PESTICIDE MITIGATION CAPACITIES OF CONSTRUCTED WETLANDS

Matthew T. Moore, Charles M. Cooper, Sammie Smith, Jr., and John H. Rodgers, Jr.[1]

Abstract—This research focused on using constructed wetlands along field perimeters to buffer receiving water against potential effects of pesticides associated with storm runoff. The current study incorporated wetland mesocosm sampling following simulated runoff events using chlorpyrifos, atrazine, and metolachlor. Through this data collection and simple model analysis, researchers conservatively predicted wetland buffer travel distances necessary to mitigate potential pesticide effects on receiving systems, which ranged from 100 to 400 m for the pesticides. This research provides fundamental answers concerning the use of constructed wetlands for pesticide mitigation in agricultural watersheds.

INTRODUCTION

In response to growing concern over agricultural pesticide runoff effects on flora and fauna of receiving water bodies, recent research has focused on potential best management practices (BMPs) to minimize such effects. One such suggestion is the use of constructed wetlands along field perimeters to buffer receiving lakes, rivers, and streams against potential effects of agricultural pesticides associated with stormwater runoff. The U.S. Department of Agriculture (USDA) established the new National Conservation Buffer Initiative in 1997, which is aimed at installing 3.2 million km of conservation buffers by the year 2002. In the Mississippi Delta, areas containing wetlands have been drained for agriculture and silviculture purposes. According to Mitsch and Gosselink (1993), draining and filling of wetlands since the mid-1800s has resulted in the loss of more than 50 percent of the Nation's original wetlands. Perhaps by placing constructed wetlands in areas where natural wetlands once thrived, agriculture could regain the original wetland area function of water-quality enhancement while minimizing potential impacts to aquatic-receiving systems.

MATERIALS AND METHODS

A series of constructed wetland mesocosms specifically designed to evaluate the fate of pesticides in wetlands was used for this research (Rodgers and Dunn 1992). Darby (1995) previously characterized wetland mesocosm sediments. Four wetland mesocosms were chosen as test cells, with one additional mesocosm serving as an unamended control. Three remaining mesocosms were used as water sources for the simulated storm event. Constructed wetland mesocosms (59 to 73 m by 14 m) were amended on two different occasions (one for the insecticide chlropyrifos, the other for a mixture of the herbicides atrazine and metolachlor). Following each pesticide amendment, a simulated cropland runoff and rainfall event equal to three volume additions was imposed on each wetland. Targeted concentrations of chlorpyrifos were 73 µg/L, 147 µg/L, and 733 µg/L, whereas targeted concentrations for both atrazine and metolachlor were 73 µg/L and 147 µg/L in addition to an unamended control (0 µg/L). Water, sediment, and plant samples were collected weekly for the duration of the experiment (chlorpyrifos, 84 days; atrazine and metolachlor, 35 days). Samples were collected from sites longitudinally distributed within each wetland and analyzed for the respective pesticides using gas chromatography.

RESULTS AND DISCUSSION

Chlorpyrifos rapidly sorbed to sediment and plant material, and the half-life in water, in this research, ranged from 5 to 13 days. Approximately 47 to 65 percent of measured chlorpyrifos was within the first 30 to 36 m (from inflow) of wetland mesocosms. Approximately 55 percent and 25 percent of measured chlorpyrifos mass were retained by sediments and plant material, respectively. Conservative mathematical models were used to derive adequate wetland design parameters for mitigation of chlorpyrifos-associated stormwater runoff. Recommended wetland travel distances were 184 m for wetlands receiving 147 µg/L chlorpyrifos runoff and 230 m for wetlands receiving either 73 or 733 µg/L chlorpyrifos runoff. It is imperative to remember that these calculations were made from conservative models.

Between 17 and 42 percent of the measured atrazine mass was within the first 30 to 36 m (from inflow) of wetlands. Atrazine concentrations were below analytical limits of quantification (0.05 µg/L) in all sediment and plant samples collected for this research. Atrazine aqueous half-lives ranged from 16 to 48 days. According to conservative design models, for atrazine concentrations of 73 µg/L, wetland travel distances for effective mitigation ranged from 101 to 164 m. For wetlands receiving initial atrazine concentrations of 147 µg/L, effective constructed wetland travel distances ranged from 103 to 281 m.

Between 7 and 25 percent of measured metolachlor mass was in the first 30 to 36 m (from inflow) of wetlands immediately following application and simulated rainfall.

[1] Moore, Cooperator, Cooper, Supervisory Ecologist and Research Leader, and Smith, Research Chemist, USDA-ARS National Sedimentation Laboratory, P.O. Box 1157, Oxford, MS 38655; Rodgers, Professor and Director, Clemson Institute of Environmental Toxicology, 509 Westinghouse Road, Pendleton, SC 29670.

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Approximately 10 percent of measured metolachlor mass was in plant samples. Based on models, adequate wetland travel distances receiving 73 µg/L metolachlor would range from 102 to 170 m. For those constructed wetlands receiving initial concentrations of 147 µg/L metolachlor, wetland travel distances necessary for effective mitigation would range from 100 to 400 m.

Based on presented wetland designs, it may not be economically feasible for a farmer to implement constructed wetlands as a sole BMP if their fields were small, e.g., < 4 ha. Constructed wetlands are not panaceas for environmental problems. Given proper situations, however, they can greatly enhance water quality in a variety of municipal, industrial, and agricultural settings. This research has offered valuable data concerning effectiveness for using constructed wetlands as buffers for pesticide-associated stormwater runoff.

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REFERENCES

Darby, M.A. 1995. Modeling the fate of chlorpyrifos in constructed wetlands. University, MS: The University of Mississippi. M.S. thesis.

Mitsch, W.J.; Gosselink, J.G. 1993. Wetlands. New York: VanNostrand Reinhold. 722 p.

Rodgers, J.H., Jr.; Dunn, A.W. 1992. Developing design guidelines for constructed wetlands to remove pesticides from agricultural runoff. Ecological Engineering. 1: 83–95.