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Enhancing Biodegradation of Herbicides using Biobed Systems

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Agrichemicals such as herbicides and pesticides are released into the environment by accidental spillage from spray tanks during mixing or cleaning processes, causing point-source contamination where these chemicals are handled. A cost-effective way of treating such contamination is biobed technology. A biobed is a lined structure filled with a mixture (biomix) of topsoil, a peat substitute and straw. The biomix retains the pesticides for a period of time and gives a chance for microbial degradation to occur, thus reducing the potential contamination of ground and surface waters. Although on-farm biobed systems have been successfully developed and used in several European countries, adaptation must be made before they can be constructed under Missouri climatic conditions.

The overall goal of this study was to develop a biobed system that adapts to the soil and environmental conditions of Missouri to treat and dispose of selected herbicide wastes; and gain understanding of biobed technology and its potential application to prevent the movement of pesticides through soil to surface and ground waters. Specific objectives were to test suitable biobed materials that can enhance degradation of different herbicides, and identify an optimal biomix ratio for enhancing herbicide degradation.

Top soil samples were randomly collected from multiple points in a hay field at the Lincoln University Carver Farm. The soil was a Wrengart silt loam (fine-silty, mixed, active, mesic Fragic Oxyaquic Hapludalfs). Soil samples, chopped wheat straw, peat and garden waste compost were mixed thoroughly at four different ratios (Table 1). Twenty-five grams of soil or biomix was placed in glass jars. A mixture of commercially formulated herbicides including acetochlor, atrazine, pendimethalin, triflurolin was added to each jar according to the highest recommendation value. Soil or biomix samples were kept at 60% water holding capacity. At day 3, 10, 20, 30, 60, and 90, three samples of each treatment were taken out. Samples were dried under room temperature, mixed thoroughly and extracted with ethyl acetate. Herbicide concentrations were analyzed using GC-MS.

Table 1. Composition and chemical properties of biomixtures.

Material	Straw: Soil: Peat/ Compost (%)	pH	Lignin Content (%)	C: N Ratio
Soil	Control	5.76	NA	8.5
Biomix 1	12.5: 62.5 :25(peat)	5.59	16.94	17.1
Biomix 2	25:50:25(peat)	5.78	19.67	22.3
Biomix 3	50:25:25(compost)	5.59	27.67	14.1
Biomix 4	62.5:12.5:25(compost)	6.13	26.85	13

Results indicated that different herbicides behave differently in each biomixture material. Apparent recovery rate at 0 day ranged from 45% to 136%. Compare to biomix materials, soil has higher recovery rate for acetochlor and atrazine, probably due to stronger adsorption bonding in biomix materials. Half-lives of herbicides are shown in Table 2. The half-lives for atrazine and pendimethalin in biomixtures were significantly shorter than in soil. The carbon to nitrogen ratios found in biomix materials were higher than that in soil, which better supported microbial growth for organic material degradation. Lignocellulosic materials such as straw and peat and compost stimulated lignin degrading enzymes such as phenol oxidase and peroxidase. Compost may be a cheaper substitute for peat in constructing biobeds. The results showed that biobed is effective in enhancing degradation of herbicides such as atrazine and pendimethalin.

Table 2. Half-lives of selected herbicides in biomixtures and soil.

	Half-life (days)				
	Biomix 1	Biomix 2	Biomix 3	Biomix 4	Soil
Acetochlor	5.9	5.7	6.4	5.7	6.7
Atrazine	15.7	10.0	15.0	16.0	35.2
Pendimethalin	12.0	9.6	9.6	13.8	43.1
Ttrifluralin	29.6	49.5	21.7	23.0	27.1