STUDY OF BURNT RICE HUSK PERFORMANCE IN REEDBEDS TO REMOVE POLLUTANT FROM LANDFILL LEACHATE

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ABSTRACT

In this study, the raw material used to treat the leachate is rice husks. Analyses were done on their physical and optical parameters to determine the removal and reduction of heavy metals (iron, chromium and nickel), BOD_5, COD, ammonia nitrogen, turbidity, colour and odour in leachate using biological treatment. For the physical, the testing was running to examine the performance of reedbed to improve landfill leachate. While for the optical parameter, scanning electron microscope (SEM) was used to investigate their morphological structures to determine the effect of burnt rice husk sizes and porosity on pollutant removal. At the end of the study, those criteria were exhibited from testing results, the treatment of leachate in reedbeds effective until four days and this reedbeds can be commercialized. Besides that, the raw materials used can be abundantly earned without cost, which in turn reduce the cost of production. Moreover, by this way, it can reduce the sludge disposal, which make it highly valuable in terms of environmental, and market value.

ABSTRAK

Dalam kajian ini, bahan mentah yang digunakan untuk rawatan air sampah adalah sekam padi. Parameter-parameter yang dikaji adalah dari segi fizikal dan optikal untuk menentukan penyingkiran dan pengurangan logam berat (ferum, kromium dan nikel), BOD_5, COD, ammonia nitrogen, kekeruhan, warna dan bau secara rawatan biologikal. Bagi ujian fizikal, pengujian dilakukan untuk menguji prestasi 'reedbed' bagi memperbaiki tapak pembuangan air sampah. Parameter optikal pula, mikroskop elektron mikrografikal (SEM) digunakan untuk mengkaji struktur marfologi bagi menentukan kesan saiz sekam padi (kasar dan halus) yang dibakar dan kadar penyingkiran pencemaran. Di akhir kajian, kriteria tersebut dipamerkan daripada keputusan ujian di mana rawatan pembersihan air sampah di dalam 'reedbed' tersebut berkesan sehingga hari ke empat dan 'reedbed' ini boleh dikomersilkan. Selain itu, bahan mentah yang digunakan boleh di dapati dengan mudah dan banyak tanpa melibatkan kos yang tinggi seterusnya mengurangkan kos pengeluaran. Dengan cara ini, kita dapat mengurangkan pembuangan enapcemar seterusnya dapat menjaga alam sekitar dan sangat berharga dari segi nilai pasaran.

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INTRODUCTION

1.1 Background

In Malaysia, most of landfill is open landfill and produced high contaminant which very harmful and danger to human and environment. Therefore, it is necessary to treat the leachate and design a proper leachate treatment plant, so that it can meets the standards for discharge into sewer or into natural waterways. Generally, leachate and runoff from the landfill site are stored in ponds at the foot of the mound. During dry periods the leachate is irrigated onto the top of the completed waste mound where it evaporates or transpires into the atmosphere. Meanwhile, during heavy rainfall the leachate is overflows into a system of landfill and contaminated a waterways especially groundwater.

Nowadays, biotechnology is a popular investment and contributes high incomes for Malaysia economic. It would be useful to evaluate the nutritive value of rice husk ash in an effort to create an attractive alternative for the rice processing industry, which could provide a new income source for a rice mill as well as eliminating or greatly reducing space for agricultural wastes. As an agro waste material rice husk is a fibrous material with high silica content. The application rice husk is not only revitalizes our plants but, it induces uniformity in growth by enhancing water retention and microbial activity. Risk husk contains high quality of nutrients that keep the soil healthy in a natural way. It acts as a top dressing that helps maintain moisture and reconditions the soil. Rice husk enhances the nutrient carrying capacity of plants.

