructed wetlands (Figures 3 and 4) receiving runoff from residential landscapes to reduce pesticide loading to receiving streams. Water and sediment samples are collected from the inlet (Figure 1) and outlets (Figure 2) of each wetland. Samples are analyzed for pyrethroids, organophosphates, fipronil, imidacloprid, and synthetic auxin herbicides. The analytes represents a wide range of physiochemical properties, allowing for a more comprehensive evaluation of analyte transport within the systems. In addition to water quality parameters, toxicity to invertebrates are evaluated. We have installed flow equipment, which will allow a mass balance of pesticide load. Bifenthrin and 2,4-D will be highlighted in this presentation. Not only are they the two most frequently detected pesticides in our systems, they represent opposite ends of the spectrum in terms of physiochemical properties.

Figure 1. Storm drain entering wetland

Figure 2. Wetland outlet

OBJECTIVES

1) Monitor inputs to evaluate presence and concentrations of pesticides typical of urban runoff

2) Determine removal efficacy of wetlands at reducing concentrations and improving water quality

3) Evaluate discrepancies between wetlands to help establish environmental factors that influence transport

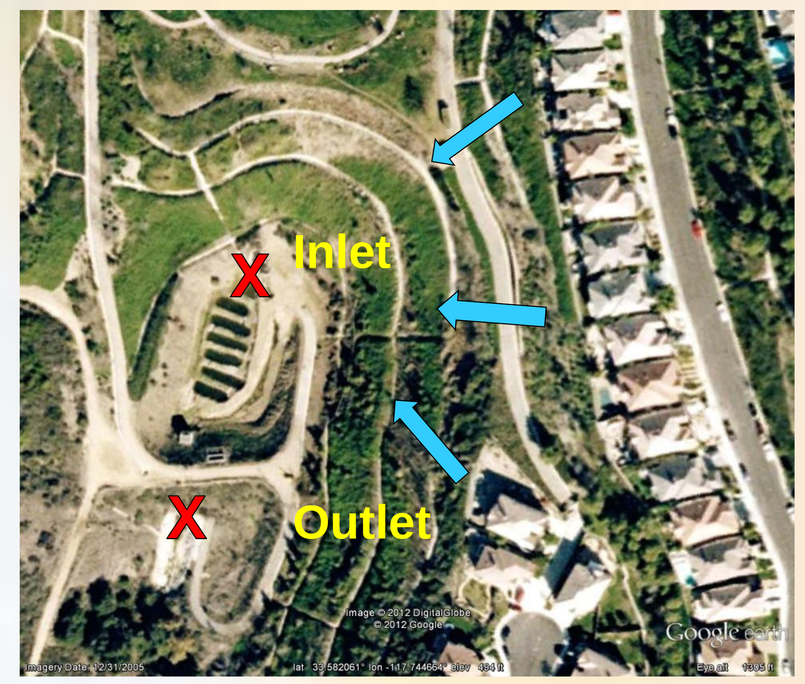

Figure 3. Wetland 1 with flow schematic

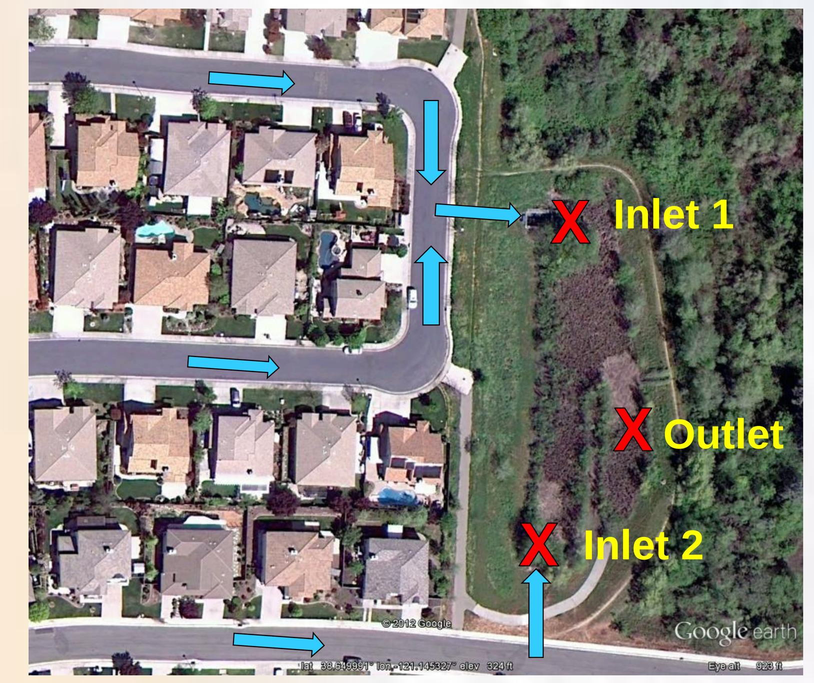

Figure 4. Wetland 2 with flow schematic

METHODS

- Water and sediment grab and composite samples collected at inlets and outlets of wetlands
- Sampling occurred during dry season and storm events
- Water samples analyzed for presence of pyrethroids, organophosphates, fipronil, imidacloprid, synthetic auxin, and photosynthetic inhibitor herbicides
- Sediment samples analyzed for pyrethroid concentrations
- Toxicity units (TU) calculated [TU = OC normalized concentration / $LC50_{OC}$]

