SUSTAINABLE WEED MANAGEMENT ON CONCRETE BLOCK PAVEMENT

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SUMMARY

Concrete block pavements are very common in urban and industrial areas in the Netherlands. Weed prevention and weed control are important components of pavement management systems. Weed control on pavements is merely by means of herbicides (glyphosate and MCPA in NL). Costs of chemical weed control are relatively low compared to non-chemical weed control, however the emission to the surface water can be relatively large and indirect costs to purify surface water that will be used to produce drinking water can be high. The emission to the surface water due to the use of 1 kg active ingredient (a.i.). herbicide on hard surfaces can be as high as the emission due to the use of 120 kg a.i. used in crop protection in agriculture.

An actor-participative project on sustainable weed control on pavements was started in 2000 in the Netherlands. The aim of the project was to develop a new concept of weed management (SWEEP) that provides cost-effective and environmental sound weed control. Practical guidelines were listed to support decision making by managers of pavements and contractors of weed control in early 2002. The guidelines are mainly focused on reduction of herbicide use and emission, with special attention for weed prevention in pavement construction (e.g. with use of elastic materials to fill joints) and by reduction of surface runoff of glyphosate using a decision support system in weed management.

The guidelines of SWEEP were tested in 2002 - 2004 residential quarters in nine Dutch municipalities ranging from 5 to 25 ha. The glyphosate herbicide use was reduced by 11 to 66 % compared to standard practice. The level of weed control remained good and ecological threshold concentrations for surface waters were not exceeded by far. Emission monitoring showed a glyphosate emission factor via the sewage water system of on average 2 %. The costs of weed control in the new concept were a little higher (0-30 % higher, i.e. 0.05-0.15 € per m^2) compared to the costs in standard practice chemical weed control, but much lower compared to those in non-chemical weed control systems.

The SWEEP concept helps managers of pavements to find an optimal trade off between costs and side effects of weed control on pavements. Sustainability of weed control can be further improved by making more use of available weed prevention options (listed in Handbooks and on websites) and by clear weed specification contracts. CROW translates this knowledge into standard contracts for the civil engineering sector.

1. INTRODUCTION

Concrete block pavements are very common in urban and industrial areas in the Netherlands. Sooner or later plants will colonise such pavements and become weeds, certainly when there is relatively much bare soil (wide joints) in the pavement, little wear on the pavement and favourable climatic conditions for plant growth. Managers of pavements have to apply weed control when plants affect the functionality, safety, durability and/or aesthetic value of the pavements. Weed control methods on pavements are chemical control (herbicides), brushing, flaming, mowing and hot water treatment (Kempenaar et al., 2006; Kortenhoff et al., 2001).

Managers often choose for chemical weed control because this is the most cost-effective and easy to use control method. The need for weed control on pavements, however, could be reduced if more weed prevention is applied. Weed prevention reduces the probability that weeds will grow, and so, reduces the need for control. E.g., less joints in a pavement reduces weed growth. There are good perspectives to integrate weed preventive measures in pavements at the level of design, construction and maintenance (CROW, 1997; Riemens et al., 2005), but this is unfortunately applied on a limited scale so far.

Four out of five municipalities in the Netherlands applied in 2001 herbicides on pavements (Ekkes et al., 2002; Kempenaar & Spijker, 2004). For pavements on industrial sites, (air)ports and railroads, this ratio is even higher. Today, glyphosate is the mostly used herbicide on pavements in the Netherlands. An important side effect of herbicide use on pavements is runoff to surface waters where it may adversely affect ecology and drinking water production. Herbicide concentrations in main rivers in the Netherlands sometimes exceed the drinking water threshold, affecting a large proportion of the drinking water production 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 general EU drinking water threshold concentration is 0.1 µg per litre per individual pesticide and 0.5 µg per litre for all pesticides. The physical chemical properties of glyphosate (high solubility in water, high sorption to soil particles) make the compound very sensitive to surface runoff while it hardly leaches to groundwater (Luijendijk et al., 2003; Ramwell & Hollis, 2003, Beltman et al., 2001). In a risk evaluation study of Saft & Staats (2002), a runoff factor for herbicides on pavements of 50 % is used.

An actor-participative project on sustainable weed control on pavements was started in 2000 in the Netherlands. 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. The main research question in the project was to see 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. If the question can be answered positively, managers that now use standard practice chemical weed control can be persuaded to apply the new concept. Another aim of the project was to determine if and how municipalities integrate weed prevention in their organisations. In this paper, results of the actor participative project are presented and discussed.

