Landscape drains and drainage that ensure excess water in the landscape is removed are a key feature of urban landscapes, especially near building foundations. Drainage often is required to prevent damage to structures or damage to plants by root diseases or other disorders favored by waterlogged conditions. Excess water in the landscape most commonly occurs as a result of rain. It also can occur when site conditions (e.g., poor infiltration and percolation of water in and down through the soil caused by soil compaction, a lack of regular irrigation maintenance, and overall poor landscape design) cause water to pool on a regular basis.

The number of drains, the size of drainage pipes, and number of discharge locations necessary vary considerably among sites, because surface runoff volumes are affected by many factors such as overall site topography, soil type and infiltration rate, and rainfall intensity and amounts. Regardless of drainage design differences, one common feature is that drainage is directly connected to the street gutter and storm drain. Although this design feature does its job by quickly and effectively carrying excess water from the landscape, it also can carry fertilizers and pesticides that have inadvertently entered the landscape drainage system directly or indirectly into the storm drain (Fig. 1).

The July 2010 issue of this newsletter highlighted studies demonstrating the ability of various pesticides to be transported from urban landscapes to storm water outfalls. Drains located near structures or on driveways, patios, and sidewalks as well as drains located in the landscape itself provide an ideal conduit for pesticides and fertilizers to travel from the application site to storm drains where they ultimately reach local water bodies such as creeks and rivers (Figs. 2 and 3).

Prior to applying pesticides and fertilizers, the applicator should identify both landscape and hardscape drains to ensure chemicals aren’t directly applied over the drain (Fig. 1). In addition the applicator might want to designate a “no-spray zone” around the drain to minimize both granules and sprayed chemicals from entering the landscape drainage system at the next irrigation. Another option is to cover drains with an impervious

... continued on Page 6
Monitoring consistently has shown that pesticides applied around houses can move in surface runoff and eventually contaminate downstream water bodies. Concrete is believed to be a major contributor to this problem, because it is impermeable and a common component of urban landscapes. Pesticides can be applied directly onto concrete surfaces, or water or wind can transfer pesticide residues onto concrete following pesticide application. However, even though pesticides have long been used in urban settings, very little actually is known about pesticide fate and transport on concrete surfaces.

With support from the California Department of Pesticide Regulation (CDPR), researchers at UC Davis and UC Riverside have started to look into the underlying processes and mechanisms controlling pesticide behavior on concrete and hence the potential for pesticide residues to contaminate runoff water. This article provides a simple synopsis of what has been discovered so far and summarizes the main findings from three new research publications (Jiang et al. 2010, 2011; Jorgenson and Young 2010).

In the first study of its kind (Jiang et al. 2010), small concrete disks were treated with different insecticides, and the treated concrete disks then were exposed to the summer sun of Riverside. The concrete disks were periodically removed and brought back to the laboratory to measure the “washable” pesticide residue by simply mixing the concrete in water for 10 minutes and analyzing the amount of pesticide transferred into the water.

The results show that following pesticide treatment, the wash-off potential quickly decreased over time. However, it also is evident that a small fraction of the pesticide somehow became “shielded” and continued to be available for release back into the water over an extended period of time. Subsequently, as shown in Figure 1, there are two stages describing the decline of washable pesticide residues from concrete.

The first phase has a very short half-life, suggesting that the wash-off potential of pesticides quickly decreased with time at the beginning. This is in contrast with the second phase showing a much longer half-life, implying that pesticide residues continued to be available for contaminating the sweeping runoff water long after the treatment. In fact, detectable levels of pesticides were found in the wash-off water even after 4 months of exposure to the harsh Riverside summer conditions. This finding highlights that small pores of concrete might protect some pesticide residues from degradation and that pesticide residues left from applications early in the year still might be able to contaminate storm runoff many months later.

In a follow-up study, Jiang et al. (2011) employed a radioisotope tracing technique to explore how pesticides adsorb and desorb from concrete (Fig. 2). In that study, 14C-labeled permethrin was used as a model pyrethroid compound. Small concrete cubes were treated with 14C-permethrin, and desorption into water was measured at 0 days (immediately), 1 day, and 7 days after pesticide treatment.

