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Onfarm Bio-purification of Pesticidal rinsate employing Biobed system

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Introduction

Pesticides are a broad term extensively used in agriculture, covering herbicides, insecticide, fungicides, nematicides, etc. The discovery and use of pesticides brought boon in agricultural crop production in the post-independence era. But injudicious use of pesticides leads to environmental degradation, health hazards to humans, other animals, and vice-versa. So, minimal use and contamination remediation systems are need of this hour. One potential solution could be the biobeds system, which is developed by a Swedish farmer Göran Ohlsson in 1992. The background of his concern about how to reduce point-source pesticidal rinsate originating from filling and washing of spraying equipment. When he came to know about the fact that the pesticide is naturally broken down by natural soil borne microbes in agricultural soil, he constructed a simple half meter deep pit filled with a mixture of straw, soil, and peat. While changing the soil in their greenhouse along with his wife this simple idea stroked into his mind. The name "biobed" was coined by Sven Norup, who was the first manager of Odling I Balans means "Farming in Balance" and is the name of a Swedish network of 18 pilot farms, founded 30 years ago to focus on balanced agriculture. Countries like England, Belgium, Italy, France, Peru, and Guatemala showing greater interest and they have started the implementation of modified original biobed design into what is renamed biofilters, biomass bed, Phytobac, biobac, and biotables, etc.

Maintaining a simple biobed model on the farm pesticide handling point could minimize

Biobed

A simple and low-cost on-farm constructed system aimed to collection, retention, and degradation of pesticidal spills facilitated by the microbial breakdown. In the ground, a 60 cm deep pit is constructed near the proximity of the on-site chemical store and water supply i.e. pesticide loading area. It comprises three layers (Fig. 1 and Fig.2.). a) A bottom 10 cm clay layer with low permeability and high sorption capacity, b) A 50 cm bio-mixture layer containing Straw, Peat, and Soil in the proportion of 50:25:25 ratio with good absorption capacity and high microbial activity, and c) A final topical hydrophilic grass cover. Additionally, it can be equipped with a cemented or iron ramp for driving and positioning the sprayer over the grassed surface. It is advisable to handle all pesticides over the surface so when any spills occur they are retained and degraded in the biobed effectively.

Types of Biobeds

Depending on presence or absence of bottom isolation from the environment, there are two types, i.e. I. Lined Biobed and II. Unlined Biobed.

Basic components of a Biobed system

Bottom clay layer: Clay acts as an impermeable layer to decrease the downwards water percolation and prolong the pesticide retention period in biobed. To avoid any cracks formation in the functioning clay layer it must be posing wetting and swelling property. The bottom of the pit is conducted to a collection well for collect excess water, which is recirculated back to the biobeds.

Biobed

Lined Biobed

This system is much similar to the original Swedish biobed with a simple modification. It is isolated from the ground by a synthetic impermeable lining (Such as plastic, concrete, tarpaulin etc.) with an additional connection well at the bottom. Drainage layer with gravels, sand or macadam are generally placed below the clay layer (**Fig. 1**).

Unlined Biobed

The unlined biobed is lack of any impermeable synthetic layer modification which act as a barrier from the ground. Original Swedish biobeds belongs from this group. There are no such arrangemens for collection of drainage water below (**Fig. 2**).

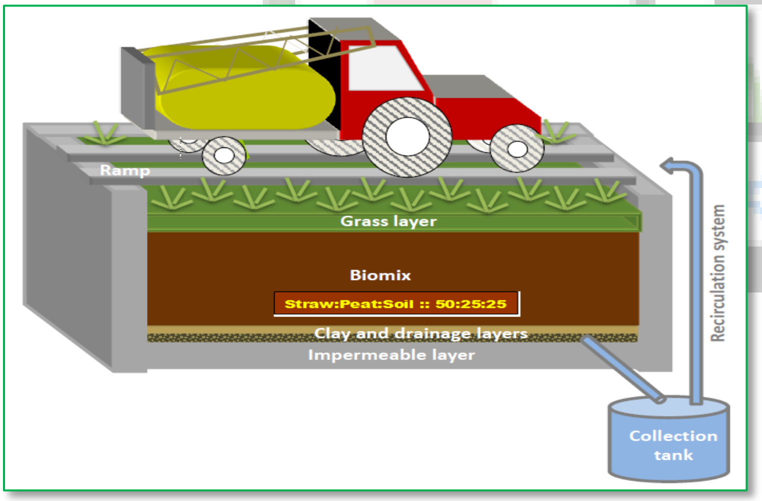

Fig. 1. Schematic view of Lined Biobed system.

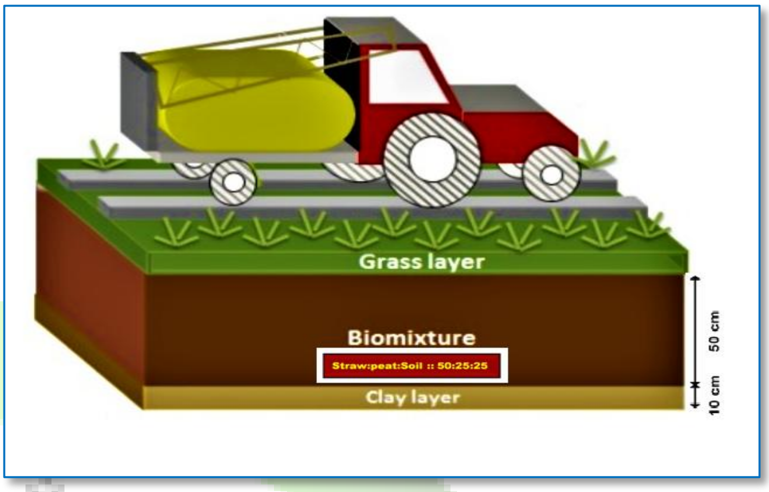

Fig. 2. Schematic view of Unined Biobed system.