2. THE SWEEP CONCEPT

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. The possibility of reducing herbicide use and emission to a level that surface water criteria are met while costs, efficacy and ease of weed control remain acceptable for the pavement managers, was studied from 2002 – 2004. The new management concept was tested in interaction with municipalities, weed control contractors, water boards and other stakeholders. The name of the new concept is SWEEP, Sustainable WEEd control on Pavements (DOB in Dutch).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 in maintenance contracts, stimulation of weed prevention (tips were provided to the managers), monitoring of herbicide use, and certification. Information on weed prevention is provided to in a handbook (Kempenaar, 2004, version 1).

3. OBSERVATIONS ON SWEEP MANAGED PAVEMENTS

The SWEEP concept was tested in urban areas in nine municipalities in the Netherlands in 2002 - 2004. The areas were residential quarters (they were a unit from management point of view) 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.

The managers involved had little influence on weed prevention in the test areas, which were two to more than twenty years old. They only had influence on the number of times the area was cleaned with a road sweeping machine (by brushing vacuum cleaning machine that removes trash, leaves, sand, etc.). The number of times the pavement was sweeped was recorded.

4. SWEEP RESULTS: PREVENTION, HERBICDE RUN OFF, EFFICACY AND COSTS

The residential quarters had pavements consisting of roads made of asphalt or brick stones, and side walks made of 30 by 30 cm concrete slabs. Typical situations are presented in Figure 1. Generally, weed control is needed on the side walks, near curb stones and poles, and in the gutters.

Figure 1. Pictures of pavements in SWEEP managed residential areas.

Table 1 summarizes the results of the observations in the test quarters. There were large differences in the number of times the pavements were swept. Sweeping had some but little effect on weed growth in the test areas (the area which was swept only one time showed more weeds than the others). In one test area, 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 areas, 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 2A). The 90-percentile was 1.3 µg per l. The ecological threshold concentration (MPC) was never exceeded, but the much smaller 0.1 µg per l drinking water threshold concentration was exceeded in several samples. The sampling points 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 sites 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 2B) and a worse case factor of 5.7 %. Runoff was affected by herbicide dose, weather (rain), pavement type and construction, positions of spraying and distance to the surface water.

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 ranged from 0.05 – 0.15 € per m^2 per year per test area, which was estimated to be maximally 30 % higher than standard practice chemical weed control. Costs of sweeping of pavements were ca. 0.03 – 0.05 € per m^2 per sweeping (number of sweeping treatment per year ranged from 1 to 8).

Table 1. Weed control parameters in test quarters of 9 municipalities in 2002, 2003 and 2004 under the SWEEP concept of weed management

Parameter	Result
Number of times the test area was swept to remove dirt etc.	1 to 8 times
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

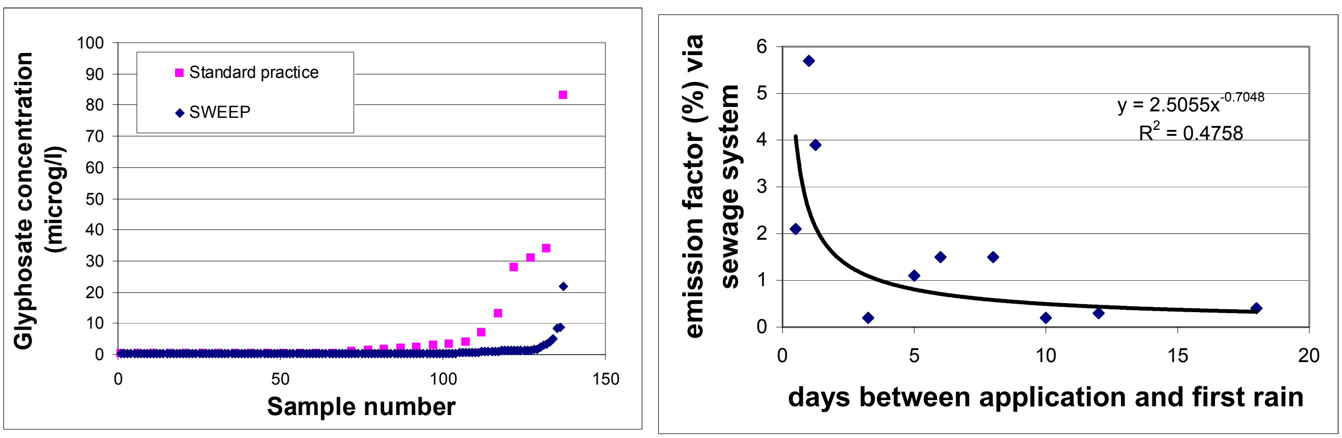

Figure 2. Glyphosate in surface water at discharge points in samples taken at moments of rain events after herbicide application on pavements (A, left), and relation between rain fall in test quarters and emission via the sewage water system (B, right) in study areas in 2002, 2003 and 2004.

