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Simulation Model for Using Polyethylene strips in Enhancement of Agricultural Drains Wastewater

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***Abstract* - This study aimed to introduce the methodology used to produce a mathematical physical model simulate the results of the field experimental work done by the operation of pilot plant using the polyethylene strips as bio media reactor in stream for enhancing the agriculture wastewater. The pilot was built inside Faqous Wastewater Treatment plant held nearby Bahr El Bakar agricultural drain in El Sharqiyah Governorate, Egypt.**

The study applied several numbers of polyethylene curtain strips lines with several interval spacing that optimized the results produced from the use of 1meter interval and six lines of polyethylene strips that achieved COD removal ratio 40.80 %. The produced equation was depending on the optimum successful experimental sequence. The study also includes the discussions for different trials till producing the targeted equation and the verification for the produced equation by using results of experimental work.

Keywords: Simulation modeling, Agricultural Wastewater treatment, new treatment techniques, In stream treatment procedure, bio reactor, Polyethylene strips.

I. INTRODUCTION

Water quality modeling has developed since its innovation in the early years of twentieth century. Most of the early modeling work focused on the urban waste load problem. A model is a small object usually built to scale, that represents another larger object. Thus, models typically represent a simplified version of reality that is amenable to testing. It can use physical models or mathematical models which represent the reality [1].

Mathematical modeling means a conception or description of a particular system, process, or situation that is put as a basis for predictions, further investigation, or calculations. Mathematical modeling is the process of abstracting a model from the system by applying two specific conceptual modeling processes, one of them is model abstraction and the other is the knowledge acquisition. Mathematical model abstraction points out the simplifications made in moving from a system description to a model. Knowledge acquisition refers to the process of finding out about the problem situation and arriving to a system description. Mathematical model is a physical representation of mathematical concepts or a mathematical representation of reality [2].

II. LITTERATURE REVIEW

The modeler aims to determine the aspects of what happened really to be included, and excluded, from the model, and at what level of detail to model each aspect. The process of conceptual modeling requires decisions to be taken regarding the scope and level of detail of the model. It also requires assumptions to be made concerning the real world and simplifications to be made to the model.

Streeter and Pheleps worked on developing the model of the Ohio River, this work and subsequent had provided means to evaluate dissolved oxygen levels in streams and estuaries. Because of non-availability of computers, model solutions were closed form, that the applications were limited to linear kinetics, simple geometries and steady state receiving waters [3].

Hozalski and Bouwer developed a model to simulate the non-steady-state behavior of biologically active filters which is used for drinking water treatment. It can simulate the substrate and biomass profiles in a biofilter as a function of time, and effect of backwashing, but only removal of biodegradable organic matter is incorporated as a biological reaction [4].

Ahmed studied the application of agricultural waste media (rice husk, cotton stalk and tree pruning) as a biological filter. A field of continuous flow pilot plant was used in this study. The study states the possibility of using agricultural wastes as a filter media. Dabble organic matter is incorporated as a biological reaction [5].

Abd El-Rahman proposed simulation model to improve self-purifications in streams by removing BOD from wastewater and divided his study into three reaches; the first reach is from the influent point (x=0) to the meeting point of water stream and media (x=0.5m). The effect of dilution only

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will influence the BOD and DO concentrations, The second reach begins from the effluent point of the first reach (x=0.5m) and ends at (x=1.4m) with biodegradation actions occurring in this reach, The third reach represents the stream after media [6].

El Nadi, M.H. & Abdel Fatah M.A., in their study by applying agricultural wastes for enhancing the water quality inside stream after sewage disposal produced a simulation model covers the achieved action in the stream. The produced model represented in equation proved its applicability to simulate the system of using the agricultural waste as bio media after the pollution point in the stream that improves the stream self [7].

Mahmoud Abd El Momen used the polyethylene strips for preliminary treatment or polishing for the wastewater for producing a simulation model represented in equation proved its applicability to simulate his study [8].

Zeinab El Haefny proved the success of the use of agricultural waste (rice husk) as biodegradable media for in stream agriculture wastewater treatment by producing a simulation model proved its validity of her study for using the agricultural waste as the best for in stream treatment technique compared with plastic media boxes and naturally rotating paddles that applied in her study, technically and financially [9].