Middle bio-mixture layer

A good bio-mixture should bear the ability to retain and degrade pesticides with high pesticide binding capacity and microbial activity. These properties depend on the composition, homogeneity, age, moisture, and temperature of the mixture. The bio-mixture layer containing Straw (wheat or barley), Peat, and Soil in the proportion of 50:25:25 in volume percentage, with good absorption capacity and high microbial activity. The straw present in the mixture stimulates the growth of lignin-degrading fungi and the formation of ligninolytic enzymes i.e. manganese and lignin peroxidases and laccases, which are responsible for multiple pesticides degradation. The soil provides sorption capacity and should have a humus and clay content that initiates the microbial activity. The bacteria present in soil microfauna also act as a synergist along with the fungi, resulting in more polar metabolites degradation. Peat in the mixture shares in water sorption, moisture control, abiotic degradation of pesticide, and decrease in mixture pH. Thus, making a favorable environment fungal enzymatic activity.

Top grass layer

Hydrophilic upper layer plays a vital role in the system because most of the pesticides are retained and degraded. The grass helps in moisture regulation through upward transportation of water and releases some root exudates viz. peroxidases to support co-metabolic processes. Also, the grass layers act as a phytotoxic indicator at the places where the concentrates are handled

Microbes and Biobed

The straw is the prime ingredient for pesticide degradation and microbial activity. Mainly the lignin-degrading fungi such as white rot fungi producing broad-spectrum enzymes phenoloxidases (peroxidases and laccases) make them suitable for degradation of mixtures of pesticides. Multiple research reveals that pesticide dissipation in a biomixture is correlated with enzyme activity, basal respiration, or both activities are correlated to the levels of straw. Thus, it quantifies an ample amount of straw in the mixture, although in practice it is not advised beyond 50 % volume, to achieve a homogeneous mixture (Fig. 3). The lignin degradation by many white-rot fungi is nitrogen-regulated. At a lower level of nitrogen, the fungus starts production of enzymes to breakdown the lignin present in the straw, on the other hand, higher nitrogen levels can enhance growth but inhibit the production of enzymes. Hence, the extra addition of nitrogen to the mixtures layer is not advised.

Fig. 3. White rot fungi in a Biobed.

Installing a Biobed in farm

Before the bed preparation selection of a proper suitable site is crucial; it must be rooted at least 10 m away from any fresh or surface water source, 50 m from any well, spring or borehole, and 250 m from any environmentally sensitive area to prevent the trafficking of potential contaminants. The design of biobeds must be in an impermeable area, with a sealed or zero drainage system on which pesticide mixing and equipment wash down activities take place.

- Use 50% by volume of chopped straw, 25% by volume of topsoil, and 25% by volume of peat (Currently, many scientists advised to use peat-free compost).
- Use chopped straw, to prove a larger surface area and easy mixing of straw by the beneficial microbes.
- If possible, use topsoil from crop fields previously treated with pesticide molecules.
- If the bottom layer is not dense, an enclosed biobed is required. In such a case, dig the pit up to 80 cm below and line the base and walls with water-resistant materials.
- Make the biobed construction large enough, ensuring residues from washing, filling, and rainfall running off the sprayer during parking are captured in it.

Maintenance of the Biobed

- The biomix needs to be regulated and replaced with fresh mixing material regularly. Since, by the process of decomposition, it will get compact.
- Allow the mix for 30 to 90 days before being added to the biobed, which allows the composting process to start to break down the straw, which makes it easier to create a homogenous hydrophilic mix-up. Very wet clay soil is not considered in the biomix as it makes difficulties while mixing.
- Soil having high pH should not use in biobeds, because it contains high amounts of bacteria which suppress the fungal activity.
- Depending on function and climate the biomix needs to be replaced every five to eight years because of the average height of the biomixture decreases by 10 cm each year.
- The grass layer needs to be maintained in good condition as it maintains the water content.
- It is beneficial to mix in some old biomix after replacing the bed material, which will act as inoculum for the new bed mixture.
- If precipitation is not adequate, the biobed should be watered timely.
- The retention period of the pesticides in the biobeds can be increased by increasing the depth of the biobeds or using a more effective adsorptive bottom layer.
- For a healthy functioning biobed system, it is

advised not to cover up with any material as it may hinder the microbial activity.

Conclusion

Studies have shown that spray equipment filling sources of pesticides are one of the most dominant reasons for pesticide pollution to groundwater or other freshwater bodies. During the peak spraying period, there is a high chance of pesticidal spills or rinsate while handling and washing of spray equipment. Those can be retained in the upper part of the biobed and most of them are degraded within a year. Thus, the use of biobeds has minimized the risks of pollution to a greater extent. The exhausted mixture can be stored securely for a minimum of 12 months to a maximum of 36 months before land spreading as farm manure. It is an attractive solution for on-farm prevention of pesticidal contamination towards natural water resources. Sometimes, government authorities impose a ban on various pesticides based on their ecological and health hazard or in the chemical stores' many products become expired, no one knows where it goes. These expire chemicals can be feed to the modified biobed models through drip or other modifications depending upon the temperature, location, and geological requirement. Nowadays, globally pesticidal hazards are becoming a major point concern for sustainable eco-health. The promotion of biobeds in a farmer's field will be able to save our environment from hazardous chemical pesticide usage

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