5. IMPROVEMENTS BY MORE WEED PREVENTION

In principle, weed prevention is better then control. After all, costs in weed management can be reduced if weed preventive methods are applied. If one wants to prevent weed growth, one has to think about the needs of plants. In order to grow, a plant needs space, water, nutrients, light etc. There are many weed preventive opportunities in design, such as reducing length and width of joints (reduction of space for weed growth). Other opportunities are special sized concrete blocks, arrangement of blocks in constructions and filling of joints with special materials. Often, there are many different objects (poles with traffic signs, traffic guiding poles, etc.) placed on pavements in the public space. The objects give extra opportunity for weed growth. If these objects and the pavement were geared to one another, less weed will develop. Traffic islands are generally more sensitive to weed development, and at these places, much money can be saved with weed prevention by design. Prevention will pay back more rapidly on traffic islands because the maintenance costs are relatively high (working conditions and safety requirements increase costs of control). Many of these design and construction examples of weed inhibiting pavements were gathered in a handbook (CROW, 1997, Riemens, 2005; www.dob-verhardingen.nl).

6. IMPROVEMENTS BY BETTER WEED MAINTENANCE CONTRACTS

Knowing how you want to manage weed as a local authority is one thing; a good contract for maintenance is another. There is a tendency towards weed specification contracts. For this, you have to know which quality level you want to maintain and how to make this clear in a contract. In the Netherlands most civil works are based on a standard for specifications for the civil engineering. This system is managed and supported by CROW: the national information and technology platform for infrastructure, traffic, transport and public space (RAW Standard Conditions, CROW, 2000). Traditionally many maintenance activities are defined by frequency of activities. For several disciplines there are descriptions of quality levels. Finally this is where it's about for the local authority; not frequencies. For weed management there are in the Netherlands four quality levels defined in this standard system for contracting. This specification system works for contracts in which chemical and non-chemical control is described. In 2006 it will be studied if these weed specification contracts can also be used for restricted chemical weed control as the SWEEP system. The challenge here is to safeguard that the contractor complies with the restrictions on use of the herbicides.

7. CONCLUSIONS

The managers of the pavements in the in the SWEEP project were satisfied about the level of control they obtained during the weed growth seasons. Combining chemical and non chemical weed control methods required more efforts from them, but was manageable. The costs of weed control increased between 0 and 30 % depending on quarter and management specific conditions. The increase in costs was for most managers acceptable in the light of meeting surface water quality criteria. It remains to be seen if this is acceptable for other hard surface managers in the Netherlands. Policies are being made to stimulate the SWEEP concept. It has become part of a certification scheme. In a recently updated Life Cycle Assessment of weed control on pavements, it was shown that the SWEEP system has a relatively positive environmental profile compared to other methods, including brushing, flaming and hot water methods (Kempenaar & Saft, 2006).

The nine municipalities involved in the project hardly applied weed prevention. Though some of them had intensive sweeping regimes, none of them had specific weed brushes on the road sweepers or asked the driver to look for weeds while sweeping. The managers wished there was more attention for weed prevention during the design phase of pavements. There is a lot to be gained with good design and good construction (CROW, 1997, Riemens, 2005).

The European Union Water Framework Directive (WFD) orders the local authorities at basin level to reach a 'good quality' of the water by end 2015. The SWEEP concept presented here can be used to reach this objective. We believe that next steps in making weed control on pavements more sustainable should come from further development of weed prevention and non chemical weed control.