This study aimed to produce a simulation model for applying polyethylene sheet strips as a treatment procedure for enhancing water criteria inside the agriculture drain and proved its validity of this study.

III. MATERIALS AND METHODS

The used material (polyethylene strips) for this study was previously used for enhancement the wastewater characteristics of sewage properties at effluent of the wastewater treatment plant in Egypt. The study was carried out on a pilot plant that was constructed by EU research project named "drains water quality enhancement". The pilot was built inside Faqous Wastewater Treatment plant held nearby Bahr El Bakar agricultural drain in El Sharqiyah Governorate, Egypt. The experimental work was made to produce a simulation model represented in equation for this study and check its validity to determine its efficiency of improving agricultural wastewater by removal of COD.

Figures 1, 2 &3 shows the pilot and the polyethylene sheets strips used for treatment inside pilot channels.

Figure 1: The pilot photo

Figure 2: Polyethylene sheets strips

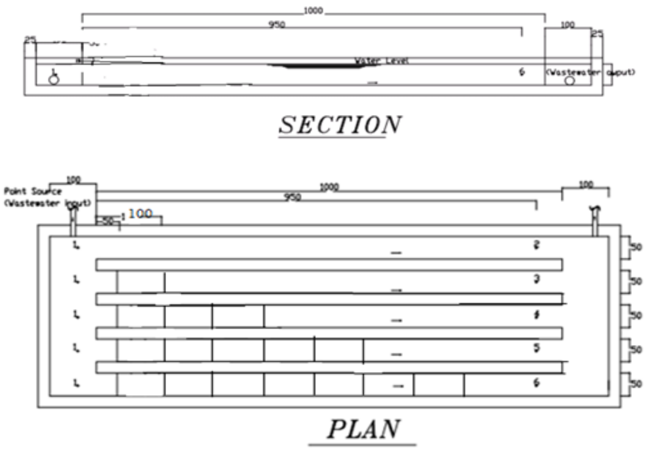

Figure 3: The pilot drawing

IV. MODEL PRODUCTION

Many procedures were applied to get the most suitable simulating model for this study. The model covered the effect of polyethylene strips on the pollutant's removal in stream to produce the model.

Three procedures could be applied, the first is to apply in the previous studies models and develop it to suite with our study. The second procedure is to use a one of probability methods to do regression analysis for the actual results to determine the nearest simulating equation to the results. The

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third procedure is done by starting from basic relations between variables to determine the suitable simulating model by applying all the possible relation equation between all the effective parameters.

The study is applied the first procedure. In this trial the last study model done by Mahmoud Abdel momen [8] for using polyethylene strips as bio media for the biological action in wastewater treatment was used by applying his equation for biodegradation treatment by using polyethylene strips as bio media in stream.

$$\% R.R = 0.0009\ COD_{in}^{2} - 0.2884\ COD_{in} + 29.661 \quad \text{... Eq. (1)}$$

So, by substituting in equation (1) by influent concentrations of this study field research the calculated effluent concentration determined. And by comparing it with the measured effluent concentrations the percentage error was determined as illustrated hereafter to check the applied equation similarity to the study results.

Apply eq. (1) for COD data results to check its validity with this study. The actual CODout is after six curtain lines for the used number effect removal efficiency and Mahmoud equation build on three lines results.

Table 1: COD Calculations in Mahmoud Equation (1)

Week	Day	COD_{in}	COD_{out}	% R.R Actual	% R.R Calc.	% Error
1	1	1200	712	40.67	979.58	-2308.81
	2	1190	712	40.17	960.96	-2292.34
	3	1190	712	40.17	960.96	-2292.34
	4	1190	712	40.17	960.96	-2292.34
	5	1190	712	40.17	960.96	-2292.34
	6	1180	712	39.66	942.51	-2276.41
2	1	1180	695	41.10	942.51	-2193.11
	2	1180	695	41.10	942.51	-2193.11
	3	1200	695	42.08	979.58	-2227.72
	4	1220	695	43.03	1017.37	-2264.18
	5	1210	695	42.56	998.39	-2245.72
	6	1200	695	42.08	979.58	-2227.72
3	1	1200	687	42.75	979.58	-2191.42
	2	1190	687	42.27	960.96	-2173.43
	3	1190	687	42.27	960.96	-2173.43
	4	1190	687	42.27	960.96	-2173.43
	5	1190	687	42.27	960.96	-2173.43
	6	1180	687	41.78	942.51	-2155.90
4	1	1200	687	42.75	979.58	-2191.42
	2	1200	687	42.75	979.58	-2191.42
	3	1200	687	42.75	979.58	-2191.42
	4	1220	687	43.69	1017.37	-2228.70
	5	1210	687	43.22	998.39	-2209.84
	6	1200	687	42.75	979.58	-2191.42

