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Mobility of herbicides applied to hard surfaces in riparian zones

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Abstract

Weed control by herbicide application is an effective strategy in the urban environment, but treatment in urban riparian zones is potentially significant with respect to wetting and run off of herbicides after rainfall events on relevant hard surfaces such as concrete or asphalt, drains, channels, and paths. In the literature, the study of herbicide loss from non-agricultural surfaces is only recent, with no such studies recorded as yet in Australia. This short communication outlines a proposed controlled laboratory study to determine the extent to which herbicides are removed from treated surfaces following a rain event, in order to minimise experimental variability frequent in the larger field studies cited. The forthcoming study is made up of the following components: test surfaces, herbicides formulations and their method of application, simulated rainfall, and its collection following runoff. Selection of relevant herbicides for riparian weed control, and laboratory experimental design are discussed.

Introduction

Herbicide use in riparian zones (vegetation communities bordering streams and rivers) presents a challenge separate from its use in other environments (e.g. forest, grassland) since within such zones, land plants border and grow directly adjacent to aquatic systems (MacLeod 2002). Any herbicide treatment within such zones therefore involves high risk of contaminating waterways by direct spray, runoff, and leaching. In urban settings, vegetation control is often undertaken along open stormwater channels, where narrow herbicide-treated strips are created to stop riparian vegetation encroaching directly onto the channel.

In addition to vegetation and soil, other components of riparian ecosystems include rock escarpments and platforms, pebble banks, and gravel. In the urban environment additional hard surfaces comprising concrete and asphalt are relevant, frequently occurring as linings of stormwater channels or surfaces of adjoining roads or paths. These surfaces are likely to receive herbicide treatment when vegetation encroaches on them. Treatment of non-agricultural zones such as paths, road, and drain edges is usually by 'spot spraying' i.e. applying a specific herbicide concentration to wet weeds to the required degree, rather than by applying a defined amount per unit area (Kent and Preston 2000). Handguns attached to tanks on vehicles or knapsack sprayers may be employed. Where spot spraying methods are used, label directions often state that target foliage should be 'thoroughly wetted' in order to ensure effective coverage (AWRC 1985). Judgements of sufficient wetness vary amongst those applying herbicides, and in any case when high-volume application equipment is used it is difficult to avoid over-application in some places that will result in excess herbicide running off. It is also impractical to always avoid spraying where small gaps in the weed cover occur. Where sparse weed foliage occurs over hard surfaces it is inevitable that wetting the leaves sufficiently will deposit considerable amounts of herbicide on the surface below. The environmental fate and transport of herbicides that deposit on hard surfaces is potentially important, and should be characterised in order to complement knowledge of herbicide behaviour after being deposited on vegetation, soil and water. This study will improve knowledge of herbicide fate in riparian systems and will also generate information relevant to roadsides and other situations involving artificial hard surfaces. Results will be used in the development of improved guidelines for herbicide use in riparian zones.

Review of existing literature

Few previous studies have investigated herbicide losses from hard surfaces, in contrast to the large body of work reporting behaviour in soils. Two studies were conducted by researchers from the Soil Survey and Land Research Centre at Cranfield University, UK (Shepherd et al. 1997, Shepherd and Heather 1999). The researchers embarked on an unpublished pilot study in 1997, which investigated the loss of the herbicides atrazine, diuron, glyphosate, isoxaben, oryzalin, and oxadiazon in rainwater runoff collected from a roadside drain (Heather et al. 1998). Although the study produced evidence for herbicide loss achieving 'steady state', where accumulated losses (expressed as a percentage of the initial amount applied) reached a maximum threshold value, the study was complicated by limitations that reduced the conclusiveness of the exercise. The researchers encountered equipment failure in the flow apparatus monitoring runoff, and therefore reported flow data needed to be back-estimated. Significantly, rainfall events were uneven during the two study treatments, where one treatment suffered rainfall on the same day as application.

