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Wetlands Creation using Secondary Treated Wastewater

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INTRODUCTION

The concept of using treated sewage effluent as a freshwater source for the creation and restoration of wetland ecosystems qualifies as an alternative wastewater management technology for meeting the objectives of the 1977 Clean Water Act Amendments promoting the use of land treatment processes that reclaim and reuse municipal wastewater. Wetlands reclamation projects are cost effective and in this particular case will allow the treatment facility to bypass more expensive dilution requirements. Depending on site conditions, energy requirements are minimal compared with landscape irrigation, agricultural, or industrial reclamation projects often requiring extensive pumping or additional treatment. Wetlands projects are also consistent with EPA's multiple use policy supporting wastewater management practices which combine open space, recreational and education considerations with such management.

During the past century, over eighty percent of the wetlands within the San Francisco Bay region have been drained or filled to make way for agricultural, residential, industrial and other uses. In addition, massive diversions of freshwater to the Central Valley and Southern California threaten the remaining natural wetlands, particularly the upper reaches of the estuary, which are subject to reduced outflow of fresh water and increased salinity levels. This loss of wetland habitat has resulted in greatly reduced wildlife and migratory waterfowl populations throughout the bay region. In 1974 the Mt. View Sanitary District (MVSD), near Martinez, California initiated a full-scale pilot wetlands enhancement program on their low-lying reclaimed tidelands. The objective of the program was to demonstrate the feasibility of utilizing sanitary plant effluent to create a wetlands environment for wildlife and migratory waterfowl habitat. Management techniques were tested to improve water quality and wildlife habitat and for recreation and education. The unique aspects of this project is the use of reclaimed wastewater as the sole hydrologic source for the site.

PROJECT OVERVIEW

The restoration area is located adjacent to the Mt. View Sanitary Facility and is 20.3 acres (8.2 ha). The wetlands plots cover 15.2 acres (6.1 ha) with a capacity of 3.8 acre feet providing a 4.8 day retention time at plant flow of 1.6 million gallons a day. The site consists of five interconnected wetland ponds with tributary edge habitat. All of the treatment plant discharge passes through the ponds and marshes into Peyton Slough which then discharges into tidal waters of Suisun Bay through a tide gate.

This area was originally a tidal marsh/estuarine complex with saline water flowing in from the San Francisco Bay. The soil was predominantly saline. Little of this original area is still present. The restoration area is currently surrounded by a Chevron oil processing facility, a county dump, an eight lane interstate highway and a small residential community. The nearest wetland area is on the other side of the interstate. The project area has no hydrologic connection to this natural wetland.

All of the wastewater flowing through the wetlands complex is powered by gravity; no pumps of any kind are used. Since a prime design objective is to provide a combination of open water and vegetated habitat, this method of channelization directs the flow through the vegetation and provides for circulation. A series of weirs between each of the wetlands allows for manipulation of water flow.

METHODS

The engineering involved in this project took the view that a well-designed project is one that requires little maintenance and can avoid nuisance problems. The purpose of the wetland construction was to provide wetland habitat for waterfowl and help improve water quality and not necessarily to mimic other natural biomes. Construction took place primarily with an emphasis on the physical structure of the wetlands and the expected hydrologic flow. The following are aspects of the restoration of primary importance to the engineers.

Levees - The area was divided into six wetland plots separated by levees. Each of the levees are at least ten feet wide, steep-sided and compacted during construction. Many wetland organisms such as muskrats, gophers, crayfish and other small mammals tunnel into levees. Proper design, to discourage degradation and minimize maintenance was crucial.

Plot Design - A multiplot system of wetlands was created to allow for variations in depth and residence time. Depth determines whether emergent vegetation or open water will be present. Depth and vegetation will also effect temperature and dissolved oxygen. Keeping dissolved oxygen values high is important to reduce odor problems that can occur in anaerobic conditions.

Disease Vectors- Avian botulism (*Clostridium botulinum*) is a deadly waterfowl disease that can be prevented by removing organic debris that collects behind the weirs, assuring circulation and avoiding anaerobic conditions. Another vector problem concerns the presence of mosquitoes. Originally this problem was addressed by attempting to avoid stagnant water through manipulations in the hydrologic design. This approach was only moderately successful and as a result mosquito fish (*Ganbusi afinis*) were added to the wetlands. The addition of mosquito fish caused an immediate drop in the mosquito populations. It also caused a drop in the presence of zooplankton. This decrease in zooplankton grazing on algae caused a significant increase in algal abundance.

RESULTS

The structural aspects mentioned in the methods section were all that was done to restore this area. Vegetational secession and establishment of wildlife occurred primarily unassisted and unmanaged. The results discussed below were quantified two years after construction of the wetland complex was completed.

Both submerged, emergent and terrestrial macrophytes had established themselves in the restoration area. Sixty-seven species were identified on the site and none were planted by the MVSD. Twelve of these identified species were emergents including *Typha spp., Scirpus spp.* and *Carex spp.*. A relatively low abundance of native plants were present on the site. Only twenty-nine of the sixty-seven species were native to California. Whether this low native density was representative of the surrounding landscape or was a function of the restoration method was not evaluated.

The presettlement condition of this area as a brackish marsh is still evident in the saline quality of the soil. Ten of the identified species were considered saline tolerant. The remaining plants in the site are field annuals, perennials, herbs and shrubs. The vegetation serves as food and habitat for a variety of animals. These also improve water quality through increased nutrient cycling. The surface area of the wetlands is approximately 63% open water combined with 37% covered with emergent vegetation. Little or no upland habitat is present with most of the ponds being enclosed by steep levees.

