MINIMIZATION OF POLLUTION INTO WATER STREAMS USING AGRICULTURAL WASTES

A Thesis
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CHAPTER I
INTRODUCTION

1.1 GENERAL

In recent years, water scarcity is a growing problem that is faced of many countries in recent years; it could endanger the countries' stability and regional dominance. Water issue in Egypt is rapidly assuming alarming proportion. In Egypt at 2020, the water consumption will increase by about 20 % more than its share. Implementation of water conversation techniques and control water pollution is important to mitigate water scarcity, it was achieved by installing more efficient irrigation techniques, and control water pollution in order to avoid a disaster by using development plans.

The discharge of domestic wastewater to the environment with a little or no treatment caused the problem of pollution, hygienic and environmental hazards. In rural Egypt, the process of disposal of wastewater (with or without treatment) in agricultural drains and sometimes to canals represents a dangerous challenge to environment and public health. Urgent need to reuse drain water for irrigation caused increasing the water demands

In Egypt, reusing of drain water is not a marginal or deviant phenomenon. Now drain water reuse is considered to be a central strategy for increasing the efficiency of water in Egypt, and so, the drain water pollution is considered to be a threat to this goal.

In Egypt, the amount of agricultural of up to wastes 30-35 million tons per year, only 11 million tons were used for animal feeding and organic manure as 7 million tons for the first, and 4 million tons for the second. The problem of agriculture wastes is very obvious in the summer season because the needing of getting rid of agricultural wastes become a big challenge. Emission of poisons gases to the air and reducing the microbial activities in the soil caused by this method are risk to the environment, therefore, although it is the most economic method still undesirable. Many researchers studied the using of agricultural wastes in wastewater treatment either as activated carbon or as a natural material without any processing.

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1.2 STUDY OBJECTIVES

The main objectives of this study were represented as follows:

- Comparing between the performance of standard rate biological filter and high rate biological filter using many types of agricultural wastes as a media.
- Studying order, depth, and type of many types of agricultural waste as a filtration media for municipal wastewater treatment before disposing into agricultural drains.
- Modifying bio-filter simulation equation to applied on the studied system.

1.3 ACTIVITIES DURING THE STUDY

The scope of work is prepared to compare between two different systems of biological trickling filter for treat raw domestic wastewater before disposing into agricultural drains. The study program was conducted into three parallel lines as follows:

1.3.1 THEORETICAL APPLICATION

This line include historical review about different types of biological trickling filter, literature review about using of agricultural wastes as a media, pilot design, and the designs of hydraulic pump for recirculation flow. It also contains result analysis, model formulating and discussion of them, and conclusions. This line would do as following:

- **Historical review:** it is done for collecting of researches studied different types of biological trickling filters, using of different types of agricultural wastes as a bio-media, and biological treatment models.
- **Measurements and discussion:** representation of the experimental results and discuss it.

1.3.2 EXPERIMENTAL APPLICATION

This line includes the field experiments to treat raw domestic wastewater, by using two types of agricultural wastes as a bio-media(ficus

tree trimming stalks and rice husk), to avoid disposing of untreated domestic wastewater into agricultural water bodies. Several laboratory tests have been performed to characterize the physical properties of wastewater used in this study. This application would do as following:

- The implementation of the pilot consists of two columns, first represents the high rate trickling filter and the second represents the standard rate trickling filter, hydraulic pump for recirculation in the high rate system, storage tank, withdrawal pump for refilling the storage tank.
- Distribution perforated spiral hoses, which simulate trickling filter arms, and prove it at the top of each columns
- Put the applied media without any treatment except cut to pieces of 2 cm in a plastic mesh bags within each column with chooses depths and orders.
- The laboratory measurements for different parameters will do for each run.
- The experimental application was done in sanitary engineering laboratory of Benha faculty of engineering, Benha University for all parameters except COD and BOD were done in the central laboratory, faculty of science, Ain Shams University.

1.3.3 ANALYTICAL STUDY & MODELING

In this line the organic load removal efficiencies for every type of both systems of biological filter, high rate and standard rate, were calculated. Also, this line is drawn to modify bio-filter simulation equation that facilitates the study of wastewater disposal in agricultural drains without polluting their water.

1.4 THESIS ORGANIZATION

The thesis consists of seven chapters, references, and abstracts. It represented as follows:

1.4.1 CHAPTER I: INTRODUCTION

The chapter consists of general introduction; focus on the problem, illustration the objective of the study, presentation of theoretical and practical work, and thesis contents.

