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Various methods of water marsh utilization for domestic sewage waste water treatment

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Various methods of water marsh utilization for domestic sewage waste water treatment

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ABSTRACT

Different methods are being used for the removal of unwanted material from waste sewage water such as mini sewage treatment plant, infiltration and filter bed. But as compared to all above methods introduction of marsh is more beneficial, as marsh efficiency is much better then above mentioned methods. Marshes also have important role in biodiversity. Domestic waste sewage water contains organic material, viruses, bacteria and pathogens, nitrate and phosphate. These all factor influence the external environment. Removal of nitrate and phosphate is necessary because if they are not removed they may cause rapid increase in the growth of algae. Algae have short life span so they die. Bacteria use a lot of oxygen for the decomposition of algae. So as a result there becomes deoxygenating in the marsh. Most of the animals die because of lack of oxygen in the water source. Marsh method is better as compared to other methods for the removal of organic material and nutrients. Subsurface flow is needed in wetland for getting the best result. Subsurface flow wetland system will make the process better and it will minimize the effect of odor and insects and these both things directly create bad effect on external environment. In the subsurface flow wetland Phragmites australis and similar plants are used. Bacteria grow on the roots of these plants and break down the nutrients. Waste water treatment marshes are best suited for smaller towns, villages and single family homes. They work best under relatively warm conditions, but many are used in temperate climate as well. For the removal of microorganisms, chlorine is to be used, as it is best way for the removal of it. A de-chlorination process is also necessary, otherwise this water will create bad effect on aquatic life.

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Abbreviations

BOD…….....Biological Oxygen Demand

COD……Chemical Oxygen Demand

WPM……Water Purification Marsh

DWT…….Duck Weed Technology

SFW……..Surface flow wetland

FWF…….. Free water surface flow

1. Introduction

1.1 Background of the marshes

In the 19th century, dramatic changes were observed in the streams and lakes of urban areas. Beautiful lakes and streams became smelly, messy bottom and became turbid. Algae bloom was observed in large scale area. After study it was realized that primary producers like algae and plants increase dramatically when phosphate and nitrate were added to these water sources in a large scale. It caused oxygen deficiency and caused death of large amount of aquatic animals. It is important to discuss that nitrate and phosphate are also essential ingredients for the animals. Nitrogen is the part of protein and amino acid. Similarly phosphorous is the component of DNA and nucleic acid. (8)

Around 1970 chemical methods were introduced to treat waste sewage water. But it is important to note that use of chemical is not an environmentally friendly method. So more recently alternative methods using natural or constructed marshes to treat waste water have been developed. The basic idea is that living organisms and land itself is to be used for treatment of water for the safety of biodiversity, instead of using chemicals, as chemical method to treat water is not an environmental friendly way. (8)

Human and animals kidneys remove unwanted material from the body. Marshes act like kidneys and they remove unwanted material in waste sewage water which is harmful for biodiversity. Periphyton (community of microorganisms) plays a very important role for the

removal of required material from waste sewage water. Open waste sewage water has viruses and pathogens in it which are harmful for external environment. Bacteria are also present in it. Some of the bacteria have positive contribution in waste sewage water treatment but some other bacteria are harmful as well. Microorganisms present in the marshes are used for the removal of organic and inorganic material from waste sewage water. (12)

1.2 Wetlands

Wetland

Wetland is consisting of swamps and marshes.

- **Swamps**

Swamps have standing water and saturated soil. They have water tolerant trees like cotton wood, black ash or silver maple.

- **Marshes**
  Marshes are types of wetland which have slow moving water or periodically standing water. They have soft stemmed plants like rushes, sedges and cattails. (16)

According to National Wetland Research Center (NWRC)

"Marshes are wetland dominated by grasses"

1.3 Advantage of Marshes

Some of the advantage of marsh or wetland is that they are involved with low energy input. For the marshes or wetland they only need solar energy for animals and plants in it. It also needs low operational maintenance. As compared to conventional waste water treatment plants, marshes or wetlands are more tolerant for varying pollutant.

Constructed treatment wetland or marsh has also some limitation as well. They need large area. They also need more time period for the growth of vegetation and to achieve better efficiency. Climate conditions also play important role for wetland performance.

Some of characteristics of wetlands are given as

Recharging of ground water and flood control

Wetlands are source of recharging of ground water. When water moves from wetland to underground aquifer, it is filtered and becomes clean for human consumption. When this ground water rises up to the surface, it enters to the other wetland water with more stable biological communities. Wetland stores the water so it is beneficial for the control of flood. (25)

Nutrients

Wetlands are the source of retaining of nutrients especially phosphorous and nitrogen. When water moves slowly, wetland accumulates nutrients. Fish also support for the nutrients in the wetland by supplying organic materials, as wetland are mostly the nursery areas for breeding of fish.

Erosion control

The roots of the plant present in the wetland hold the bottom sediment in place and prevent erosion in it. In wetlands toxic substances, like pesticides and other materials are settling down. This settlement further becomes attractive when different plants like reeds and grasses are present in the wetland. Otherwise this removal of sediments is very costly in man-made dams. (25)

Disposal of waste

Wetlands are source of conversion of nitrates to nitrogen gas which is harmless. This is done by denitrifying bacteria. These denitrifying bacteria are active in water logged anaerobic soils. Wetlands are good sources of detoxification and purification of toxic substances.

Safe place

Salt marshes and sea grass bed have enormous biological productivity. They are source of nursery ground for fishes and birds. Wetlands have shrubs and hedgerows which are used by pest enemies and for bird feeding. Wetland gives habitat to reptiles, birds, mammals and thousands of species of fish. Nations´ 35% rare species of wild life are dependent on wetland. Wetland works like natures´ kidney. It filters sediments and pollutants from surface water. Wetland plants reuse and circulate phosphorous and nitrogen and other necessary nutrients. (25)

Recreation and Tourism

Wetlands are the source of boating, fishing and birds watching. So we can say that wetlands are also the source of recreation and tourism. This is especially true for many constructed or reclaimed wetlands. (25)

1.4 Wetland management

Some of the management considerations are:

- It is not good to create wetland or marshes with roads or buildings
- It is necessary to provide buffer of 100 feet for vegetation to protect wetland from chemical runoff, degradation or sediments.
- Maintain plants with the dense grass on buffer place. It is also better to haves shrubs within the grasses.
- It is good to leave naturally decaying and dying trees on buffer area of wetland.
- To prevent marshes or wetland from chemicals, pesticides and petroleum product because their presence will be harmful for aquatic life
- Allow natural fluctuation of water level.
- Grow such plants which create cover and food for wetland birds and variety of other wild life like cattails, smartweed, cattails, sedges, reeds.
- Wetland or marshes are to be minimum disturbed by people. Too many disturbances may create problem for breeding, nest abandonment for birds.
- Birds must not be disturbed by grassland manipulation like burning, grazing, and mining after July 15 and before August 30 to reduce impact for nesting of birds.
- It is necessary not to cut all grassy area each year. Only one third of grassy area is to be cut each year. Other area is to be left for wild life habitat. (16)

1.5 Human impacts on marshes

- Finishing wetland or marshes for the purpose of construction of buildings and roads.
- Dumping wetland or marsh for the increase of lawn or field size (Agriculture purpose)
- Pollution of industries and vehicles
- Construction of dams, roads and highways.

Many reports indicate that separation distance from wetland for human should be 15 to 100 meter for the purpose to minimize the impact. The distance should be kept as a buffer in order to decrease the adverse impact of human. (9)

1.6 Status of marshes in the world

In Sweden one quarter of wetland area has disappeared because of cultivation and drainage and other human activities. Fifteen percent of the species which are on the red list are contained by marshes or wetlands. Half of the wetland lost in Sweden has been lost because of drainage by the forestry industry. Almost 40 percent of the wetland has been converted to farmland. Large number of wetlands has been finished in southern Sweden. Many valuable wetlands have been finished by making roads, airports and railway lines. After even these losses, Sweden is a country which is rich in wetlands.

It is estimated that 70 percent of wetland have been finished world-wide in the last 50 years. Only in America, 870 000 km^2 of wetlands have been lost because of agriculture. It means that 80 percent of the American wetlands have been lost because of agriculture. At the end of the 20^{th} century almost half of the nation's fish population was having pollution problem. Wetlands are finished because people are working to make the land for agriculture and are trying to, what they think, better use this wetland water. (6)

Wetlands are used to clean the water, flood control, fisheries support and also for recreation purposes as well so it is necessary to think seriously about the destruction of them. It is necessary to use land for agriculture but at the same time it is also necessary to save the environment.

Portugal has lost 70% of area of wetland for industrial development and agriculture purposes.

