A Constructed Wetland System for Water Quality Improvement of Nursery Irrigation Wastewater[1]

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Most nurseries use agri-chemicals in their operations to obtain maximum production from their crops. Not all of these chemicals are utilized by the crops. Irrigation wastewater and natural runoff can carry nutrients and agri-chemicals to an off-site waterbody or into the groundwater. This contributes to non-point source pollution and can lead to eutrophication of streams, reservoirs, and other bodies of water. It can also contaminate the groundwater. Eutrophication often results in undesirable aquatic plant growth (Hammer, 1989). However, the nutrient-laden water can be diverted into a relatively small area where a treatment system has been established. The system resembles and functions like a natural wetland to remove nutrients, sediment, and other contaminants before the water returns to surface or ground water (see Figure1).

Figure 1. The Cedar Draw Water Quality Demonstration and Research Project located in southern Idaho 5 miles Norh of Buhl, ID (near the Snake River). This constructed wetland system is only 2 years old.

A Constructed Wetland System (CWS), sometimes referred to as a nutrient and sediment control system, is both a biological and a physiochemical treatment system that utilizes wetland plants and microbes to assimilate and break down excess nutrients and remove them from the irrigation wastewater (DuPoldt et al., 1993). It is a cost effective way to treat agricultural wastewater before it is returned to surface or groundwater. Few systems of this type that treat nursery wastewater have been built, especially in the arid and semi-arid West. These ecoregions pose special problems for the operation of a year-round constructed wetland system. The first problem is that much of this area receives 10-40 cm (4-16 inches) total annual precipitation, most of which comes in the form of snow. This natural precipitation must be supplemented with irrigation water if crops are to be economically produced. The moisture required for most wetland plants to survive and spread is only available from April through October when water is turned into the irrigation system.

Another problem with the arid and semi-arid west are the temperature extremes. Many of the wetland plants that have been used in Constructed Wetland Systems for water quality improvement in the eastern and southern United States do not grow in the typical weather extremes of the drier West. So, other wetland species must be used to efficiently operate a Constructed Wetland System during the irrigation season and yet survive with almost no water through late fall, winter, and early spring.

A Constructed Wetland System is designed to mimic a natural wetland's purification process by removing a variety of nutrients, sediment, and other contaminants. The actual size of each component is based on contaminant levels (e.g. nitrogen, phosphorous, or total suspended solids) in the water, hydraulic loading rates, and water retention time. The system is not meant to replace proper nursery management, only to supplement it, especially in situations where no other cost effective alternatives are available.

A few advantages of a CWS are: only a small area is needed, low construction costs, long life, easy management, and potential economic returns from harvesting green manure. A CWS is inexpensive, usually constructed on site, and mimics the way natural wetlands treat runoff.

A Constructed Wetland System can also be used in a wide variety of situations other than nursery wastewater treatment. For example, dry cropland, irrigated cropland, irrigation wastewater recovery drains, pastures, and animal waste facilities. A properly designed system can remove a significant amount of nitrogen, soluble and insoluble phosphorus, and sediment from wastewater. It can also improve water quality by reducing the total suspended solids, total dissolved solids, turbidity, some heavy metals, bacteria, and several trace elements (Dortch, 1992).

Constructed Wetland Systems for water quality improvement of irrigation wastewater in the arid and semi-arid West are based on a System that was designed and constructed in Maine (Wengrzynek and Terrell, 1990). USDA holds a public patent on this five-component system based on the biological action of the plants and microbes (US Patent Office, 1992). Each component is specifically designed and sized to reduce or remove various contaminants from the wastewater as it makes its way through the system and eventually returns to surface or ground water. The components are also sized to take excess water that a 25-50 year flood event may produce. During flooding events, the retention time will decrease from the 4-5 day rule to as little as 1 day depending upon the storm event. The lowered retention time will not allow as thorough removal of nutrients as would be normally expected, but it will act as a filter and erosion control complex (Wengrzynek and Terrell, 1990). In Maine, it has been reported that even after storm events of 5 cm/hr that occurred on saturated ground, the system was able to remove 94% of Total Phosphorous and 95% of Total Suspended Solids (US Patent Office, 1992).

The 5 components in a Constructed Wetland System are:

1) Sediment basin - wastewater first enters the CWS at the sediment basin. The sediment basin is designed to collect organic matter, larger sediment particles and adsorbed phosphorus from the wastewater before it enters the next component. It regulates flow and acts as a buffer to protect the majority of the other components from abnormal runoff. Nothing is planted in this component. Over time submergent vegetation will establish, but will be removed with periodic cleanout.

