Article 16

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Diazinon Sources in Runoff From the San Francisco Bay Region

Diazinon is a common broad spectrum insecticide that is widely applied by homeowners and pest control professionals alike. In California alone, diazinon is contained in over 200 different pesticide formulations. The primary use for diazinon is for general insect control, with the most common targets being ants, fleas, ticks, grubs and spiders. It is often the insecticide of choice to deal with fire ant problems in the South.

There are several reasons why watershed managers are concerned about the use of diazinon. To begin with, diazinon is highly toxic to aquatic life at exceptionally low levels. Toxicologists have found that diazinon causes mortality in the popular bioassay organism, *Ceriodaphnia dubia* (water flea) at exposure levels as low as 300 parts per trillion. In addition, diazinon is very soluble and therefore very mobile in the urban environment. Although it eventually breaks down in the environment, diazinon has a half-life of about 40 days in surface waters. In addition, diazinon is typically sprayed as a concentrate on a spot basis near foundations, driveway cracks, sidewalk crevices and other impervious surfaces.

Given these factors, it is not surprising that researchers are frequently finding diazinon in stormwater and dry weather flows in urban streams, particularly in the South (Schueler, 1995). Diazinon has been detected in urban streams in Sacramento, CA (O'Connor, 1995) Atlanta, GA (Hippe *et al.*, 1994) and Dallas-Fort Worth, TX (Brush *et al.*, 1996). In each case, diazinon was detected in nearly 90% of all stream samples. In the Texas study, the mean runoff concentration of diazinon at 11 residential catchments was a whopping 1,800 ng/l (parts per trillion).

Until recently, our understanding of the sources and pathways of diazinon in urban watersheds has been very sparse. A much clearer picture, however, has recently emerged from a comprehensive research effort in the San Francisco Bay region. The study team included James Scanlin, Tom Mumley, Revita Katznelson, Val O'Connor and many other colleagues. The study team has progressively traced diazinon sources to increasingly smaller watershed units. The team investigated diazinon at the regional scale, and then proceeded to urban watersheds, and even smaller subwatersheds. From there, they continued to trace diazinon through individual storm drain outfalls, to street gutters and finally, to individual homes. In addition, the team profiled how diazinon is actually used in residential areas, through surveys and retail sales statistics. Taken together, the story of their search is both interesting and very disturbing.

The story begins with how diazinon is actually used. Scanlin and Cooper (1997) started by checking statistics on retail sales of diazinon, which are required under California's extensive pesticide reporting system. For the California and the Bay region, Scanlin and Cooper estimated that 0.04 lbs. of active diazinon was applied outdoors per person each year in the San Francisco Bay area. As such, it was the leading insecticide used in California, in terms of retail sales of active ingredient. The primary reason cited for applying diazinon was general insect control (about 80%), with some additional use to control garden pests (20%). About half of the diazinon was applied to structures, and half applied to lawns and landscaped areas. Diazinon users were roughly split between homeowners and pest control companies. Users applied diazinon as a liquid concentrate about 65% of the time, and as granules about 34% of the time.

Concern about diazinon in the Bay area was initially prompted by a series of toxicity tests conducted by Steve Hansen and others the early 1990s. Of 130 runoff samples from Bay area creeks, 22% caused mortality in *Ceriodaphnia dubia* within 48 hours, and further testing revealed that diazinon was the primary cause (Katznelson and Mumley, 1997). Consequently, a synoptic study was undertaken in 1995 to monitor diazinon, and 167 urban creek samples were collected around the Bay. Potentially toxic levels of diazinon were found in 27% of the storm samples (Table 1). The study concluded that diazinon was a widespread problem in many urban creeks, and also suspected that chlorpyrifos, another insecticide frequently found in creek runoff, might also be a problem.

The next chapter of the story involved extensive diazinon sampling across the San Francisco Bay region. New sampling methods made it easier to detect diazinon at both lower levels and lower cost. The study team compiled hundreds of samples, and detected diazinon in rainwater, urban runoff, dry weather flow, creek sediments, wastewater effluent, and even the waters of

San Francisco Bay (Table 2). The highest levels were found in stormwater and dry weather flows in urban creeks. Rainfall was initially suspected as a major source of diazinon, since previous research had found rainwater concentrations as high as 4,000 ng/l. These very high levels, however, were collected in the highly agricultural Central Valley of California, and were apparently influenced by the drift of diazinon from orchard spaying. In the San Francisco Bay region, diazinon was detected in less than one half of rainfall samples, and no rainfall sample exceeded 100 ng/l.