Philippines lost almost 300,000 hectares which becomes 67% of wetland area in 60 years (1920-1980). (6)

List of countries with percentage wetland loss in Europe are

Country	Period	Percentage loss of wetlands
Italy	1938-1984	66%
Netherland	1950-1985	55%
Germany	1950-1985	57%

Wastage of marsh created biodiversity problem so now people belonging to different nationalities are working for the improvement of natural marshes. At the same time it is also being worked for the construction of artificial marshes as well. (6)

2. Theory

Domestic sewage waste water contains organic material, nitrate and phosphate, bacteria, viruses and other parasites. Removal of nitrates and phosphates is necessary, if they are not removed then these nutrients are used by algae and as a result, it may cause algal bloom. Algal bloom is rapid increase in the population of algae. Most of the algae die as algae have a short life span. Decomposition of algae requires a lot of oxygen. Because of this high consumption of oxygen for the decomposition of algae by bacteria, a lack of oxygen will happen and as a result most of the animals die because of anaerobic conditions in the water resource. (20)

In many developed countries essentially all municipal waste water is treated in sewage treatment works using at least primary and secondary treatment and also often tertiary treatment. These sewage treatment works give a good quality effluent but are expensive to build and requires a high level of technical skills to maintain and run. They require an uninterrupted supply of electricity for pumps, blowers and all monitoring equipment and also chemicals for the tertiary treatment. In many countries these high-tech sewage works are not an option, they will instead look for methods, which are simpler and less expensive, but which will still give a good degree of purification. The most promising of those methods are wetland treatment systems, which are attracting more and more attention also in developed countries. (1, 4, 6, 9, 10, 15, 21, 22, 24, 27, 31, 36, 40, 41) Most of these systems require a primary sedimentation step from which the effluent water is released to the wetland. In many cases the bottom of the wetland has to have a liner, either clay or polymer membrane to keep the water from disappearing through infiltration.

2.1 Problem causing microorganisms in waste sewage water

Following are the micro organisms which cause problem for external environment.

- **Coli-form bacteria**

Coliform bacteria occur throughout the environment. They may be present in soil and surface water. High amounts of coliform bacteria occurs because of waste from animals and human. Coliform bacteria cause mild illnesses and waterborne diseases. It is of rod shaped. In warm blooded animals´ feces, coliform bacteria are present in abundant amount. These are also present in soil as well as in aquatic environment. In the warm blooded animals feces many other pathogenic organisms are also present including protozoa, viruses, multi cellular parasites and bacteria. Diseases which are formed by the coliform bacteria are dysentery and typhoid fever. (13)

Coliform bacteria can enter the animal's body by nose, ear, mouth or cuts in the skin. (13)

- **Viruses**

In the human animal's fecal wastes and urine almost all types of viruses are present. Most important varieties of virus are respiratory and enveloped enteric viruses. Viruses present in semi solid animals and human waste can be contaminated in air if the waste is not properly disposed off. At high temperature viruses are inactive. But at low and moderate temperature and pH, viruses can live for considerable time. It varies from hours, days and until weeks. Overall virus growth is inversely proportional to temperature. Virus can be inactivated at different temperature but there becomes varies of time with increase or decrease of temperature. Viruses become inactivated after 15 weeks at a temperature at 5 ºC. Similarly at temperature 20 ºC it is inactivated after 2 weeks. Under mesophilic conditions, viruses are inactivated after 5 hours. Also at thermal conditions it stops working at 55 ºC. (2)

Studies have shown that virus of human waste have the ability to survive in soil when water is supplied for agriculture purposes.

- **Parasites**

The parasites are the organisms which depend upon other organisms for their food and survival. According to world health organization (WHO), 3.5 billion people suffer from infections caused by parasites. Giardia lamblia and Cryptosporidium are two of these parasites and they cause stomach problem, slight fever and diarrhea. Round worms are also parasites and they cause stomach pain, trouble in breathing and coughing. World-wide 0.6 to 4.3% of humans are infected by Cryptosporidium and 1.5 to 20% humans are infected by Giardia. Cryptosporidium and G. lamblia are two wide spread parasites. Entry of these in poor countries takes place because of poor sanitation. The entry of G. lambia or Cryptosporidium may take place from person to person or by focally contaminated food. Transmission of them may also take place because of contaminated drinking or recreational water. (3) In Sweden, recently two outbreaks of Cryptosporidium-caused illness have been reported to come from municipal drinking water, where the surface water source had become contaminated. (35) This parasite is also very resistant to chemical disinfection.

Giardia genus cause problem in public health. These both parasites may easily live in water treatment systems. (18)

Figure 1: Giardia lamblia (18)

- **Fungi**

There are very many species of fungi. Fungi are considered to be plant with not having chlorophyll. Fungi do not make their own food and they are dependent upon other sources for their food. They mostly grow on dark places. They usually use dead matter for food. Fungi use trash as their food and make it in to the soil. Otherwise without fungi there would have been piles of trash every place. Alternaria is one another fungi in the environment. Spores of Alternaria are sources of allergens in the atmosphere generally causing respiratory problems. Chaetomium is another fungus that is present in 80 different species. It grows in interior buildings and also on plant debris. Fungi are used in medicine making antibiotics like penicillin. (19)

2.2 Biological Oxygen Demand (BOD)

Biological Oxygen demand measures the amount of organic material in water. Biological oxygen demand is the amount of oxygen that will be used by bacteria to decompose organic matter under aerobic condition. High BOD indicates polluted water and low BOD value good quality of water. Dissolved oxygen is the amount of oxygen present in water in dissolved form. Dissolved oxygen is very important for aquatic life. If amount of dissolved oxygen becomes low below a certain level, the aquatic life and fish are unable to survive. When organic matters are added to the water sources it causes an increase in biological oxygen demand (BOD). Dissolved oxygen can be measured in parts per million or milligram per liter. Amount of dissolve oxygen requirement is different for different species. Trout needs 8 mg/per liter. Minimum dissolve oxygen requirement for most of warm water fishes is 2 mg per liter. Dissolve oxygen requirement for striped bass is preferably to be at least 5 mg per liter. (14)

2.3 Micro organisms (bacteria and planktonic organisms) contribution in waste water treatment of marshes

The microorganism community is named as periphyton. Periphyton is a complex mixture of heterotrophic microbes, cyanobacteria and algae. Periphyton have important role in water quality. Periphyton in aquaculture system is used for removal of dissolved and solid pollutants. Periphyton is also considered as a source of food for many animal plankton, tadpoles, fish and invertebrates. (12)

2.4 Bacteria working in decomposition of organic waste

Bacteria decompose organic matter present in the marsh by two processes

Anaerobic digestion

Organic waste + water ------**Enzymes**-------->water soluble nutrients -----**Bacteria**---> water + carbon dioxide+ methane

Aerobic digestion

Organic waste + water -----**Enzymes**----> water soluble nutrients + ----**Bacteria**---> water + carbon dioxide

In both cases enzymes act to make the organic matter into water soluble form and then bacteria act and use it for their food and leave methane, carbon dioxide and water. (28)

2.5 Enzymes

Bacteria and enzymes break down organic waste into carbon dioxide and water. Bacteria use the organic waste for their growth and reproduction. Through a complex reaction organic molecules in waste are decomposed into water, carbon dioxide and methane and it provides energy to bacteria to sustain their life. Enzymes are chemical catalysts and they are used to decompose complex waste into smaller molecules. The smaller molecules can be digested by bacteria.

