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CLOGGING, OPERATION AND MAINTENANCE OF CONSTRUCTED WETLAND

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Abstract

Constructed wetlands can be considered as a secondary treatment step since suspended solids, larger particles including toilet paper and other rubbish as well as some organic matter need to be removed before wastewater can be treated in subsurface flow cws. Pre-treatment is extremely important to avoid clogging of subsurface flow cws, which is an obstruction of the free pore spaces due to accumulation of solids.

The apparent simplicity of cws often leads to the false assumption that this technology does not need specialised design knowledge or regular maintenance. In fact, most cws which show poor treatment performance had design flaws or lack of maintenance. The most important maintenance tasks include regular checking of the efficiency of the pre-treatment process, of pumps, of influent load and distribution on the filter bed. The actions required to prevent clogging of the filter bed are also explained in this document.

Index Terms: *Clogging, Hydraulic conductivity, Constructed wetlands, Wastewater etc.*

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1. INTRODUCTION

1.1 Definition and Terminology

Constructed wetlands (cws) are "engineered systems, designed and constructed to utilise the natural functions of wetland vegetation, soils and their microbial populations to treat contaminants in surface water, groundwater or waste streams" (ITRC, 2003). Synonymous terms of cws include: Man-made, engineered, and artificial or treatment wetlands. There are also a number of terms used for subsurface flow cws, which can be confusing for novices:

a. Planted soil filters: Their vegetation is composed of macrophyte plants from natural wetlands and this sets them apart from the unplanted soil filters, also called subsurface biofilters, percolation beds, infiltration beds or intermittent sand filters.
b. Reed bed treatment system: A term used in Europe resulting from the fact that the most frequently used plant species is the common reed (Phragmites australis).
c. Vegetated submerged beds, vegetated gravel-bed and gravel bed hydroponics filters. This great number of terms is confusing for novices who are searching for information. In this document, the terms "bed", "filter" or "filter bed" are used interchangeably, denoting the sand filled main body of the subsurface flow cws. We use the term "pre-treatment" in this document to denote the treatment step before the wastewater reaches the subsurface flow CW filter bed. Other authors call this step "primary treatment", and the treatment in the CW would in that case be called "secondary treatment".

1.2 Applications of the Constructed Wetlands

Constructed wetlands can be used for a variety of applications are:

a. Municipal wastewater treatment
b. Treatment of household wastewater or greywater
c. Tertiary treatment of effluents from conventional wastewater treatment plants
d. Industrial wastewater treatment such as landfill leachate, petroleum refinery wastes, acid mine drainage, agricultural wastes, effluent from pulp and paper mills, textile mills.
e. Sludge dewatering and mineralisation of faecal sludge or sludge from settling tanks
f. Storm water treatment and temporary storage
g. Treatment of water from swimming pools without chlorine.

2. LITERATURE SURVEY

2.1 Operation and Maintenance

2.1.1 Operational Tasks for HFBs and VFBs

Whilst constructed wetlands are "low tech" systems they still require adequate maintenance by a trained person with basic skills.

The pre-treatment unit requires maintenance as indicated depending on the type of technology. The efficiency of the pre-treatment units has to be checked on a regular basis. The larger the system, the higher the required frequency. The effluent from the pre-treatment system should be analysed for Settleable solids by using an "Imhoff cone" in order to know the quantity of solids being transferred to the wetland. The sludge of the pre-treatment systems has to be removed regularly.

Fig.1: Maintenance by trained person with skills.

The operational tasks required for the constructed wetland filter bed includes regular checking of:

a. Pumps
b. Inlet structures for obstructions and for the water level
c. Outlet structures for the water leveld
d. Hydraulic loading rate and pollutant loads i.e. Influent and effluent concentrations of BOD and SS as well as influent flowrate.
e. Wetland vegetation for disease, insects, etc. (remove weeds and predatory plants until the wetland vegetation is fully established).

If maintenance is ignored, the following consequences will occur sooner or later:

a. Uneven flow distribution
b. Local overloading and odour
c. Deterioration of treatment efficiency.

2.1.2 Tasks for the Operation of HFBs

It is very important to check the filter bed for clogging. Clogging occurs for example in HFBs which were built too long, i.e. where the horizontal distance Between inlet and outlet is too long. Such HFBs have a high hydraulic load in a relatively short inlet zone.

A possible refurbishment step for such HFBs is to split the HFB in the middle after half of the horizontal length, by digging a trench and placing drainage pipes there. the new trench will thus become an inlet or "feeding" trench as well.with this modification, the inlet zone doubles and the flow distance is halved.

