BIOBEDS - BIOTECHNOLOGY FOR ENVIRONMENTAL PROTECTION FROM PESTICIDE POLLUTION

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Abstract. Point sources of pesticides, for instance frequently occurring at the filling of spraying equipment, are one of the most dominant reasons for pesticide pollution of surface and ground waters today. This contaminant risk can be minimized by using biobeds. Biobeds are facilities intended to retain and degrade pesticide spills. In its original design they consist of a biomixture, a clay layer at the bottom and a grass cover on the surface. The typical Swedish biomixture consists of straw, topsoil and peat (50-25-25 % v/v). The straw stimulates the growth of lignin-degrading fungi and the formation of ligninolytic enzymes (such as manganese and lignin peroxidases), which can degrade many different pesticides. The soil provides sorption capacity and other degrading microorganisms and the peat contributes to high sorption capacity and also helps to regulate the humidity of the system. A grass layer covering the biobed also helps to keep the correct humidity and can be used as an indicator revealing pesticide spills. The clay acts as an impermeable layer at the bottom. More than 1500 biobeds are in use in Sweden today and this concept has proven to be an effective and inexpensive solution to mitigate the release of pesticides to the environment.

Keywords: biobeds, pesticides, peroxidases, white-rot fungi

1. Introduction

It is known that the unsatisfactory management of pesticides and chemicals in general can result in residues in surface and ground waters as well as in large areas of soils. Danish (Helweg, 1994, Spliid, et al., 1999, Stenvang and Helweg,

M.D. Annable et al. (eds.), Methods and Techniques for Cleaning-up Contaminated Sites, 145–151.

2000), German (Fischer, et al., 1998a, Fischer, et al., 1998b, Frede, et al., 1998, Seel, et al., 1966) and Swedish (Kreuger, 1999) experiences have shown that point sources of pesticides are one of the most dominant reasons for pesticide pollution of creeks, streams and lakes, groundwater and local water supplies.

An important point source of contamination is the filling or cleaning of spraying equipment. This activity is often done at the same location on the farms due to the convenience of a water supply. High concentrations of pesticide residues have been found at such sites (Helweg, 1994). If the spill takes place in a farmyard where the topsoil layer has been replaced by a layer of gravel and sand, there is an obvious risk of groundwater contamination from leaching.

However, the use of biobeds has minimized the risks of pollution when filling the spraying equipment.

2. What is a Biobed?

A biobed is a simple and inexpensive construction on farms intended to collect and degrade spills of pesticides (Torstensson, 2000, Torstensson and Castillo, 1997). Biobeds are facilities composed of a biomixture of straw, mineral topsoil and peat. A grass layer on the top and a clay layer at the bottom are also part of the biobed system. A driving ramp is necessary for the parking of the spraying equipment (Fig. 1).

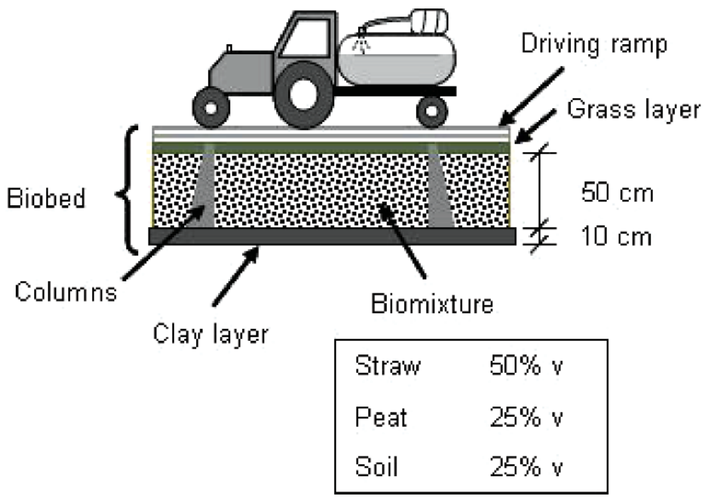

Figure 1. Diagram of a biobed.

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

The typical Swedish biomix consists of straw, topsoil and peat (50-25-25 % v/v). The soil provides sorption capacity and degrading microorganisms and the peat contributes to high sorption capacity and to regulate the humidity of the system. A grass layer covering the biobed also helps to maintain the correct humidity and can be used as an indicator to reveal pesticide spills (Fig. 2). The main microbial activity producing degradation of the pesticides comes from straw degradation. The straw stimulates the growth of lignin-degrading fungi and the activity of ligninolytic enzymes (such as manganese and lignin peroxidases and laccases), which can degrade many different pesticides (Castillo, 1997, Castillo, et al., 1997, Castillo, et al., 2000, Castillo, et al., 2001, von Wirén-Lehr, et al., 2001).