The results validated that desorption of permethrin initially was fast but became gradually slower over time. As the contact time between the pesticide and concrete increased, the desorption potential also quickly decreased, implying that the longer the time interval is between pesticide application and the onset of a runoff event, the less would be residue available for contaminating the runoff water.

For example, while 56% of permethrin was desorbed into water for freshly treated cubes, only 24% was desorbed when the concrete cubes were tested 7 days after the treatment. The... continued on the next page
results also showed that permethrin decomposed substantially on concrete and the decomposition likely was due to the concrete matrix’s high pH. The degree of decomposition increased quickly with the pesticide residence time on concrete.

Together, these studies clearly suggest that when pesticide-contaminated concrete surfaces come into contact with runoff water, high levels of contamination can be expected initially, but sustained contamination also is possible due to the extended slow desorption.

Jorgenson and Young (2010) at UC Davis evaluated pesticide runoff from small concrete slabs using simulated rainfall. A number of factors were considered in their studies, including runoff onset time (i.e., time after application), rainfall intensity, and formulation types.

Runoff loss of pesticides was rapid initially followed by a more gradual trend, confirming similar observations made in the Jiang et al. studies. Rainfall intensity did not show any discernable effect. Pesticide runoff decreased as the runoff onset was delayed. For instance, mass runoff loss of β-cyfluthrin from slabs 7 days after treatment was 9 times smaller than that from surfaces 1 1/2 hours after pesticide treatment.

However, among all the factors considered, the type of formulation appeared to be the most important factor, causing up to orders of magnitude differences in pesticide runoff losses. Surfactants in the liquid formulations were found to generally enhance pesticide runoff from concrete surfaces. The effect of surfactants was validated by evaluating the effect of the addition of linear alkylbenzene sulfonate (LAS), a common surfactant, to technical pesticides. The influence of surfactants was further confounded by other factors including types of surfactants and other inert additives in formulations.

Types of surfactants and other additives often are considered as proprietary information, and such information is not readily available to researchers. This complexity might prevent a more comprehensive investigation of the role of surfactants in commercial formulations.

Both UC Riverside and UC Davis research groups currently are carrying out new studies to further improve our understanding of pesticide runoff potential from concrete under different conditions. Factors being considered include types and properties of surfactants, hard surface types, relationships between pesticide runoff potential and pest control efficacy (e.g., ant toxicity), and pesticide decomposition.

Looking forward, a critical information gap is to characterize the contribution of urban hard surfaces to pesticide runoff in relation to other landscape components such as soil and grass. Another critical need is to develop simple tools for predicting pesticide runoff potentials from landscapes of different compositions.

References


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Figure 2. Small concrete slabs with different surface finishes have been constructed at the South Coast Research and Extension Center for studying pesticide runoff.
Choosing Pesticides with Fewer Water Quality Risks

The best way to reduce pesticide contamination of our creeks, rivers, and oceans is to avoid pesticides that have high potential for moving into water and adversely affecting aquatic wildlife. For most landscape pests and some structural pests, there are safer alternatives that provide just as effective control. In some cases, nonchemical management methods are the best choice. In other situations, you can choose pesticides that pose minimum risks.

A pesticide’s likelihood of causing harm relates first to how toxic it is to aquatic organisms but also to how easily it will move in irrigation or storm water runoff to storm drains or bodies of water.

A good place to start if you need to manage insects and want to reduce water quality risks is with organically acceptable insecticides. (See Table 1 on Page 5.) Almost all available organic insecticides—pyrethrins are the exception—have low toxicity to aquatic organisms. Organic insecticides generally break down in the environment rapidly, thus further reducing their potential for harm. Using these insecticides eliminates the risks associated with problem insecticides such as fipronil and abamectin (Avid) or materials in the pyrethroid group including bifenthrin, cyfluthrin, and permethrin.

