Weed control in the public area: combining environmental and economical targets

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Summary

Herbicide weed control on pavements has the lowest direct costs to control weeds compared to available non-chemical methods. However, side effects of herbicides on pavements (e.g. run-off to surface water) can be large when used without special precautions. In this paper data are shown on costs and side effects of different weed control methods on pavements under Dutch conditions. An Environmental Life-Cycle Assessment shows that the environmental effect of herbicide control system depends to a large extent on the amount of herbicide run-off. In this paper also data of an actor participative project on sustainable weed control on pavements are presented. The objective of the project was to develop a management system that gives a substantial reduction of herbicide run-off while maintaining good level of control at acceptable costs. Surface water, efficacy and cost monitoring in this SWEEP-project showed that the environmental and economical targets could be achieved. It shows that knowledge of costs, efficacy and side effects of weed control methods can be translated into management guidelines that support managers to implement more sustainable weed control.

Introduction

After world war II, the use of synthetic pesticides per area of cultured land has increased enormously, mainly because of economic advantages pesticides offered. With time, side effects of use of pesticides became evident. As a result, most countries introduced pesticide laws, enforcing science based risk evaluations of admitted pesticides and banning of noxious pesticides. Pesticide regulation, integrated management concepts and certification (e.g. environmental labels) has reduced side effects of pesticides during the past 20 years, but further reductions are still needed. On the other hand, non chemical management also has side effects. It is today still difficult for managers to find a sustainable balance between the economics and the side effects of their management. This paper is on finding this balance for weed control on pavements.

For comparison of environmental or toxicological effects of pesticides, systems like environmental yard stick and pesticide exposure risk index have been developed (e.g. Venderbosch et al., 2004). These systems allow a science based choice of pesticides with smallest side effects. For comparison of environmental effects of different control methods (pesticides versus mechanical control), instruments such as Environmental Impact Assessment, Life Cycle Assessment (LCA), Environmental Risk Assessment, Multi-criteria Analysis and Cost Benefit Analysis are available. These instruments vary considerably in objectives, scope, simplicity and data intensity. However all instruments have in common that they provide an integrated approach to environmental assessment. This is increasingly recognised as an important technique for managing the environmental impacts of human actions. It may be defined as the interdisciplinary process of identification, analysis and appraisal of all the relevant natural and human processes, which affect the quality of the environment and environmental resources.

In this paper, results of recent studies on costs and side effects of weed control on pavements are summarized. Firstly, data of two desks studies on costs and side effects (LCA) are presented. Secondly, results of an actor-participative project on sustainable weed control on pavements in municipalities in the Netherlands are presented. Finally, some concluding remarks are made.

Weeds and weed control on pavements

It is the nature of plants to colonise the soil of pavements. Conditions that favour plant growth are much open and nutrient-rich soil in the pavement, few traffic, much rain and day temperatures between 20 and 30 °C. Plants become weeds when they adversely affect the functionality, safety, longevity or aesthetic value of pavements. As a result, managers of pavements have to apply weed control when such adverse effects are expected.

Currently, mechanical (brushing, sweeping, mowing, hand weeding), thermal (flaming, hot water) and chemical (herbicides) weed control methods are applied on pavements (e.g. Kortenhoff et al., 2001). In 2001, four out of five municipalities in the Netherlands used herbicides to control weeds on pavements (Ekkes et al., 2002; Kempenaar & Spijker, 2004). On industrial sites, herbicide use on pavements is probably even higher. Many other countries in the EU have a similar situation, but there are also differences due to regulations or culture (see Clean Region paper on policies in different EU countries).

An important side effect of herbicide use on pavements is emission to surface and soil waters, where they may adversely affect ecology and drinking water production. Concentrations of herbicides that are used on pavements, sometimes exceed the drinking water threshold of 0.1 µg/l in rivers in the Netherlands. This affects a large proportion of the drinking water production in the country. Today, glyphosate is the mostly used herbicide on pavements in the Netherlands. The maximum permissible concentration (MPC) of glyphosate in surface water is 77 µg per litre (*e.g.* Withagen et al., 2004). The physical chemical properties of glyphosate (high solubility in water, high sorption to soil particles) make the compound very sensitive to surface run-off while it hardly leaches to groundwater (Luijendijk et al., 2003; Ramwell & Hollis, 2003, Beltman et al., 2001). In risk evaluation studies of Saft & Staats (2005, 2002), a run-off factor for standard practice herbicide use on pavements of 50 % is used.