Reedbeds is essentially a channel, lined with an impermeable membrane, filled with sand/gravel, and planted with reeds used for treatment of leachate and can be functional as wetland. Leachate that has black or grey colour is passed through the root zone of the reeds where it undergoes treatment. In this study, the cattail is used for absorption of nutrients, particularly nitrogen and phosphorus in wastewater. While, a burnt rice husks was assimilate with sand to absorb the pollutant in leachate and to study the performance of pollutant removal. Reedbed have three types of design, where commonly used are surface flow (SF) reedbed, sub surface flow (SSF) reedbeds, and vertical flow (VF) reedbeds. However in this study sub surface flow (SSF) is used to investigate the performance of precursor integrated reedbed with burnt rice husk.

1.2 Problem Statement

By products of rice husk is a large problem and sold at low costs. Hence, this by product should be used for an increased value application and expand the knowledge of biotechnology to improve human life. Rice husk is a waste from the industry, which is, founded easily in north Malaysia especially Kedah and Perlis. Rice husk can be functional as a good adsorbent especially as a filter to treat the leachate. It not only reduces the cost of leachate management but also adds values to waste.

The methods currently employed for the removal of heavy metal from leachate are cation-exchange and precipitation. However, these methods have several disadvantages that include high cost and toxic sludge. Lately, several Malaysian newspapers have reported the problem faced by local government regarding contamination cause by obstruction of landfill leachate into river and groundwater, which affect the quality of water resources. Therefore, it is necessary to treat leachate before it was discharge into waterways especially river and groundwater. The precise mechanism by which bacterial/pathogenic microorganism removal occurs in SSF systems are not well understood although it is attributed to a combination of physical, chemical and biological. These comprise natural decay, predation, sedimentation, adsorption, filtration, and the excretion of anti-microbial compounds from the roots of plants.

1.3 Objectives

The purpose of this study is to identify the properties and characteristics of burnt rice husk to be used in reedbeds and it potential as a filter media. There are three (3) objectives to be achieved:

i. To determine the effect of burnt rice husk sizes and porosity on pollutant removal.
ii. To examine the performance of integrated reedbeds assimilate with burnt rice husks to improve landfill leachate.
iii. To determine the removal and reduction of heavy metal (Fe, Cr and Ni), BOD_5, COD, ammonia nitrogen, turbidity, colour and odour in leachate in integrated reedbed.

