Temporal Changes in Pyrethroid Urban Runoff from California Surface Waters

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INTRODUCTION

Urban pyrethroid insecticide use has increased concomitantly with decreased chorpyrifos and diazinon urban use since 2001 (http://calpip.cdpr.ca.gov/main.cfm). At their peak use, over 800,000 pounds active ingredient (lb. ai.) of pyrethroids were applied in California by pest management professionals (PMPs). Since 2006 this use has decreased, but current urban use is almost 500,000 lb. ai. applied by PMPs. With this high urban use, pyrethroids enter urban surface waters, where they have been detected at concentrations that are toxic to sensitive aquatic species in laboratory studies (Holmes et al., 2008; Weston et al., 2009; Weston and Lydy, 2010) or exceed US EPA aquatic benchmarks (Ensminger et al., 2013). Due to this toxicity, the California Department of Regulation (CDPR) placed pyrethroids into reevaluation in 2006, with the outcome of new CDPR surface water regulations instituted in 2012 to curtail the urban runoff of 17 pyrethroids (http://cdpr.ca.gov/docs/legbills/calcode/040501.htm#a690). CDPR has been monitoring pyrethroid runoff at several long-term urban monitoring sites since 2009 (Ensminger et al., 2013). With this historical monitoring data, CDPR can determine the effectiveness of the new regulations in reducing pyrethroid loading into surface waters at these long-term monitoring sites.

METHODS

Study Sites and Sampling

- Six stormdrain outfalls and one urban creek site (receiving water) were sampled in the Sacramento area of northern California and six stormdrain outfalls and two urban creek sites were sampled in Orange County in southern California (Figure 1).
- Sediment samples were taken at a subset of the sites.
- Samples were taken approximately four times a year, two during dry season monitoring and two during rainstorm monitoring.
- Monitoring was initiated in 2009.

Chemical Analysis

- Pyrethroids analyzed: bifenthrin, cyfluthrin, cypermethrin, deltamethrin/ tralomethrin, esfenvalerate/fenvalerate, fenpropathrin, λ-cyhalothrin, permethrin, and resmethrin by the California Department of Food and Agriculture (CDFA) or the California Department of Fish and Wildlife (CDFW).

Statistical Analysis

- Statistical analyses were conducted using the non-parametric Kruskal-Wallis test, significance at the 0.05 level, with Minitab® Statistical Software. Trend analysis was conducted either using Akritas-Theil-Sen regression line with associated Kendall's tau (Helsel 2012).
- For the statistical analysis of water concentrations, bifenthrin was used as the representative pyrethroid due to its higher detection frequency (>80%) over the other pyrethroids analyzed.

Figure 1. Long-term monitoring sites

OBJECTIVES

Compare pre- and post-surface water regulations for changes or differences in:

1) pyrethroid (bifenthrin) concentrations in surface water samples at long-term water monitoring sites
2) sediment toxicity units at long-term sediment monitoring sites

RESULTS and CONCLUSIONS

- Water samples from stormdrain outfalls in northern California had significantly lower median concentrations of bifenthrin since the implementation of the new surface water regulations in July 2012. Reductions were only observed during dry season monitoring (Figure 2).
- In southern California, there were no significant changes in the median bifenthrin concentrations after the surface water regulations went into effect (Figure 3).
- At the urban creek sites (receiving waters) in both northern and southern California, there was no observed change in bifenthrin concentrations after the surface water regulations took effect. Bifenthrin concentrations at these sites were frequently below the reporting limits (1-5 ng L^{-1}) and changes in bifenthrin water concentrations at the watershed level could not be ascertained.
- Decreased bifenthrin median concentrations in northern California were only observed during dry season monitoring. Trend analyses show that there was a significant downward trend in bifenthrin concentrations in northern California during the dry season but not during rainstorm monitoring since CDPR began monitoring in 2009 (Figures 4 and 5).
- Reductions in bifenthrin concentrations in dry season monitoring may be related to overall reduced urban runoff and water conservation. The data suggest that bifenthrin applied during summer applications is subsequently washed off in rainstorm events.
- Although there were no significant differences in median bifenthrin concentration in southern California pre- and post-regulation, there was a significant upward trend in bifenthrin concentrations during rainstorm monitoring since 2009 (Figure 6). This trend was not observed during dry season monitoring in southern California (Figure 7) and is independent of the surface water regulations.
- In both northern and southern California, there have been no significant changes in sediment toxicity units (TUs) collected after the surface water regulations took effect in 2012 (Figure 8). Statewide, about 80% of sediment TUs are due to bifenthrin.

