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APPLICATION OF GREEN ALTERNATES FOR THE MANUFACTURING OF BIOLOGICAL TREATMENT UNITS

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Abstract: As the contact synthetic materials like plastics and fibers with treated wastewater may cause many adverse consequences on the quality of the treated water in addition to their cost, the trend is mounting for their replacement with green environmental friendly alternatives. Three plants originated alternates were tested as the fillings of a trickling filter in order to study their possible use for the municipal wastewater treatment of. The bark of date palms, desert thorn plant, and arum plant were tested individually in a small scale trickling filter system of 150cm height and 40cm diameter, which was operated under various governing parameter sets like the ambient temperature, flow rate, and contamination load in order to determine their efficiencies for the removal of the biological contamination. Very good removal efficiencies of BOD_5 were accomplished via the use of each of the three filling Medium s as compared to those reported as gained with the use of synthetic materials, especially under an ambient temperature range of (38-42)°C and slow trickling flow rate of $15m^3/m^2$.d. The major limits for the usage of these greens were the clog of palm bark filter against flow rates that exceed $30m^3/m^2$.d, in addition to the high attraction of these green alternates to flies around the model.

Key words: Biological treatment, Greening, Trickling Filter, Wastewater.

1. INTRODUCTION

The trickling filter approach is considered for decades as a main selection for the biological treatment of industrial and municipal wastewater, especially for limited areas. Plastic medium began to replace the rock medium whens the supply gain of rock medium may not offer the required demand. Poor quality rock medium breaks down more rapidly and allows growths of the microbial fields that may clog the trickling filter medium and also, the overall economics soon favored plastic medium over rock medium [1]. The plastic medium allowed long filters and higher loading rates to be used in order for (50-80)% final efficiencies to be achieved for the treatment of industrial and municipal wastewaters [2]. Trickling filter with low cost and arbitrarily spread plastic fill medium have proved around (78-82)% efficiencies for the treatment of industrial wastewaters [3], and thus, made it so interesting to investigate more durable, locally abundant and lesser cost alternates for the plastic medium.

This paper is dedicated for the examination of three randomly distributed medium types of plant origin that regionally exist all around the world and especially in Iraq. The main selection criteria for these alternates is their compatibility to plastic regarding its major specifications that made it desirable for trickling filters, such as lightweight, high specific surface area, high void ratio, low cost, mechanical robustness and chemical resistance [4].

1.1 Operational parameters of the trickling filter

The trickling filters design was studied by many researchers in order to develop practical and empirical models that work under various operational circumstances. Table 1 illustrates some of these models and their main features [5]:

Table 1. Various models for the trickling filter variable determination.

Model name	**Medium**			**Organic. Hydraulic loading**	**Recycle**	**Comments**
	Type	Depth	Area			
Velz	All types	*				1^{st}. order kinetics
Schultz	All types	*		*		Velz model for the definition of the residence time
Kincannon and Stover	All types		*	*		Based on Monod kinetics
Eckenfelder	All types	*	*	*	*	1^{st}. order kinetics with an area term
Germain	Plastic	*		*		Schultz model
Gottas	Stone	*		*	*	Based on data analysis

The performance Trickling filters for the removal of soluble Biological Oxygen Demand BOD via all kinds of filling mediums may be articulated by Schultz approach [6]:

$$\frac{S_e}{S_0} = e^{-KD/Q^n} \qquad (1)$$

K in equation (1) above is a replacement for the term (k A_B).

This equation may be used for a certain and nonreactive type of filling, that supports a continual biological layer and receive a uniformly spread hydraulic load. The bed of particles general structure can often be characterized by the bed fractional void ratio; *e*, and the effective specific surface area. A model system of the process would be efficient follow in order to experimentally determine the reaction rate constant; *K*, and the exponent; *n*, and to use these data for the design purposes. Hence, the necessity for discrete determinations of (k) and (A_B) would evade and this is exactly the major pros of Schultz approach, taking in consideration the consequences that (K) will fluctuate with flow rate in a complex way due to the variations in the effective specific surface area [7].

1.2 Calculation Procedure

Rearranging equation (1), yields the following (2):

$$\log(S_e / S_0) = -KD / 2.3Q^n \qquad (2)$$

where:

– S_0 and S_e - The filtered influent BOD concentration and filtered effluent BOD concentration (mg/l), respectively;
– K - Reaction rate constant ($d^{-(1-n)}m^{-n}$);
– D - Depth of the filter (m);
– Q - Hydraulic load ($m^3/m^2.d$);
– n - A constant (function of the medium`s specific surface and configuration).