Desk studies on costs and environmental effects

Costs of weed control

In 2005, costs of weed control systems on pavements in municipalities were studied (Syncera, 2005). The systems are named after the main control method applied during a season: brushing, flaming, hot water and herbicide weed control (selective application technology is obligatory). The methods are applied in different frequencies to keep weed growth on pavements below a certain specification. Table 1 contains both frequencies and costs per year for different systems and two specifications of acceptable weed growth (the level of weed growth not to be exceeded). The figures in Table 1 reflect the current practical situation in the Netherlands.

Table 1. Frequencies of application per year and costs per m^2 per year of important weed control methods in the Netherlands (2005 price level).

System	Threshold weed growth specification			
	Little weed growth		Very little weed growth	
	Frequency	Costs (€ m^{-2})	Frequency	Costs (€ m^{-2})
1. Brushing	3	0,19 - 0,38	3,5 - 5	0,20 - 0,40
2. Flaming	Not applicable		5	0,15 - 0,35
3. Hot water	2,5	0,22 - 0,32	3 - 4	0,30 - 0,40
4. Herbicides	2	0,05 - 0,08	2,5	0,07 - 0,10

Little weed growth means less than 25 % of bare soil in pavement covered by weeds, very few weeds taller than 5 cm and no clumbs of weeds; very little weed growth means less than 5 % of bare soil covered by weeds, no weeds taller than 5 cm and no clumbs of weeds (after scale of Eco Consult, English translation of scale in Kempenaar et al., 2006).

A few studies also address the issue of the external costs, for instance the abatement costs made by drinking water companies to remove herbicides and other impurities from their resource water. The external costs can have a significant influence on the integrated cost level. However to date a sound allocation of costs has been hampered by major uncertainties.

Life Cycle Assessment

Environmental Life-Cycle Assessment (LCA) provides a framework for identifying and evaluating environmental burdens associated with the life cycles of materials and services in a "cradle-to-grave" approach. LCA is a technique for assessing all the inputs and outputs of a product, process, or service (Life Cycle Inventory); assessing the associated wastes, human health and ecological burdens (Impact Assessment); and interpreting and communicating the results of the assessment (Life Cycle Interpretation) throughout the life cycle of the products or processes under review. The term "life cycle" refers to the major activities in the course of the product's life-span from its manufacture, use, maintenance, and final disposal; including the raw material acquisition required to manufacture the product. When deciding between two alternatives, LCA can help decision-makers compare all major environmental impacts caused by both products, processes, or services. This ability to track and document shifts in environmental impacts can help decision makers and managers fully characterize the environmental trade-offs associated with product or process alternatives. It was this ability to show trade-offs that initiated the LCA studies for chemical weed control versus non-chemical weed control in 2002 and 2005.

In the LCA study a number of work packages has been described that are able to fulfill to functional unit of controlling 1,000 m^2 of municipal pavement to a level of very little weed growth. These workpackages are described in table 2.