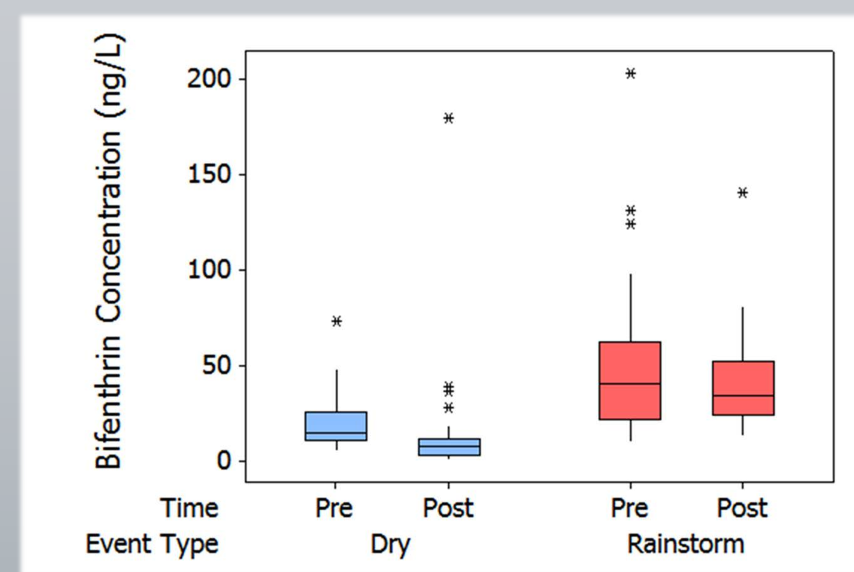

Figure 2. Bifenthrin concentrations from northern California stormdrain outfalls at long-term monitoring sites (dry, p=0.001; rainstorm, p=0.431)

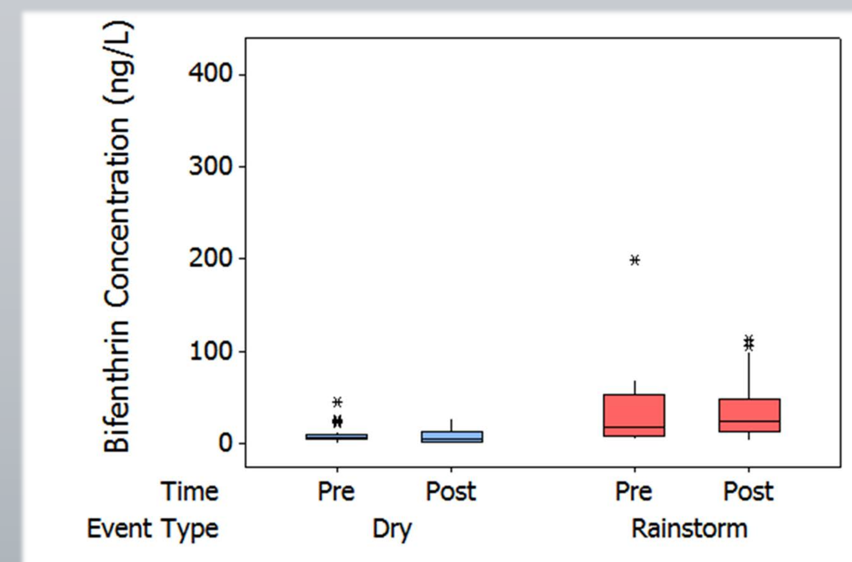

Figure 3. Bifenthrin concentrations from southern California stormdrain outfalls at long-term monitoring sites (dry, p=0.73; rainstorm, p=0.432)