This pilot field study led to a laboratory study where rainfall and delay between herbicide application and onset of rain were controlled variables. While the same group of herbicides were applied, the study involved three test surfaces: concrete, asphalt, and ballast (50 mm graded granite). After application, simulated rain was applied after a time gap varying between 6-128 hours (7 days). Rainfall events of 5, 10 and 15 mm were simulated, with samples taken at the beginning, middle, and end of rainfall events. It had been noted in the pilot study that, for all herbicides, the highest runoff loss occurred under approximately 7 mm of rainfall, with no further loss recorded after 13 mm. It is expected that the proposed doctoral study will follow similar experimental parameters in the design of the surface-runoff models, but the system must avoid the design flaws that were experienced by Shepherd and Heather (1999).

A field study conducted by the US Geological Survey, to assess the impact to water quality from herbicides in roadside vegetation management, was broader in scope and tracked herbicide concentrations over three months (Wood 2001). The herbicides tested were those used along roadsides by the Oregon Department of Transportation (ODOT), with the aim of the study being to evaluate the contribution from ODOT procedures to herbicide loads in nearby streams. For the study, test plots were established on a highway edge. The plots were treated with herbicides and simulated rainfall applied, with samples collected from an existing drainage ditch adjacent to the plots. While the study concluded that herbicide usage by ODOT in roadside vegetation management did not significantly contribute to herbicide loads present in nearby streams, the analysis was limited by high variability, causing the quality of herbicide concentration data to be termed semi-quantitative. Such problems are one reason why the present study has opted for a bench-scale laboratory model rather than field simulations.

Experimental design

In this project the nominated herbicides are a selection of those commonly used in Australia for the control of either grass or broadleaf weeds in relevant situations (Table 1). Each compound represents a different chemical class so that a range of behaviours might be expected. All products are common to municipal vegetation management strategies in Melbourne. Of the selected herbicides only certain formulations of glyphosate are registered for use in aquatic situations. The first two surfaces to be tested will be concrete and asphalt. Considerable effort is being put into obtaining samples of concrete and asphalt from demolished footpath and road surfaces, respectively. This is because of the possibility that weathered surfaces will have different properties to freshly produced ones. Small blocks of these surfaces will be sprayed with different herbicides and then treated with a controlled rate of simulated rainfall in the laboratory. Herbicides will be applied to surfaces via calibrated spray nozzles in a track sprayer system at the Keith Turnbull Research Institute, ensuring a high degree of uniformity amongst replicate blocks. The blocks will then be transported to RMIT for the drying time and application of simulated rain.

Runoff will be collected and analysed and the amounts of fluazifop, triclopyr, and glyphosate analysed via gas chromatography in accordance with the APHA standard methods for acidic herbicide and glyphosate analysis (APHA 1995). For the metsulfuron methyl analysis, various journal publications have described enhanced high-performance liquid chromatography methods for sulphur-containing compounds (Henion *et al*. 1982).

Also present in the water samples besides the herbicide compound of interest there will in some cases be solvents, surfactants, or wetting agents included in herbicide formulations or added in accordance to label directions (metsulfuron methyl requires the addition of a wetting agent for all uses). Amounts of these compounds will also be determined because the risk of these substances to fauna can be greater than that posed by the companion herbicide (Goodwin and McBrydie 1999).

Initially, behaviour of the selected herbicides on concrete and asphalt following a range of drying times will be investigated. Subsequent work may examine the effect of optional surfactants on herbicide mobility, or the study may proceed to look at other relevant materials such as wood or bark chips that are used as mulch in riparian planting, or more herbicides may be included.

Project progress to date

Contact was made with local authorities that coordinate weed management programs in riparian environments in order to establish choice of herbicides and methods of application in the field.

A source of used concrete and asphalt has been found and concrete samples have been prepared for testing. This involved cutting around 100 pieces to size (approximately 20 × 20 cm) followed by an outdoor exposure period in an attempt to standardise each test sample surface.