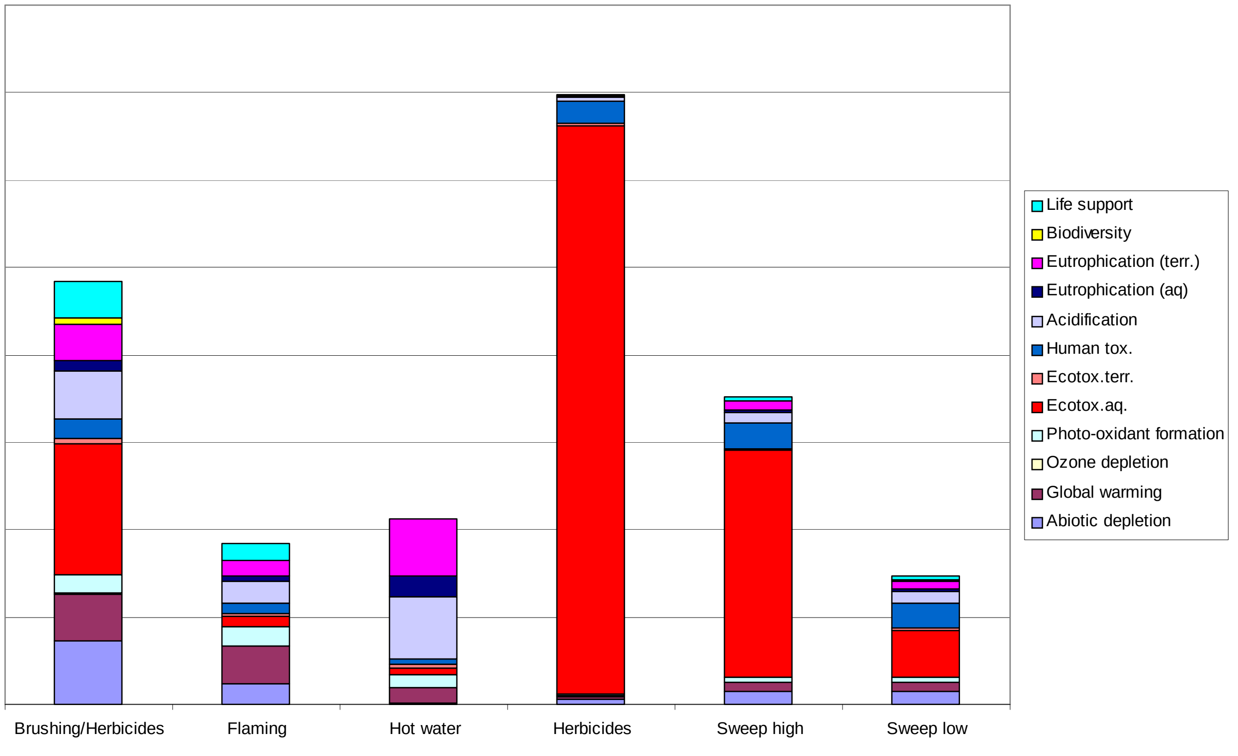
Table 2. Defined workpackages (wp) for the LCA.

System	Frequency	Specification
1. Brushing	3,5	brusher machine 1,200 m^2/h, diesel fuel, waste to composting, partial weed control with glyphosate
2. Flaming	5	flaming unit 1,200 m^2/h, LPG fuel
3. Hot water	3	hot water unit, 1.872 m^2/h, diesel fuel
4. Herbicides	2,5	sensor controlled application, 2,500 m^2/h, petrol fuel, glyphosate dose 0,43 kg a.s./ha per application, 50% run-off
5a SWEEP* high	2,5	see description below, 25% run-off
5b SWEEP* low	2,5	see description below, 3% run-off

* Explained in next section

The results of the LCA study were presented as a number of impact category scores. A higher score means a higher (potential) impact on ecosystems and human health. Figure 2 gives an outline of the impact scores per category. The values on the y-axis are unitless and used only for relative comparison.

Fig.2 Impact scores from the LCA weed control on pavements (explanation of wp in Table 2).



From these results we learned that the use of herbicides has a major impact on the total score. The final emission of glyphosate caused by direct and indirect emissions (i.e. after sewage water treatment) is assigned to the impact category of aquatic ecotoxicity. The brushing workpackage has a less favourable score due to the relative high fuel consumption and the additional use of herbicides in less accessible areas. Flaming, hot water and SWEEP have similar scores, although the latter is influenced by the run-off fraction.

For policy makers and managers this information has proved useful to support their decision making. Certainly however additional input is needed in the decision making process as the LCA tool does not take into consideration site specific circumstances or local impacts e.g. on the local surface water quality or the local air quality.