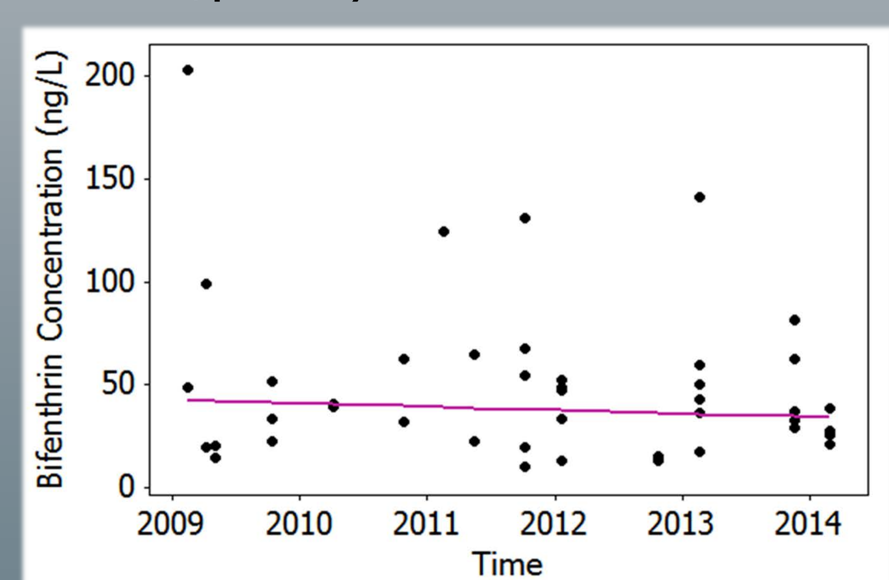

Figure 4. Trend in bifenthrin concentrations at stormdrain outfalls in northern California. Samples were collected during rainstorm sampling (p=0.504)

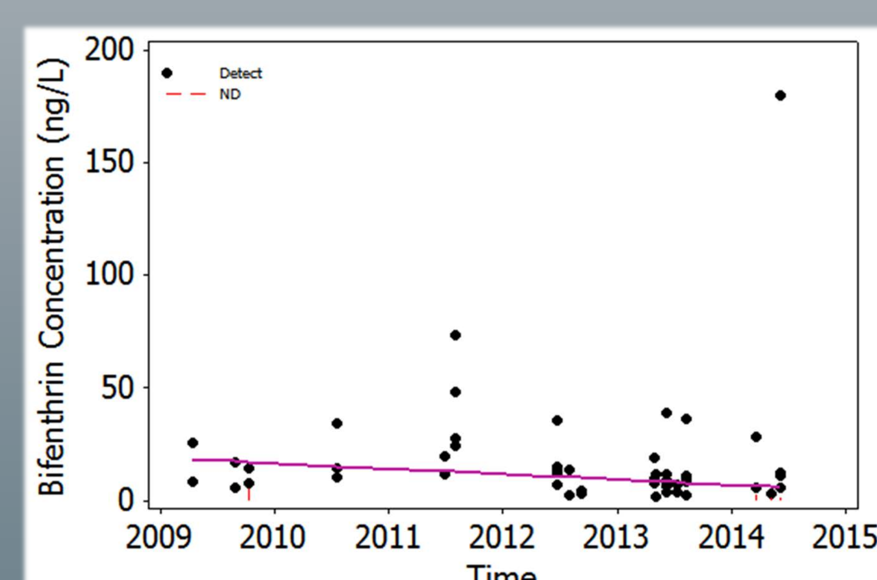

Figure 5. Trend in bifenthrin concentrations at stormdrain outfalls in northern California. Samples were collected during dry season sampling (p=0.006)

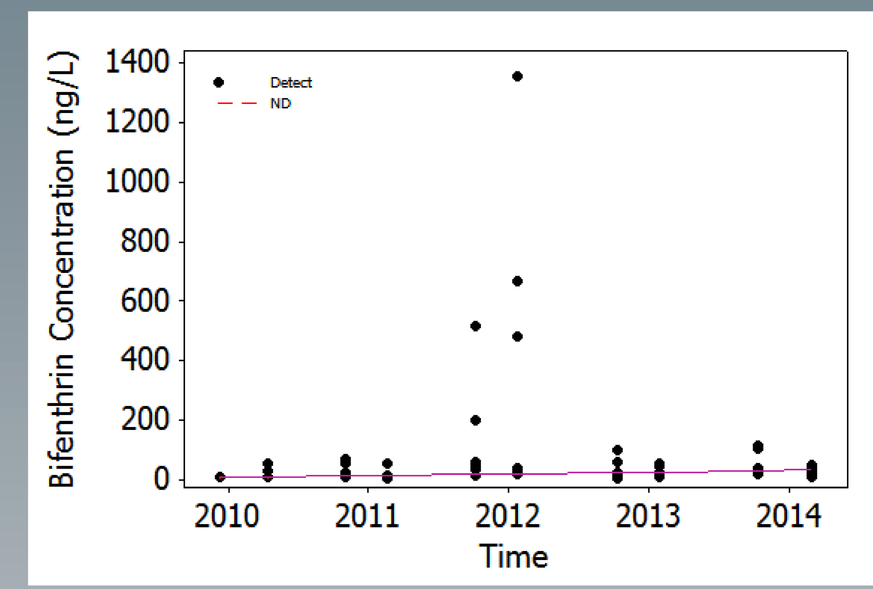

Figure 6. Trend in bifenthrin concentrations at stormdrain outfalls in southern California. Samples were collected during rainstorm sampling (p=0.008)