Algal growth within the wetlands has been prodigious and beneficial. The growth of algae helps to remove ammonia from the water, oxygenate it and act as a food source for the zooplankton. Algal growth is highest in the summer. Few problems with nuisance algae, such as filamentous mats, blue-green growth or other odor producers has occured. Such growths can be a problem in nutrient rich environments. Algal density increased significantly with the introduction of the mosquito fish which preyed on algae grazing zooplankton. In future years increased predation on the mosquito fish by egrets may help restore a balance with less algal abundance.

Twenty-one species of large vertebrates, not including birds, live at the MVSD wetlands; ten species of mammals, four species of amphibians, four species of reptiles, three species of fish. One study found heavy use of the levees by mice (*Mus musculus* and *Reithrodontomys megalotis*) and muskrats (*Ondatra zibethica*). All of the animals present came to the MVSD wetlands on their own.

Eighty-five species of birds either live in or stop at the wetlands to feed during migration, a relatively large variety for such a small area, especially when compared with the surrounding, highly developed, area. Of the eighty five species 15 are ducks, 32 species of water and shorebirds, 30 passerine species, and 6 species of raptors. There are a number of bird families that have inhabited the wetlands for several generations.

More than 34 species of aquatic invertebrates live in the wetlands including bugs, beetles, flies and zooplankton. The volume of invertebrates and rate of reproduction are impressive. During the summer of 1977, up to 3.8 lbs/hr of zooplankton (mainly Daphnia) were trapped in an outlet weir. There has been some interest in selling this food source to local fish stores for supplementary income.

Biochemical oxygen demand (BOD), a measure of the amount of oxygen needed by microbes engaged in the process of organic decomposition, was used as a quantitative measure of water quality. Water entering and leaving the wetlands tended to be equal in BOD. Although the BOD was equal at the input and output of the system it is important to note that human waste is the primary organic substrate at the input and algae serves this purpose at the outflow This shows that nutrient cycling is occurring within the wetland.

The dissolved oxygen (DO), a measure of oxygen dissolved in the water, varies diurnally and seasonally. The highest DO occurs in the summer during periods of peak algal production and the lowest DO occurs in the winters in early morning. An overall increase of DO in the effluent is due primarily to algae. Suspended Solids (SS), the turbidity of the water, was also measured to assess water quality. SS has increased and this is due mainly to higher densities of algae and not inorganic sources such as silt and clay that can have negative effects on the ecosystem. Nitrogen concentrations measured as nitrate, ammonia and organic nitrogen significantly decrease as water flows through the wetlands system. Phosphorous (measured as PO_4) decreases as well, probably accumulating in the sediment and plants.

CONCLUSIONS AND CRITIQUE

The Mt. View Sanitary District was fairly successful in meeting the goals of habitat creation for megafauna. A great number and variety of species use the wetlands either permanently or temporarily. The wetlands have also proven to be beneficial to the larger community that uses this site for recreational wildlife observation. The wetlands are a popular site for the local chapter of the Audubon Society. This environment also provides an educational environment for local high schools and colleges.

The designers were moderately successful in improving the water quality of the treatment plant effluent. There has been an overall increase in the suspended solids of the effluent. This natural turbidity has less of a detrimental effect than inorganic suspended solids would. The net decrease in nitrogen is very beneficial to the water quality and serves as evidence that this tertiary treatment provides functional as well as aesthetic benefits.

The in house analysis of the project (Demgen & Nute, 1979) states that the designers do not feel that phosphorous is the limiting nutrient in this environment, yet there is no documented case of blue-green algae blooms, a common occurrence in nitrogen limited environments. Long term phosphorous build up in the sediment and vegetation is an issue that is important and unfortunately not addressed. Will there be periodic harvesting of the vegetation or removal of the sediment? Discussion with current scientists working at the site show that they are looking at disposing of this excess phosphorous tied up in vegetation through incineration or composting. The difficulty of composting is the potentially high concentrations of heavy metals that are found in the municipal waste stream. This raises other issues of the safety of effluent water for use by wildlife. Although no detrimental effects have been observed there is very little research in the area of how pollutants could potentially effect the physiology of organisms on the site.

Another issue not addressed in their analysis is the chlorination of the effluent previous to its entry to the wetland. This provides reduced coliform concentrations in the effluent but may prove detrimental to the wetland environment. They recently remedied this problem by installing a UV radiation treatment to the effluent treatment process, negating the need for chlorination.

Although much information was given on the structural aspects of the wetland, I would be very interested in finding out more about the functional processes that are occurring. Nutrient cycling, organismal interaction, annual vegetational surveys, nesting success of waterfowl and rates of predation are all aspects that could provide a better picture of this wetland restorations success or failure. These aspects are outside the scope of the project as it was intended but may provide more information on the success of this project in areas other than those defined by its progenitors.

One of the greatest successes of this project comes from the impact it can have on the desirability of wetland restorations. This restoration is one of the unique situations where a wetland environment was established for reasons other than mitigation or replacement. The project is also a recognition that natural systems have the ability to function beneficially in a utilitarian as well as aesthetic manner.

LITERATURE CITED

Demgen F. and W. Nute, Welands Creation Using Secondary Treated Wastewater, American Water Works Assoc. Proceedings, 1979 V.1, p. 727-739