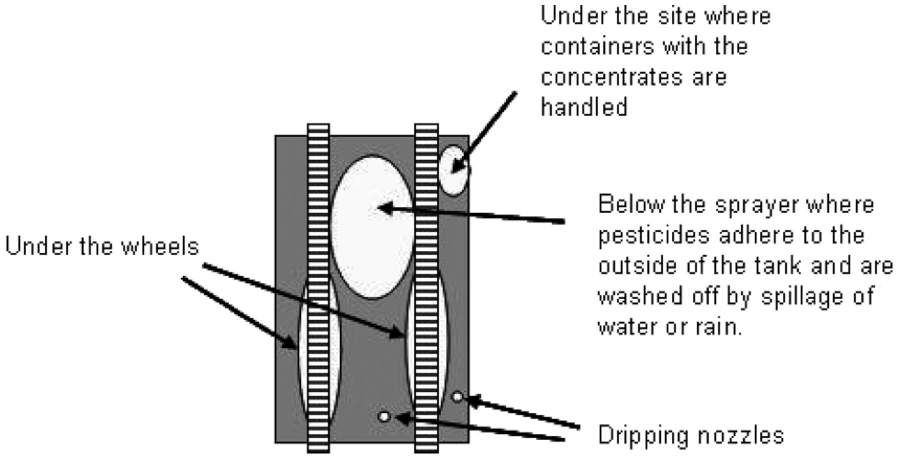

Figure 2. Spillage pattern in a biobed (modified from Torstensson, 2000).

The period where the highest pesticide levels are observed in a biobed is during the spraying season, i.e. when they are used more intensively (Torstensson, 2000, Torstensson and Castillo, 1997). Once spilled, the pesticides are retained in the upper part of the biobed and most of them are degraded within one year (Fig. 3). Levels near or below the detection limit are found in the lower levels of the biomixture suggesting low transport to the bottom.

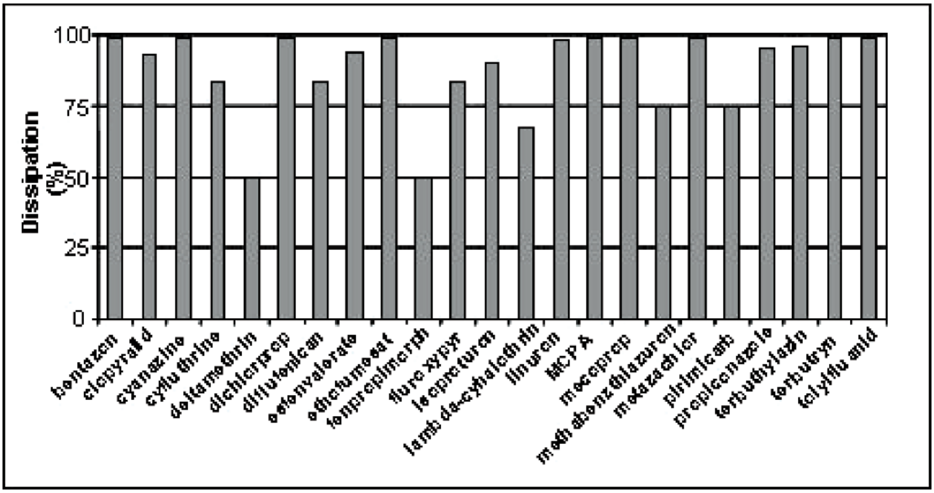

Figure 3. Dissipation of pesticides in biobeds after one year.

Due to degradation of the straw, the carbon content in the core of the biomixture decreases with time to levels similar as the ones in agricultural soils. Therefore, the biomixture should regularly be replaced with a fresh one. This is recommended to be done every 6 to 8 years under Swedish conditions. The removed material may contain small amounts of pesticides residues, either from pesticides used just before removing the biomixture or from pesticides that are slowly degraded. Therefore, we recommend an after-composting process of one year to decrease the levels of the pesticide residues to below the limit of detection (Table 1).

TABLE 1. An after-composting of the removed biomixture reduces the levels of the pesticides residues to levels under the limit of detection. Data from a biobed at the south of Sweden.