8. ACKNOWLEDGEMENTS

The project described in this paper is an initiative of a Dutch regional water purification board (ZHEW), the association of Dutch Water Companies (VEWIN), an herbicide manufacturer (Monsanto) and a research institute (Plant Research International). The authors acknowledge the many persons within VEWIN, ZHEW, Monsanto, Wageningen UR, water board Zuiderzeeland, PPO, Alterra, CLM, Stichting Milieukeur and the participating municipalities and contractors for their contributions to the work described in this paper. The project benefited from knowledge developed in R&D program 397 of the Dutch Ministry of Agriculture, Nature and Food. The project obtained in 2004 financial support from the EU-life program (SWEEP-project).

9. REFERENCES

Beltman, WHJ, Wieggers, HJJ, de Rooy, ML, Matser, AM, 2001. Afspoeling van amitrol, atrazin en glyfosaat vanaf betonklinkerverharding; veldproeven en simulaties (in Dutch, title in English: Runoff of amitrol, atrazin and glyphosate from concrete brick pavement: field studies and simulations). Report 319. Alterra, Wageningen, NL.

CROW, 1997. Ontwerpvoorbeelden onkruidwerende verhardingen (in Dutch, title in English: Handbook weed preventive pavements). CROW-publicatie 119. Ede, CROW, 1997.

CROW, 2000. RAW Standard Conditions 2000. Ede, CROW, 2000.

Ekkes, JJ, Horeman, GH, Besseling, PAM, van Esch, JWJ, 2002. Evaluatie Bestuurlijke Afspraken Uitvoering MJP-G Openbaar Groen. Eindevaluatie van de taakstellingen. Report 2003/179 (in Dutch, title in English: Evaluation of the national covenant on pesticide use in public areas). Expertisecentrum LNV, Ede, NL.

Kempenaar, C, Spijker, JH, 2004. Weed control on hard surfaces in The Netherlands. Pest Management Science 60, 595-599.

Kortenhoff, A, Kempenaar, C, Lotz, LAP, Beltman, W.H.J., den Boer, L., 2001. Rational weed management on hard surfaces. Note 69A. Plant Research International, Wageningen, NL.

Kempenaar, C, 2004. Handleiding DOB-systeem, Version 1 (in Dutch, title in English Manual SWEEP-system). Plant Research International, Wageningen, NL.

Kempenaar, C, Lotz, LAP, van der Horst, K, Beltman, WJ, Leemans, KJM, Bannink, AD, 2006. Trade off between costs and environmental effects of weed control on pavements. Crop Protection: paper accepted in 2006, in press.

Kempenaar C & Saft RJ, 2006. Weed control in the public area: combining environmental and economic targets. Symposium paper Clean Region Conference on policies of weed control on pavements, april 2006, Wageningen.

Luijendijk, CD, Beltman, WHJ, Wolters, MF, 2003. Measures to reduce glyphosate runoff from hard surfaces. Note 269. Plant Research International, Wageningen, NL (report on www.dob-verhardingen.nl).

Saft, RJ, Staats, N, 2002. Beslisfactoren voor onkruidbestrijding op verhardingen 'LCA, risico-beleving, kostenanalyse en hinderbeleving'. Document 0205 (in Dutch, title in English: Decision factors for weed control on pavements 'Life cycle assessment, costs analysis and perception', update of report is available on www.dob-verhardingen.nl). University of Amsterdam, NL.

Ramwell, CT, Hollis, JM, 2003. Herbicide dissipation on concrete and asphalt. In: Abstract book of International Symposium on Non-Agricultural Use of Pesticides, Environmental Issues and alternatives, May 7-9 2003, Copenhagen, p. 39. The Royal Veterinary and Agricultural University, Copenhagen, DK.

Riemens MM, Groeneveld, RMW, & Uffing, A, 2005. Onkruidpreventie op verhardingen. Study report (in Dutch, English title is Weed prevention on pavements, see www.dob-verhardingen.nl).

Van Zeeland, MG, Kempenaar, C, 2005. Duurzaam OnkruidBeheer op verhardingen. DOB-project Lelystad, Flevoland 2004. Study report (in Dutch). Plant Research International, Wageningen, NL.

Withagen, ACL, van der Horst, CLM, Beltman, WHJ, Kempenaar, C, 2004. Resultaten monitoring afspoeling glyfosaat en AMPA en waarnemingen van onkruidbeelden in zeven proefgemeenten in 2003. Note 297 (in Dutch, title in English: Monitoring runoff glyphosate and weed control efficacy in 2003 in 7 municipalities). Plant Research International, Wageningen, NL (report on www.dob-verhardingen.nl, reports of 2004 and 2005 are also on the site).