The application of the following steps would results the values of the design constants; n and K, for each type of the filling materials:

1. Plot the logarithm of (S_e/S_0) against the filter`s filling depth (D). Each line`s slope for a certain hydraulic load is defined as in equation (3):

$$\text{Slope} = -KQ\text{-}n/2.3 \qquad (3)$$

2. The logarithm of both sides multiplied by (-1) would yield (4):

$$\log(\text{Slope}) = \log(K/2.3) - n \log Q \qquad (4)$$

3. The slope of the line from plotting log (Slope) vs. log (Q), would be the value of (n), while the line from plotting log (S_e/S_0) versus (D/Q^n) would be used for the determination of the constant (K) as the value of (-K/2.3) equals to its slope.

2. EXPERIMENTAL ARRANGEMENTS

A cylindrical column is made to ensure a good hydraulic distribution of the wastewater (Figure 1). The distribution of wastewater is accomplished by a (2mm mesh) stationary screen, above the open topic end of (1.5m) column that is consisted of three vertically arranged cylindrical plastic containers (0.4m diameter and 0.5m length) with a (0.2m) spacing between each other in order to simplify the construction in addition to the natural air supply. About (100) base-holes are made in each single container, in order to act as a spreading means for the next stage of the system, each hole is of about (1cm) diameter (Figure 2). These properties of the column make it light and easy to handle while filling, lifting, and adjusting with other parts of the system.

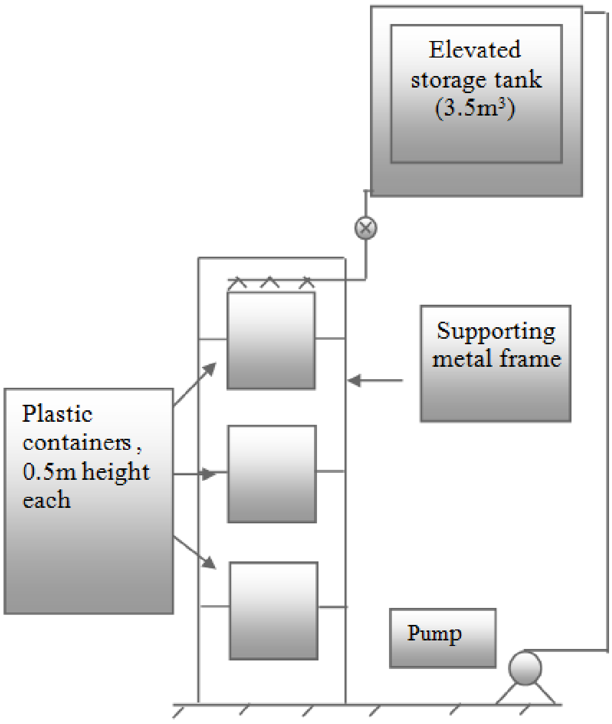


Fig. 1. A diagram for the trickling filter model

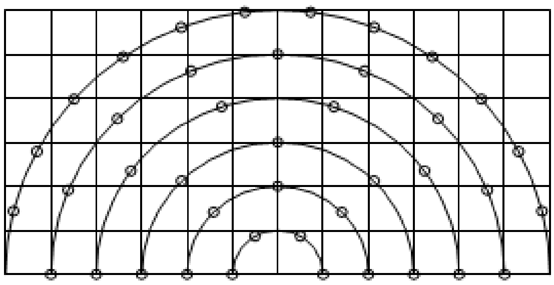


Fig. 2. Bottom half section of each container

2.1 Filter medium

The impacts of the filling medium on the overall performance and design constants of a trickling filter`s system are investigated via a trickling filter`s model for each of the three green materials; Wild Thorn, Arum Plant and Date Palm Bark (Figure 3). The experimentally determined specifications of these mediums are summarized by Table 2. Well pre-operation, surfaces biomass colonization is guaranteed for these mediums by around (18-24 hours) submergence in intense waste water.

Fig.3. Sample of each of the filling medium to be tested in the trickling filter model; from left to right Wild Thorn, Arum and Date palm Bark

Table 2. Properties of the different filling medium

Filling material	Void ratio %	Density Kg/m^3
Wild Thorn	> 98	998
Arum Plant	95	290
Date Palm Bark	86	75

2.2 Hydraulic loading

A storage tank of $3.5m^3$ volume, elevated to 4m height is used to ensure a stable, equalized and continuous supply of wastewater for the trickling filter`s model.