Enzymes are chemicals and they are used and produced by bacteria for digestion of waste. When these enzymes are added to organic waste, they immediately work to break down the waste. Organic waste after breakdown is prepared food for bacteria to consume. After it

growing bacteria generate and produce their own enzymes to keep cycle in working position. (28)

2.6 Removal of phosphate and nitrate from waste sewage water in marsh

Two main nutrients found in waste water are nitrogen and phosphorus. High amount of nitrates present in drinking water and surface water may cause health effect in human being and eutrophication in water bodies. Marshes and constructed wetland have the ability to reduce the level of nutrients in the waste domestic sewage water. For the removal of contaminants all process like physical and biological process are combined together in wetland for the removal of contaminants from waste water. Waste water treatment in a marsh occurs when this waste water passes through rhizosphere plant and medium of wetland. (21)

Figure 2: Microorganism on the roots of plants (27)

In the past for many years marshes and wetlands have been used for pollution control in water. Treatment process in wetland causes the removal of nitrate, phosphate, bacteria and viruses. Treatment involves process like sedimentation, filtration, removal of BOD and nutrients. (21)

2.7 Removal of nitrogen from marshes

In the marshes nitrogen mostly is present in form of ammonia, organic nitrogen and nitrite. Nitrogen cycle is consisting of three main processes. The first step is ammonification. Ammonification is the conversion of organic N, such as urea, to NH_4^+. Then nitrification is consisting of two steps. First, NH_4^+ is converted to nitrite and then nitrite is converted into nitrate. The last step is the de-nitrification process. In this step nitrate is changed to nitrite and then this nitrite is converted into N_2 gas. (21)

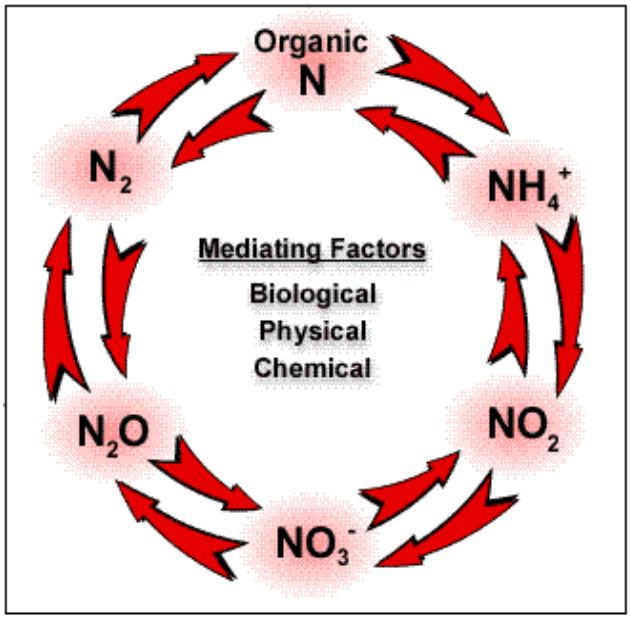


Figure 3: Nitrogen cycle (21)

Nitrogen removal process starts work with nitrification process.

$NH_4^+ + O_2 \rightarrow NO_2^- + 2H^+ + H_2$

Nitrite is oxidized to nitrate

$2NO_2^- + O_2 \rightarrow 2\ NO_3^-$

In the de-nitrification process nitrate is converted into elemental nitrogen gas. The process of de-nitrification occurs in the absence of oxygen and a carbon source is required. Organic matter is used as carbon source. The process is catalyzed by Pseudomonas sp bacteria. As a result of de-nitrification process the N_2 formed is returned to the atmosphere.

$NO_3^- + C$ (organic) $\rightarrow N_2 + CO_2 + H_2O$ (21)

2.8 Phosphorus removal

Phosphorus is found in wetlands as part of sediments. Adsorption plays important role in phosphorus removal in the wetland. Adsorption process occurs because of calcium and iron sediments. Basic to neutral pH condition is needed for adsorption of calcium ions. Decomposition of organic matter and dead plants are also useful for taking up organic matter in the wetland. It results in organic matter storage and it is released eventually. Plants present in wetlands also use phosphorus. Removal of phosphorus is different from nitrogen as it is not removed completely. Removal of phosphorus takes place by fixing in the clay minerals, taken up by plant or absorbed to the metal ions. (21)

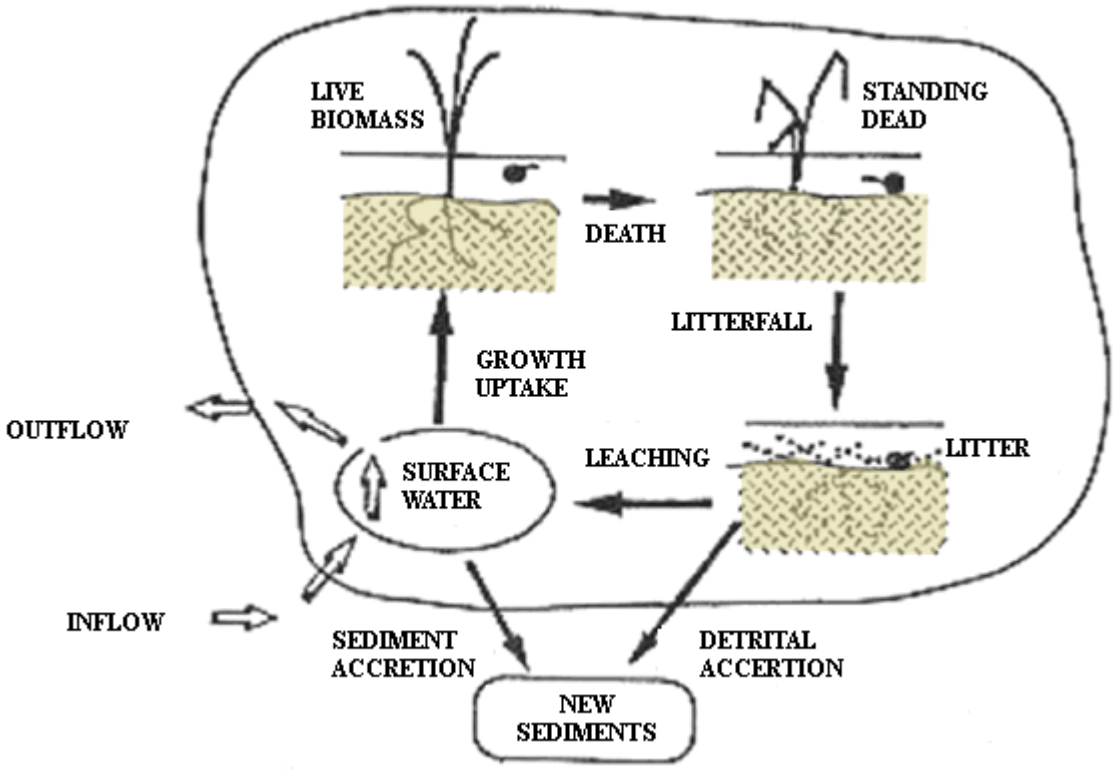


Figure 4: Phosphorus cycle in wetland (21)

2.9 Components of Artificial marsh

In order to understand nutrients removal and waste water treatment process, it is necessary to understand the main components of the artificial marsh. The main components of artificial marshes are

- **Soil or substrate**
  Substrate for the wetland is sand, gravel, rock and soil. In most constructed wetlands gravel is used as substrate for the purpose to increase the surface area for chemical and biological process and to remove pollutants.

- **Living organisms**
  Living organisms present in wetland like fungi, bacteria and protozoa play their role for the treatment of waste water. Microorganisms like bacteria and fungi play their role in biochemical reaction which occurs in wetland for the treatment of waste water. (21)

- **Wetland vegetation**
  Plants used in wetland should have the ability to adapt to the water logged and climate conditions of the area. Plants which are mostly used in wetland are reed (Phragmites australis) and bulrushes (Scirpus). One important function of this vegetation is to produce oxygen during photosynthesis process which is needed for aerobic reactions. This vegetation also has the functions to reduce the velocities of inflowing water so that it becomes suitable condition for sedimentation of suspended solids. (21)

- **Water column**
  Water is basic requirement for the biochemical reaction in the wetland. Transportation of nutrients, organic solids and gases happens because of this medium. (21)

2.10 Certain features of constructed wetlands

Wetlands for treatment of waste water can be found in many parts of the world. They have proven to be competitive solutions for waste water treatment. In some cases, existing wetlands have been used or restored, but in the majority of the cases, constructed wetlands have been developed. Their main advantage is that they can be located also where there is no natural wetland.

Some of the features of constructed wetlands are

- Low energy requirement
- Natural waste degradation
- Little or no maintenance required
- Treatment efficiency is relatively high
- Construction cost is relatively low (29)

Wetland needs low energy as compare to other waste water treatment processes. Constructed wetland needs very less maintenance. Efficiency of constructed wetland for the treatment of sewage waste water treatment is satisfactory, in other words it is high.

2.11 Designing of constructed wetland

A constructed wetland has the potential to treat water from different sources like

- Storm water
- Runoff from highways
- Municipal waste water
- Sewage water from individual homes, farms and communities
- Agriculture waste water (21)

Wetlands can be constructed according to two different principles.

- Surface flow wetland
- Subsurface flow wetland

In surface flow wetland water flow is above the ground. This means that there is an exposed water surface at least most of the time. In subsurface flow wetland, the water level is kept below the surface of the gravel media or rock. Here, there is no visible and exposed water surface.