Another possibility is to introduce a small dam after 2 m of the inlet to the bed. with this measure, the first part of the HFB serves as an inlet zone.

Further tasks for the operator and thus considerations for the designer include are:

a. When sludge accumulates in the inlet zone of the HFB, the filter bed has to be taken out of operation so that it can dry out. in the worst case, all affected filter material in the inlet area has to be exchanged. until the filter material is exchanged, the CW cannot operate and treat wastewater.
b. Especially in the case of HFBs it is recommended to have the possibility to occasionally dam up the filter bed completely in order to be able to control the growth of the wetland plants.
c. In order to guarantee sufficient aeration of the filter bed it is recommended to have the option to lower the water level down to the bottom of the HFB.

2.1.3 Tasks for the Operation of VFBs

VFBs need more operation and maintenance than HFBs. The following operation and maintenance activities should be performed for VFBs:

A. The even distribution of pre-treated effluent on the entire surface is important for VFBs and has to be monitored. valves at the front of the distribution pipes and removable caps at the end allow the cleaning of the pipes during the pumping phases. in case a filter bed, or areas of the filter bed, is affected by clogging and has to rest, the valves can be closed.

b. Wastewater feeding intervals have to be maintained by an automatic system with pumps or siphons. however, VFBs for the treatment of grey water of households can be designed without a pump or siphon, if the production of grey water has suitable and regular intervals.

c. The surface has to have the possibility to dry out between each charging with wastewater.

d. Immediate action has to be taken in the case of clogging. a VFB can recover well after a resting period of two weeks where the filter bed can dry out. however, in cold climate zones with low temperature and freezing periods (temperature 0-8°c) a VFB cannot recover so quickly. that is why VFBs have to be designed much larger in cold climate zones.

e. It is better to overload one part of the filter bed in order to give the other part a rest than to expect the entire system to recover at the same time. once clogged, the system does not recover without resting periods. it has been shown that a VFB can almost completely regain its efficiency after longer resting periods (Platzer and Mauch, 1997). such a resting period is needed to completely dry out the clogged layer and may be as short as three weeks in a dry, sunny climate to about six months in a cold, wet climate.

Fig.2: Pipe cleaner

2.2 Soil Clogging and Soil Aeration in VFBs

An extremely important aspect of VFBs is the potential risk of soil clogging which results in a general failure of the system (Cooper and Green, 1994; Platzer and Mauch, 1997; Winter and Goetz, 2003). "Temporary" soil clogging occurs regularly in VFBs and is part of the process. regular resting of the beds reverses the temporary Soil clogging.

In VFBs clogging occurs as an obstruction of the surface area by suspended solids or due to a fast growing bio film (sludge). it is caused by poor pre-treatment, high loading or too fine filter sand. the term used in the literature is "soil clogging" even if the term "bed clogging" may be better.

Clogging is a normal reaction caused due to the biological activity of the microorganisms. therefore the system has to be designed large enough so that resting Periods in parts of the filter bed can occur. another possibility to avoid clogging is to keep the load low enough so that, it does not occur due to the natural degradation processes.

The experiences with soil clogging in constructed wetlands differ widely since the problem depends on many factors. sufficient soil (or bed) aeration is the main Factor for the proper functioning of VFBs, and therefore the following design aspects are very important:

a. The wastewater needs to be pumped onto the VFBs intermittently (4-12 times per day).
b. VFBs treating municipal wastewater should have at least 4 beds in order to be able to rest the beds on a regular basis: 6 weeks in operation and 2 weeks of rest.
c. A uniform distribution of the wastewater is required.
d. The filterable solids loading should be less than 5 $g/(m^2 \cdot d)$ and this requires efficient pre-treatment.
e. Adequate plants with well developed rhizome/root systems play an important role in maintaining and restoring soil conductivity.
f. The hydraulic and organic load to the VFBs need to be checked out regularly and should not exceed the design values given in the previous section.

In VFBs oxygen supply is the key consideration for efficient degradation of organic matter, for nitrification and to avoid clogging. that is why the commonly used design parameter "area per person equivalent" is not sufficient to guarantee good treatment results.

The dimensioning of VFBs based on oxygen demand was first developed by Platzer (1999). The design depends on the oxygen demand for oxidation of organic matter and for nitrification as well as the oxygen input (loading frequency, loading volume, roots and surface area).

The intermittent batch loading is most significant for oxygen input: an adequate oxygen transfer in vfbs is only guaranteed when application and infiltration occur in a short time with sufficient time lag to the next application.