1.4.2 CHAPTER II: LITERATURE REVIEW

This chapter represents previous studies of wastewater treatment. Also, in this chapter the ways other people have constructed their own research have been presented to derive the assignment of this work.

1.4.3 CHAPTER III: MATERIALS AND METHODS

In this chapter the practical study location was showed. It described the pilot and standard lab equipment, the program of experimental work, and measurement analysis.

1.4.4 CHAPTER IV: RESULTS

This chapter presents experimental results for different phases of treatment of rue domestic wastewater through tables and figures.

1.4.5 CHAPTER V: STUDY MODELING

This chapter illustrates the studies of modify bio-filter simulation equation for both studied types of treatment system, high rate and standard rate trickling filters.

1.4.6 CHAPTER VI: DISCUSSION

This chapter discussed the results of the experimental work and showed it. It discussed the comparisons between different processes of treatment. Also, it included the verification for the produced model.

1.4.7 CHAPTER VII: CONCLUSION

This chapter illustrate the conclusion which containing a summing up of the study points and a statement of opinion or decisions reached from the results. Also, it illustrates the recommendations which show the future points needed to investigate, and the advices for the application of the system.

CHAPTER II

LITERATURE REVIEW

2.1 GENERAL

World nowadays faces a great problems related to water resources, for this reason they should deals achievement between neighboring countries to cover and control water supply resources and how it can be developed, to cover all human activities

These complicated problems can be solved by performing another ways to reserve water demands through sea water desalination or/and wastewater purification projects. Agricultural drains water reuse was practiced in the Lower Egypt since 1970. At present, drainage reuse is widely practiced in delta region, **[1].**

Activities like flushing toilets, bathing, preparing meals, doing laundry, and washing dishes generate domestic wastewater; consists of 99.9 % pure water, and the other 0.1% is pollutants. These pollutants pose risk on a large scale in spite of its low concentrations. Centralized sewage treatment plants used for treating domestic sewage in urban areas, where it was designed to control conventional pollutants of BOD, COD, and total suspended solids. Secondary treatment or over can remove more than 90% these pollutants. When treating of nutrients and pathogens were required, additional sub-systems were applied to the plants.

About 80% of Egyptian Rural areas dispose their wastewater directly to water stream bodies, drains or even canals, without treatment. This pollutes these streams and kills life inside it. Moreover, when reaches to rivers and oceans, it can cause a threat to both human health and the environment. This contamination leads to significant numbers of infectious diseases linked to bathing and swimming in marine waters and to the consumption of seafood. Wastewater should be treated before disposal in the neighbor water bodies to reserve environment.

Disposing of untreated wastewater with high concentrations of pollutants into the agricultural drains considered a severe problem where self-purification disappears in this case. So, a low cost treatment method was needed to be applied to prevent to some extent wastewater of high pollutants concentrations reach agricultural drains.

Treated wastewater is either reused or disposed of in the environment. Hence, a fundamental element of wastewater disposal is the associated environmental impact. The most common means of treated wastewater disposal is summarized by discharge and dilution into ambient waters, and land application, where the wastewater seeps into the ground and recharging underlying ground water aquifers, **[2]**.

From the previous consideration, it is clear that, it is very important to interest in water of agricultural drains and its limits of disposal according to Egyptian law.

2.2 WASTEWATER TREATMENT

Continuous and accelerated disposal of wastes caused a great problem of the environmental pollution. One of the main problems is the contamination of stream bodies with wastewater either industrial or domestic; this requires, under the dire need of fresh water, the treatment of wastewater before disposed into stream bodies.

Sewage treatment is the process of removing contaminants from wastewater and household sewage. Produced of both, treated sludge and environmentally safe fluid waste stream to be suitable for disposal or reuse (usually as farm fertilizer), are the aim of this treatment.

Wastewater treatment may be one or more processes according to the target of the treatment. It may classify according to the treatment degree as primary treatment, secondary treatment, tertiary treatment, and fourthly treatment.

Also it can classify according to methodology into three types, physical treatment, chemical treatment and biological treatment. It can be a combination between two or three of them.