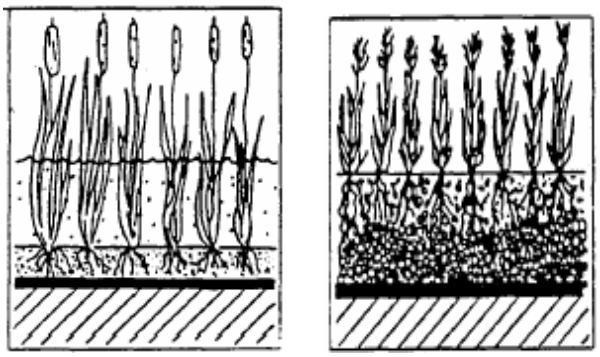


Fig 5: Surface flow wetland Sub-surface flow wetland (32)

2.12 Advantages and disadvantages of surface flow wetland

Advantages of surface flow wetland are:

- They can be used for higher suspended solid
- It provides area for habitat of wildlife and plants

Some of the disadvantages of surface flow wetland are:

- Direct exposure of human and animals as it is surface flowing waste water
- Insect and odors can be a problem in this case, as it is surface water. Insect mostly contains mosquito's problem.
- It provides lower rate of contaminant removal per unit of land when it is compared to sub-surface flow wetland. (32)

2.13 Advantages and disadvantages of sub-surface flow wetland

Advantages of sub-surface flow wetland:

- It has higher contamination removal per unit area then surface flow wetland.
- It contains minimum ecological risk. The reason is because of absence of exposure of water surface.
- One of the best advantages is that it has not insects and odor problem, as water surface is below the surface of the medium.
- It is less sensitive to winter conditions. (32)

The disadvantages of sub-surface flow wetland are:

- It may cause plugging problem when water is high suspended solids.
- It is costlier in construction as compare to surface flow wetland on the basis of cost per acre. (32)

2.14 Design of artificial marsh for single family using subsurface flow

An artificial marsh for sewage waste water treatment could be designed for a single family home. It is designed on basis of subsurface flow. Subsurface flow of water in domestic sewage waste water marsh is better because in this way odor and insect problem, especially mosquito problem has to be solved in this way. In subsurface flow, water passes from the roots of the plant and it increases the efficiency of marsh. Average sewage waste water for one family on daily basis is estimated to $1.5m^3$/day. (10)

- Marsh receives domestic sewage waste water.
- It is designed on basis of subsurface flow.
- Degree of slope may be found out by hydraulic conductivity of gravel. If conductivity of gravel is 41 m/day, then in this case degree of slope will be 0.05.
- Fresh water marsh plants can be planted 0.5 meter in the center.

- Length of marsh is to be 30 meter and its width is to be 5 meter. (10)
- Area of domestic sewage waste water marsh is 150 m^2.
- Domestic sewage marsh is filled with 15 cm gravel.

Evapotranspiration process will reduce the volume of waste water. It varies with weather. During peak weather like July and August with temperature in the upper 20s ^oC, a 5 m* 30 m trench, may lose about 1.7 m^3/day, which will be about 1.2 cm/day. (10)

The sewage waste water marshes can also work in cold climate as well. But its efficiency decreases in cold temperature conditions. Experiments performed in Wisconsin showed that marsh system is frozen from December to March and the above ground parts of the marsh plants died in this time period. But in spring again new shoots grew from rhizomes of plants. (10)

The domestic sewage waste water marsh needs little maintenance. Its system is virtually automatic.

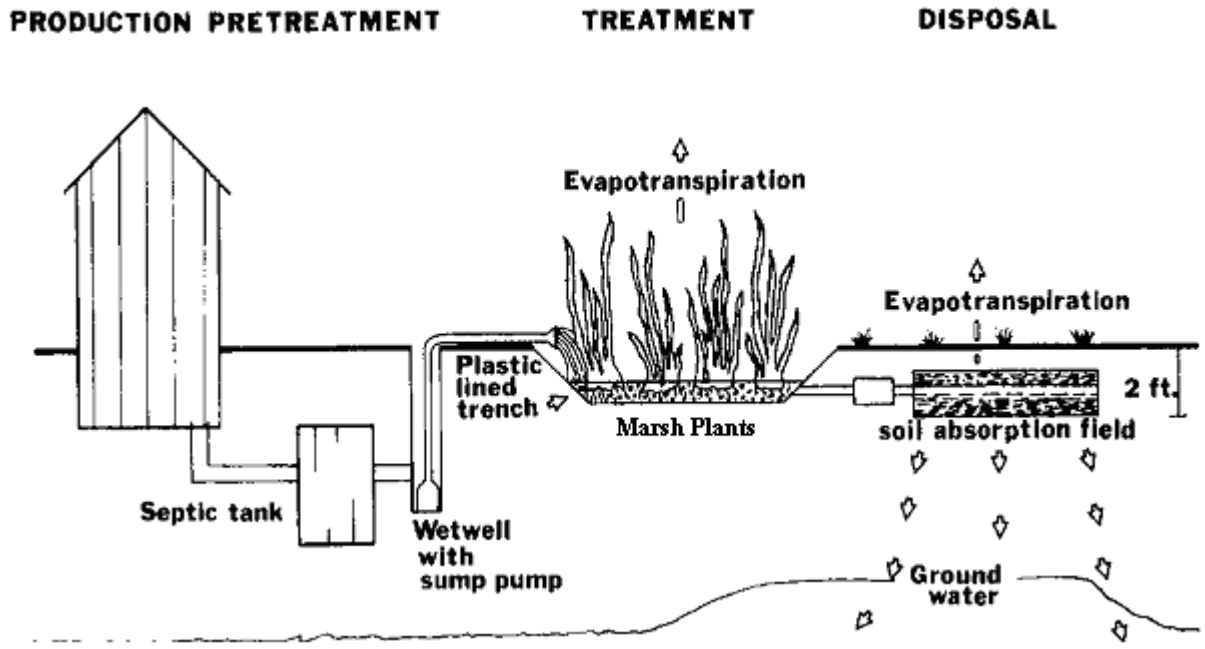


Figure 6: Artificial marsh for single family, subsurface flow (10)

2.15 Design of artificial marsh for a small village using subsurface flow

This is the design of an artificial marsh for around 160 residents in the town of Iselin, PA. It is designed for a flow of 45 m^3/day, consisting of six main parts in series. These are

described below. Marsh receives domestic sewage waste water. It is designed on basis of subsurface flow. Water obtaining from artificial marsh can be used for agriculture purposes

- Bypass screen and comminutor removes large solid.
- Aeration cell is used for primary treatment by bacterial metabolism. It also improves the odors of sewage entering the marsh.
- In the marsh sedimentation, filtration and adsorption takes place. Plants present in the marsh provide oxygen to bacteria through their roots and these bacteria are used to break down nutrients.
- After the marsh there is pond. In the pond bacteria metabolism takes place. Conversion of ammonia to nitrogen gas also takes place.
- Meadow acts as polishing unit. Additional removal of nutrients and organics is achieved in the meadows. It works just like marsh.
- In the chlorination unit, chlorine is added in order to limit the fecal coliforms. (31)

Comminutor is used in this case and the dimension of bypass bar screen is

5.1 cm *0.64 cm * 2.5 cm openings

0.051 m* 0.0064 m* 0.025 m (31)

For aeration cell

Volume of aeration cell is to be 130 m^3. Its depth is to be 1.52 meter. For total mixing 1700 watt or 2.3 hp per cell is to be used for it. Its detention time is 2.86 days.

Marsh flow rate is to be 470 m^3/ha/day.

Pond size is 1000 m^3. Its depth is 1.5 meter. Length to width ratio is 2/1.

Meadow Flow rate is 940 m^3/ha/day

Chlorination tank is 4.7 m^3. Contact time in this case is 120 minutes. Required chlorine residual is 2 mg/liter. (31)

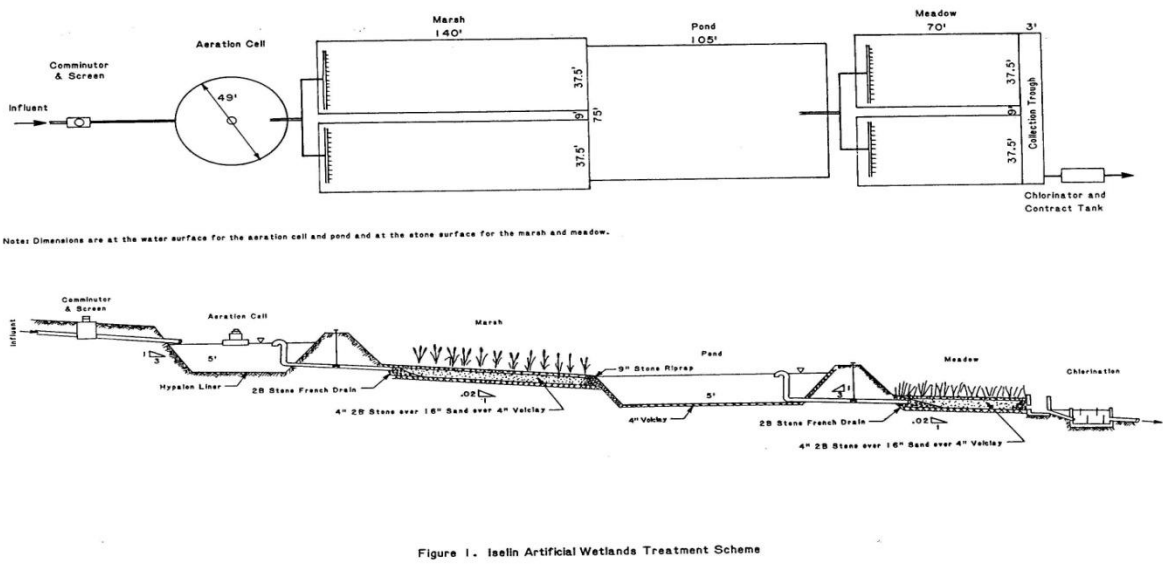


Figure 1. Iselin Artificial Wetlands Treatment Scheme

Figure 7: Artificial marsh design for large scale area (31)

2.16 Designing of parts of large scale artificial marsh on basis of flow rate (31)

Length to width ratio is 20.