There is still a lack of knowledge about the total impact of all the factors which can influence the treatment efficiency of the constructed wetland: the climate conditions, wastewater characteristics, plant influences and microbial degradation processes. their interactions between each other are not yet fully understood. every well planned, operated and monitored constructed wetland can give us important information to gain a better understanding of the treatment process.

2.3 Clogging in Horizontal Subsurface Flow Constructed Wetlands

HSSF CW clogging is the process of bed media pores occlusion. The clogging Progression speed depends on the design and operation context of the constructed Wetland (Knowles et al., 2011).

In other words, clogging is the bed media porosity loss by solids Accumulation.

Accumulated solids might be organic or inorganic, and they may origin from the wastewater or from biological activity.

Clogging is a severe operational issue that may lead to the increase of disease dissemination as well as diminish the treatment efficiency. commonly, rehabilitation measures are only taken when visible symptoms show up, such as pond formation or surface run off.

The clogging process depends on a wide variety of factors and on the dynamic relationships between these factors among themselves. due to that complexity, clogging phenomena is not currently known in detail. nevertheless, during this research, many clogging related factors were identified, and hereby organized in three categories. the factors of the first two categories (influent characteristics and system design), where the chance of intervening is bigger, have a strong influence over the third category (bed activity) factors.

Each factor might be related with more than one clogging mechanism and have influence in different ways. the main clogging mechanisms are suspended solids retention, bio film growth, excessive load of organic matter and uneven influent distribution. suspended solids entrapment occurs mainly in the inlet zone where the wastewater has a higher content of suspended matter. due to the low speed of the flow, suspended solids settle at the inlet. the more the pores volumes diminish, the lower the hydraulic conductivity will be.

The biofilm growth is prevalent in the inlet zone because of the high content of organics present in the influent wastewater (Ragusa et al., 2004; García et al., 2007; Tietz et al., 2007).the development of biofilm is dependent on the rate of particles and soluble organics that entry in the bed, therefore it is affected by the nature of the wastewater to be treated. The porosity loss resultant from biological activity Contributes to an important decrease in hydraulic conductivity at the inlet. The Influent excessive organic matter content exacerbates the microbial biomass growth. usually, the organic load is related to the amount of accumulated solids(A. Pedescoll et al., 2013).

According to the Rosseau et al. (2005) and Griffin et al. (2008) poorly maintained by distribution systems lead to an uneven distribution. Therefore, bed media clogging may be uneven likewise (P. Knowles et al., 2011). If the wastewater flows only through the same holes of the distribution pipes, it is likely that surface plugging will happen. In such cases maintenance and improvement of the distribution system may prove beneficial (USEPA, 2000).

The HSSF CW clogging produces a chain of adverse effects since the accumulated solids within the bed media favours short-cuts and hence the hydraulic conductivity decreases as well as the pores‟ volume. As a consequence, water insurgences and other undesired events may happen, leading to a reduction of the treatment efficiency, a negative impact in the environment, and an increase of the expenses with the maintenance (Turon et al., 2009).

The main clogging preventive measures consist of an efficient pretreatment, an adequate distribution system, as well as the choice of an appropriate bed media and Guaranteeing the accomplishment of maintenance procedures.

The existence and the appropriate operation of the pretreatment is important to avoid the entrance of coarse solids and to decrease the influent concentrations of BOD5 and TSS. This way, the coarse solids entrapment and consequent bed clogging is prevented (Pedescoll et al., 2011).

The conventional clogging remediation measures are the improvement and/or distribution pipes cleaning, the bed media washing or replacement, accumulated organic matter oxidation by hydrogen peroxide, and the recirculation of the effluent in order to decrease the influent organic load. An alternative to the bed media washing is the application of worms, since they graze the accumulated solids and also aerate the bed media while moving.10

3. FINDINGS OF STUDY

3.1 Basic Design Considerations

The necessary conditions to be able to use constructed wetlands for wastewater treatment are listed below:

a. Enough space must be available because it is a low-rate system with a higher Space requirement than high-rate systems.
b. Climates without longer freezing periods are preferable, even though subsurface flow CWs with adjusted designs do work in cold climates (Jenssen Et al., 2008).
c. Full sunlight situation is preferable and full shadow conditions need to be avoided. Especially for subsurface flow cws it is very important that the surface area can regularly dry out completely because otherwise the risk of clogging rises due to excessive biofilm growth in wet conditions.
d. Plants used must be adapted for growth under partially submerged conditions, The local climate and the sunlight/shadow conditions of the respective wetland location.
e. As for all biological treatment processes the wastewater should not contain toxic substances, although the high retention time makes constructed wetlands more robust to toxic events compared to more highly loaded systems.
f. Well trained maintenance staff to carry out the basic maintenance tasks is needed.
g. Urbanisation and future population development have to be considered when calculating the expected waste water flow rate to the constructed wetland.