2.2.1 DEGREES OF WASTEWATER TREATMENT

2.2.1.1 PRE- TREATMENT

Pre-treatment is a physical process aimed to remove materials that can be easily collected from the raw sewage before they clog or damage the pumps or sewage lines of primary treatment clarifiers such as tree

limbs, branches, leaves, trash, etc), **[3]**. It consists of screening and grit removal as following:

- The screening removes or reduces the large solids to protect the pumps and prevent large solids from fouling subsequent units, **[4]**.
- Grit chambers remove material such as gravel, seeds, bone chips, and large organic particles (food wastes) to prevent the accumulation of sand in tanks and piping, **[5].**

2.2.1.2 PRIMARY TREATMENT

Primary treatment is a physical process; it consists of quiescent basin to hold the sewage where oil, grease and lighter solids float to the surface while heavy solids can settle to the bottom. This process can be improved by chemical addition. Floating material are removed as the settled. On The other hand, the discharging or subjecting was the way to eliminate the remaining liquid, **[6] & [7].**

2.2.1.3 SECONDARY TREATMENT

Secondary treatment follows the primary treatment to removes dissolved and suspended organic matter. For the removing of the micro-organisms from the treated water prior to discharge or tertiary treatment, a separation process was required to the secondary treatment.

2.2.1.4 TERTIARY TREATMENT

Tertiary treatment is an advanced treatment exists in the final treatment stage. It is required to protect the environment; sea, river, lake, ground water, etc, by raising the effluent quality before disposing. It can remove Suspended solids, Dissolved organic and inorganic compounds, nitrogen and phosphors, **[4].**

2.2.2 METHODOLOGY OF WASTEWATER TREATMENT

2.2.2.1 PHYSICAL TREATMENT

Physical operations used for wastewater treatment by means of or through the application of physical forces are known as *physical unit*

operations. Those units form the basis of most process flow diagram. The physical unit operations most commonly used in wastewater treatment includes, **[2]:**

- Screening.
- Comminution .
- Flow equalization.
- Mixing.
- Sedimentation.
- Accelerated gravity settling
- Floatation.
- Heat transfer and drying.

2.2.2.2 CHEMICAL TREATMENT

Chemical processes used for wastewater treatment by means of or through the chemical reactions are known as chemical unit processes, **[2]**. Those units are used to improve the results of to reach the target of treatment. These processes include, **[8]:**

- Adsorption
- Chemical neutralization
- Chemical coagulation
- Chemical precipitation
- Chemical oxidation
- Chemical disinfection**.**

2.2.2.3 BIOLOGICAL TREATMENT

Biological treatment is used for reduce the organic content and the nutrients by activates the existing microorganisms in wastewater. Table (2/1) represents the major biological treatment processes used for waste water treatment, **Metcalf and Eddy [2]**.

In biological treatment there are two actions may occur, aerobic action which acts in the presence of oxygen, and anaerobic action which acts in the absence of oxygen. In each, there are two methods of bacterial growth:

- Suspended growth: it depends on the suspended particles existing in the effluent to act as a surface media.
- Attached growth: it depends on the using of a fixed media for bacterial action.

In this work the meaning of biological action which depends on the attached growth will be focus by using the agriculture wastes as a fixed media for bacterial action.

Table (2-1): Major Biological Treatment Processes Used for Wastewater Treatment, [2] &[10].

Type	Sub type	Common Name
A- Aerobic processes	1- Suspended-growth	١. Activated-sludge process Conventional (plug flow) Complete mix Step aeration Pure Oxygen Sequencing batch reactor Content stabilization Extend aeration Oxidation ditch Deep tank Deep shaft ٢. Suspended growth nitrification ٣. Aerated lagoons ٤. Aerobic digestion Conventional air Pure oxygen
	2- Attached-growth	Trickling filter. Standard (Low rate) High Rate Super Rate Bio-tower. Up flow filter. Fluidized bed. Biological aerated filter (BAF). Dual Flow Bio-Filters (DBAF). Rotating biological contactor (RBC).
	3-Combined suspended – and attached-growth processes	Activated biofilter processes, trickling filter solids contact process, biofilter activated-sludge process, series trickling-filter activated-sludge process
B- Anoxic processes:	1-Suspended-growth. 2-Attached-growth	Suspended-growth denitrification Fixed-film denitrification

