BIOBEDS – A SWEDISH CONTRIBUTION TO ENVIRONMENTAL PROTECTION FROM PESTICIDE POLLUTION

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Biobeds originated in Sweden as a response to the need for simple and effective methods to minimise environmental contamination from pesticide use, especially when filling spraying equipment, a typical point source of contamination.

Point sources

Spraying equipment is often filled at a particular place on the farm close to a water supply. If any spillage takes place in a farmyard where the topsoil layer has been replaced by a layer of gravel and sand, there is an obvious risk of groundwater contamination from leaching. High concentrations of pesticide residues have in fact been found at such sites and Danish (*1*-*3*) German (*4*-*6*) and Swedish (*7*) studies have shown that such point sources of pesticides are one of the most dominant reasons for pesticide pollution. However, the use of biobeds has minimised the risks of pollution when filling spraying equipment.

What is a biobed?

A biobed is a simple and cheap construction on farms intended to collect and degrade spills of pesticides (*8*, *9*). It consists of three components in a 60 cm deep pit in the ground (Fig. 1): a) a clay layer at the bottom (10 cm), b) a biomixture or biomix of straw, peat and soil (50:25:25 vol-%) filling the remaining 50 cm depth, and c) a grass layer that covers the surface. The biobed is also equipped with a ramp for driving and positioning the sprayer over the grassed surface.

The idea is that all handling of pesticides when filling spraying equipment should be done above the biobed so when spills occur they are retained and degraded in the biobed. The composition of the biomixture is intended to promote microbial degradation activities.

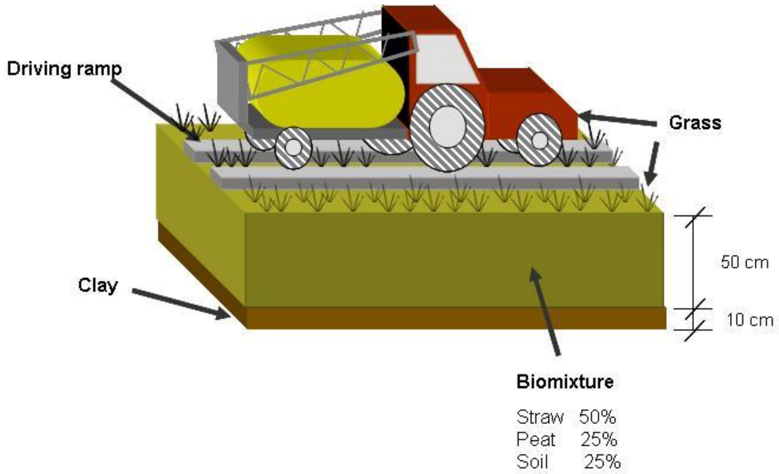


Fig. 1. Diagram of a biobed.

Components of a biobed

The clay layer

Clay is used as an impermeable layer to decrease the water flow downwards and to increase the pesticide retention time in the biobed. The precondition for an effectively functioning clay layer is that it must be wet and swollen to avoid formation of cracks and to prevent preferential flow processes.

The biomixture

The biomixture should have the ability to retain and degrade pesticides. A good biomixture promotes high pesticide binding capacity and microbial activity. Both of these properties are affected by the composition, homogeneity, age, moisture and temperature of the mixture. The original Swedish biomixture consists of straw, peat and soil in the proportions 50:25:25 vol-%. Each component of the biomixture plays an important role in the efficiency of retention and degradation of pesticides.

The straw stimulates the growth of lignin-degrading fungi and the formation of ligninolytic enzymes (such as manganese and lignin peroxidases and laccases), which can degrade many different pesticides (*12, 16-20*).

The soil provides sorption capacity and should have a humus and clay content that promotes microbial activity (*10*). The soil is also an important source of pesticide-degrading microorganisms that can act synergistically with the fungi. The presence of soil bacteria can enhance the extent of pesticide degradation, as has been observed for other organic pollutants, *e.g.* fungal transformation followed by bacterial degradation of the more polar metabolites enhances the degradation of benzo(a)pyrene (*11*).

The peat in the biomixture contributes to sorption capacity, moisture control and also abiotic degradation of pesticides (*12*). It also decreases the pH of the biomixture, which is favourable for fungi and their pesticide-degrading enzymes.

