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CONSTRUCTED WETLAND SYSTEM FOR WATER QUALITY IMPROVEMENT OF IRRIGATION WASTEWATER

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Most farms 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. This contributes to non-point source pollution and can lead to eutrophication of streams, reservoirs, and other bodies of water. It can also contaminate 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.

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 agricultural 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 this area receives 10-25 cm (4-10 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. Enough moisture to allow 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 other 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 the fall, winter, and early spring.

The Constructed Wetland Systems for water quality improvement for 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 patent on this five component system based on the biological action of the plants and microbes (US Patent Office, 1992). The average total annual precipitation is about 102 cm (40 inches) in Maine. The System was installed to treat natural runoff from a 65 hectares (160 acre) potato field. Irrigation water is not needed. Indications are that the system had a removal efficiency of 65 to 100% for nitrogen and total phosphorus (Wengrzynek and Terrell, 1990).

A few advantages of a CWS are: low number of acres used, low construction costs, long life, easy management, and return benefits from harvesting green manure. Agricultural wastewater can be treated several ways. A CWS is inexpensive, usually constructed on site, and mimics the way natural wetlands treat runoff.

A Constructed Wetland System can be used in conjunction with 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).

A Constructed Wetland System for water quality improvement is designed to include 5 components. 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 returns to surface or ground water. The components are also sized to take excess water that a 25-50 year flood event can produce. During these abnormal water times, 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 may not allow as thorough a 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 TP and 95% of TSS (US Patent Office, 1992).

The 5 components in a Constructed Wetland System are:

1) Sediment basin - 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.

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. A subsurface tile is normally installed to pick up water percolating through the soil. This component removes fine sediment, nutrients, 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.

4) Deep water pond - designed to provide a limnetic ecosystem for nutrient 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.

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.

A Constructed Wetland System for water quality improvement is designed to mimic a natural wetland's purification processes that remove 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 on-farm management, only to supplement it, especially in situations where no other cost effective alternatives are available.

Maintenance of the system is necessary on an annual basis. Harvesting above-ground vegetation in the different components 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 particularly 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 to the 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). 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.

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 on-farm or multi-farm irrigation wastewater water quality improvement, agriculture can demonstrate its commitment in helping to improve the nation's surface and ground water quality.

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