Combining environmental and economic targets in SWEEP-project

The aim of the project was to develop a new concept of hard surface weed management that provides cost-effective and environmental sound weed control. In the actor participative project, it was studied from 2002 – 2004 if herbicide use and emission could be reduced to a level that surface water criteria are met while costs, efficacy and ease of weed control remain acceptable for the majority of hard surface managers. The new management concept was tested in interaction with municipalities, weed control contractors, water boards and other stakeholders. The core of the concept is emission reducing measures. A summary of the measures is given hereafter (for details, see www.dob-verhardingen.nl under shortlists (in Dutch and English)):

1. No herbicide use if the pavement is within 10-km upstream of surface water that is used for drinking water production,
2. No herbicide use on 1-m wide zones of pavements bordering surface waters,
3. No herbicide spraying when weather forecasts are favourable for run-off (probability of rain > 40 % and > 1 mm),
4. Restricted herbicide use near gully pots,
5. Best practices have to be applied (e.g. weed sensors for selective spraying).

Other elements of the concept are professional organization with maximum weed growth specifications, stimulation of weed prevention, monitoring of herbicide use, and certification. Information on weed prevention is provided to in a handbook (Kempenaar, 2004, version 1). The name of the new concept is SWEEP, Sustainable WEEd control on Pavements (DOB in Dutch).

Observations in SWEEP managed test areas

The SWEEP concept was tested in management units in urban areas of nine Municipalities in the Netherlands in 2002 - 2004. The units were residential quarters (areas) of 5 – 25 ha with ca 30 % paved area to be managed. The following observations were done in the management units:

- Type and frequency of weed control methods applied, and herbicide use,
- Herbicide run-off (glyphosate, AMPA, MCPA, glufosinate ammonium) to sewage water, sewage water purification facilities and surface water. Point sampling and flow rate proportional sampling was done,
- Efficacy of weed control (weed infestation was estimated on 20 random positions in the quarter on 3 - 5 dates per season,
- Costs of weed control per quarter per m^2.

For details, see reports on www.dob-verhardingen.nl and Kempenaar et al., 2006.

Run-off, efficacy and costs

Table 3 summarizes the results of the observations in the test quarters. In one test quarter, the manager decided not to use herbicides because there were many canals in the quarter. He applied a combination of flaming, sweeping and brushing. In the other quarters, generally two times per year herbicides were applied under the SWEEP restrictions. The new concept gave on average a surface water concentration of 0.8 µg glyphosate per l at the discharge points of sewage water to surface water shortly after rain fall (worse case moment) (see Figure 3A). The 90-percentile was 1.3 µg per l. The ecological threshold (MPC) was not exceeded, but the 0.1 µg per l threshold was in at least 33 out of 137 samples (precise number cannot be given because detection limit was 0.5 µg per l). However, all test quarters were located more than 10 km away from surface waters that are to be protected waters according the register of surface waters used for drinking water production. In some reference quarters in 2003 and 2004 with standard practice chemical weed control, the average glyphosate concentration at discharge points was 7.8 µg per l (see Figure 3A) (Van Zeeland et al., 2005).

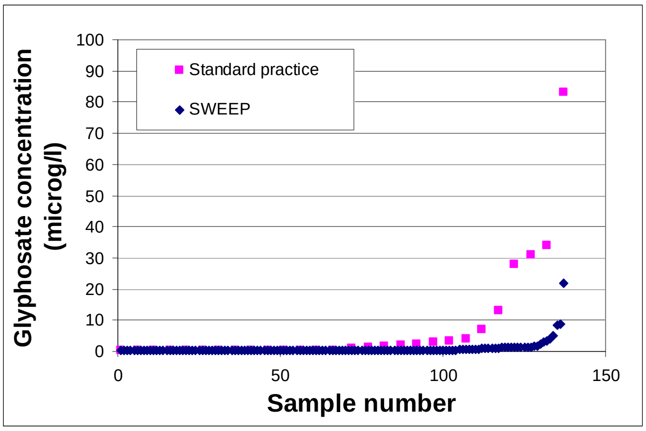
Regression analysis of the emission data showed that rain fall, the amount of herbicide used, and the places within the quarters where the herbicides were sprayed determined to a large extent the emission. Flow rate proportional sampling showed an emission factor of on average 2 % (see figure 3B) and a worse case factor of 5.7 %. These figures were used to define SWEEP low in the LCA.