2.3 Sampling procedure

The target municipal wastewater that is characterized by a BOD_5 of about (177-200mg/l) needs to be settled and screened via (1cm) mesh in order for the large undissolved solids to be discarded. The coverage of a comprehensive range of operational parameter variations would be assured by applying the required tests for a period of four months that cover a broad range of seasonal and operational variations, such as flow rate, biological loads and ambient temperature. Three different superficial flow-rates (15, 30 and $45m^3/m^2d$) are applied during that period. The (30min.) settled samples would be filtered through Whatman (No.42) filter paper previous to BOD_5 tests.

3. RESULTS AND DISCUSSIONS

Operation results for the trickling filter model are summarized in Figures 4, 5 and 6, in different circumstance (filling materials, hydraulic loadings, biological loadings, and ambient temperatures).

Many notes could be drawn from these results:

1. In addition to the simplicity in handling and installation, all the three filling mediums have proven good BOD_5 removal efficiencies.
2. Wild Thorn is the most efficient filling medium, Arum plant is the second and then comes the Date Palm Bark. The differences in void ratio and superficial surface area as shown in Table 2 above, may justify this result.
3. The removal efficiency increases as the ambient temperature increases for all filling medium under all hydraulic flow rates. This may point out the high temperatures affinity of the surface microorganisms of the filter medium.
4. Date Palm Bark fails under high flow rates due to its lower void ratio that makes it susceptible to clogging under heavy loads although it shows satisfactory performance against low hydraulic loads, and/or low contaminations.

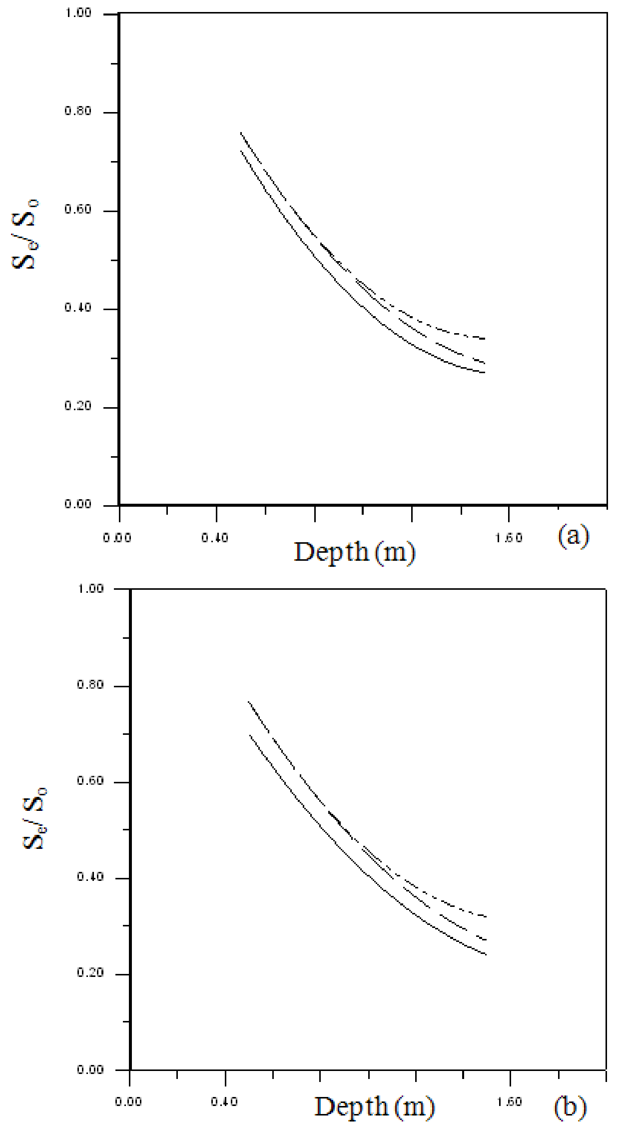


Fig. 4. Variation of effluent's BOD_5 with the depth of the trickling filter model (Medium: Wild Thorn): (a). Ambient Temperature 24-26ºC; (b). Ambient Temperature 36-40ºC