1.4 Scope of Study

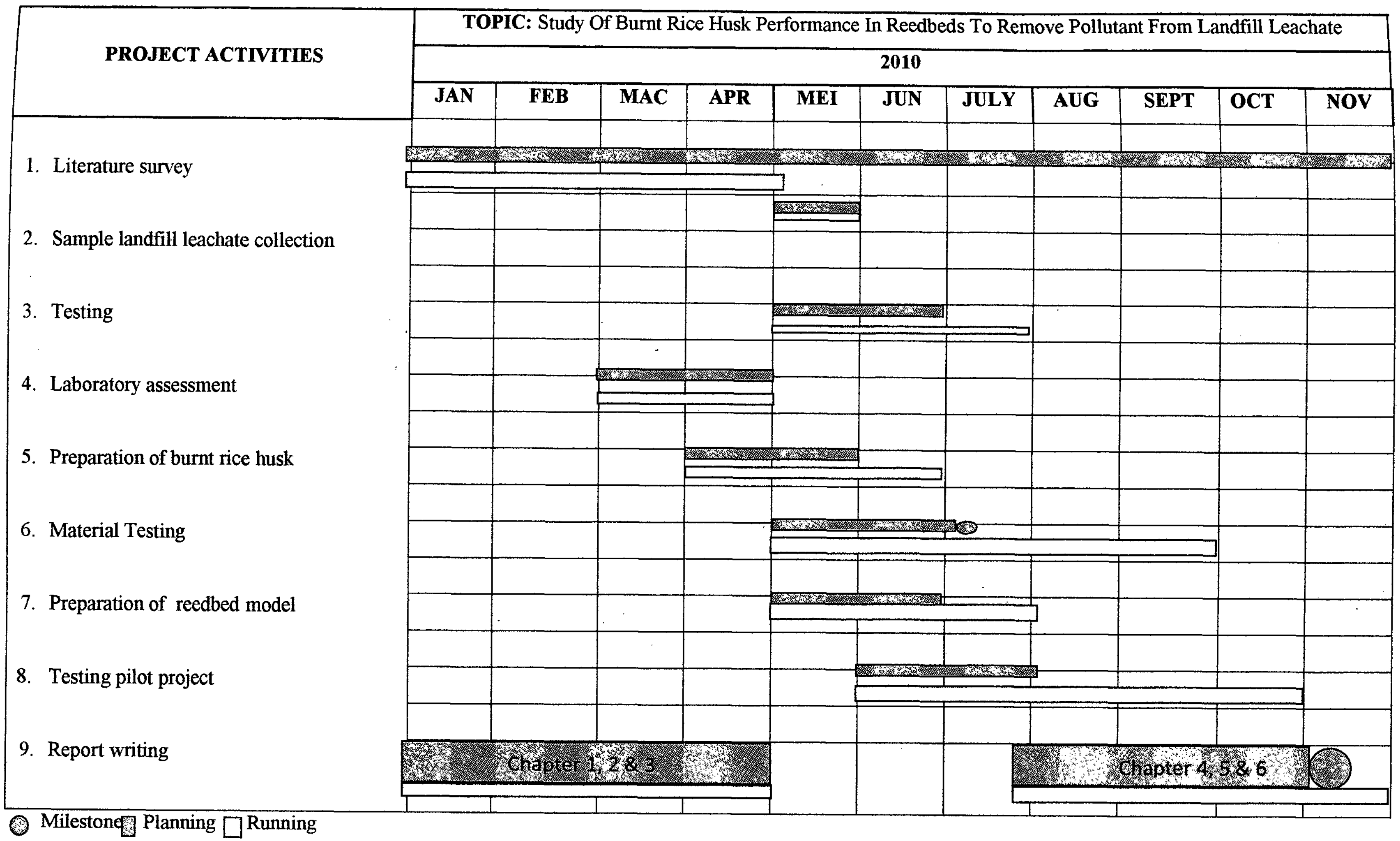
The rice husk was collected in Bukit Besar, Alor Setar, Kedah.While, the cattails (Macrophytes) is taken at Gebeng and the sample of landfill leachate were collected from Jerangau landfill and brought to the Environmental Laboratory in FKASA of Universiti Malaysia Pahang for testing. These tests are done for one month to get accurate result in experimental.

The rice husk was burnt and sieved according to two size sieve (600μ to 63μ mm for powdered and 3.35 mm to 2 mm for granular) and placed into three pilot tanks of reedbeds, to determine the effect of burnt rice husk and pollutant removal.

In this study, there are three pilot tanks of subsurface flow reedbeds were design to examine its performance of reedbeds to improve landfill leachate. The three pilot tanks were design according to ratio 4 (long): 3 (wide): 2.5 (depth) to avoid hydraulic problem. There is some parameter and calculation for design reedbed are neglected such rain precipitation due to limited focuses of study. The expected results were obtained through comparison graph are followings:

i. BOD_5 *versus* Time (day)
ii. COD *versus* Time (day)
iii. Ammonia Nitrogen *versus* Time (day)
iv. Turbidity *versus* Time (day)
v. pH *versus* Time (day)
vi. Metals *versus* Time (day)
vii. Colour *versus* Time (day)

1.5 Gantt Chart



CHAPTER 2

LITERATURE REVIEW

2.1 Reedbeds

A reedbed is essentially a channel, lined with an impermeable membrane that is filled with gravel and planted with macrophytes i.e. reeds, rushes (Figure 2.1) and used to treat wastewater. Wastewater, black or grey, is passed through the root zone of the reeds where it undergoes treatment. Inlet and outlet pipes are positioned below the gravel surface, so that the water always remains below the gravel surface, thus excluding human exposure to the wastewater, mosquito breeding and unpleasant odours.