Diazinon was also routinely detected in wastewater effluent, which was presumably due to indoor use and disposal. Treatment plants had great difficulty in removing this soluble insecticide, and it frequently caused the plants to flunk their effluent toxicity tests. Diazinon levels in the water column of San Francisco Bay were well below potential estuarine toxicity thresholds (30 ng/l chronic, 80 ng/l acute). It is worth noting that the highest concentrations in the Bay were almost always found near urban creeks.

Based on the regional monitoring data, the study team narrowed their focus to urban creeks, where the greatest potential for toxicity existed. The search for watershed sources of diazinon then began in earnest. Scanlin and Feng (1997) performed automated sampling of runoff and dry weather flow in Castro Valley Creek, a 5.5 square mile residential watershed in Alameda County. They sampled 22 storms over two years and detected diazinon in all events. The mean storm concentration was 343 ng/l and ranged from 90 to 820 ng/l. As might be expected, higher diazinon levels were found during spring storms when application rates were greatest. Diazinon concentrations also tended to be greater if it had been dry for several weeks before the storm.

High concentrations persisted for several days after storms and often exceeded 200 ng/l. In general, diazinon levels dropped only 50% two days after a storm. Scanlin and Feng (1997) computed a mass balance for Castro Valley Creek and concluded that 90% of the diazinon load was delivered by stormwater runoff. They concluded the mass load discharged by the Creek could be

Table 1: Occurrence of Diazinon in San Francisco Creeks Spring 1995 Coordinated Survey (N=167) (Katznelson and Mumley, 1997)

Diazinon Levels	Toxicity to *Ceriodaphnia*	Percent of storm samples
< 30 ng/l [1]	Not detectable	43
30 to 150 ng/l	Non-lethal	29
150 to 300 ng/l	Lethal 4 to 7 days	16
300 to 500 ng/l	Lethal within 96 hours	11

[1] ng/ l = nanograms per liter (or parts per trillion)

Table 2: Summary of Diazinon Levels (ng/l) from Different Sources in the San Francisco Bay Region (Katznelson and Mumley, 1997)

Diazinon source sampling	N	Mean	Maximum	Minimum
Rainfall [1]	8	58 [3]	88	33
Stormflow [2]	23	262	590	< 30
Dry weather flow	43	282 [4]	3,000	< 30
Creek sediments *(µg/kg)*	43	19	59	2.6
San Francisco Bay	55	10	98	< 0.1
Wastewater effluent [5]	21	78	809	< 30

[1] Mean of rainfall samples with detectable diazinon concentrations.

[2] Selected streamflow samples.

[3] Diazinon levels in rainfall from the Central Valley of California influenced by agricultural pesticide drift were about two orders of magnitude higher than the Bay area samples which were not influenced by agricultural spraying.

[4] If two extreme values are excluded, the mean dry weather concentration drops to 170 ng/l.

[5] Mean of effluent discharge from Bay area wastewater treatment plant, presumably reflects household disposal. Removal rates at treatment plants averaged only 35 percent.

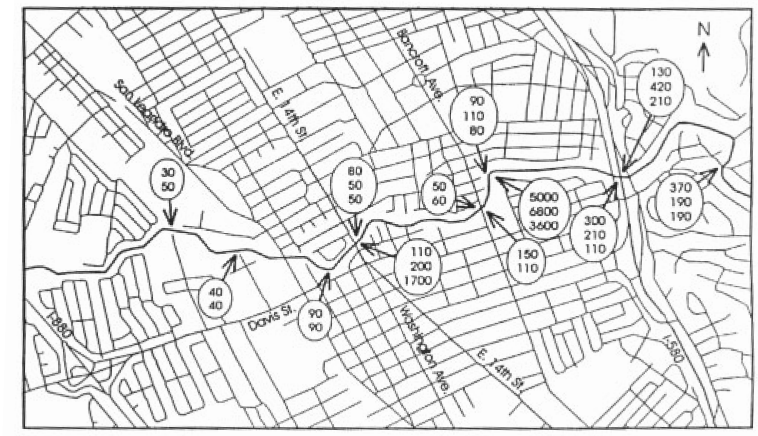

Figure 1: Street Gutter Sampling of Diazinon in Castro Valley Creek (Scanlin and Feng, 1997)