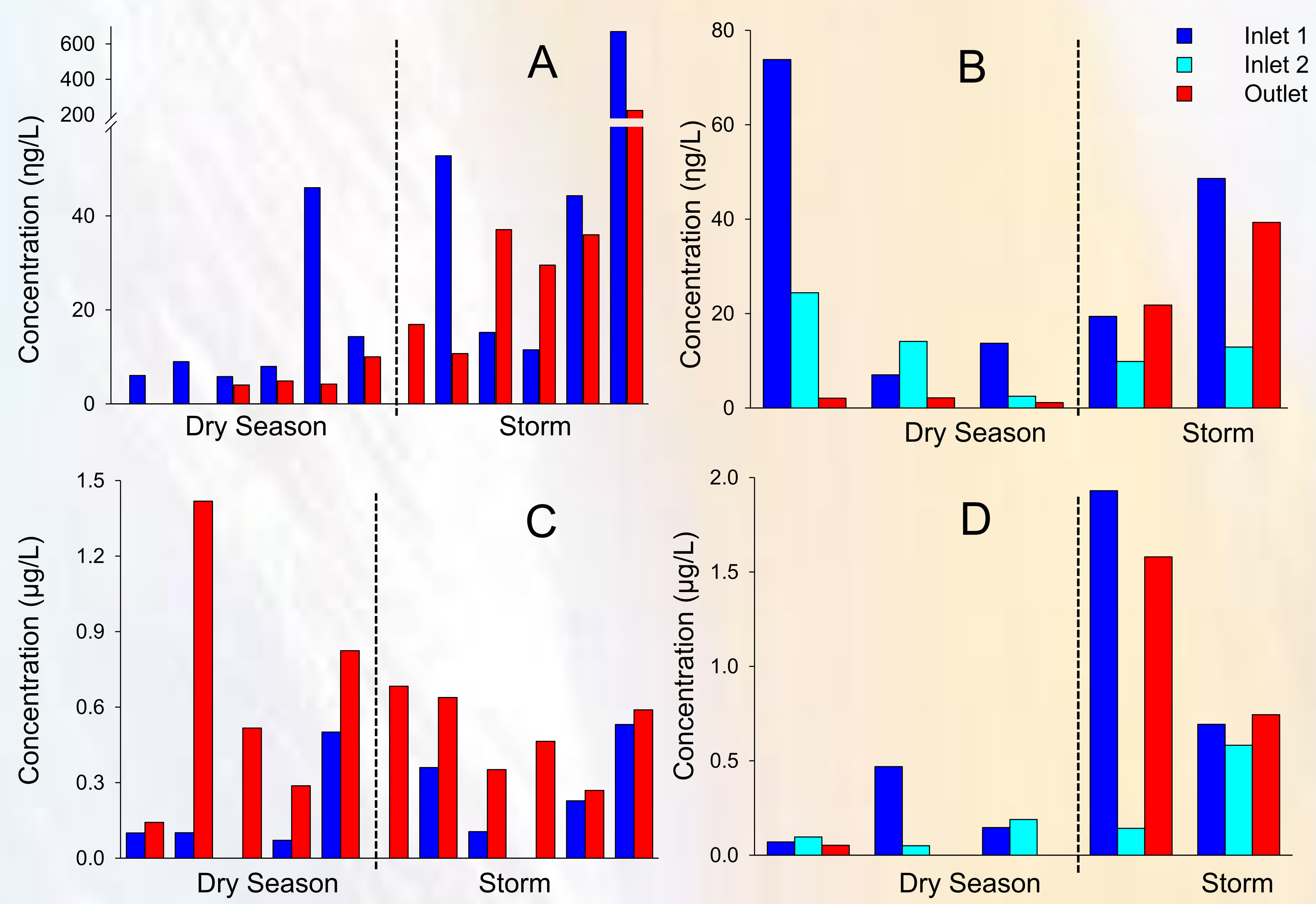

Figure 3. Sampling event concentrations; A) Bifenthrin in Wetland 1, B) Bifenthrin in Wetland 2, C) 2,4-D in Wetland 1, and D) 2,4-D in Wetland 2

RESULTS and CONCLUSIONS

- Pesticide removal efficacies generally decrease during storm events (Figure 3)
- Higher removal rates of bifenthrin compared with the more water soluble 2,4-D in both wetlands (Figure 3)
- Lower relative frequency of detection of pesticides at outlet of Wetland 2 compared to Wetland 1 suggests differences in system characteristics (i.e. vegetation density, stream velocity) responsible for removal (Figure 4)