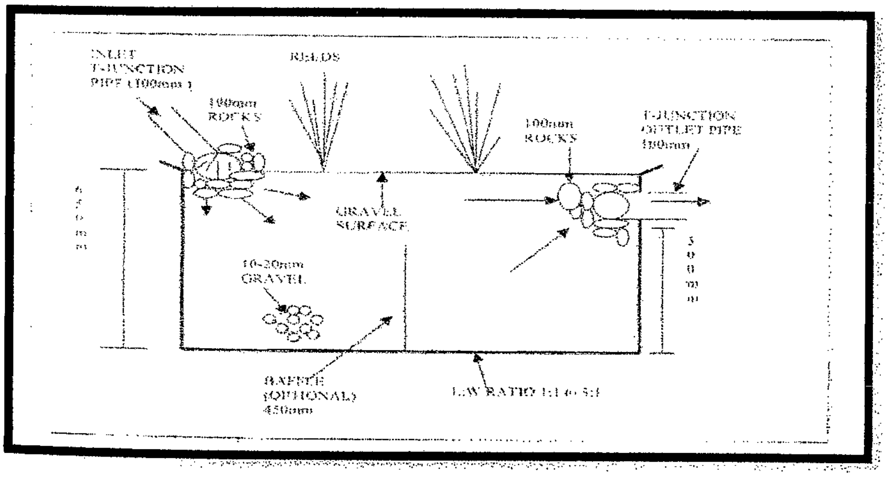


Figure 2.1: Basic Reedbed Design (Lateral View)

Reedbeds are generally designed to detain the wastewater for a period of 5 to 7 days. This residence time aids with the treatment by allowing sufficient time for the settling and filtering of suspended solids, nitrification/denitrification to occur, fixation onto the substrate, breakdown of organic matter and nutrient removal via micro-organisms and plant uptake. Residence time is generally governed by the surface area and depth of the reed bed. The die-off of pathogens in a reed bed is due to predation by micro-organisms on the surface of the gravel and roots, unfavourable conditions provided by a long residence time, and the aerobic and anaerobic zones in the reed bed. Therefore, the quality of treated effluent improves with increased residence time. Effect/advantages of reedbeds as following:

i. The bio-degradation of effluents through a vertical flow, aerobic natural filter system can produce clean clear water and no smell.
ii. Reedbeds are a low cost alternative, designed for low maintenance and lasts for many years.
iii. Reedbeds work well on installation, and improve to optimum effectiveness within three months.
iv. Reedbeds have been successfully tested with Domestic, Agricultural and Industrial effluents.
v. While a Reedbed Filtration System does need a certain area of land, the size can be remarkably small.
vi. Reedbed Filtration can bring about much needed and cost effective solutions to the major contamination of freshwater systems.

2.1.1 Types of Reedbeds

According to Van Oirschot et. Al (2002), there is three types of reedbeds can be used in commercial systems which are Surface flow (SF) reedbed, Sub surface flow (SSF) reedbeds, and Vertical flow (VF) reedbeds.

However in this study, SSF reedbeds were design to conduct the pilot test. Subsurface flow (SSF) reedbeds are constructed wetlands for the biological treatment of wastewater with the principal advantages of avoidance of odour, mosquitoes and public contact as the wastewater level is maintained below the media surface. It is also more efficient and hence requires less land than SF, SSF and VF wetlands (Kadlec and Knight, 1996). Pathogen removal, as indicated by fecal coliform levels, in SSF wetlands is generally recognized as being superior to that of SF wetlands. Research by Green et al. (1997) has confirmed the ability of SSF reedbeds to achieve 2 log removals of *E.* coli and coliform at retention times of 24 h or more.

Based on previous studies, treatment wetlands (reedbeds) have been used successfully in tropical Asia (Koottatep and Polprasert, 1997) and Africa (Kaseva, 2004) however little information exists on their use in the tropics of Latin America. Experience with reedbeds for the successful treatment of grey water exists in Australia (Ho et al., 2001), United States (Del Porto and Steinfeld, 1999) and Europe (Otterpohl, 2001). Reedbeds have been used in Mexico for domestic grey water treatment using papyrus, typha and scirpus (CITA, 2002) although no performance data are available and reedbeds (*biofiltros*) have been used successfully in Nicaragua for the treatment of primary treated domestic sewage (Platzer et al., 2002).