An important factor that often activates the fungal lignin-degrading system is nutrient limitation, especially nitrogen deficiency, and therefore addition of plant nutrients to the biomixture is not recommended.

The grass layer

The grass layer contributes towards increasing the efficiency of the biobed, especially in the upper parts of the biomixture where most pesticides are retained and degraded. The grass also helps to regulate the moisture of the biobed by creating upward transport of water and can produce root exudates (*e.g.* peroxidases) to support cometabolic processes (*13*). The grass layer is also an excellent visual tool since it reveals spillages, especially of herbicides. Grass damage is often observed at places where the concentrates are handled, below the middle of the sprayer tank from surface runoff, below pesticide-contaminated wheels and below faulty tubings and leaking nozzles (Fig. 2).

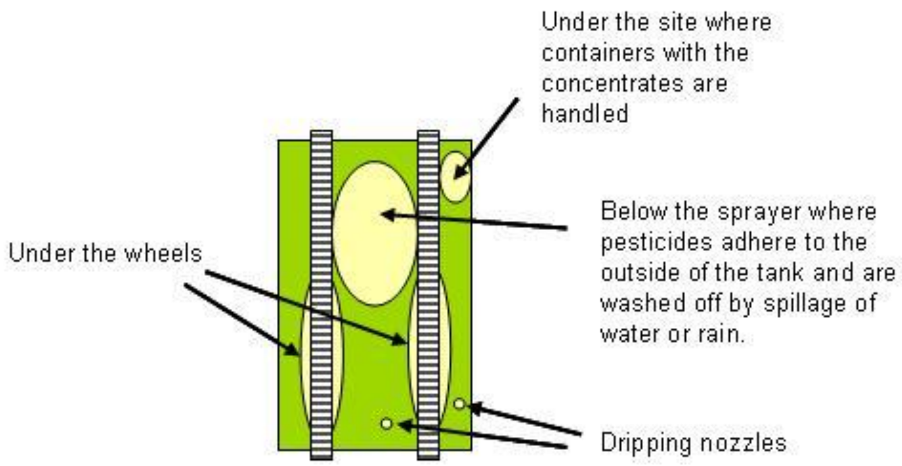


Fig. 2. Spillage pattern in a biobed (*14*).

Biobeds in Sweden

The biobed is the result of a collaboration between *Odling i Balans* (info@odlingibalans.com) and the Department of Microbiology, Swedish University of Agricultural Sciences (Lennart

Torstensson and Maria del Pilar Castillo). Biobeds have been in use in Sweden since 1993 when the first prototypes were built and studied (*9*, *15*). Several models have been built by farmers, who often reuse old building materials from the farm (Fig. 3). At present it is estimated that there are more than 1500 biobeds in use in Sweden. The biobed is also often used for safe filling of the fuel tank of tractors and other machinery.

Fig. 3. Some examples of biobed models (*8*, *14*).

The period when the highest pesticide levels are observed in biobeds is during the spraying season, *i.e.* when they are most intensively used (*8*, *9*). Once spilled, the pesticides are retained in the upper part of the biobed and most of them are degraded within one year (Fig. 4).

The height of the biomixture decreases by approximately 10 cm per year under southern Swedish conditions due to degradation of the organic matter, especially the straw. The lost volume is replaced by adding a fresh quantity of biomixture every year before the spraying season.

