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Sustainable Aquaculture for a Secure Future

Title: **Role of aquaculture pond sediments in sequestration of annual global carbon emissions**

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Abstract: Efforts to quantify carbon sequestration in inland water bodies have focused on inland seas, natural lakes, and large river impoundments (Mulholland and Elwood, 1982; Dean and Gorham, 1998). A recent study in Iowa (Downing et al., 2008) suggested that small, agriculturally-eutrophic impoundments bury carbon at an average rate of 2122 gm^{-2} yr^{-1} e five times higher than in large, river impoundments, 30 times more than in small, natural lakes, and over 400 times greater than in inland seas and large natural lakes (Mulholland and Elwood, 1982; Dean and Gorham, 1998). The combined water surface area of small impoundments in farming areas was estimated at 21,000 km^2 in the United States and 77,000 km^2 globally (Smith et al., 2002; Downing et al., 2006), and these impoundments may bury more carbon than the world's oceans (Downing et al., 2008).

The area of agriculturally-eutrophic impoundments used for estimating carbon sequestration (Downing et al., 2008) did not include aquaculture ponds. According to statistical data on aquaculture production maintained by the Food and Agriculture Organization (FAO) of the United Nations, there are 110,830 km^2 of aquaculture ponds worldwide (Verdegem and Bosma, 2009). Aquaculture ponds also may be important in global, carbon sequestration.

Aquaculture ponds do not have large external sediment loads typical of river reservoirs or small, watershed ponds in agricultural or other rural areas (Boyd, 1995). However, earthwork of aquaculture ponds is eroded by rain, waves, and water currents generated

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by mechanical aerators, activities of culture species, and harvesting operations. Manure, grass, and other agricultural wastes traditionally have been applied to ponds as organic fertilizer to increase aquatic animal production, but high-quality, pelleted feeds are rapidly replacing fertilizers as a means of achieving greater production (Boyd and Tucker, 1998). Fertilizers and feeds contain inorganic nutrients that stimulate organic carbon production by phytoplankton photosynthesis in ponds (Boyd and Tucker, 1998).

Coarse, soil particles suspended by internal erosion settle near edges of ponds while smaller particles tend to settle in deeper areas (Boyd,1995). Organic matter from dead plankton, organic fertilizers, uneaten feed, and excrement of culture species settles on pond bottoms and gradually mixes with soil particles. Aquaculture management favors microbial decomposition of organic matter. For example, organic matter inputs usually have a narrow carbon: nitrogen ratio, ponds with acidic, bottom soils are limed, and mechanical aeration avoids oxygen-depletion at the sediment-water interface (Boyd and Tucker, 1998). Much recently-settled organic detritus is discharged when ponds are drained for harvest (Ayub et al., 1993). After draining, pond bottoms usually are dried to enhance soil aeration and accelerate decomposition of labile organic matter (Boyd, 1995). Nevertheless, a layer of sediment with an organic carbon concentration higher than that of the original pond bottom soil and with a characteristic profile of well-defined strata or horizons develops (Munsiri et al., 1995).

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