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C- Anaerobic processes:	1-Suspended-growth.	Anaerobic digestion Standard rate, single-stage High rate, single stage Two-stage Anaerobic contact process Upflow anaerobic sludge blanket
	2-Attached growth	Anaerobic filter process Expanded bed
	3-Combined aerobic, anoxic, and anaerobic processes:	Suspended-growth Single-or multi stage processes various proprietary procrsses Combined Suspended and Attached growth Single-or multi stage processes
	4-Pond processes	Aerobic pond Maturation pond Facultative pond Anaerobic pond

2.3 BIOLOGICAL FILTER

Biological filter is one of the most kinds which are used for secondary treatment of municipal wastewater. It consists of a highly permeable media to attach microorganisms on it and percolate wastewater through it. The theory of work of this kind is depended on the interaction between organisms and organic material in the wastewater, which include carbonaceous, nitrogenous and phosphorus compounds.

2.3.1 TYPES OF BIOLOGICAL FILTER

Biological filter can be classified according to the hydraulic load, with taking the media type, flow direction and operation procedure into consideration, to seven main types, **[9]:**

1. Trickling filter (TF).

2. Bio-tower.
3. Up flow filter.
4. Fluidized bed reactor (FBR).
5. Biological aerated filter (BAF).
6. Dual Flow Bio-Filters (DBAF).
7. Rotating biological contactor (RBC).

2.3.1.1 TRICKLING FILTER.

Trickling filter is one of the attached growth process which characterized by low initial cost, low operating and maintenance cost, and simple operation. It consists of a fixed bed filled with broken stones. In its operation, feeding of wastewater was from the top and the wastewater contacts to the media for a short time. The bed was then drained and allowed to rest before the cycle was repeated. A typical cycled is required 12 hours (6 hours for operation and 6 hours for resting), **Figure (2-1), [10].**

The fixed bed of modern trickling consists of highly permeable medium to attach the microorganisms to the bed and percolate or trickle wastewater through it, **[11]**.

The relatively high incidence of clogging, the relatively low loading that could be used and long rest period required are the disadvantages of (TF). So, the usage of trickling filter is constrains.

The advantage of trickling filters compared to other wastewater treatment systems is that its operating costs are low. It has no power consumption in agitation or gas compression for the creation of gas-liquid contact area. Transferring liquid to and from the unit and in distributing it over the packed bed is the only consumption of the power in it. Rate and manner in which the wastewater load is applied to the bed, provide the solid support for the film of microbial slime, and the material used as the packing to form the bed are the principal variation between the differentiates alternative versions of biological filters systems.