L/W=20

The design based on the flow of 380 m^3 per day.

So

Length*Width= Area

x*20 x= 217,800 ft^2

x = 104.4 ft and it is equal to

x= 31.82 m

It is approximately equal to 100 ft or 32 meter width

So length will be 2178 ft. approximately we take it as 2200 ft (**670 m**)

Cell is 100 foot wide.

2200 foot long.

Further calculation

As in this case 4 parts are there then

$217.899/4 = 54.450\ ft^2$

If we assume length to width ratio as 10

L/W = 10.

In this case dimensions will be equal to $10\ x^2 = 54.450$

And x= 74 ft

And in meter it becomes

x= 22.55 m

Length will be 736 ft, equal to 740 ft.

Or = 225 m

Bed slope is to 0.1 %, so we can say that there should be 0.228 meter difference between inlet and outlet, for the bed whose length is equal to 225 m.

Domestic sewage waste water marsh best working days are in summer but it keeps on working in winter as well. If waste water marsh is designed in cold climate area, then in winter its efficiency of working is decreased, as marsh frozen in cold climate areas in winter.

2.17 Arcata waste water treatment plant

Arcata is small city located on coastal redwood Humboldt Bay, Northern California. Arcata now has the population of 15,000. The waste water treatment system of Arcata collects water from showers, toilet, drains and sinks. The treatment system is of the surface flow type. It is one of the most well known and well studied in USA. It has been operating since the 1970ies. (27) Long term reduction for BOD and total N are 96-96% and 93% respectively. However, following heavy rains, the detention time for the waste water in the marsh

decreases so much that effluent values are exceeded. This is a problem shared with most waste water treatment systems and not specific to Arcata or marshes.

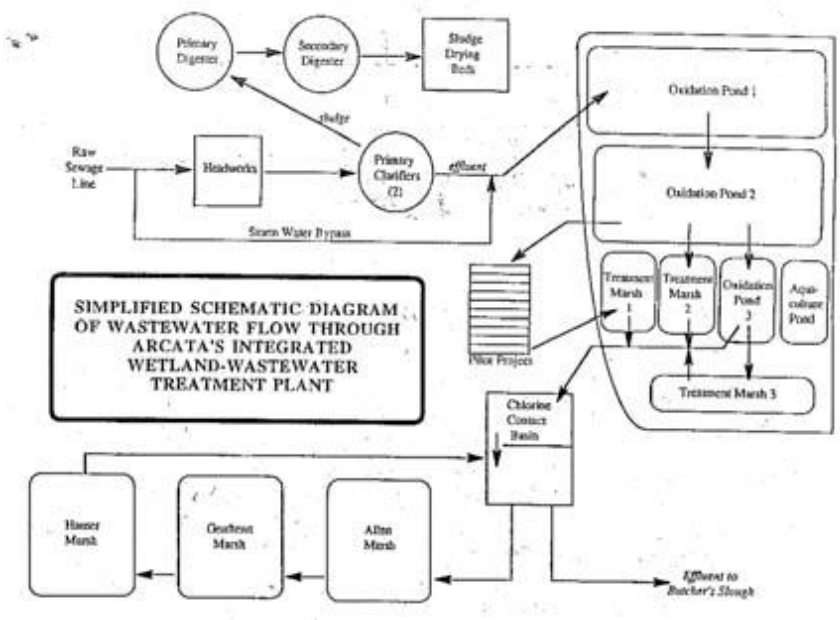


Figure 8: Arcata waste water treatment flow diagram (11)

Primary treatment involves

- Headworks
- Clarifier
- Digester

Headworks

Headwork is the first step towards the treatment of waste water. Water from underground pipes reaches the headworks. In the headworks screw pumps lift the waste water almost fifteen feet up and then this water is passed from grit separators and bar screens. The headworks removes paper product, clothing, glass, other dense solid, sticks and other large pieces of wood. (22)

Clarifier

Water remains in the clarifier for four hours. There are two clarifiers and their specification are one about 8 m and other is 18 m diameter. Settling of suspended material takes place in the clarifiers. Waste water is then sent to oxidation pond. The solid suspended materials are then sent to digester for further process. (22)

Digester

The digester stabilizes the solid which is removed during waste water treatment. It is done in order to reduce the mass of sludge and convert into non-hazardous form. There may be two types of digestion, aerobic and anaerobic digestion. (27)

In Arcata sewage waste treatment plant anaerobic digestion is used. The digester produces methane, hydrogen sulfide and carbon dioxide as by product. The raw digester gas, mainly methane gas, is compressed with compressors and used to heat the digester. The solid residue after digester is dried for six months in sludge beds and is mixed with hydrocotyl and yard waste. This compost is then used as fertilizer in city parks. (22)

Secondary treatment

Oxidation ponds

After primary treatment water reaches the secondary treatment process. After the clarifier, water flows to the oxidation pond. Break down of organic matter enhances the growth of algae. In this case sunlight plays important role as algae consume sunlight and because of photosynthesis process produce oxygen. This oxygen is then used by microorganisms for the metabolism of nutrients in the oxidation pond. These microorganisms remove biological oxygen demand up to 50% in the waste water.

An oxidation pond covers an area of about 22 ha and is 1.5 m deep. In the oxidation pond, smaller solids are settled out and these small solids were not settled during primary treatment. (22)

Treatment marshes

After the oxidation pond, water is pumped to the treatment marshes. Each treatment marsh is about 0.8 ha and there are three treatment marshes. They were built by dividing original oxidation pond. The treatment wetlands are consisting of hardstem bulrush. (27)

Roots of this plant help the microorganisms to grow and break down organic material. These plants slowly down the flow of water and settle down suspended solids and prevent the growth of new algae as well. (22)

Disinfection: Chlorination

Chlorine is effective for the destruction of most pathogenic microorganisms. Chlorination technique for sewage waste water is the best practice for the disinfection of waste water today and it is inexpensive way as well. (27)

There are two disinfection stages. First disinfection process takes place after passing of water from treatment marshes and second disinfection process takes place after the passing the water from the enhancement marshes. After second disinfection process, water is sent to the Humboldt Bay. The reason for chlorination is to eliminate toxins, odor management, and ammonia removal and foam reduction. Chlorination is used because huge amount of microorganism are not removed during primary and secondary process. (22)

De-chlorination

Chlorine is necessary for killing of harmful pathogens but it is toxic in nature. If chlorinated water is sent to bay or wetland, it may disturb wildlife and fishes as it will be harmful for them. So de-chlorination of water is also necessary. De-chlorination is performed by the use of sulfur dioxide gas. Sulfur dioxide gas takes one second to turn chlorine into chloride ion. (22)

Tertiary treatment

Enhancement marshes

Enhancement marshes are located north west of the oxidation ponds. The three enhancement marshes are named for three initial supporters of the constructed wetland system, Dr. George Allen, Dan Hauser and Dr.Bob Gearheart. These three enhancement marshes cover area of 12.5 ha and their average depth is 0.45 m. (27)

Waste water is disinfected by chlorine and then it is send to enhancement marshes. Flow directed through sluice gates and wooden stop-log weirs. First of all disinfection process is done then flow of waste water is then forward to George Allen Marsh. After George Allen Marsh waste water is then send to Robert Gearheart Marsh and finally to Dan Hauser Marsh.