- Average 66% reduction in sediment total pyrethroid concentrations in conjunction with an average 64% in toxicity units display importance of deposition in removal of sediment bound pesticides (Figure 5)
- Inverse relationship between water pyrethroid concentrations and toxicity to *Hyallela azteca* (Figure 6)
- Toxicity to *Hyallela azteca* reduced at outlets of wetlands (Figure 7)

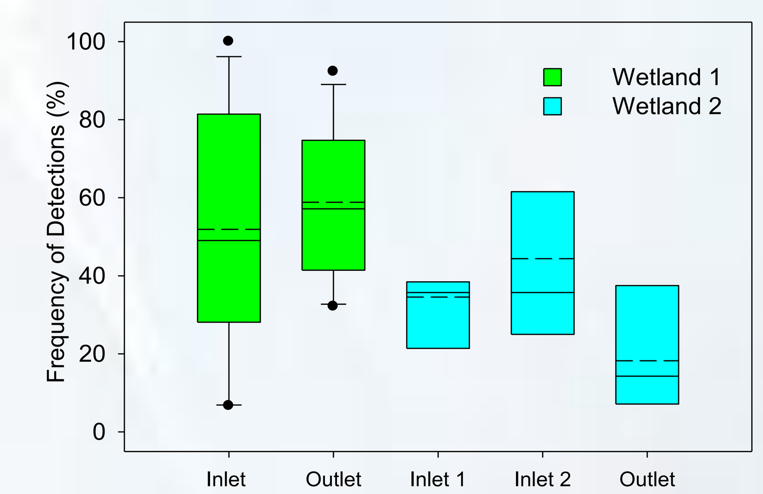

Figure 4. Box plots of frequency of detections of all monitored pesticides within wetlands 1 and 2

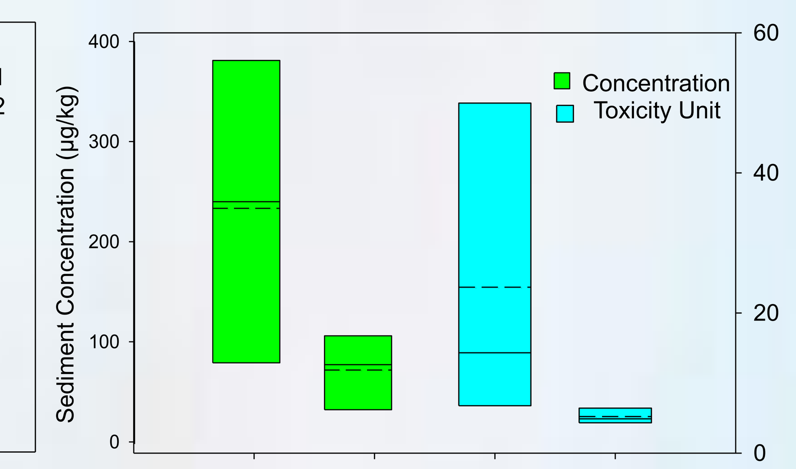

Figure 5. Box plots of sediment total pyrethroid concentrations and toxicity units

