The Transport and Fate of Current-use, Sediment Bound Pesticides into a Coastal Marine System

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Current-use pyrethroid pesticides are being transported into the marine environment from agricultural and urban applications in the surrounding watersheds via river suspended solids. Sediment collected only a few miles upstream of the mouth of coastal rivers contained concentrations of these pesticides acutely toxic to some invertebrates. However, no detectable amounts of pyrethroids were found in marine benthic sediments of Monterey Bay, probably due to dilution and further pesticide degradation.

The purpose of the investigation was to determine whether current-use pesticides, used in both agriculture and urban areas, are being transported by suspended solids into the marine environment. Focusing on pyrethroid insecticides, the study examines their transport by coastal rivers on to the shelf of Monterey Bay, and then finally into the deep marine canyon.

Procedures:

Pyrethroid pesticides are used in both agriculture and urban settings. These current-use insecticides are known to be transported into creeks and rivers at amounts toxic to invertebrates, especially amphipods. However, in coastal watersheds in which pyrethroids are used, no work has been done to study the further transport downstream into the marine environment. The Monterey Bay has three major watersheds which have distinctly different watershed land-uses. The San Lorenzo River watershed includes mostly open spaces full of coastal redwoods and one major city, Santa Cruz. The Pajaro River watershed is mainly agricultural and residential. The Salinas River supports a large area of agriculture, known as the “salad bowl of America,” and a couple major cities, including the city of Salinas.

The first part of the experiment included sampling water from all three rivers during major rain events in 2008 and 2009. The sample sites were about one to two miles away from the mouths of each major river to represent what would reach the ocean, but were upstream beyond the range of saltwater influence. The suspended solids were centrifuged out of the water and analyzed for pyrethroids. Bed sediments were sampled in Elkhorn Slough (through which the Salinas River usually flows), at many locations throughout shelf depths of Monterey Bay, and in the Monterey Canyon

Freshwater to Marine Transport:

Analysis of suspended sediment samples indicates that toxic amounts of pyrethroids are being transported in river water to the ocean. Nearly all samples contained pyrethroids, and they were present on suspended sediment at concentrations that would be acutely toxic to sensitive benthic invertebrates if exposed to those sediments after deposition. The pyrethroids bifenthrin and permethrin were most frequently found, though several other pyrethroids were present in occasional samples. There was no unique signature of pyrethroids unique to each river, for all contained similar compounds. Also, it appeared that permethrin and cypermethrin had been used more heavily in the months leading up to the 2007/2008 rainy season, than during the 2008/2009 rainy season.

Bed Sediment Analysis:

Due to the hydrophobicity of pyrethroids, the primary sink for these insecticides would be in bed sediments. Bed sedimentts in the innermost portions of Elkhorn Slough, at the point where agricultural drainages enter the system contained pyrethroids, most notably bifenthrin, permethrin, and esfenvalerte. Those sample sites that had pyrethroids, were found to be slightly toxic when tested with the marine amphipod, *Leptocheirus plumulosus*, though the concentrations were sufficient to cause high mortality in other species for which pyrethroid sensitivities are reported in the literature.

Marine benthic samples were taken using a modified Van Veen grab sampler, while deep sea marine canyon sediments were taken using a remote operating vehicle and corers. The majority of this sampling was done during the summer and fall of 2007, and the spring of 2008. Historical samples from years of higher rainfall, including samples from 2005 and 2006, were also analyzed for pyrethroids. Toxicity tests with *L. plumulosus* showed no toxicity, and chemical analysis of these sediments found no detectable amounts of pyrethroids in these samples.

Significance of Findings:

Transport of pyrethroid pesticides is well documented into freshwater creeks and rivers close to areas of application. However, this study shows that pyrethroids are being transported further downstream, reaching the periphery of Monterey Bay. However, while pyrethroids are entering the marine system on suspended sediment following rain events, once those sediments are deposited on the shelf and in the canyon, pyrethroids are no longer present at measurable concentrations due to dilution. Pyrethroids are known to move from their point of application to freshwater systems. They could have negative effects on freshwater communities of the rivers, and confined shoreline embayments, like portions of Elkhorn Slough. They are unlikely to have acute effects on open water marine communities of Monterey Bay, and chronic effects, if any, would be difficult to demonstrate since they could occur at concentrations below current detection thresholds.

Collaborative Efforts

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