Enhancement marshes have become habitat of wildlife species like snowy egret, American kestrel and brown pelicans. After the enhancement marshes water is sent for second chlorination and then it is sent to the Humboldt Bay. Water spends almost fifty days from entry point (headworks) to its release to the Humboldt Bay. (22)

2.18 Benefits of Arcata waste water treatment plant

Almost 150,000 visitors per year come to see the Arcata waste water treatment plant with Arcata Marsh and Wildlife Sanctuary. There are almost 270 species of birds. It has developed the focus of people towards importance of wetland.

2.19 Effect of temperature on the efficiency of domestic sewage waste water marsh

Efficiency of a domestic sewage waste water marsh depends upon temperature situations. To know the result of it, experiment was done on different temperatures situations. This temperature varied from 16 ºC to 38 ºC and similarly experiment was also performed on -2 ºC to 22 ºC and -4 ºC to 22 ºC. Efficiency of different marsh plants were checked like reeds, bulrush and yellow iris in different temperature conditions. It was overall concluded that there was a temperature effect variation between the different species of plants. But overall efficiency of all marsh plants for the removal of nutrients was higher at high temperature (summer time) and its efficiency decreased when the temperature was low (winter times). However, the differences are relatively small, 96% removal of BOD in the winter versus 98% in summer for a wetland in Iselin, PA. (31) Similar efficiences have been shown in other wetlands. The working efficiency for the removal of nitrate and phosphate was different in different marsh plants like iris, reed and bulrush. (30)

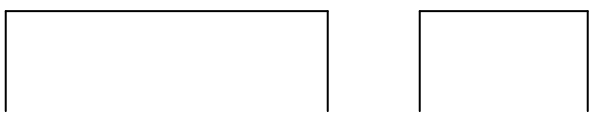
3. Methodologies

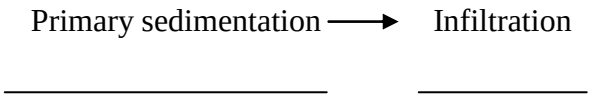
3.1 Comparison of marsh waste water treatment with other methods

- **Infiltration**

Infiltration in waste water treatment is always preceded by primary or primary plus secondary treatment. In its simplest form it consists of a subsurface infiltration bed for household waste water pretreated in a septic tank. An infiltration bed requires a certain hydraulic permeability and has a limited life time and needs restoration when the infiltration rate becomes too slow. Infiltration process depends upon, evaporation, soil mixture storage and ground water reservoir. It is the process through which ground water enters the soil. Measurements in this case are taken in millimeters per hour or inches per hour. If less water enters the soil then less water is stored in the soil for use of plants.

Rate of infiltration depends upon many factors. Rate of infiltration is maximum at the starting of rain. It also depends upon amount of water on soil surface as well. The entry of water is slowed down by frozen surface. Infiltration role in hydrologic cycle was first recognized by Horton in 1933. Maximum capacity of infiltration process occurs at the start of the rain and then its rate decrease because of soil surface structure and its moisture. (17, 42, 43)





- **Mini sewage treatment plant**

There are different types of mini sewage plants. The most advanced types use primary, secondary and tertiary treatment. They require both electric connection and chemicals. They are expensive and are not further discussed here.

A mini sewage treatment plant usually consists of three sections. In the first section, organic load is broken down under anaerobic condition. In this section organic material is broken down by microorganisms in the absence of oxygen.

This water is then transferred to another tank with aerobic conditions. Aerobic process is done in presence of oxygen. In this case certain bacteria groups are used. Bacteria in the sewage break down the organic material and they grow with high speed. When bacteria in sewage tank becomes in excess then in case of small tank they are pumped to the anaerobic section of the plant. In anaerobic section of plant, anaerobic bacteria eat aerobic bacteria and as a result they produce methane gas and carbon dioxide.

In mini sewage treatment plant the third section is settling tank. In this section problem can occur if the volume of settling tank is small compared to the flow. These systems are intended for up to about 200 person equivalents. (5)

- **Filter bed**

There are different kinds of filter beds for different purposes. The bio-sand filter, intended for purification of drinking water is a slow sand filter and is discussed below. It is not suitable for the large volumes in waste water treatment.

Sand filters can be said to be a form of infiltration system. If used after a primary sedimentation step, they develop a population of various microorganisms capable of oxidizing ammonium to nitrate. However, they require a limited and intermittent flow. They can be used at the outflow of wetland treatment systems. (44)

The bio-sand filter, intended for drinking water, is consisting of five zones. First zone is called inlet reservoir zone. It is the place where water is poured into the filter. Second zone is

called standing water zone. The function of second zone is to keep sand wet so oxygen can pass into the bio layer. Third zone is called biological zone. It is consisting of 5 to 10 cm filtration sand, which removes suspended particles and pathogens. Fourth zone is called non biological zone. It does not contain nutrients and oxygen so non living organisms stay here. Fifth zone is called Gravel zone. It holds the sand in place. (7)

In a bio-sand filter bed, pathogens are removed as they are physically trapped in spaces in the sand layer. Microorganisms are present in sand layer, so pathogens are consumed by microorganisms already present in sand layer. Death of pathogens occurs because they become attach with suspended solid and sand grain and they automatically die because of lack of food or oxygen for them in non biological zone. After finishing of water flow, it should be given pause period. The pause period is the time given to microorganisms to use pathogens and nutrients in the water. Pause period time may vary from 1 hour to 48 hours. More pause period time gives the chance to microorganisms to consume maximum pathogens. (7)

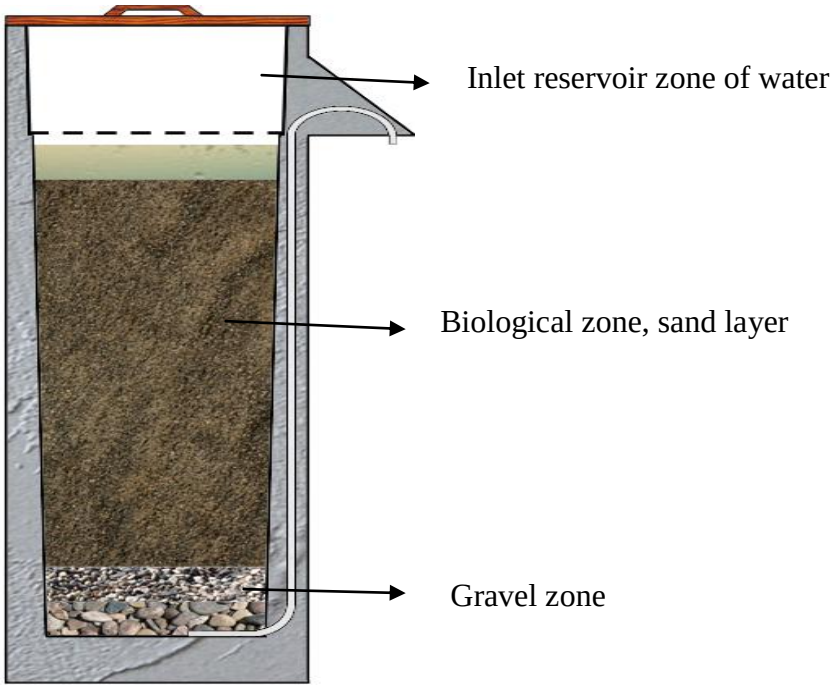


Figure 9: Bio-sand filter (7)

Bio-sand filter may be used for cleaning of any water source like ground water, surface water, lakes and rivers for production of water for human consumption.

Some of the collected data is given

Table 1: Waste water treatment methods and their reduction percentage (24)

Reduction method	Reduction percentage			
	Tot-P	Tot-N	BOD	Bacteria
Filter bed	10-40	25-50	90-99	95-99
Infiltration	25-80	20-40	90-95	99
Mini sewage treatment plant	70-90	20-50	80-95	60
Only three compartment tank	5-10	10-15	10-20	25
Bergum WPM	91	90	96	84

It is necessary to select such a process which has better efficiency to control microorganisms, nitrate and phosphate concentration. From above data, it can be seen that the filter bed has better efficiency to control bacteria but its reduction of nitrate and phosphate is not satisfactory. Almost the same is the case with infiltration method. Mini sewage treatment plant working is also not up to mark level. The Bergum wastewater purification marsh shows the best results among these methods.

3.2 Marsh method is suitable in most cases

Working efficiency of filter bed in case of phosphorus removal is 10 to 40 percent. Nitrogen removal is 25 to 50 percent and bacteria removal is 95-99%.

Reduction percentage of infiltration method for phosphorus is 25 to 80 percent. Similarly percentage removal of nitrogen is 20 to 40 percent. And BOD reduction is 90 to 95 percent and bacteria reduction is 99%.