Pesticide	April	August	Oct	Dec	Limit of detection
Difuflenican	0.30	0.07	<0.05	<0.05	0.05
Esfenvalerate	0.16	0.11	0.06	<0.02	0.02
Fenpropimorph	0.10	0.04	<0.04	<0.04	0.04
Isoproturon	0.07	<0.01	<0.01	<0.01	0.01
Metazachlor	0.08	<0.04	<0.04	<0.04	0.04
Menthabenzthiazuron	0.10	<0.05	<0.05	<0.05	0.05
Pirimicarb	0.07	0.03	<0.02	<0.02	0.02
Propiconazole	0.12	0.06	<0.05	<0.05	0.05
Terbuthylazine	0.11	0.08	0.04	<0.04	0.04

Due to the Swedish climate the activity in the biobed is limited to the spring, summer and part of the autumn. The highest temperatures are observed during the summer and can reach 20°C in biobeds at the south of Sweden. During the winter the temperatures can be 2 - 4°C (Fig. 4) and low or no microbial activity is expected. Lower temperatures are observed in biobeds in the north of Sweden (data not shown) especially in winter where the middle part of the biobed freezes.

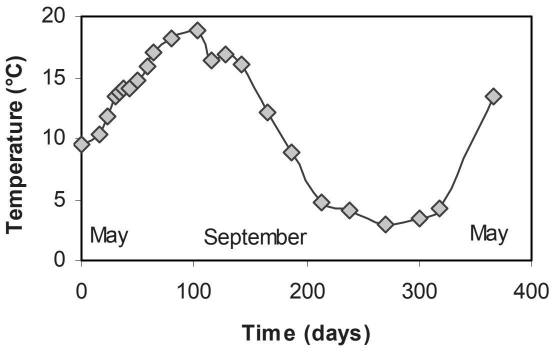

Figure 4. Temperature in a biobed during a period of one year. The biobed is located at the south of Sweden.

The water balance is a delicate issue in a biobed. Non-saturated conditions are needed to allow aerobic degradation processes which are important for most pesticides. Fewer pesticides are degraded under near saturated conditions, which also increase the risk for transport and leakage of pesticides from the biobed. To avoid this situation the Swedish biobeds are not recommended for treatment of large amounts of waters, for instance those from internal washing of the sprayer. This activity should be done at the fields. The moisture in the Swedish biobeds is kept at an optimal level for microbial activity if they are subjected to normal rainfall and to the water coming from the external washing of the sprayer (Fig. 5).

The first biobeds were built in 1993 and it is estimated that there are more than 1500 biobeds in Sweden today. This successful spread is due to the fact that the biobed is simple, effective and inexpensive and therefore has gained acceptance among the Swedish farmers who in turn have developed several models by using materials at hand from the farms (Fig. 6).

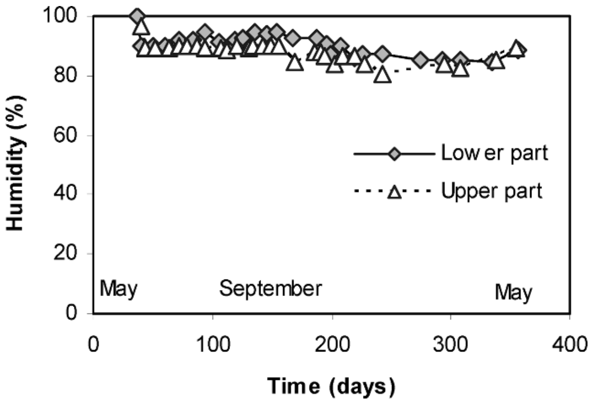

Figure 5. Relative humitidy in a biobed during a period of one year. The biobed is located at the south of Sweden.

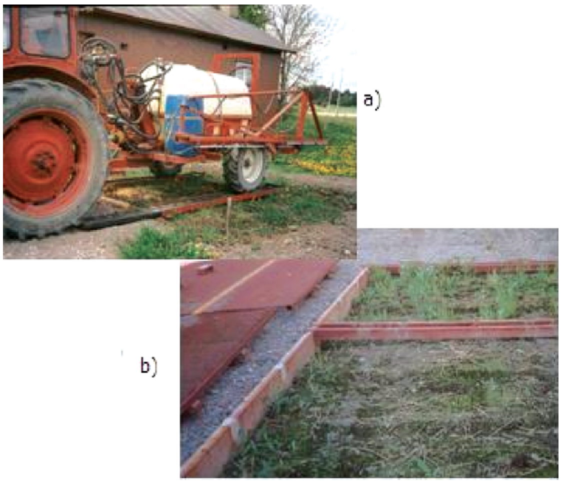

Figure 6. Some examples of biobed models, a) with a wooden driving ramp and b) with an old iron lattice.

3. Biobeds in Other Countries

The biobed system has some interesting properties (e.g. effective and cheap) thus it has gained interest in many other European countries, for example Denmark, Finland, Norway, France and Great Britain. The system also is of interest in developing countries since it does not require much maintenance or skilful expertise. Biobeds today are being introduced in Latin American countries such as Peru and Guatemala.

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