2.1.2 Hydraulic Loading Rate and Hydraulic Residence Time

The amount of wastewater entering a reedbed over a given period of time is described by the hydraulic loading rate (HLR) which is calculate as follows:

$$HLR\ (q) = Q/A$$

Where: Q = Flow rate (m^3/day)

A = Reedbed area (m^2)

The average length of time wastewater spends in a reedbeds governs the degree of treatment it receives and is known as the hydraulic residence time (HRT) usually given in days. It can be calculated theoretically as follows:

$$HRT = LWDn/Q$$

Where:
- L = Length of wetland (m)
- W = Width of wetland (m)
- D = Depth of water in wetland (m)
- n = Porosity of wetland media
- Q = Flow rate (m^3/day)

The equation does not take into account any other factor such as seepage, precipitation (p), evaporation (E) and evapotranspiration (ET). An overall water budget can however be determined if these elements are known and assumptions made (e.g. seepage is negligible) as follows:

Water balance: $Q_o = Q_i + (P - ET) A$

Where:
- Q_i = Inflow rate (m^3/day)
- Q_o = Outflow rate
- P = Precipitation rate (m/d)
- ET = Evapotranspiration rate (m/d)
- A = Wetland top surface area (m^2)

The effect of rainfall is to reduce the retention time, raise water levels and dilute concentrations whereas evapotranspiration has the opposite effect. Kadlec and Knight (1996) indicate that for design purposes the historical monthly average precipitation is sufficient, and that as specific ET rates are difficult to accurately measure, it is common practise to assume that wetland ET rates are some percentage of open water or pan evaporation rates. ET rates will vary depending upon plant type and density but rates 1.5 to 2 times the pan evaporation has been reported for SSF wetlands (USEPA, 1999). ET losses of 5 mm/day have been reported in summer in southern USA which may be more than half the daily inflow as many wetlands are typically only receiving 10 mm/day hydraulic load (Kadlec and Knight, 1996).

Conducting a mass balance is the most accurate way to characterise water quality functions in a wetland as it allows closure for the chemical of interest to be achieve, but as the outflow volume is often not monitored this is rarely achieved (Kadlec and Knight, 1996).

2.1.3 Media in Reedbeds

The substrate in reedbeds is defined to include the bed media (usually gravel), roots and plant rhizomes (WEF, 2001). The purpose of the media is:

i. To provide a substrate with high hydraulic conductivity around which the wastewater can flow.
ii. To provide a surface area for biofilm growth (periphytic attached-growth microorganisms).
iii. To assist in the removal of fine particles by sedimentation and filtration.
iv. To provide support for the roots of emergent plants.

(DLWC, 1998)

Typically, the media for reedbeds consists of sand, gravel or crushed rock. This is generally excavated locally to minimise haulage cost and represents the exploitation of a non-renewable resources. In the US the cost of imported gravel was found to be between 40 to 50% of the total construction cost. This range was dependent upon the distance the gravel is hauled and whether an artificial liner was also required (USEPA, 2000). From and economics viewpoint, this high cost of the media represents the single largest disadvantage SSF wetlands have over FWS systems (Crites and Tchobanoglous, 1998; WEF, 2001). An alternative low-cost media for SSF wetlands has the potential to greatly increase the uptake of this technology, particularly in developing countries.

The gravel used in SSF system typically varies in size from 3 mm to 38 mm. The requirements of a gravel-based substrate are that it be clean, hard, durable and capable of retaining its shape and maintaining permeability of the wetland over the long term (USEPA, 2000). It should also presumably be inert. The flow of wastewater through a reedbed will be determined by the hydraulic gradient, hydraulic conductivity, size and porosity of the media. Typical media characteristics are given in Table 2.1.

