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OPTIMIZATION OF DESIGN OF ROOTZONE SYSTEM FOR DAIRY WASTEWATER

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Abstract - *The main aim of study is to design, construct, and monitor the performance of a constructed wetland and examine the removal efficiency. In addition, the study was undertaken with the objective of design a constructed wetland with reduced plan area. Initial wastewater loading estimations were used to design the system. Performance evaluation of constructed wetland using influent and effluent concentrations of pH, three day Biological Oxygen Demand (BOD3), Chemical Oxygen Demand (COD), Total Solids (TS), Total Dissolved Solids (TDS), Total Volatile Solids (TVS), Total Fixed Solids (TFS), and Total Suspended Solids (TSS). This study describes the design of wetland for dairy wastewater treatment by considering the various characteristics of the dairy waste to show the advantages of wetland treatment over other waste water treatment methods.*

Key Words*: *Constructed Wetland, Design, pH, BOD3, COD, TS, TDS, TVS, TFS and TSS.

1. Introduction

In view of the alarming urban and industrial growth in the developing countries, especially in India, the pollution level in the water, air and soil has increased substantially over the years. Considering the magnitude of investment needed in wastewater treatment, government and private sector have only been able to mobilize funds towards construction of treatment plant employing conventional methods in few large towns, metropolitan areas and industrial complexes. Constructed wetlands promise to serve as an ideal alternative technology, which is simpler, economical and environment-friendly. The concept of this technology has been taken from the natural wetlands, which are as old as our earth. The constructed wetland systems for wastewater treatment facility involve the use of engineered system that are designed & constructed to utilize natural processes. This System are designed to remove contaminates from wastewater effluents (EPA, 1993). Constructed wetlands (CWs) as artificial basin according to engineering design that create ecological condition same to natural wetlands for treating wastewater in different physical, chemical and biological conditions (Wallace and Knight, 2006). Wastewaters from agricultural animal operations contribute large quantities of sediment, biochemical oxygen demand and nutrients to receiving waters.

1.1 Constructed wetlands are different from natural wetlands in that they are designed, built and operated for human use and benefit. Environment protection agency (USEPA, 2000) defined the constructed wetland as —artificial wastewater treatment system consisting of shallow ponds or channels which have been planted with aquatic plants and which rely upon natural microbiological, biological, physical and chemical processes to treat wastewater.‖

1.2 Types of Constructed Wetland Constructed wetland systems are classified into two general types: the horizontal flow system (HFS) and the vertical flow system (VFS). HFS has two general types: surface flow (SF) and sub-surface flow (SSF) systems (Halverson, 2004).

2. Materials and Methods

2.1Constructed Wetland Design

2.1.1. Liner

Artificial liner is one of the determinations to be made in designing a constructed wetland. The structural and watertight integrity of the liner is essential. Failure of either will result in loss of water, potential water pollution, and potential loss of plants as the water level declines. The liner may be a heavy duty synthetic membrane, or compacted soil. Generally the most economical choice is to produce a liner by compacting the onsite soils, especially low permeability clays. If they are not naturally occurring at the site, it may be required to bring some appropriate soils on-site.

2.1.2. Wetland Size Determination The characteristic wastewater to be treated by the CW includes BOD, COD, suspended solids (SS).The main difference between Reed's approach and that of Kadlec and Knight is the basis for their choice of rate constants. One of the limitations of the Kadlec and Knight approach is that, as the required effluent concentration approaches the minimum pollutant concentration, their predicted area for the treatment increases exponentially, leading to severe overestimation of the required area in cases near the pollutant concentration limit. (S. Kayombo,) Reed's method for the design of constructed wetlands Constructed wetlands can be designed based on mass loading of a specific pollutant on a daily loading basis. Designers must have accurate information on the flow volume and the pollutant concentration of wastewater. The wetland might be sized based on the equation proposed by Kickuth:

Ah =Q ln Ci–ln Ce KBOD Eq.2.1 (EPA, 1993) Ah = Surface area of bed (m2) Q = average daily flow rate of sewage (m3/d) Ci

= influent BOD5 concentration (mg/l) Ce = effluent BOD5 concentration (mg/l) KBOD = rate constant (m/d) KBOD = KT × d × n Eq.2.2 (EPA, 1993) KT = Rate constant at Temperature, d-1. d = depth of the wetland (m), n = porosity (percent, expressed as decimal fraction) KT = K20 × θ(T−20) Eq.2.3 (EPA, 1993) K20 =Rate constant at 200 C, d-1. K20 =1.104 θ =1.06 Table1.For sub-surface flow wetlands (S.Kayombo.et al) Sr.No Parameter BOD removal 01 K 20 (day -1) 1.104 02 θ 1.06 The cross sectional area and bed width are determined on the basis of Darcy's law, as follows:

Qs = Ac × Kf × dH dS Eq.2.4 (EPA, 1993) The bed cross-sectional area and bed width is independent of temperature and organic loading, since they are controlled by the hydraulic characteristics of the media. The cross-sectional area of the flow is then calculated as:

Ac=Qs(Kf×dHx dS) Eq.2.5

Ac = Cross sectional area of the bed (m2) perpendicular to the direction of flow (m2), Qs = average flow (m3/s) Kf = hydraulic conductivity of the fully developed bed (m/s) dH/ds = slope of bottom of the bed (m/m) For graded gravels a value of Kf of 1 x 10-3 to 3 x 103 m/s is normally chosen. The bed width is then calculated as follows: Substrate slope: - The longitudinal slope of the substrate bed parallel to the flow path should not be less than 1%. The surface of the substrate should be level (J. B. Ellis, 2003). Aspect ratio: - An aspect ratio (length: width) of 4:1 for SSF wetlands (J. B. Ellis, 2003). Depth: - HF wetlands have commonly been designed with beds 30 cm to 45 cm deep. An experimental study carried out in Spain showed that shallow HF wetlands with an average depth of 27 cm were more effective than deep HF wetlands with an average water depth of 50 cm. (UN-HABITAT, 2008) Hydraulic Loading Rate: - HLR = 100Q Ah Eq.2.6 HLR = hydraulic loading rate (cm/day), Ah = treatment area of the wetland (m2), Q = average flow rate through the wetland (m3/day), Hydraulic residence time: - Hydraulic residence time is the time that it takes for the wastewater to pass through the system.

t (days) = LWnd/Q Eq.2.7 (EPA, 1993) 2.1.3 Vegetation Planting Plant selection plays an important role in the initial step towards vegetation establishment. The major benefit of plants is the transferring of oxygen to the root zone. Their physical presence in the system (the stalks, roots, and rhizomes) penetrate the soil or support medium, and transport oxygen deeper than it would naturally travel by diffusion alone.(EPA,1998) Another general consideration in vegetation selection is the availability and cost. Allen et al. (1989) also recommended that plants be selected from more local wild stock so that the plants are more adapted to the local climatic conditions. Following are the plants which are mostly used in constructed wetland

- Phragmites australis (Reeds)
- Typha spp (cattail)
- Scirpus spp. (bulrush)
- Canna-Indica
- Colacasia

2.2 Experimental Setup: The experimental set up used for study of wetland process is illustrated in Fig 1 Approximately 15 liters of raw effluent from factories was brought to the laboratory in plastic containers and the experiments were set up in plastic craits. The plants used for the study was an emergent wetland plant Canna Indica. Wetland is made from fiber material with 5mm thickness, 1.06m length, 0.35 m width and 0.30 m depth and was equipped with two ports; one port was for sampling (inlet) and other for port was used to collect treated water The longitudinal slope of the substrate bed parallel to the flow path provided to be 1%. Polyethylene liners provided to the wetland to prevent the loss of water, potential water pollution, and potential loss of plants. Four baffle walls as shown in fig 4.2 are provided in wetland with 5mm thickness, 0.27m width and 0.40m height to reduce the plan area. The base of the tank was filled with gravel and wetland soil up to 0.30m in height. Gravel placed as the substrate of the wetland having size average 100 mm diameter up to the 10 cm from bottom, above this up to the 5cm fine well cleaned gravel with size average 5-10 mm diameter, above this up to the 10 cm fine sand and above this up to the 12 cm soil is filled. Plant selection plays an important role in the initial step towards vegetation establishment. So the locally available plants i.e.canna indica is select for wetland. For treatments, the plants which maintained in the stock tanks were collected, cleaned and introduced in the experimental tanks.1000 ml of effluent from the treatment sets were collected periodically for analyzing the changes in its physicochemical characteristics subsequently with an interval of 8 days.

Fig 1. Experimental Setup

Conclusions

- By providing the baffle walls wetland plan area is reduced without hammering the removal efficiency.
- System performance for the reduction of COD resulted up to the 92.5%.

- The advantages of this method (wetland) compared to other ones are simple performance, the use of indigenous and natural canes at a building site, low cost of construction and the disadvantages of this method include bed obstruction, increased costs of cleaning, etc.

- Given the lack of experiences with the application of constructed wetland technologyto high strength wastes it is most apparent that additional research is needed, along withmore innovative designs and configurations.

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