

University Curriculum Development for Decentralized Wastewater Management

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Suggested Course Materials

Robert W. Seabloom, P.E.
Emeritus Professor of Civil and Environmental Engineering
Dept. of Civil and Environmental Engineering
University of Washington

Adrian T. Hanson, P.E.
Professor of Environmental Engineering
Frank M. Tejada Center
New Mexico State University

September 2004

NDWRCDP Disclaimer

This work was supported by the National Decentralized Water Resources Capacity Development Project (NDWRCDP) with funding provided by the U.S. Environmental Protection Agency through a Cooperative Agreement (EPA No. CR827881-01-0) with Washington University in St. Louis. These materials have not been reviewed by the U.S. Environmental Protection Agency. These materials have been reviewed by representatives of the NDWRCDP. The contents of these materials do not necessarily reflect the views and policies of the NDWRCDP, Washington University, or the U.S. Environmental Protection Agency, nor does the mention of trade names or commercial products constitute their endorsement or recommendation for use.

CIDWT/University Disclaimer

These materials are the collective effort of individuals from academic, regulatory, and private sectors of the onsite/decentralized wastewater industry. These materials have been peer-reviewed and represent the current state of knowledge/science in this field. They were developed through a series of writing and review meetings with the goal of formulating a consensus on the materials presented. These materials do not necessarily reflect the views and policies of University of Arkansas, and/or the Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT). The mention of trade names or commercial products does not constitute an endorsement or recommendation for use from these individuals or entities, nor does it constitute criticism for similar ones not mentioned.

Acknowledgements

The authors would like to thank the following persons for reviewing the materials in this module:

Mark Gross
Mike Hoover
Jim Kreissl
Richard Otis
Scott Wallace

Citation of Materials

The educational materials included in this module should be cited as follows:

Seabloom, R.W. and A. Hanson. 2005. Constructed Wetlands: A Critical Review of Wetland Treatment Processes - Text. *in* (M.A. Gross and N.E. Deal, eds.) University Curriculum Development for Decentralized Wastewater Management. National Decentralized Water Resources Capacity Development Project. University of Arkansas, Fayetteville, AR.

Seabloom, R.W. and A. Hanson. 2005. Constructed Wetlands: A Critical Review of Wetland Treatment Processes - PowerPoint Presentation. *in* (M.A. Gross and N.E. Deal, eds.) University Curriculum Development for Decentralized Wastewater Management. National Decentralized Water Resources Capacity Development Project. University of Arkansas, Fayetteville, AR.

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Suggested Course Materials

Table of Contents

Agenda	1
Overview.....	2
Outline.....	3
Goals	5
Learning Objectives	6
Prerequisites	7
Evaluation Forms	8
Problems Sets.....	10
Problem Sets with Solutions.....	11

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Overview

The definitions pertaining to constructed wetlands and large polishing wetlands and their history will be covered. The two types of constructed wetlands share the same characteristics, but are distinguished by the location of the hydraulic grade line. The removal mechanisms for pollutants in both types are outlined, such as biochemical oxygen demand (BOD), total suspended solids (TSS), nitrogen, phosphorous, pathogens, metals and trace organics. Construction, operation, maintenance, and design considerations are also discussed. Finally, the four common misconceptions concerning constructed wetlands are presented.

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Agenda

The goal of this module is to introduce the student to constructed wetlands, which is a relatively new technology used in the small scale wastewater management field. They employ the same biological processes found in larger wetland systems to provide treatment of residential septic tank effluent to raise the quality up to secondary effluent standards. The instructor should make it clear, if nitrogen and phosphorous removal are requirements, constructed wetlands may not be the appropriate technology. Also, the use of constructed wetlands has a certain degree of risk due to possible dermal contact with the septic tank effluent. There are two basic types of constructed wetlands that share many of the same characteristics, namely the free water surface (FWS) and the vegetated submerged bed (VSB). It is recommended this material be introduced toward the end of a 10 week quarter or 12 week semester course with three classes per week using 50 minute class periods. This material should be covered in two class periods.

- Class 1: Introduction, definitions, history, pretreatment. Two types of constructed wetlands. Free water surface (FWS) and vegetated submerged bed (VSB). Removal mechanisms of FWS, BOD, TSS, nitrogen, phosphorous, sulfur, pathogens, metals, synthetic organics. Performance FWS.
- Class 2: Vegetated submerged bed removal mechanisms, BOD, TSS, nitrogen, phosphorous, sulfur, pathogens, metals, synthetic organics, performance VSB. Design considerations. Conclusions FWS and VSB. Common misconceptions. Performance.

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Module Outline

- I. Introduction
 - A. Definition
 - B. History
- II. Pretreatment
- III. Types of Passive Constructed Wetland Treatment Systems
- IV. Free Water Surface (FWS) Constructed Wetlands
- V. Removal Mechanisms on Free Water Surface (FWS) Wetlands
 - A. Removal of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS)
 1. Discrete and Flocculent Settling
 2. Filtration/Interception
 3. Resuspension
 - B. Nitrogen Removal Mechanisms
 1. Chemistry of Nitrogen
 - C. Phosphorous Removal Mechanisms
 1. Physical Chemical Separations
 2. Biological Transformation of Phosphorous
 - D. Pathogen Removal
 1. Removal Mechanisms
 - E. Metals
 1. Removal Mechanisms
 - F. Trace Organics
 1. Removal Mechanisms
- VI. Performance
- VII. Vegetated Submerged Bed (VSB) Constructed Wetlands
- VIII. Removal Mechanisms in Vegetated Submerged Bed (VSB) Constructed Wetlands
 - A. Removal of Biochemical Oxygen Demand (BOD)
 - B. Nitrogen Removal Mechanisms
 - C. Phosphorous Removal Mechanisms
 1. Physical Chemical Separations
 2. Biological Transformations
 - D. Pathogen Removal
 1. Removal Mechanisms
 - E. Metals
 1. Particulate Filtration
 - F. Trace Organics
 1. Removal Mechanisms
- IX. Performance
- X. Construction, Operation, and Maintenance
 - A. Containment Structures
 - B. Inlet and Outlet Devices