Table 2.1: Characteristics of typical media, Source: (Crites and Tchobanoglous, 1998; WEF, 2001).

Media type	**Effective size d_{10}, (mm)**	**Porosity, n**	**Hydraulic Conductivity, K ($m^3/m^2/day$)**
Medium sand	1	0.30	5,000
Coarse sand	2	0.32	1,000
Gravelly sand	8	0.35	5,000
Medium gravel	32	0.40	10,000
Coarse gravel	128	0.45	100,000

2.2 Macrophytes (Cattails) in Reedbeds

Paul D. N. Hebert (2007) has been reported that, Macrophytes are the conspicuous plants that dominate wetlands, shallow lakes, and streams. Macroscopic flora includes the aquatic angiosperms (flowering plants), pteridophytes (ferns), and bryophytes (mosses, hornworts, and liverworts). An aquatic plant can be defined as one that is normally found growing in association with standing water whose level is at or above the surface of the soil. Standing water includes ponds, shallow lakes, marshes, ditches, reservoirs, swamps, bogs, canals, and sewage lagoons. Aquatic plants, though less frequently, also occur in flowing water, in streams, rivers, and springs.

Macrophytes constitute a diverse assemblage of taxonomic groups and are often separated into four categories based on their habit of growth: floating unattached, floating attached, submersed, and emergent. Floating unattached plants are those in which most of the plant is at or near the surface of the water. Roots, if present, hang free in the water and are not anchored to the bottom. Floating attached plants have leaves which float on the surface, but their stems are beneath the surface, and their roots anchor the plant in the substrate. Submersed plants are found when the entire plant is below the surface of the water. Emergent plants are those whose roots grow underwater, but their stems and leaves are found above the water. Figure 2.2 has shown the method to planting the plant on the sewage plant.