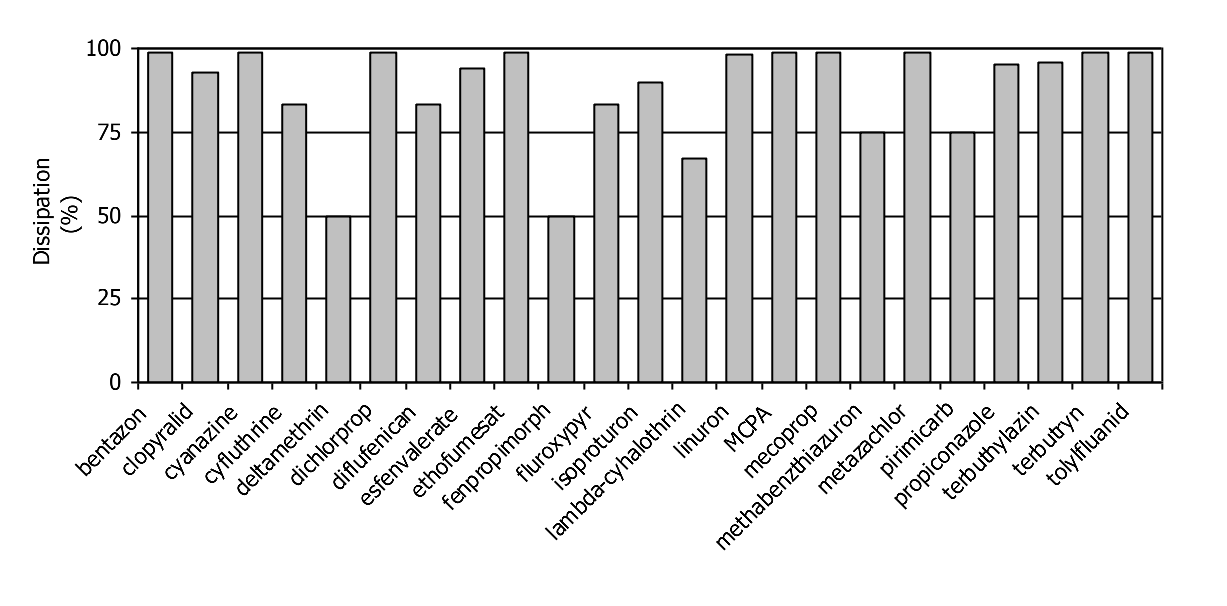


Fig. 4. Dissipation of pesticides in biobeds after one year (*14*).

However, eventually the efficiency of the biomixture decreases and it therefore has to be replaced by a fresh 50 cm of biomixture. Under Swedish conditions, it is recommended that this is done every 6 to 8 years. Because the removed material can contain small amounts of pesticide residues, it is recommended that the material be composted for one year, which is more than sufficient to decrease the levels of pesticide residues to below the limit of detection (*8*).

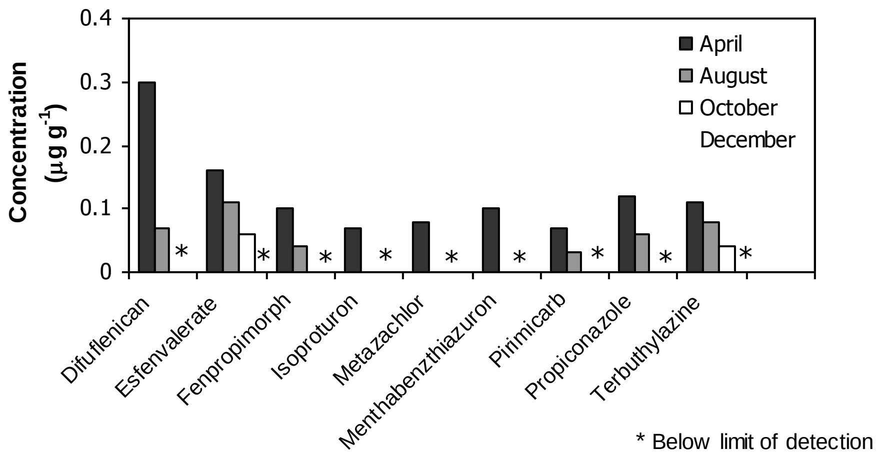


Fig. 5. After composting of the removed biomixture for 6 months the pesticide residues are generally below the limit of detection. However, a one year of composting is recommended.

The highest temperatures in the biobeds (Fig. 6) are observed during the summer and the levels depend on where the biobed is located (*8*). Due to the temperature variations in the Swedish climate, the main activity in the biobed is limited to the spring, summer and part of the autumn.

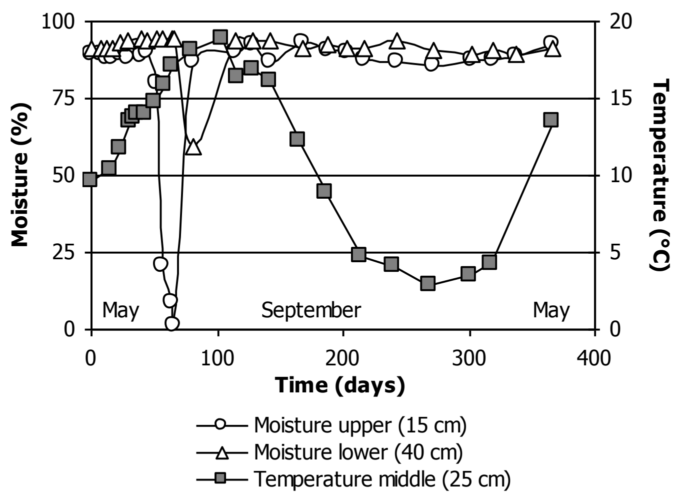


Fig. 6. Temperature and moisture fluctuations in a biobed in southern Sweden during a one-year period.