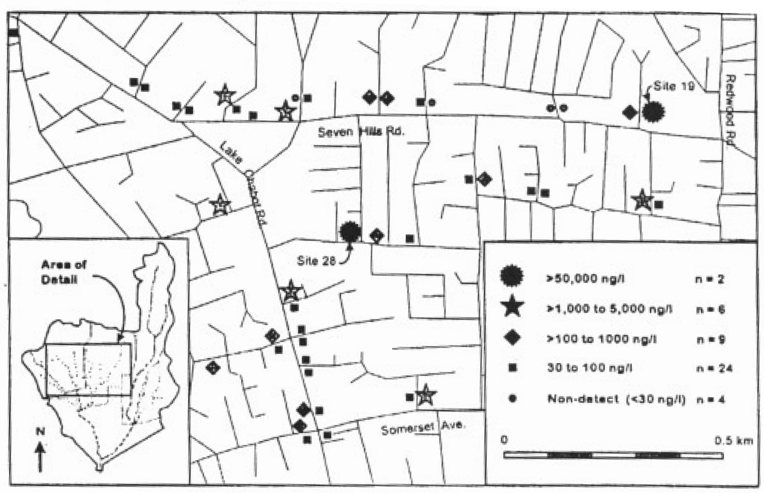

Figure 2: Diazinon Levels in Small Drain Outfalls in San Leandro Creek, Spring, 1996 (Katznelson and Mumley, 1997)

accounted by approximately 0.3% of diazinon applied outdoors in the watershed. This finding suggests that it takes very little washoff of the applied diazinon to produce the observed instream concentrations.

Sampling continued at smaller catchment scales. Scanlin and Feng collected grab samples in five smaller catchments within Castro Valley Creek during a single storm event in April of 1996. The range of diazinon levels found in these catchments (mean 390 ng/l, range 201-675 ng/l) was nearly identical to that seen in Castro Valley Creek, despite the fact though each catchment differed greatly in pervious area, residential area, and open space. This suggested that diazinon loads could not be predicted on the basis of general land cover variables.

The search for diazinon continued on an even smaller scale. Scanlin and Feng moved up the catchments to sample individual street gutters. They collected samples at 45 randomly selected street gutters within two catchments of Castro Valley Creek during a single storm event in May of 1996. Each street gutter served about four of five homes. At last, they were able to find diazinon hotspots (Figure 1). The mean diazinon level climbed to 3,900 ng/l in all of the street gutter samples, but the range spanned three orders (30 to 70,000 ng/l). After a block-by-block search, they concluded that diazinon levels in Castro Valley Creek were produced at a very small number of individual residential hotspots. As few as two to 4% of residential homes in the watershed accounted for the bulk of diazinon observed in Castro Valley Creek. A similar pattern was also observed in monitoring of small storm drain outfalls to San Leandro Creek (Figure 2).

The final stage of monitoring evaluated diazinon runoff from individual homes. Two homes were selected for intensive source area sampling. Diazinon was applied to each home at recommended rates and in accordance with label instructions. Source area samples were collected from roof drains, patios and driveways following rainfall events for 50 days after application (Table 3). As might be expected, the highest diazinon concentrations were recorded when it rained a few days after initial application (1,100 to 1,200,000 ng/l). Nevertheless, high diazinon concentrations were still recorded in runoff three and even seven weeks after application. The largest source areas were patios and driveways, followed by roof drains.

Implications

The diazinon research has several profound and troubling implications. The first is that harmful diazinon levels can be produced in urban streams from a handful of individual homes within any given watershed. Once diazinon gets into urban streams, it is not easy to remove it. Because of its solubility, current stormwater and even wastewater treatment technology cannot significantly reduce diazinon levels. The only real tool to control diazinon in urban watersheds is source control—to either reduce the use of diazinon or to apply it in a safer manner. It should be noted that residential source areas monitoring indicated that "proper use" still produced very high diazinon levels, even when label directions were scrupulously followed.

Consequently, a strong case can be made that the use of diazinon should be restricted or banned in residential areas. Fortunately, for the first time since diazinon was initially registered in 1956, a unique opportunity is currently available to consider such actions. Every pesticide must be re-registered under 1988 federal pesticide regulations, and diazinon's registration is being reviewed right now. Accordingly, formulations

Table 3: Concentrations of Source Area Runoff Samples Over Time From Single Family Homes Where Diazinon Was Applied According to Label Instructions (Katznelson and Mumley, 1997)

	First week	Third week	Seventh week
No. of samples	5	6	12
Mean	281,600	166,500	19,200
Minimum	1,100	350	50
Maximum	1,200,000	880,000	110,000

and applications that cause runoff toxicity should be investigated and removed from USEPA's sanctioned list of registered diazinon uses.

In the meantime, watershed managers should send a strong message to homeowners that killing ants could very well harm streams, and encourage residents to practice integrated pest management (IPM) around their homes. The Urban Pesticide Committee is currently devising an outreach campaign to educate homeowners on safer ways to control insect pests in the Bay area that stresses IPM (Scanlin and Gosselin, 1997). Southern watershed managers may also wish to launch an aggressive homeowner IPM campaign, since diazinon use for fire ant control in these regions produces higher diazinon levels than the Bay area.

—TRS

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