- C. Media
 - D. Vegetation Establishment
 - E. Operation and Maintenance
 - XI. Design Considerations
 - XII. Performance
 - XIII. Conclusions
- Constructed Wetlands – Common Misconceptions

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Goals

To make the student aware that constructed wetlands may be an appropriate wastewater treatment technology for small communities where inexpensive land is available, skilled labor is scarce, and nitrogen and phosphorous removal are not requirements. At the same time the students will be informed of the aesthetic appeal to the general public which lends to make them even more attractive in spite of their limitations.

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Learning Objectives

The main objectives are to see to it that the students understand the terminology of constructed wetlands and the processes within the two types. Also to teach students to differentiate between the constructed wetland being studied and the larger natural wetlands which have historically existed.

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Prerequisites

It is intended for senior civil engineering and environmental health students who have previously completed an introductory course in environmental engineering.

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Evaluation Form

Reviewer: _____

We are requesting your assistance in reviewing the modules developed through the On-Site Consortium curriculum project. Please complete the following form while reviewing the materials

With a rating scale of 1 (Disagree) to 5 (Agree), please respond to the following questions

Review of printed materials:

	Disagree				Agree
The text completely covers the topic area.	1	2	3	4	5
The visuals completely cover the topic area.	1	2	3	4	5

Review of learning objectives:

1.) The need for primary treatment of the influent to a small constructed wetland was adequately explained.	1	2	3	4	5
2.) While the two types of constructed wetlands share many of the same characteristics, it was made clear that the one distinguishing characteristic was the location of the hydraulic grade line.	1	2	3	4	5
3.) The contrast between small constructed wetlands and naturally occurring large polishing wetlands was made clear.	1	2	3	4	5
4.) It was made clear why the FWS could not be counted upon for removal of nitrogen and phosphorous from the wastewater.	1	2	3	4	5
5.) While the inherent aesthetic appeal of constructed wetlands to the general public is very high, there may be times when the designer has to convince the public that they are not a viable option. The student will be prepared to handle such a situation.	1	2	3	4	5
6.) The four common misconception about constructed wetlands were given proper consideration.	1	2	3	4	5

What specific recommendations would you provide for the text. _____

What specific recommendations would you provide for the visuals.

Please give specific positive or negative comments on the topic/module. _____

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Problem Sets

- 1.) Other than size, what is the important distinction between the widely used large polishing wetlands and the small constructed wetlands?
- 2.) Why does the use of constructed wetlands have a greater degree of public health risk than the other forms of small scale wastewater management?
- 3.) Describe the main difference between the Free Water Surface (FWS) and Vegetated Submerged Bed (VSB) wetlands.
- 4.) In the operation of the FWS and VSB wetlands, nitrogen and phosphorous may be assimilated by plant uptake, yet they both cannot be counted upon as being removed from the wastewater. Explain.
- 5.) Explain why normal non-pathogenic organisms known as coliforms are used to identify the presence of pathogens in wastewater.
- 6.) Although most species of animals are probably harmless or even beneficial to the function of a constructed wetland, there are a few nuisance species. Name and describe two species and their impact on the wetland.
- 7.) In general does the climate have any influence on the functioning of a wetland? Explain.
- 8.) In spite of the wetland's inherent appeal, there may be times when the designer may have the unhappy experience of having to convince the public that they are not a viable option. Discuss.
- 9.) At the present time wetland design is based upon current and reliable information. True or False? Discuss your answer.

Constructed Wetlands: A Critical Review of Wetland Treatment Processes

Problem Sets with Solutions

- 1.) The distinction is based upon the strength of the wastewater entering. Constructed wetlands receive septic tank effluent and treat it to secondary effluent standards, while the large polishing wetlands receive secondary effluent and provide further tertiary treatment.
- 2.) The use of constructed wetlands has a certain degree of risk due to possible human dermal contact with the incoming septic tank effluent. Also they may provide conditions favorable for the growth of mosquitoes, some of which may provide for possible transmission of disease.
- 3.) They are distinguished by the location of the hydraulic grade line, which in the FWS wetland is at the surface and with the VSB it is subsurface.
- 4.) The uptake of nitrogen and phosphorous by plants occurs during the growing season, but during senescence in the fall and winter, plant death occurs and unless harvested and removed, the nutrients are recycled right back into the system.
- 5.) It is very difficult and expensive to isolate and identify pathogens in wastewater, and since coliform organisms are excreted in large numbers by warm blooded animals and are relatively easy to identify and enumerate, their presence is taken as presumptive, but not definite evidence of pathogens.
- 6.) Burrowing rodents may disrupt berms and dikes and consume emergent vegetation, and water fowl in large numbers may stir up sediments and add excessive nutrients from their droppings.
- 7.) Since wetlands rely partly on biological decomposition, the warmer climates are preferable. In addition if ice covers the open water surface, it will impede the transfer of oxygen.
- 8.) Wetlands may not be an appropriate option for small communities where land and skilled labor are scarce and expensive. They should not be suggested if nitrogen and phosphorous removal are required.
- 9.) False. At the present time wetland design is based upon a limited amount of observed data rather than scientific theories, and thus the design is still empirical.