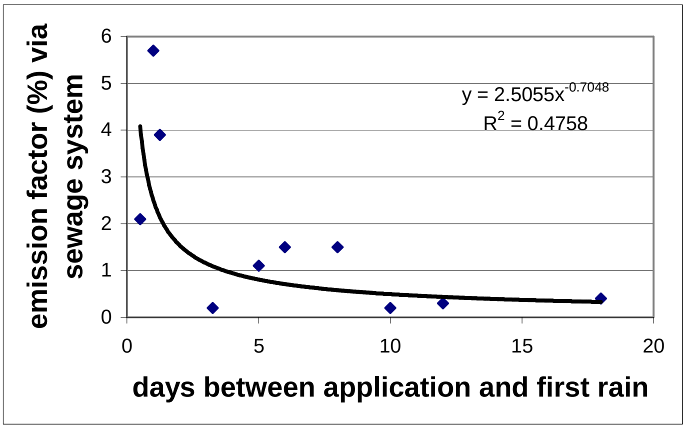
The managers of the pavements in the test quarters were satisfied about the level of control they obtained during the seasons. Combining chemical and non chemical weed control methods required more efforts from them, but was manageable. The costs of weed control (0.05 – 0.15 € per m^2) increased 20 - 30 % depending on quarter and management specific conditions (compare costs in Table 3 with those in Table 1). It remains to be seen if this is acceptable for the majority of hard surface managers in the Netherlands.

Table 3 Weed control parameters in test quarters of 9 municipalities in 2002, 2003 and 2004 under the SWEEP concept of weed management.

Parameter	Result
Herbicide reduction in test quarters compared to previous years.	11 % to 66 %
Control methods on areas where herbicide could not be used in the test quarters	Flaming, hand mowing, brushing, sweeping
Surface water quality: Mean concentration glyphosate in surface water at discharge points shortly after rain (137 samples)	0.8 µg/l
Efficacy of weed control	Moderate to good
Costs of weed control per year	0.05 – 0.15 € per m^2

Figure 3A and 3B. Glyphosate in surface water at discharge points in samples taken at moments of rain events after herbicide application on pavements (A, left), and relation between rain fall in test quarters and emission via the sewage water system (B, right) in study areas in 2002, 2003 and 2004.





Concluding remarks

Scientific knowledge of costs and side effects of pesticides and other control methods are essential to be able to combine environmental and economic targets in management practices. Cost and LCA studies on weed control on pavements provide useful information to promote more sustainable management practises. What the optimal trade off between targets is, differs from country to country and site to site and because of differences in regulations, needs, culture and environmental sensitivity, at national and local levels. SWEEP allows restricted herbicide spraying if the ecological standard of the herbicide applies for the surface water near the pavements, but no herbicide spraying when the drinking water standard applies. Also, personal considerations play a role. Alternative non-chemical methods on pavements are preferred if highest priority is given to keeping all surface waters free from residues of pesticides.

Herbicide use on pavements should be reduced to meet surface water quality criteria. The SWEEP system under Dutch conditions reduced herbicide run-off in the order of 90 % compared to standard practice herbicide weed control on pavements (Figure 3A), while costs of weed control increased by 20 – 30 % and level of weed control remained good. Non chemical methods are integrated with herbicide weed control in SWEEP. Herbicide weed control is not allowed in SWEEP when a pavement is close (10 km upstream) to surface water where to 0.1 µg/l criterion applies. SWEEP is a practical example of how knowledge on costs and side effects can be translated into guidelines for managers which want to combine economic and ecological targets in their management of pavements.

The EU Water Framework Directive (WFD) orders the local authorities at basin level to reach a ‘good quality’ of the water by end 2015. Herbicide use under SWEEP concept and non-chemical weed control methods can help to reach this objective. However, as the current market shares of both the SWEEP concept and non-chemical weed control methods are relatively small in the Netherlands, additional efforts are inevitable for a further reduction of the application of herbicides.

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