available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/agwat

Short communication

Controlling nitrogen release from farm ponds with a subsurface outflow device: Implications for improved water quality in receiving streams

W. Gregory Cope [a,*], Robert B. Bringolf [a], Shad Mosher [a], James A. Rice [b], Richard L. Noble [b], H. Clifton Edwards [c]

[a] Department of Environmental and Molecular Toxicology, North Carolina State University, Box 7633, Raleigh, NC 27695, USA
[b] Department of Zoology, North Carolina State University, Box 7617, Raleigh, NC 27695, USA
[c] Premier Ponds, Inc., P.O. Box 36, Louisburg, NC 27549, USA

ARTICLE INFO

Article history:
Received 17 August 2007
Accepted 24 January 2008
Published on line 10 March 2008

Keywords:
Nitrogen
Nutrients
Eutrophication
Best management practice
Water quality
Pond management

ABSTRACT

The retention of nutrients in farm ponds has many potential benefits, including reduction of nitrogen and phosphorus (promoters of eutrophication) in receiving streams. The aim of this study was to evaluate the efficacy of a commercial subsurface pond outflow control device (Pond Management System^{TM}) on nutrient retention in farm ponds. Four ponds of similar size and water chemistry in the upper Tar River basin of North Carolina, USA were studied; three were equipped with the pond outflow control device and one was retained without a device (normal surface outflow) that served as a reference site. Water samples were collected monthly from each pond at 0.3 m intervals from the surface to 2.1 m at a fixed station adjacent to the pond standpipe and from the pond outflow pipe from March to October 2005. The water samples were analyzed for total Kjeldahl nitrogen (N), total phosphorus (P), chlorophyll *a*, and a suite of other physicochemical variables. In ponds with the subsurface outflow device, the mean N concentrations in the outflow were substantially less (6.2–20.7%) than concentrations at the pond surface. Concentrations of N in the outflow were similar to N concentrations at intermediate pond depths (0.9–1.5 m), the depth of the outflow devices, indicating water was drawn from these depths and that N was being retained in the surface layers of the pond. Also, mean water temperatures were 1.1–1.9 °C cooler at intermediate depths compared to the surface, suggesting potential application of the outflow device for minimizing warm water outflows to receiving streams. These results provide evidence that under these conditions a subsurface pond outflow device can reduce nutrient release to receiving streams, thereby increasing overall stream water quality.

1. Introduction

Agriculture, urban activities, and atmospheric deposition are all major sources of nitrogen (N) and phosphorus (P) to aquatic ecosystems (Carpenter et al., 1998). Recent agricultural research, policy, and regulation have focused on the development and implementation of best management practices (BMPs) such as controlled drainage, riparian buffers and land

* Corresponding author. Tel.: +1 919 515 5296; fax: +1 919 515 7169.
E-mail address: greg_cope@ncsu.edu (W.G. Cope).
0378-3774/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.agwat.2008.01.015

and livestock waste management to limit nutrient influx into surface waters (Borin et al., 2005; Dukes and Evans, 2006; Gassman et al., 2006). Farm ponds are surface water bodies in agricultural settings that serve as an important source of water for livestock, irrigation, fire protection, recreational fishing and even fish production. Because of the proximity to the many agricultural activities that use or generate excess nutrients, farm ponds are often among the first aquatic systems to retain, sequester, and cycle nutrients like N and P.

Many studies have documented the process of eutrophication, the over-enrichment of water bodies including lakes and farm ponds with N and P (Carpenter et al., 1998; Smith, 1998), yet none, to our knowledge, have evaluated the retention of nutrients in farm ponds as a potential BMP to limit nutrient release to receiving streams. When most farm ponds are built, the outlet is constructed in such a way that only the upper surface layers of water are discharged (USDA, 1997). This surface discharge allows the nutrient and phytoplankton rich surface layers to be released to the receiving stream, thereby contributing to downstream eutrophication.

The aim of this study was to investigate a simple solution, the installation of a commercially available subsurface outflow device, to retain nutrients within farm ponds and to assess its potential benefits to water quality in the receiving streams.