Mini sewage treatment plants using primary and secondary purification have phosphorus reduction percentage of 70 to 90 percent. Nitrogen removal is 20 to 50 %, BOD is 80 to 95 % and bacteria 60%. (24)

Working efficiency of the Bergum marsh is better than all other methods. When comparing to other wetland treatment systems, the wetlands have a high reduction of BOD, suspended solids and bacteria and acceptable reduction of N and P. (31, 39) So over all it is better than all other used methods. It is certain that chemical process has even better efficiency then marsh method, but it is also to be observed that use of chemical is not environmental friendly method. So more recently alternative method (marsh) to treat water is has received increased

attention and use. The basic idea is that living organisms and land itself is to be used for treatment of water for the safety of biodiversity, in spite of using chemicals. (8)

4. Analysis

4.1 Analysis about marshes

Mosquito problem is often disturbing issue for people visiting to or living around marsh areas. This mosquito problem is in case of exposed water surfaces as in surface flow wetlands. When domestic sewage waste water is used then odor problem also happens. In order to solve this problem, use of subsurface flow wetlands is the best option as compared to surface flow wetland.

In cold climate areas, snow cover around plant and ice cover of the wetland can affect the flow of water (hydraulic failure) to much extent. So in this way water marsh system cannot work properly during such times. In order to avoid this problem, use of subsurface flow wetland system is the best option in snowy areas. In case if we already are using free water surface flow wetland (FWF) system already, then in this case cold climate effect on wetland can be minimized by using extruded polystyrene(XPS, 10 cm) and this way will stop the formation of ice even it temperature reach until -10 ºC. In hot climate area it is option rather to use surface flow wetland or subsurface flow wetland. But in cold climate area, it will be good idea to design subsurface flow wetland (SSF) because surface layer acts as insulator and it saves the water from being frozen so working of wetland continues. (48)

For the removal of nutrients in the wetland many plants like Phragmites australis. Cattails (Typha), bulrushes (Scirpus) and duckweeds (Lemna) are used. On the roots of these plants bacteria grow and they decompose nutrients. Duckweed may only be used in case of free water surface flow wetland. But all the other plants may be used in both surface flow wetlands and in subsurface flow wetlands.

Sand filters can be used for reducing suspended solids and bacteria. However maintaining a proper flow rate requires good maintenance. Bio-sand filter method may be used for the purpose of drinking water but it is too small scale for a marsh, so it cannot be used for the purpose to kill germs on this large scale. So in order to kill viruses and bacteria, introduction of chlorine is the best option to disinfect the germs. After using chlorine in sewage waste water treatment, de-chlorination is also necessary by introducing sulfur dioxide. If it is not de-chlorinated then chlorine will harm the aquatic life as it is toxic in nature. Certain microorganisms, such as Cryptosporidium, are quite resistant to chlorination and if these are going to be removed, a UV treatment is required. This is done in many waterworks in Sweden, but seldom in waste water treatment.

4.2 Structure and working of the Bergum marsh

Bergum water marsh is located about 20 km northeast from Gothenburg. It was built in 1995 as a pilot plant. Marsh gets domestic sewage waste water of almost 30 people which gives an average flow of 4.5m^3/day.

It consists of six consecutive ponds. Length of water marsh is 125 meter between inlet and outlet. Its average depth is 19 cm. The waste water first goes to a septic tank as a primary step. The effluent from the septic tank is treated in the ponds. (8)

Figure 10: Bergum domestic sewage waste water marsh (8)

Waste sewage water is used in marsh, so the marsh in our case cleans the waste sewage water by biological way (microorganisms, soil and micro plants). So now the question arises that how this marsh may cause effect on external environment and within the marsh. As this marsh contains sewage waste water, so this water may cause effect on external environment of marsh and also at the same time effect on the internal environment of the marsh as well. (24)

4.3 Improvement method for the betterment of Bergum marsh in case of subsurface flow

In case of Bergum marsh, sewage waste water is collected from some homes. In Bergum marsh water has surface flow. The sewage waste water is collected in the marsh so that it is processed and then flows to the water reservoir, so this waste sewage water does not create problem for external environment and water reservoir.

Most important thing for improvement of the Bergum marsh is to make it as subsurface flow artificial wetland. When there will be subsurface flow of water in marsh, then there will be less effect of water on environment and there will be minimum chances of water that it will effect external environment (32)

In the Bergum marsh, water is being cleaned only on the basis of microorganisms naturally present in the water. Study has shown that microorganisms widely grow on the roots of different water plants like reeds and Phragmites. And they can increase the efficiency of the process. The roots and stem of plant continuously collect particles from the surrounding water. Particles present in domestic sewage waste water are trapped by the roots of these plants. (4)

- **Designing of waste water marsh as subsurface flow**

For getting better result of domestic sewage waste water marsh, if we change the design of Bergum marsh to subsurface flow instead of surface flow wetland then it will be easy for us to reach our goals.

Basic criticism in Bergum marsh is that its domestic sewage water marsh may create bad effect on external environment. So if possible then it will be good to change its design and make it subsurface flow. In this way odor and insect problem, especially mosquitoes problem will become minimized because of changing its design. (32)

Subsurface flow wetland is more suitable to work in cold weather as compared to surface flow wetlands because it is more insulated from frost by earth. Reeds (Phragmites) are mostly used in subsurface flow wetland. On the roots of the plants, bacteria and fungi grow and remove organic and inorganic matters. Working efficiency of subsurface flow wetland for removal of nutrients is better.

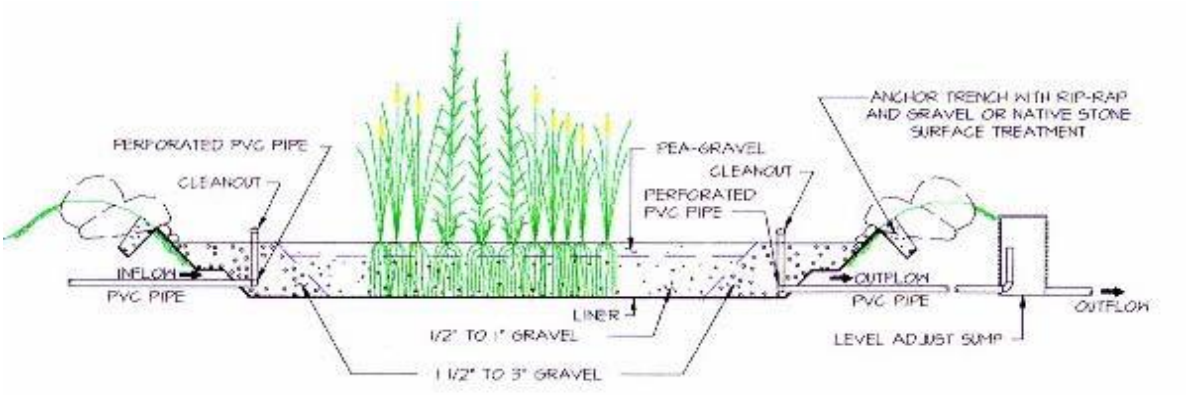


Figure 11: Sub-surface flow wetland (32)

- **Phragmites australis and other plants**

Phragmites australis is a wetland plant used for domestic sewage water treatment. Waste water enters to the marshes where bacterial action occurs on the surface of leaf and roots and removes the nutrients. (4)

Phragmites australis is also called common reed and it is marsh plant. It has the advantage of purification of waste water in marshes, ponds and river and as a result of it, provides good quality water. It is used for industrial water and municipal sewage waste water. It has ability to bring oxygen to the rhizomes (mass of roots). In the rhizomes growth of bacteria occurs with great speed that is effective for cleaning of domestic waste sewage water. (4)

Plant like cattail (Typha) can also be used for waste water removal. Nutrient uptake capacity of cattail is considered to be high. Cattail is one of the most common plants for waste water removal in the constructed wetland. (33)

A bulrush (Scirpus) is also used in constructed wetland for waste water treatment. Bulrush is mostly to be used in ammonia rich wastewater. For ammonia dominated waste water plants like bulrush and cattail are to be used in series for N removal. They convert ammonia to nitrate and then by de-nitrification process, it is converted to N_2 gas. (34)

4.4 Improvement method for Bergum marsh in case of surface flow

If subsurface flow marsh is not to be used and it is only concentration towards to use surface flow wetland process then duckweed and bio-sand filter option is to be used. Duckweed option may only be used in surface flow wetland. As in subsurface flow wetland, water is not exposed on the surface.