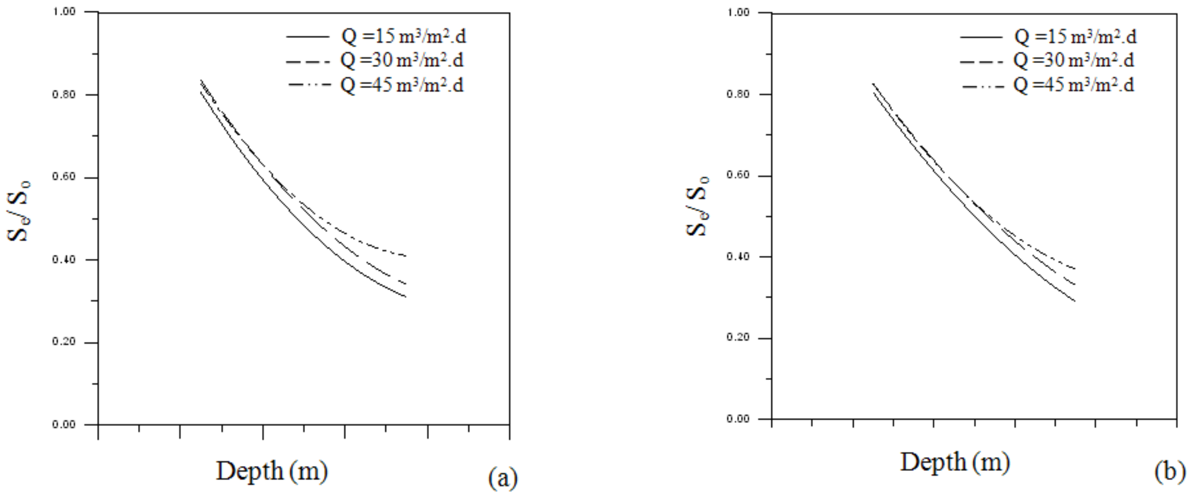


Fig. 5. Variation of effluent's BOD_5 with the depth of the trickling filter model (Medium: Arum): (a). Ambient Temperature 24-26ºC; (b). Ambient Temperature 36-40ºC

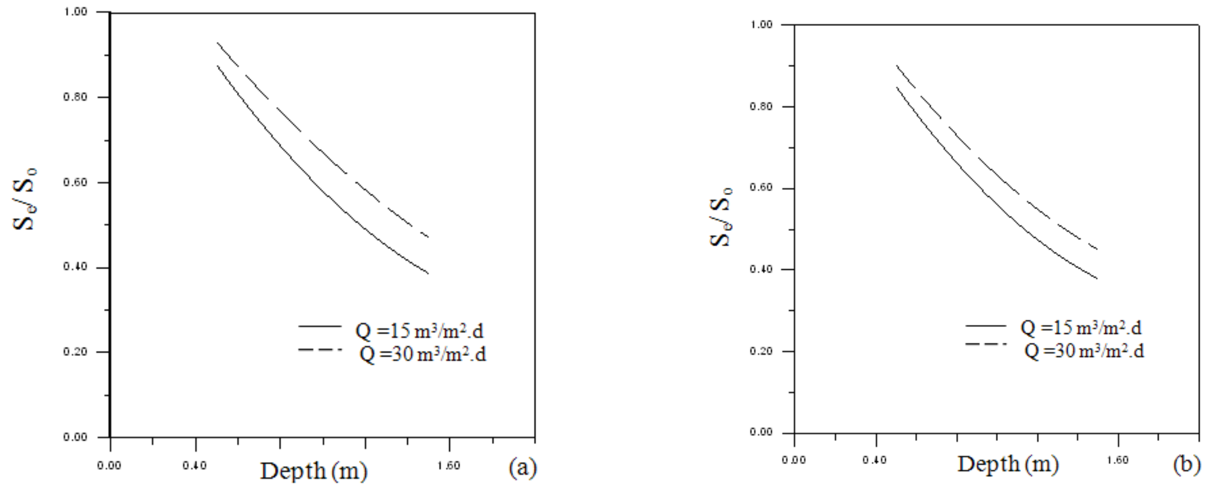


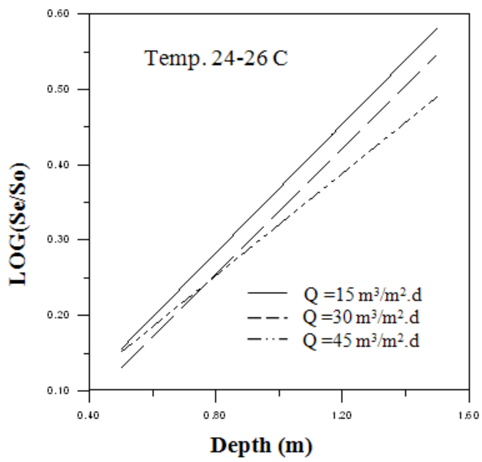
Fig.6. Variation of effluent's BOD_5 vs. the depth of the trickling filter model (Medium: Date Palm Bark): (a). Ambient Temperature (24-26)ºC; (b). Ambient Temperature (36-40)ºC