There are some general considerations about constructing subsurface flow CWs, which are usually adhered to:

a. A 15 cm freeboard for water accumulation is recommended.
b. The surface must be flat and horizontal to prevent unequal distribution or "surface run-off" (which means in the case of HFBs that wastewater is flowing across the surface of the CW to the outlet but not infiltrating and hence not receiving treatment).
c. The design of the inlet area and distribution pipes has to assure uniform distribution of the wastewater, without allowing short circuits of the flow.
    i. The right selection of filter material is crucial
    ii. The wastewater is applied to the bed via distribution pipes which have small holes equally distributed along the length of the pipes.
d. Drainage pipes collect treated wastewater at the base below the filter bed.
e. Liner at the base: Plastic PVC lining, a clay layer or a concrete base is used to seal the filter bed at the base. For HFBs this is always necessary. For VFBs it is only necessary when the effluent will be reused or when the groundwater table is high and groundwater is used for drinking water purposes. Sometimes the authorities also stipulate the sealing of the base.
f. The lining prevents contact of wastewater with groundwater but otherwise does not improve the effluent quality nor prevent clogging.
g. Disadvantages of lining are the additional costs, the difficulties with finding a local supplier (especially in rural areas), environmental pollution during production of PVC lining and the need for specialists to lay the PVC sheets properly in the hole.

Special attention should always be paid to the pretreatment years and these plants are still producing good treatment results.

3.2 Scope of This Study

This study focuses on treating domestic/municipal wastewater or grey water with subsurface flow constructed wetlands with coarse sand as a filter medium. The emphasis is on the application in developing countries and countries in transition (with a moderate to warm climate), although constructed wetlands can in principle be used in all types of countries and climates. Constructed wetlands are generally used as a decentralised wastewater treatment process. They are used as a secondary treatment process which means that the wastewater is treated in a primary treatment step before entering the CW filter bed; except for the “French System” which works without primary treatment.

This study provides an overview and basic guidance on the design and maintenance of horizontal flow beds (HFBs), vertical flow beds (VFBs) and the “French System”.

3. CONCLUSION

The subsurface flow constructed wetlands are an excellent and easy solution to provide sanitation systems for smaller populations to whom the connections with centralized systems are not viable. Nonetheless, the clogging phenomenon threaten treatment efficiency, increases the risk of wastewater exposure to people or animals, and also shortens the system life time.

There have been identified clogging preventive and rehabilitative measures to significantly increase beds‟ life span. These would be relevant to avoid surface runoff and to accomplish treatment goals.

Clogging degree assessment of both HSSF CW through saturated hydraulic conductivity measurements allow us to conclude that Martinlongo‟s WWTP is heavily clogged apart from the initial area. It allow us infer that Barrada‟s WWTP has a heterogeneous pattern in what respects to hydraulic conductivity distribution, pointing towards the existence of preferential flow paths.

Martinlongo‟s WWTP should, therefore, aim to correct Imhoff‟s tank efficiency or implement a complementary solution as sedimentation basin previous to primary effluent distribution. Additionally, intermediate layer bed media replacement with a larger bed media may prove of greater potential to increase bed hydraulic conductivity as well as to avoid clogging effects.

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REFERENCES

[1]. Abegglen, C., Joss, A., Boehler, M., Buetzer, S. And Siegrist, H. (2009) “Reducing the natural colour of membrane bioreactor permeate with activated carbon or ozone”, Water Science and Technology 60(1), 155-165.

[2]. Brisson, J. And Chazarenc, F. (2009)“Maximizing pollutant removal in Constructed wetlands: should we pay more attention to macrophyte species selection?”Science of the Total Environment 407(13), 3923-3930.

[3]. Cooper, P. And Green, B. (1994) “Reed bed treatment systems for sewage treatment in the United Kingdom-the first 10 years experience”, Water Science and Technology32(3), 317–327.

[4]. Kadlec, R.; Knight, R.;Vymazal, J.; Brix, H.; Cooper, P. E Harbel, R. (2000). “Constructed Wetlands for Pollution Control - Processes, Performance, Design and Operation”, IWA Publishing, London.Knowles, P.,Dotro, G.,Nivala, J., & García, J.(2011). “Clogging in subsurface flow treatment wetlands: Occurrence and contributing factors” Ecological Engineering, 37(2), 99–112