2) **Primary filter** - a level area that receives sheet flow from the sediment basin. It is planted with rhizomatous grasses or wetland plants to establish a dense sod. Species include 'Garrison' Creeping Foxtail (*Alopecurus arundinaceus*), or a combination of Baltic Rush (*Juncus balticus*), Nebraska Sedge (*Carex nebrascensis*), and Creeping Spikerush (*Eleocharis palustris*) depending upon specific landowner objectives. This component removes fine sediment, nutrients (mainly nitrates), and acts as a buffer to protect the vegetated wetland from abnormal runoff.

3) Shallow wetland - constructed to maintain shallow water and saturated soil conditions. It receives water flow from the primary filter. This component is especially important in the removal of nitrates, ammonia, and bacteria. The conditions are suitable for growth of a dense stand of emergent aquatic plants and habitat for important micro and macro organisms. This component is normally planted to Hardstem Bulrush (*Schoenoplectus acutus*) and Cattails (*Typha latifolia*).

4) Deep water pond - designed to provide a limnetic ecosystem for nutrient (mainly ortho-phosphorous) and fine sediment removal. Water from the shallow wetland flows into the deep water pond. The pond ecosystem is a living filter which provides habitat for a variety of organisms. This component is too deep for emergent vegetation. It is usually planted with Duckweed (*Lemna* sp.), Pondweeds (*Potamogeton* sp.), and other submergent plants.

5) Final filter - relatively level, stable, vegetated area between the deep water pond and the surface or ground water where the cleaned irrigation wastewater is deposited. The final filter will remove algae and nutrients that occasionally might move through the system during spring runoff or flood conditions. This component is planted to a wide variety of native wetland plant species. It can also have woody riparian plant species in it.

Maintenance of the system is necessary on an annual basis. Harvesting above-ground vegetation in the Primary Filter and occasional sediment removal from the sediment basin and deep water pond are critical parts of system maintenance (USDA Soil Conservation Service, 1993). Removal of the above ground biomass in the Primary Filter is necessary to remove assimilated nutrients. This can be accomplished by haying and feeding the harvested plant materials or by chopping the plant materials and applying it on other fields as fertilizer. Decay of unharvested above ground plant materials would release the nutrients back into the water when it reenters the system the next year (Mitsch and Gosselink, 1986). Vegetation in the Shallow Wetland should not be harvested on a regular basis. The living and dead material provide sites for microbial activity that is necessary to break down the excess nutrients in the water. Phosphorous is also removed from the wastewater by attaching itself to the suspended solids. The majority of these solids are removed in the sediment basin (Dortch, 1992). Cleanout of the sediment basin and reapplication of the sediment on fields allows long term removal and reduces fertilizer costs.

Additional benefits can be achieved from the sale of plants from the different components as the system matures. Since most of the nutrient breakdown is accomplished by microbial activity in the rhizosphere, extensive adventitious root growth provides more total area for microbial attachment sites (Brix, 1987). As the plants mature, less adventitious root growth occurs as the plants put more energy into seed production. By removing some of the plants from the colony, the remaining plants tend to put out more adventitious roots again. The plants that are removed can then be sold to help defray the original cost of construction or continued maintenance costs.

Existing systems have produced removal efficiencies of 66 to 95% for nitrogen, total phosphorous, and total suspended solids (Dortch, 1992). Extensive application of this technology would result in significant improvements in water quality, wildlife habitat, aesthetics, and quality of life. By using this system for nursery wastewater quality improvement, the entire nursery trade can demonstrate its commitment in helping to improve the nation's surface and ground water quality.

Plants necessary to populate the various components are not readily available on the market. This is especially true of performance-tested ecotypes. In order to address this need, the Interagency Riparian/Wetland Plant Development Project, USDA-NRCS Plant Materials Center, Aberdeen, ID recently released 22 performance-tested ecotypes of six different species of wetland plants:

Nebraska Sedge, *Carex nebrascensis* **(CANE2)**

Creeping Spikerush, *Eleocharis palustris* **(ELPA3)**

Baltic Rush, *Juncus balticus* **(JUBA)**

Threesquare Bulrush, *Scirpus pungens* **(SCPU3)**

Alkali Bulrush, *Scirpus maritimus* **(SCMA)**

Hardstem Bulrush, *Scirpus acutus* **(SCAC)**

Plants from each of four different ecoregions (based on Land Resource Regions as defined in Agriculture Handbook 296) located in the Plant Materials Center Service Area of Idaho, eastern Oregon, northeastern California, Nevada, and Utah were selected based on their performance in low precipitation, medium elevation areas of the Intermountain and Great Basin regions. In addition, they were selected based on seed production, spread, and vigor (Figure2). These plants were released under the new alternative plant release procedures defined by AOSCA as Selected Releases (Young, 1995). Release notices are available upon request. Seed can be obtained by collecting at the Selected Release source.

Figure 2. The Prairie habitats' "Prairie Seed Stripper can be used to collect the seeds of all the wetland plants worked with in the Constructed Wetland Systems.

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