Several fungicides pose significant water quality risks, including organically acceptable copper products such as copper sulfate. Other common landscape fungicides with high water quality risks include mancozeb and chlorothalonil (e.g., Daconil). Fungicides with low risk include oil products such as horticultural oils, neem oil, and jojoba oil as well as fungicidal soaps, Bacillus subtilis (Serenade), triforine, and fosetyl-al (Aliette).

Many herbicides pose risks to aquatic life, often due to their impact on phytoplankton. Landscape herbicides with high overall runoff risks to aquatic life include oxydiazon (Ronstar), pendimethalin (Pendulum, Pre-M), trifluralin (Treflan), and benefin (Balan).

Common landscape herbicides with low risk to water quality include halosulfuron (Sedgehammer/Manage), glufosinate (Finale), cloethidim (Envoy), and mecoprop (MCPP). Glyphosate (Roundup) has a moderate potential for aquatic toxicity due to runoff. The product 2,4-D generally is considered to have low water-quality risk, although some studies have shown negative impacts to fish from ester forms of 2,4-D, primarily when it is applied directly to water. Also the organic oil and acetic acid herbicides have little potential to runoff and cause water contamination problems.


—Mary Louise Flint, Ph.D. Associate Director for Urban and Community IPM and Extension Entomologist
Table 1. Common organic insecticides for landscape use. Only pyrethrins have significant toxicity to aquatic organisms.