- **Duckweed for waste sewage water treatment**

Duckweeds are small floating plant. They belong to Lemnaceae family. They can live in both low light and full sunlight. They can tolerate pH range from 4.5 to 8. Duckweed species can grow extreme rapidly way under good environmental condition. The rapid growth of duckweed has made it as the best candidate for waste water treatment. Duckweed purifies waste sewage water by collaboration with anaerobic and aerobic bacteria. Heterotrophic bacteria change organic waste material to orthophosphate and ammonia and nitrate and it is used by duckweed plants. Layer of 10 cm of surface is aerobic because of atmospheric oxygen is sent to duckweed roots. Organic matter oxidation and nitrification is facilitated by bacteria here in that bio-films area and it is given by duckweed roots. Phosphorus is removed by chemical precipitation, absorption to clay particles and due to sludge removal. (1) Reductions reported from warm climate (Egypt) show BOD 90%, total P 50%, NO_3^- 100% and TSS 96% reduction after 8 days. (36) Duckweed is suitable at water temperatures between 20 and 30ºC, but they can endure shorter periods with 10ºC without dying.

Duckweed Technology, DWT, has a lot of capacity for livestock industries and sewage waste water treatment. When livestock or human waste enters the marshes or ponds, the first step in this case is the removal of solid waste. It is done by bacteria and they start breakdown and fermentation of solid waste. As a result of solid waste removal by bacteria as a primary treatment, it was found that high level of ammonification occurs and duckweed has the capacity to tolerate it. It has been found that at 240 mg/L high ammonium level duckweed may grow and tolerate it. (46)

Ideal conditions are suitable temperature and nutrient availability. Duckweeds can double their mass in two days under optimal conditions. For growing duckweed, it is better to take the seed of duckweed from same region area, because seasonal condition of every duckweed seeds is different for every area. New seed crop may take some more time to adjust for nutrient conditions. (1)

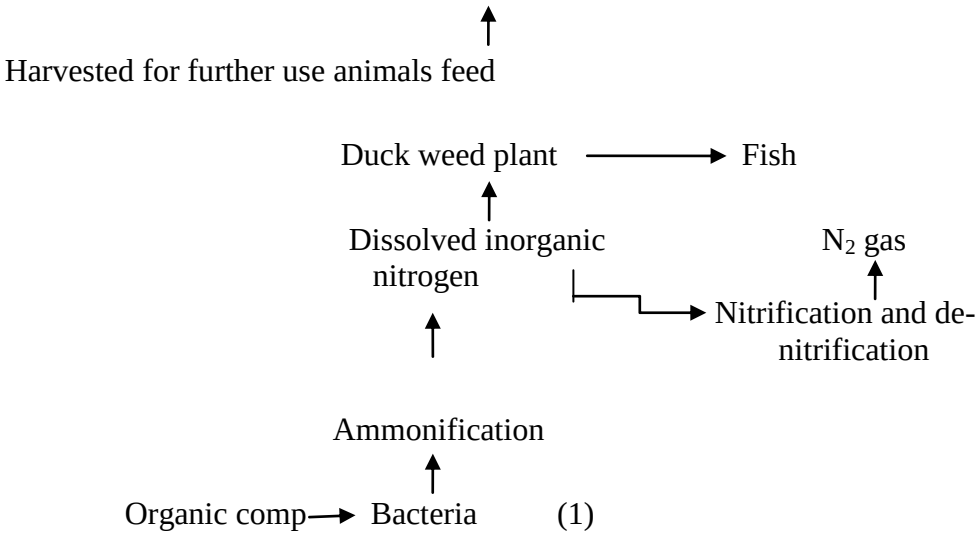
Duckweed plants as floating on the water surface so they are sensitive to high winds. Presence of high winds can disturb DWT. So a floating grid is necessary for duckweed in order to save the mat of duckweed from destruction by high winds pressure. Size of grid is determined by the wind conditions.

There are number of choices for the safety of duckweed plants by high winds. These are sealed PVC, bamboo or polyethylene pipes. The grid is tightened at certain points and individual baffles are loosely connected. Harvesting of the duckweed is required at intervals. (1)

Figure 12: Harrington sewage treatment plant, duckweed and grid (1)

Reuse options for DWT

One important thing for DWT is that duckweed is a valuable by product as well. Duckweed plant has a high nutritional value. It contains 45% crude protein and high value of amino acids. It has low fiber content and also has good level of pigments and vitamin A. It is a good source of food for chickens, pigs, ducks and fish. If duckweed is dried, it will be environmental friendly feed for fishmeal and other livestock systems as well. (15)



- **Introduction of chlorine for domestic sewage waste water treatment**

Introduction of chlorine in domestic sewage waste water for the removal of microorganisms is the most inexpensive way. In the process we have used chlorine instead of using sand filter. Chlorine is highly effective against coliform bacteria, but not effective against Cryptosporidium parasites. Chlorine can easily be neutralized after killing microorganisms by using sulfur dioxide.

- **Domestic sewage waste water treatment plants**

In case of surface flow wetland, water plants like bulrushes, cattails and Phragmites australis are also to be used, as they are helpful for the removal of nutrients from domestic sewage waste water. Duckweed is the only plant which can only be used in case of surface flow wetland only. But all other plants like Phragmites australis, catttails and bulrushes are to be used in both cases even if it is subsurface flow or surface flow wetland.

5. Conclusion for the use and improvement of marsh

Wetlands for waste water treatment are efficient, low cost and low technology solutions. They are dependent on microbial activity for the degradation of organic material. Therefore, it is imperative that no toxic material reaches the wetlands, or the microbial activity might stop. Also, they work less effectively during cold weather. This puts some limit on their use in the temperate climate zone. In warmer climate they are most suitable. Also, they require relatively large areas, why they are not suited for major cities. For smaller towns and villages, they are definitely a method worth investigating.

According to me, following practices should be done in order to improve the quality of marsh for waste water treatment and to safe waste water effect on external environment. Details for the construction of treatment wetlands can be found in many references. (40, 45, 31, 39, 36, 44, 10, 42, 4, 5, 32, 41, 1)

- Sedimentation process is necessary for the reduction of suspended solid. It is used in all modern waste water treatment plant in a primary stage.
- Use of subsurface flow wetland is the good option, as in subsurface flow wetland water is not exposed on the surface and it does not create problem of odor and insect problems. As domestic sewage waste water is being used for treatment purpose, so if water level will be above the surface, then it may create bad effect on external environment. Subsurface flow wetland result is also attractive for cleaning of domestic sewage waste water. Subsurface flow wetlands require a smaller area, but are more expensive to build.
- Subsurface flow wetland provides more surface area for the bacteria to grow. It gives greater treatment efficiency as per square meter as compare to surface flow wetland.

- It was one of the major criticism on water marsh is that they create mosquitoes problem, so this problem is also solved in subsurface flow, as water is not exposed outside. One more advantage of surface flow wetland is that it has not much effect of cold climate, as insulation of sand save it from external effects.
- Removal of BOD is temperature dependent. When there is warmer temperature then residence time of system will increase as a result of evapotranspiration rates. Like that there is strong relation between nitrogen and phosphorus removal with water temperature.
- It has been found that heavy rain water creates negative impact on the efficiency of domestic sewage waste water marsh working. In order to minimize the effect, first of all marsh design should be according to subsurface flow. As in subsurface flow wetland, rain water may not directly involve with it, as in subsurface flow water is not expose to outer environment.
- If surface flow wetland is to be used then tree present near to marsh are necessary to cut down.

- Use of chlorine is the best option for the removal of viruses and bacteria. If they are not treated with chlorine then they may cause negative impact on external environment. After removal of viruses and bacteria, it is also necessary to neutralize chlorine as well by using sulfur dioxide. If chlorine is not neutralize then it may create problem for wild life and aquatic plant in the marsh as it is toxic in nature.
- Chloride ions are formed during neutralization of chlorine. They are necessary for metabolism process in human.
- Different water plants are to be used for the waste sewage water natural treatment, as some plants like duckweed absorbs most of nutrients like phosphates and nitrates present in it with the help of bacteria present on the surrounding of its roots. But duckweed option may only be used, if surface flow wetland is to be used.
- Ends of marshes should be strong so that no leakage may occur and it may not create bad effect on external environment.
- If possible then mix some amount of fresh water with waste sewage water in order to finish bad smell effect and to reduce its concentration of sewage water in surface flow system.
- Location of marsh play also very important role. It is to be tried that its location is to be away from the locality. So that contact of marsh with people is to be minimized.
- There is need to have fence against the covered area of marsh so that no external effect may happened because of entering of animals in it and this condition is for surface flow wetland.
- Efficiency of domestic sewage waste water marsh will be less in the winter.

5.1 Future research

The thesis was for a limited period of time and in this limited period of time it was not possible to cover all aspects of waste water sewage marsh. Waste water sewage marsh is a very vast subject. Some suggestion have been given by me on the basis of my knowledge that how to minimize the effect of marsh on external environment. But for the future research these suggestion are to be practically applied and observe which suggestion is most suitable and practicable according to our environment.

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