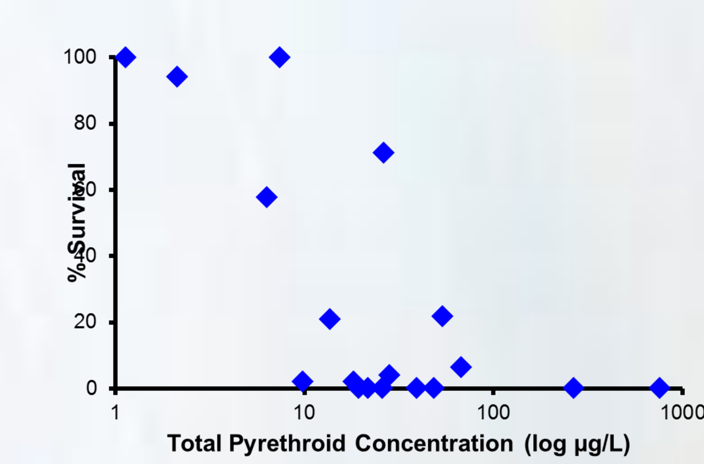

Figure 6. Total pyrethroid water concentrations plotted against 96-hr percent survival of *Hyallela azteca*

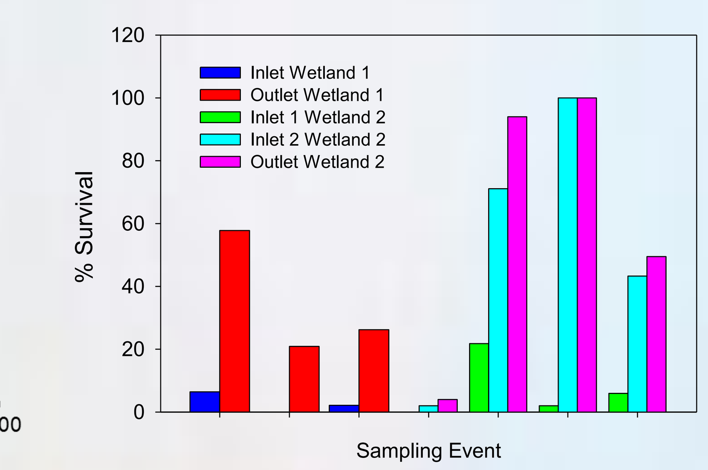

Figure 7. 96-hr percent survival of *Hyallela azteca* at inlets and outlets of wetlands

FUTURE EFFORTS

- Determine removal efficiencies of additional pesticides
- Calculate mass balance using flow data from newly installed sensors
- Determine toxicity of inlet and outlet waters to amphipod *Hyalella azteca*
- Evaluate subsurface transport using piezometer monitoring

REFERENCES

1. Ensminger, M., Budd, R., Kelley, K., and S. Goh. 2012. Pesticide occurrence and aquatic benchmark exceedances in urban surface waters and sediments in three urban areas of California, USA, 2008-2011. Environmental Monitoring and Assessment, online at DOI:10.1007/s10661-012-2821-8.
2. Shulz, R., Hahn, C., Bennett, E., Dabrowski, J., Thiere, G., and S. Peall. 2003. Fate and effects of azinphos-methyl in a flow- through wetland in South Africa. Environmental Science and Technology, 37, p. 2139-2144.
3. Budd, R., O'Geen, A., Goh, K., Bondarenko, S., and J. Gan. Efficacy of constructed wetlands in pesticide removal from tailwaters in the Central Valley, California. Environmental Science and Technology, 43, p. 2925-2930.

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