Detention Basin Design and Performance for Pyrethroid Removal

REPORT TO THE
California Department of Pesticide Regulation

Contract No. 20-C0071

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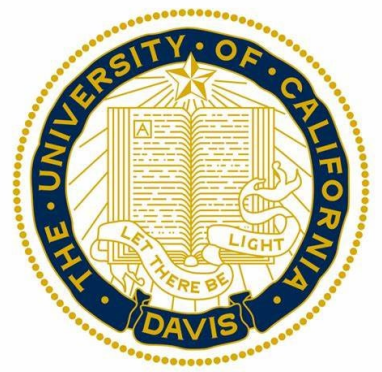
DRAFT FINAL REPORT

June 30, 2024



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ACKNOWLEDGEMENTS

The following staff members in the Department of Civil and Environmental Engineering at the University of California, Davis made important contributions to the method development, sample processing, and sample analyses conducted in this report:

- Chris Alaimo – Spectroscopist
- Luann Wong – Staff Research Associate
- Katelyn Magallon – Undergraduate Student Researcher
- Lindsay Vaughan – Undergraduate Student Researcher

The authors thank Xin Deng, Senior Environmental Scientist at the California Department of Pesticide Regulation, for assistance and guidance as project contract manager. Additionally, we thank Pedro Lima, Senior Environmental Scientist at the California Department of Pesticide Regulation, for assistance with sample collection and transportation. We thank Marie Stillway Garcia, Laboratory Research Supervisor at the UC Davis Aquatic Health Program Laboratory, for conducting the *H. azteca* toxicity testing on collected and prepared agricultural runoff samples. Lastly, the authors would like to thank Khiet Huynh, UC Davis PhD student, and Matthew Rooney for assistance with field sampling and transportation.

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ACRONYMS

AHPL	Aquatic Health Program Laboratory
bif	bifenthrin
C_{DOC}	colloid-bound concentration
C_{Free}	freely-dissolved concentration
C_{Tot}	total concentration
C_{TSS}	particle-bound concentration
cyf	cyfluthrin
cyp	cypermethrin
df	degrees of freedom
DOC	dissolved organic carbon
DPR	Department of Pesticide Regulation
fen	esfenvalerate
f_{OC}	fraction of organic carbon
GC	gas chromatography
HLB	hydrophilic-lipophilic balanced
HPDE	high density polyethylene
K_{DOC}	dissolved organic carbon normalized partition coefficient
K_{OC}	organic carbon normalized partition coefficient
LC50	lethal concentration 50
LOD	limit of detection
LPDE	low density polyethylene
MS	mass spectrometry
MSD	mass selective detector
NCI	negative chemical ionization mode
OC	organic carbon
perm	permethrin
PES	polyethersulfone
PI	prediction interval
PMP	polymethylpentene
POC	particulate organic carbon
PSD	particle size distribution
PTFE	polytetrafluoroethylene
PYR	pyrethroid
QC	quality control
rpm	revolutions per minutes
RSD	relative standard deviation
SIM	selective ion monitoring
SPE	solid-phase extraction
SPME	solid-phase microextraction
TDS	total dissolved solids
TSS	total suspended solids
TU	toxic unit
UASE	ultrasonic-assisted solvent extraction
λ-cyh	lambda-cyhalothrin

EXECUTIVE SUMMARY

Background:
Pyrethroid insecticides are frequently detected in agriculturally impacted surface waters in California at concentrations that are toxic to aquatic organisms.[1–3] Detention basins detain runoff for extended periods of time to allow particles and associated pollutants to settle. Detention basins offer a promising solution to remove particles and particle-bound pyrethroids from agricultural runoff,[4] however research on their efficacy is generally lacking. The goal of this research is to collect agricultural runoff samples from a top agricultural area in California, the Central Coast region; assess particle and particle-bound pyrethroid settling processes; and develop a model to estimate the efficacy of detention basins for particle and pyrethroid removal in agricultural runoff.

Methods:
Agricultural runoff samples were collected from four agricultural sites in the Central Coast region of California. Whole-water samples were collected and analyzed for general water quality and initial pyrethroid concentrations. A flow-through centrifuge was used to separate and collect clarified supernatant and separated sediment at each site. The supernatant and sediment samples were recombined to measure pyrethroid organic carbon partition coefficients (K_{OC} and K_{DOC}) and assess particle settling and associated pyrethroid removal processes via settling column experiments. Small-scale quiescent settling column experiments with suspensions of varying total suspended solids (TSS) concentrations were conducted to assess particle and particle-bound pyrethroid removal over time. Large-scale quiescent settling column experiments were conducted in collaboration with the UC Davis Aquatic Health Program Laboratory (AHPL) to assess particle removal, pyrethroid removal, and changes in *Hyalella azteca* (*H. azteca*) survival. RStudio and Shiny R package was used to develop an interactive web application that models particle and pyrethroid removal in detention basins. The app allows users to input parameters (i.e. amount of runoff, basin surface area, basin holding time, starting TSS concentration, site characteristics, and pyrethroid concentrations) and predicts the particle removal, pyrethroid removal, and pyrethroid phase concentrations in hypothetical detention basins located at each site.

Results:
The measured total pyrethroid concentrations in the whole-water samples ranged from 43.0 to 1,734.4 ng/L, with the highest concentrations observed in site #3, Sal-Chualar. The measured K_{OC} values ranged from 553,000 to 3,050,000 L/kg with an average of 1,510,000 L/kg across all sites and compounds. The measured K_{DOC} values ranged from 88,700 to 3,840,000 L/kg with an average of 1,080,000 L/kg across all sites and compounds. The small-scale settling column experiments revealed that starting TSS concentration influenced settling behavior, indicating that flocculant settling is occurring where particles interact with each other as they settle.[5] The large-scale settling column experiments conducted at field-relevant water depths and holding times resulted in the significant particle and pyrethroid compound removal. After the 6-hr settling point, all sites achieved 85.4-93.7% TSS removal and 74.0-96.4% total pyrethroid removal. After the 24-hr settling timepoint, all sites achieved 94.5-96.8% TSS removal and 89.6-98.8% total pyrethroid removal. The interactive RStudio Shiny app uses the partition coefficients and settling column experimental data to predict particle removal, pyrethroid removal, and pyrethroid phase distributions based on the parameters input by the user. A video example of the use of the app to design a theoretical detention basin at site #3 is provided with this report