The moisture content of the biobed (Fig. 6) is of critical importance, since it affects oxygen availability and microbial activity and since oversaturation of the biobed can give pesticide leaching. In Sweden, biobeds are intended to be used exclusively for handling of pesticide concentrates and for long-term storage of the spraying equipment. It is recommended that washing of the sprayer, as well as of the tractor, be performed in the field. However, rainwater is allowed to enter the biobed.

Microbial activity in biobeds – Straw-degrading fungi are the driving force

The straw is the main substrate for pesticide degradation and microbial activity, especially from lignin-degrading fungi such as white rot fungi (Fig. 7), which produce phenoloxidases (peroxidases and laccases). The broad specificity of these enzymes makes them suitable for degradation of mixtures of pesticides.

Fig. 7. White rot fungi in a biobed.

The degradation of individual pesticides by white rot fungi/peroxidases has been demonstrated in several studies (*16-20*). Moreover, in laboratory scale biobeds the dissipation of most of the pesticides in a mixture is correlated with phenoloxidase activity and/or basal respiration and both activities are correlated to the levels of straw (Fig. 8) (*12*). Therefore, a high amount of straw in the biomixture is recommended, although in practice not more than 50 vol-% due to the requirement to achieve a homogeneous mixture (*9*, *12*).

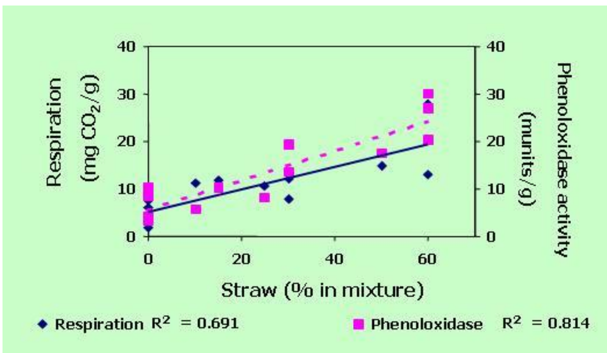


Fig. 8. Basal respiration and phenoloxidase activity as a function of straw content in the biomixture (*12*).

The lignin-degrading system of many white rot fungi is nitrogen-regulated (*21*). At low nitrogen levels the fungi activate the production of phenoloxidases, while higher nitrogen levels can enhance growth but inhibit the production of enzymes. Therefore, addition of nitrogen to biomixtures is not recommended in Sweden.

Biobeds in the world

The biobed has generated interest in other countries (*e.g.* England, Belgium, Italy, France, Peru and Guatemala) and its implementation has sometimes led to modifications of the original biobed design into what are renamed biofilters, biomassbed, Phytobac, biobac and biotables (Fig. 9).

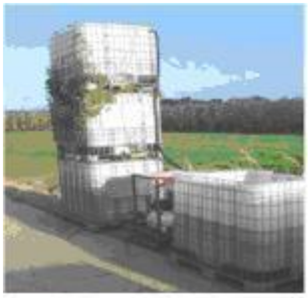
Biobeds - UK

www.biobeds.info

Biomassbed – Italy

(*22*, *23*)

Biofilter – Belgium
(*24-28*)



Phytobac® - France
(*29*)

Biobac – France
http://www.international.inra.fr/press/
detoxifying_plant_health

Fig. 9.Bioprophylactic systems in other countries.

Links

SJV http://www.sjv.se/

SLF http://www.lantbruksforskning.se/

Biobeds in the UK. http://www.biobeds.info/content/default.asp

Interreg 'Clean Region'. http://www.cleanregion.dk/

First European Workshop on Biobeds, Malmö, Sweden, 2004. http://www.cleanregion.dk/

Second European Workshop on Biobeds, Ghent, Belgium, 2007. http://www.cleanregion.dk/

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