2. Materials and methods

The subsurface outflow control device called the Pond Management System™ (E. W. Ventures, Raleigh, NC, USA; United States Patent No. 6,142,705) was evaluated in this study. The device is constructed from heavy gauge aluminum pipe, can be custom designed to fit over the diameter of any existing pond standpipe (e.g., outflow structure), and can be tailored to a length that achieves a subsurface outflow in a pond of any depth. Outflow devices used in this study had an exterior diameter of 30.5 cm and were 1.5 m long (Fig. 1). The top had an adjustable air relief valve secured to a heavy gauge aluminum plate, which was welded to the pipe. Aluminum stabilizers were welded to the inside of the pipe to keep the device aligned and secure on the pond standpipe. A set of crossbars inside the pipe 30.5 cm from the top allowed the device to rest on the pond standpipe without flow restriction, while preventing debris and other obstructions from clogging the standpipe opening. The device operates by drawing water through the bottom of the pipe. The effective subsurface depth from which water was drawn in this study was 1.2 m below the pond surface. When the valve at the top is in the open position (as was the situation during this study), the device maintains the water level in the pond at the height of the standpipe. When the valve is in the closed position, a siphon is created and the pond can be drained to the depth of the bottom of the device.

Four ponds of similar size (2.8–6.5 ha) in the upper Tar River basin of North Carolina, USA were selected for study. Ponds 2–4 were equipped with the pond outflow control device and Pond 1 was retained without a device (normal surface outflow) that served as a reference site. The maximum water depth of the four ponds ranged from 3 to 5 m.

Water samples (500 ml) were collected monthly by boat from each pond at 0.3 m intervals from the surface to 2.1 m with a water sampler at a fixed station adjacent to the pond standpipe (within 4–6 m) and by hand from the pond outflow pipe from March to October 2005. Temperature, dissolved oxygen (DO), pH, and conductivity were measured monthly at

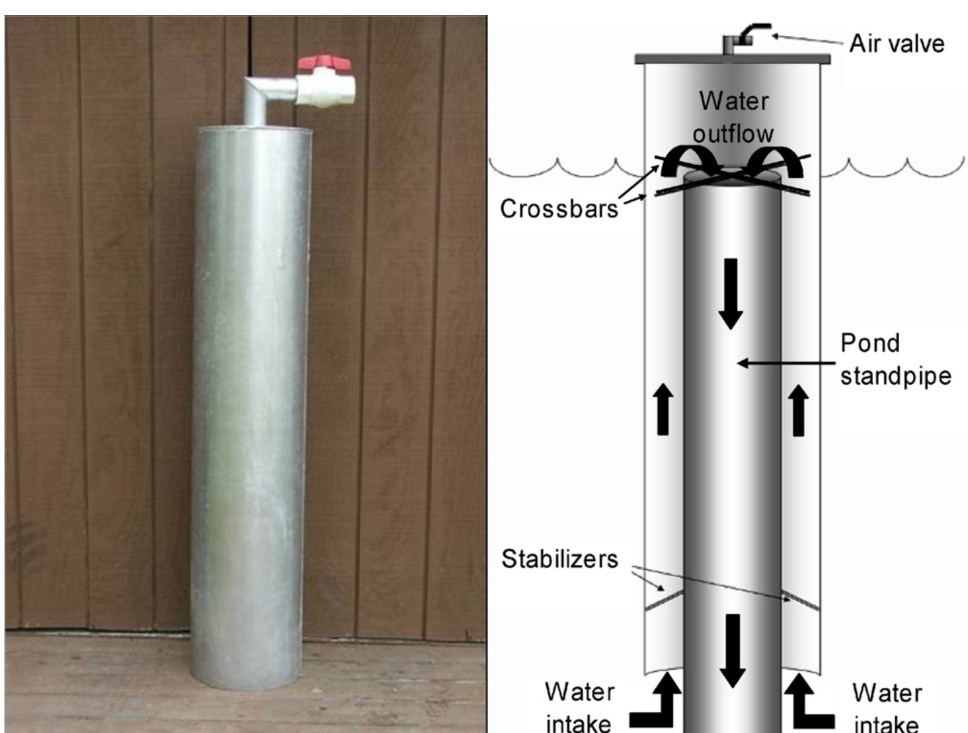

Fig. 1 – Photograph (left) and schematic diagram (right) of the Pond Management System™ outflow control device.