A pump-regulated rainfall simulator system has been developed to deliver controlled and reproducible amounts of water to test surfaces at a realistic rate. Application of herbicides to the concrete samples will commence soon.

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Table 1. Summary information for herbicides chosen for the study.

Herbicide	Chemical class	Herbicide group	Mode of action	Notes*
Fluazifop-p butyl	Aryloxyphenoxy propionate	A	Acetyl coA carboxylase inhibitor	Moderately hazardous to fish
Metsulfuron methyl	Sulfonylurea	B	ALS inhibitor	Avoid streams, rivers or waterways
Triclopyr	Pyridine	I	Plant cell growth disruptor	Highly toxic to fish and other aquatic organisms
Glyphosate	Glycine	M	EPSP synthase inhibitor	Avoid dams, rivers or streams

* Notes summarise 'PROTECTION OF WILDLIFE, FISH, CRUSTACEA AND ENVIRONMENT' statement as seen on product labels.

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Weeds in wild places – managing environmental compliance

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Introduction

Wild places abound. There was a time when wild places were 'out there', certainly not in capital cities or in the suburbs. An increasing awareness of the value of and an interest in Australian native plants (and animals) has heightened the perception of previously neglected pockets of land. Also, increasing urban density and suburban spread, industrialization and clearance for agriculture has brought into focus the realization that we are dealing with a finite resource.

A key component of most management processes is protection and prevention of weed spread and invasion. Agricultural chemicals (herbicides) have become almost an indispensable part of the process. However, although important, they are only one of a suite of options that is open to the creative manager.

More important than any one technique is the overall process. To this extent, native vegetation is no different to a wheat field. The manager must prescribe a regime, set the standards, objectives, timelines and monitor the success of the operation. This approach takes the bushland or parks officer into the realm of 'facilities management', a concept that many may find unpalatable.

Characteristics of wild places

Wild places, particularly within the urban spread, come in many dimensions. A small pocket of land around a utility asset, a nature strip development, linear corridors within largely developed areas and recreation areas can all potentially have equal significance to formally reserved state and national parks. The loss of diversity close to major urbanization or from agricultural land clearance has not only physically reduced the area of undisturbed native vegetation but also left only a relatively small source from which various threatened species can rebound. As such, these areas, however insignificant, may be worth the use of scarce resources to foster their protection.

The characteristics that define wild places assist in identifying the threats to their existence and the realistic management opportunities available. Because they are often ancillary to another primary land use, they may not be under intense management pressure in the their own right. However, they may be under indirect pressure from the management consequences of the primary use. As often extensive land parcels, their size may be disproportionate to the management resources allocated to their protection or operation. An even harder issue is often justifying any expenditure on protection measures. Apportionment of value on the organizations accounts maybe unpalatable, but unless they have notional financial or possibly social worth to an organization, then they potentially have no value. As a manager, how can expenditure be justified on an asset with no value?

And finally, as areas of natural vegetation significance, it may be difficult to define a management regime. In prescribing objectives or outcomes we can only work on historical change and not what will or could have evolved naturally. A common feature of vegetation evaluation for quality or degradation is the assessment of condition relative to pre-European colonization. This is only a best guest and pegs all values at a past status. The use of heavy machinery has hastened the pace of change and increased the pressure many areas would have experienced naturally. This does not mean just accepting that species or ecosystems present 200 years ago is all that should be aspired to or accepted.

Process

More important than any specific technique is the overall management process that is established. Without in-depth thought being given to all the factors, weed control measures will flounder, waste resources and increasingly drain staff and management time as the problem spirals through Band-Aid approaches to its resolution.

Use of a structured approach provides definition of the type and magnitude of the overall problem, allows formal allocation of resources, is an integral part of a strategic management program, allows setting of targets and measurement of progress. The process consists of the five elements below:

- Area and asset type.
- Standards.
- Audit.
- Management type.
- Threats and other issues.

Each of the elements is a topic in its self, however; only chemical weed control (as a management type) and audit will be focused on in-depth.