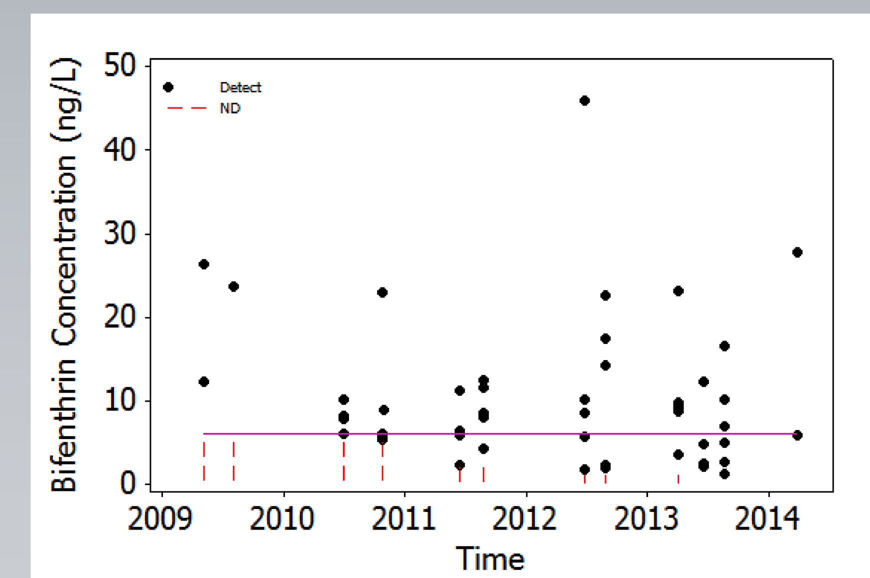

Figure 7. Trend in bifenthrin concentrations at stormdrain outfalls in southern California. Samples were collected during dry season sampling (p=0.97)

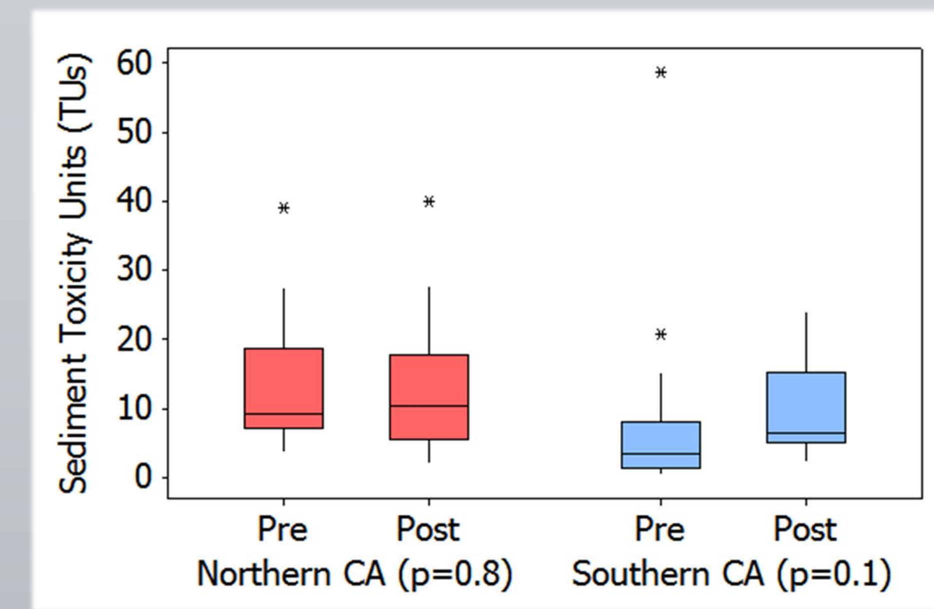

Figure 8. Sediment toxicity pre- and post-regulation.

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