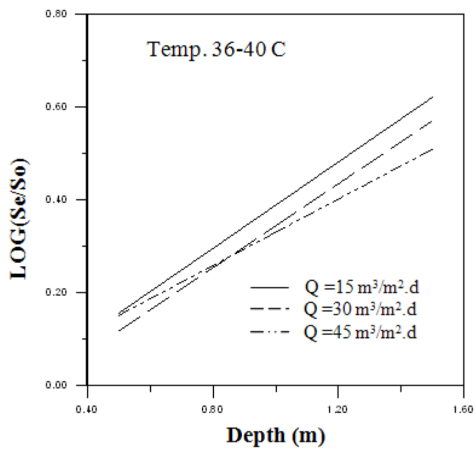
The above good news is accompanied with the drawback that significant number of flies are observed in the location where the model was built.

Filter's design constants for each filling medium as tabulated in Table 3, are determined according to the above mentioned procedure as shown in Figures 7 and 8. Unsatisfactory data for Date Palm Bark fill due to filter clog has prevented the determination of its constants.

Table 3. Trickling Filter design constants for the studied filling medium

Filling medium	K		n	
	Temperature 24-26°C	Temperature 36-42 °C	Temperature 24-26°C	Temperature 36-42 °C
Wild Thorn	1.1477	1.8595	0.1906	0.149
Arum Plant	0.9056	1.425	0.1324	0.0975





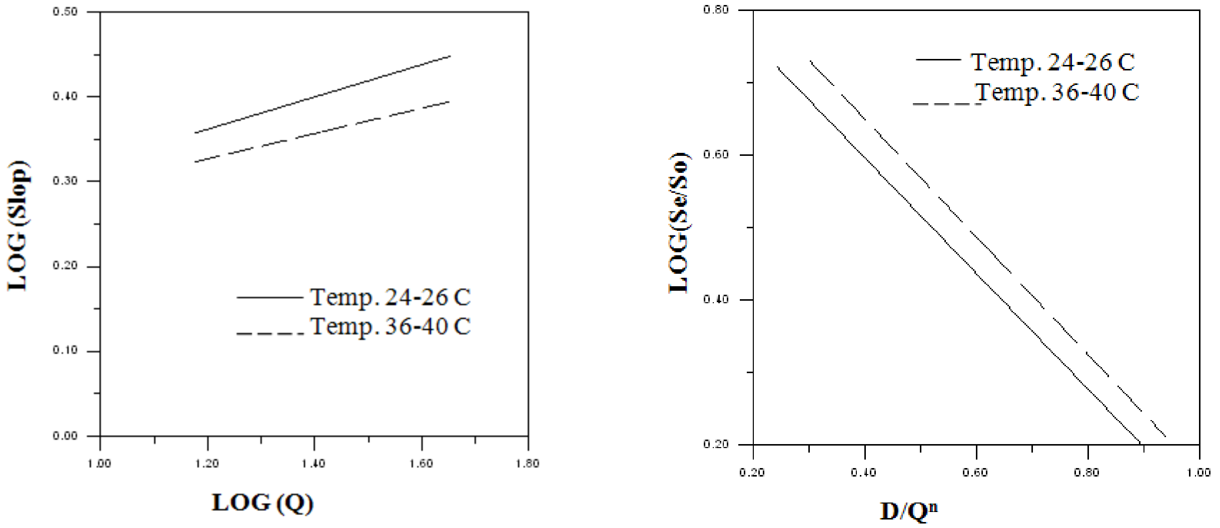


Fig. 7. Determination of the design constants fir the trickling filter (filling medium: Wild Thorn)