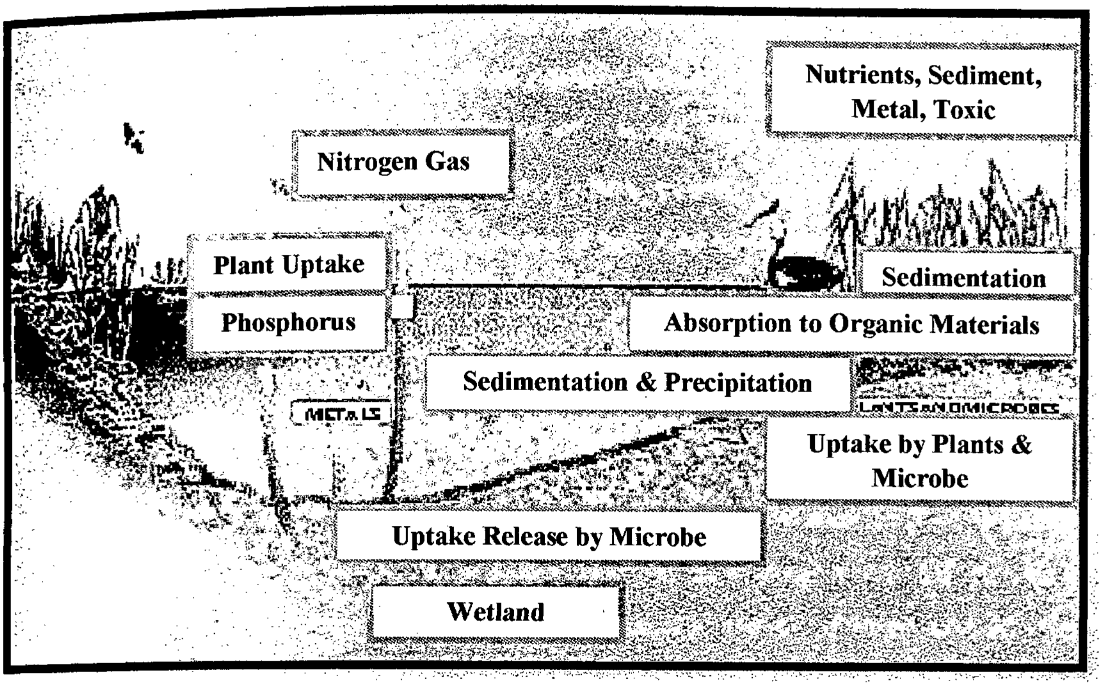


Figure 2.2: Method of implementation to planting the plant

Cattails are ubiquitous in distribution, hardy, capable of thriving under diverse environmental conditions, and easy to propagate and thus represent an ideal plant species for constructed wetlands. They are also capable of producing a large annual biomass and provide a small potential for N and P removal, when harvesting is practiced. Cattail rhizomes planted at approximately 1 m (3.3-ft) intervals can produce a dense stand within three months (Miller, I.W.G., and S. Black.).

Figure 2.3: Cattails

In late summer and fall, they form the brown seed heads that so many of us associate with cattails. A small area of cattails can be visually pleasing as well as provide fish and wildlife habitat. However, cattails rapidly spread via seeds and roots. In just a few short years without management, cattails takeover a ponds shallow water areas. It is not unusual to see ponds that are completely surrounded by cattails. This ruins the ponds visual and recreational benefits. Fortunately, cattails can be successfully managed. This is largely up to the owner to decide, based on his or her management goals.

Many pond owners prefer not to have any cattails because of their explosive ability to spread and the subsequent effort required to manage them. Other owners like areas of cattails because of the natural, pleasing aspect of them and for their value as fish and wildlife habitat. Most often, these owners like to limit cattails to about 10% of the shoreline areas. In a round one-acre pond, this would result in about 75 feet of shoreline. If you are an owner desiring some cattails, it is important for you to physically mark the areas you desire cattails and then prevent their spread outside the area. This requires occasional vigilance by the owner.

Two chemical compounds are the most effective in controlling cattails and are approved for aquatic use. These are diquat and glyphosate. Common trade names for these products are Reward (diquat) and Rodeo (glyphosate). However, a number of companies market other aquatic products using these compounds. They are generally available or can be ordered through agricultural supply or feed stores. Using either compound in accordance with the product label should not result in adverse effects on fish.

Diquat is a contact herbicide, meaning it kills only those portions of the plant that it touches. Thus, complete coverage of the cattail is needed to eliminate the plant. This requires spraying the area of cattails from several directions, a definite drawback. Another drawback is that diquat does not travel through the plant and therefore does not reach the cattails roots. The root system is not killed, allowing the same roots to grow new shoots the following year. Using diquat will require yearly applications.

Glyphosate is a systemic herbicide, meaning that it travels throughout the plant killing both the roots and vegetative portions. Systemic herbicides are preferred in the elimination of perennial plants, which the cattail is classified as. In treating cattails, a person can walk the shore making sure to spray glyphosate liberally on the portions of the cattails that can be reached. There is no need to spray from multiple directions. Another advantage is that one application can totally (or nearly so) eliminate the cattail stand. One drawback of glyphosate is that it is more expensive systemic herbicides usually are.

It is recommended with both compounds that a non-ionic surfactant be added to the solution prior to spraying. Surfactants result in uniform sheeting of the herbicide over the vegetative surface which increases the uptake of the herbicide. Cattails have a thick waxy coating on the leaf which slows down herbicide uptake. Without the surfactant, much of the herbicide would be lost to the liquid beads that would form and roll off the plant. One ounce of surfactant is generally recommended for each gallon of spray solution for controlling cattails.

Application timing is critical for cattail control and differs between diquat and glyphosate products. The contact herbicide diquat can be applied any time the cattails are green and actively growing. Most owners using diquat products apply in the summer. Glyphosate products have a narrower window for optimum results. These products should be applied just after the seed head has formed. Energy reserves are at their lowest in the roots and the plant begins to store food in the roots in anticipation of next year's growth. This food is produced in the leaves and transported to the roots. The application of glyphosate at this time results in its transport to the roots as well, thereby killing the root system.