<table>
<thead>
<tr>
<th>Common name (examples)</th>
<th>Active ingredient</th>
<th>Pesticide type</th>
<th>Pests effective against</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacillus thuringiensis</strong> (B.t.) (Caterpillar Killer, Dipel, Green Light BT Worm Killer)</td>
<td><em>Bacillus thuringiensis</em> var. <em>kurstaki</em> (var. <em>israelensis</em> isn't effective on caterpillars but is used for mosquito larvae)</td>
<td>insecticide</td>
<td>caterpillar larvae of moths and butterflies, especially newly hatched larvae feeding exposed on leaves or buds</td>
<td>Bacteria that kills some caterpillars. Must be consumed by caterpillar within 24 to 48 hours of application. Breaks down rapidly. Not harmful to organisms outside moth and butterfly group. Good coverage essential.</td>
</tr>
<tr>
<td>Borate based baits (Gourmet Liquid Ant Bait)</td>
<td>boric acid, disodium octaborate tetrahydrate, borax</td>
<td>insecticide</td>
<td>ants</td>
<td>For use in bait dispensers. Low toxicity to humans and most nontargets but must be 1% or less boric acid to be effective. Baits containing these products are much safer than sprays.</td>
</tr>
<tr>
<td>Entomophagous nematodes</td>
<td><em>Steinernema</em> species, <em>Heterorhabditis</em> species</td>
<td>biocontrol for certain insects</td>
<td>clearwinged moth larvae, carpenterworm, lawn cutworms, lawn grubs</td>
<td>Usually mail ordered and used right away. Read UC Pest Notes for directions. <em>Heterorhabditis</em> used for lawn grubs, <em>Steinernema</em> for others.</td>
</tr>
<tr>
<td>Insecticidal soap (Safer Insecticidal Soap)</td>
<td>potassium salts of fatty acids</td>
<td>insecticide, miticide</td>
<td>aphids, whiteflies, immature scale insects, spider mites</td>
<td>Good coverage essential, as insect must be completely covered. Provides partial control (70 to 80%) and no residual, but natural enemies will mostly survive to help control the population. Repeat application might be required.</td>
</tr>
<tr>
<td><strong>Spinosad</strong> (Garden Insect Spray, Entrust)</td>
<td>Spinosad</td>
<td>insecticide</td>
<td>caterpillars, leafminers, thrips, and katydids</td>
<td>Some beneficial insects or bees might be killed in the first 24 hours, but rapidly breaks down. Low toxicity to people. Derived through fermentation of a naturally occurring bacterium.</td>
</tr>
<tr>
<td>Pyrethrins or pyrethrum</td>
<td>pyrethrins</td>
<td>insecticide</td>
<td>a range of insects</td>
<td>Derived from the chrysanthemum daisy. Products formulated with Piperonyl butoxide (PBO) aren’t organically acceptable. <strong>High toxicity to fish, aquatic organisms, and fish.</strong></td>
</tr>
<tr>
<td>Neem seed extract (Amazin Plus 1.2% ME, Safer Brand Bioneem Multi-purpose Insecticide &amp; Repellent Concentrate)</td>
<td>Azadirachtin</td>
<td>insecticide</td>
<td>beetles, thrips, aphids, white grubs, mole crickets, crane flies</td>
<td>Insect growth regulator. Not effective on adults. Can cause injury to some tender plant tissue.</td>
</tr>
<tr>
<td><strong>Horticultural oil, insecticidal oil</strong> (Saf-t-Side, Year Round Spray Oil, Volk Oil Spray, JMS Stylet)</td>
<td>petroleum oil, superior oil, supreme oil, narrow range oil, paraffinic oil</td>
<td>fungicide, insecticide, miticide</td>
<td>aphids, whiteflies, scale insects, spider mites, mealy bugs, lacebugs, psyllids, thrips, other sucking insects, some insect eggs; also powdery mildew on many plants, black spot on roses,</td>
<td>Good coverage is essential. Insect must be smothered. Best activity on insects when temperatures are greater than 45°F. Some products might cause plant injury if applied when temperatures are above 85°F. Don’t apply during periods of drought or when plants exhibit moisture stress. Natural enemies might be killed by contact but not by residue.</td>
</tr>
<tr>
<td>Neem oil (Green Light Rose Defense, Garden Safe Fungicide 3, Safer Brand 3-in-1 Garden Spray)</td>
<td>neem oil</td>
<td>fungicide, insecticide, miticide</td>
<td>aphids, whiteflies, scale insects, spider mites, mealy bugs, lacebugs, psyllids, thrips, other sucking insects, some insect eggs; also powdery mildew on many plants, black spot on roses</td>
<td>Good coverage is essential. Insect must be smothered. Best to apply in early morning or late evening to minimize the potential for leaf burn. Might also cause injury to plants with tender tissue. Don’t apply during periods of drought or when plants exhibit moisture stress. Natural enemies might be killed by contact but not by residue.</td>
</tr>
<tr>
<td>Other plant-based insecticidal oils (many brands and mixtures)</td>
<td>d-Limonene, canola oil, cottonseed oil, rosemary, thyme, clove and sesame oils</td>
<td>insecticide, miticide</td>
<td>soft-bodied insects and mites as described for other oils</td>
<td>These oils work similar to horticultural oils. Good coverage is essential.</td>
</tr>
</tbody>
</table>
material such as a secured plastic sheet prior to application.

Some landscape architects have started to incorporate structural elements that reduce runoff into the overall design such as vegetative filters, swales, and dry streambeds (Fig. 5). These landscape features break the direct connection between landscape drains and storm drains, allowing surface runoff to infiltrate into the landscape at a safe distance from building structures. Water from excess irrigation and small storm events no longer runs off the landscape carrying pesticides and fertilizers to the storm drain. Landscapers also are installing perforated drainage pipe to improve overall drainage and to reduce root diseases common in heavy, waterlogged soils (Fig. 6).

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Have a question? E-mail it to ucipm@ucdavis.edu.

Biological Control Resources

Want to reduce your reliance on insecticides by encouraging beneficial insects in the landscapes you manage? The UC IPM program has a number of resources to help you do this. At the Natural Enemies Gallery page of the UC IPM Web site, http://www.ipm.ucdavis.edu/PMG/NE/index.html, you’ll find photos and information about 40 of the most common predators and parasites in California landscapes. These lists are sortable by pest attacked, common and scientific name, or insect family.

This page also has a link to a new 24-minute narrated presentation about biological control, which can familiarize you with common natural enemies and how to use them. Other resources accessible through this page include the free Biological Control and Natural Enemies Pest Note and information about ordering the Natural Enemies Handbook: The Illustrated Guide to Biological Control.