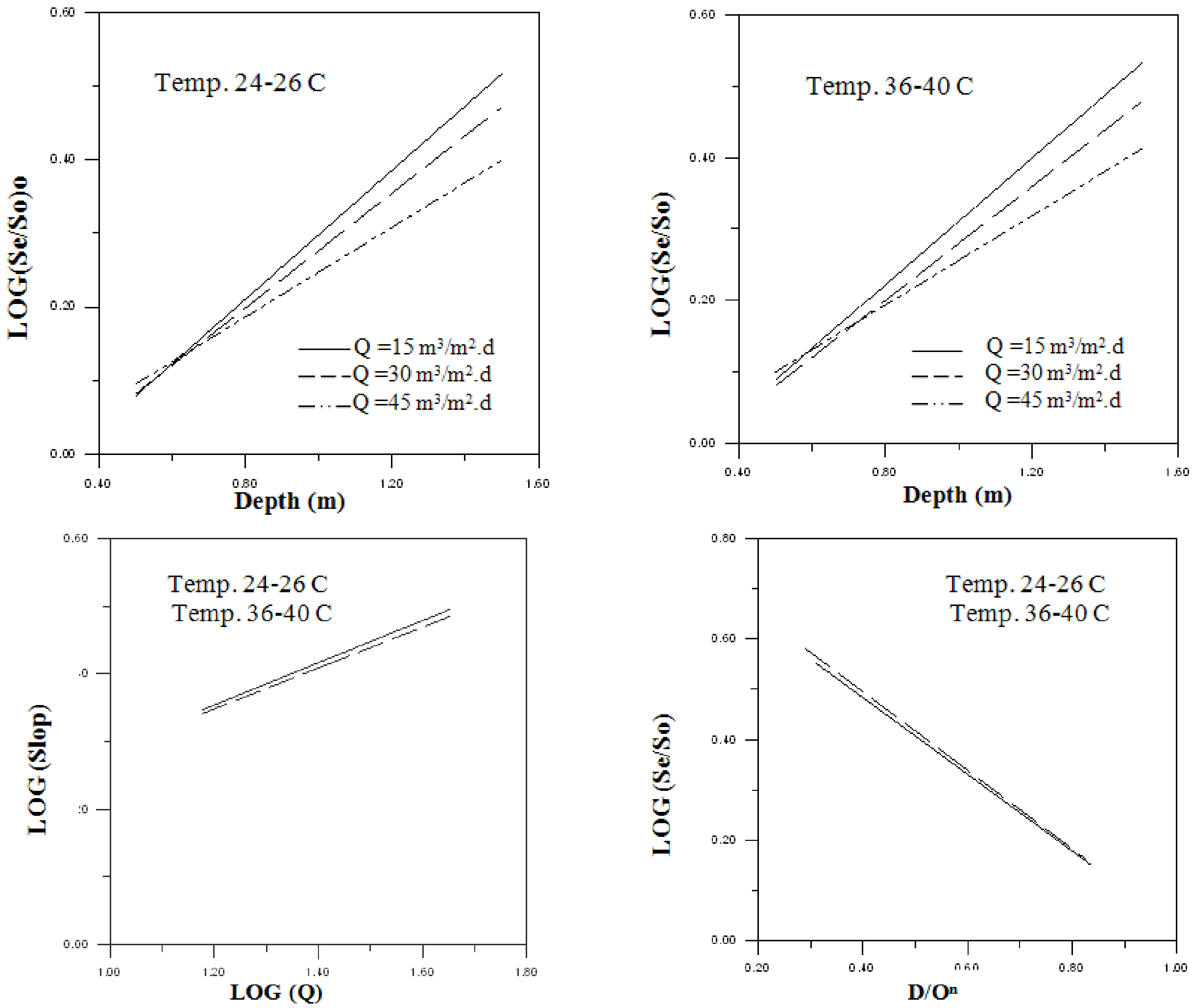


Fig. 8. Determination of the design constants fir the trickling filter (filling medium: Arum)

4. CONCLUSIONS

The effectiveness of green alternatives as filling materials; Wild Thorn, Arum and Date Palm Bark, for trickling filter instead of synthetic plastics is tested in a small laboratory sized trickling filter model in order to prove that Mother Nature is full of useful, low cost and environmentally friendly resources that can overcome the cost and negative impacts of synthetic materials for various uses. Significant high performance indices were recorded from the use of each of the three tested filling medium for the treatment of municipal wastewaters with efficiencies that are comparable or even exceed those reported ones with the use of plastic filling, with the limitation that Date Palm Bark would not make a good choice as a filling medium for trickling filters under heavy, hydraulic and/or organic, wastewater loads. High ambient temperatures were found as the desirable environment for the three tested filling mediums in order to result good performance indicators. The only faced drawback was that public or residential areas should be away from the locations of such systems because of the possible annoyance that may be initiated due to the heavy abundance of flies.

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