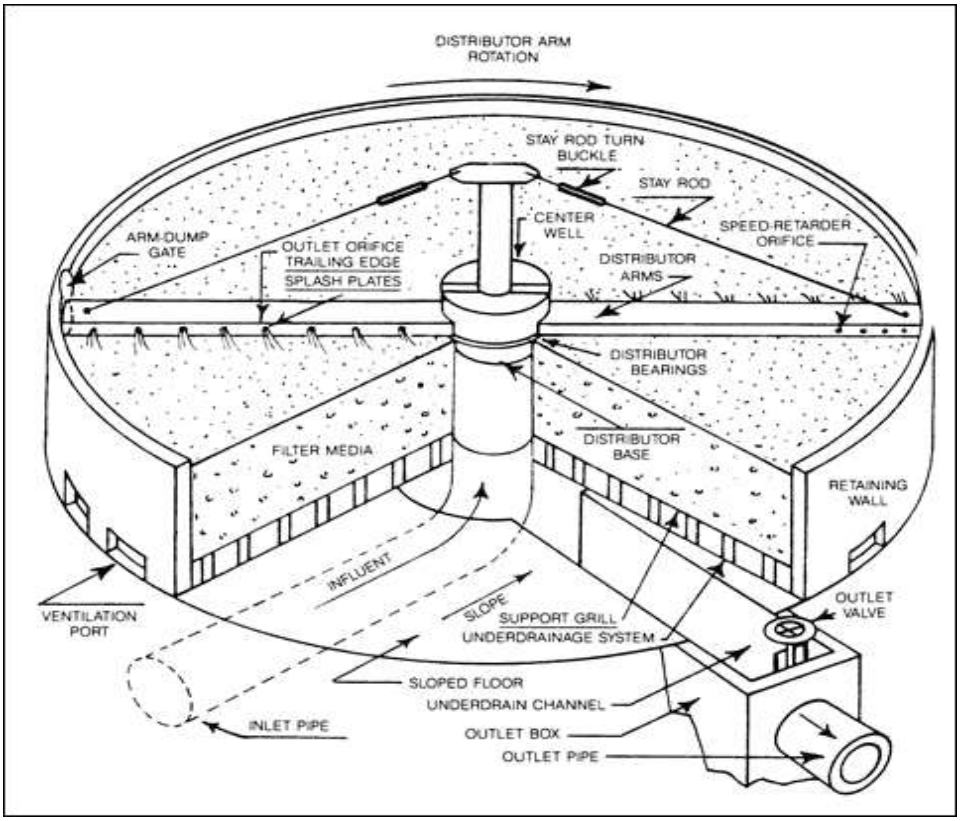

Figure (2-1): Cutaway view of trickling filter [11]

When wastewater passes through the filter media, the organic material adsorbed from wastewater onto the slime layer. Aerobic microorganisms decomposed the organic material in the outer layer of biological slim, which had a ranged thickness of 0.1 to 0.2 mm, as shown in **Figure (2-2).** Because of the growth of microorganisms, the thickness of the slime layer increases, and the diffused oxygen is consumed and cannot penetrate the full depth of the slime layer and then the organic matter is decomposed by anaerobic microorganisms. Thus anaerobic ambience is established near the surface of the media, **[2]**.

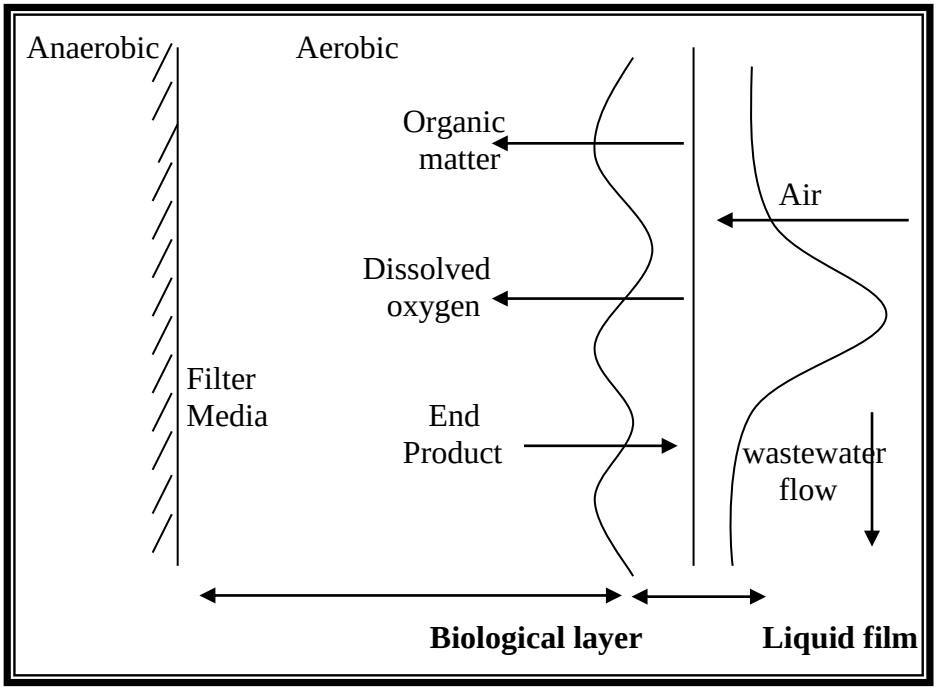

Figure (2-2): Theory of Action in Trickling Filter [2]

Sloughing phenomenon is a process at which, the media of the filter loses the slim layer of microorganisms. This process occurred when there is no available external organic source for cell carbon. Then, the ability of microorganisms near the media face to cling to the media was lost and it enters into an endogenous phase of growth. Then, the slime was washed off the media by the liquid, and a new slime layer starts to grow. Sloughing phenomenon is a function of the organic loading which represents the rate of metabolism in the slime layer. Also, it is a function of the hydraulic loading which represents the shear velocities. The hydraulic loading is modified in modern trickling filters to preserve a slime layer of uniform thicknesses. The hydraulic components of trickling filter are as the following:

1. Influent distributors:

It consists of central column supports two or more horizontal pipes, which are available for feeding filter beds with diameter ranging from 20 to more than 200 feet. Pressurized oil, neoprene gaskets or air-gap (non-seal) methods will be seal the distributors. At minimum flow, the