The errors are very high for COD. So, this equation could not simulate our study for big deviation that resulted between actual measures and calculated removal efficiency by it.

The resulted of dissimulation for Mahmoud equation could be due to one or more reasons from the following:

- The effect of curtain lines number and their interval distance may cause the difference

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- The relation between channel depth and interval
- The methodology of curtain fixation that make it vertical during operation than with Mahmoud it was free that make it float nearby horizontal due to water flow.

For all the previous reasons and the wide variation range. A need to modify this equation to meet the study field results should be made. The maximum error resulted will be taken as 10% and vice versa substituting in error equation to determine the new calculated removal ratio then by substituting in Eq.(1) resulted the constant correction value for the Mahmoud equation to be applied in the study then repeat this work with several high errors and determine the most suitable correction factor to be applied, Then apply the modified equation on all the field readings to check its suitability by determining the errors and be less than + 10% as follows:

$\% R.R = 0.0009*COD_{in}^2 - 0.2884*COD_{in} + 29.661$... Eq. (1)

$\% Error = (R.R_{actual} - R.R_{calc.}) / R.R_{actual}$ … Eq. (2)

Allow with 10% error

$10\% = (75.60 - R.R_{calc}) / 75.60$, get $R.R_{calc} = 68.04$

$\% R.R = (0.0009*COD_{in}^2 - 0.2884*COD_{in} + 29.661) *K_1$

Where K_1 is a factor related to interval/ depth, Get K1 =0.614

By trial and error and apply with readings in equation get new K1= 0.69 and the new equation is

$\% R.R = 0.00062*COD_{in}^2 - 0.198*COD_{in} + 20.466$ ... Eq. (3)

Table 2: COD calculations due to inlet concentrations

Week	Day	COD_{in}	COD_{out}	$\% R.R_{actual}$	$\% R.R_{calc.}$	% Error
1	1	1200	712	40.67	675.67	-1561.47
	2	1190	712	40.17	662.83	-1550.14
	3	1190	712	40.17	662.83	-1550.14
	4	1190	712	40.17	662.83	-1550.14
	5	1190	712	40.17	662.83	-1550.14
	6	1180	712	39.66	650.11	-1539.18
2	1	1180	695	41.10	650.11	-1481.72
	2	1180	695	41.10	650.11	-1481.72
	3	1200	695	42.08	675.67	-1505.54
	4	1220	695	43.03	701.71	-1530.65
	5	1210	695	42.56	688.63	-1517.94
	6	1200	695	42.08	675.67	-1505.54
3	1	1200	687	42.75	675.67	-1480.51
	2	1190	687	42.27	662.83	-1468.12
	3	1190	687	42.27	662.83	-1468.12
	4	1190	687	42.27	662.83	-1468.12
	5	1190	687	42.27	662.83	-1468.12
	6	1180	687	41.78	650.11	-1456.05
4	1	1200	687	42.75	675.67	-1480.51
	2	1200	687	42.75	675.67	-1480.51
	3	1200	687	42.75	675.67	-1480.51
	4	1220	687	43.69	701.71	-1506.17
	5	1210	687	43.22	688.63	-1493.19
	6	1200	687	42.75	675.67	-1480.51

When the equation of COD applied, the errors were very high, so this equation was not suitable for COD readings and need to be modified and produce a new convenient equation to this work.

By modifying in equation (3) to get the best equation convenient to this work

$\% R.R = 0.00062*COD_{in}^2 - 0.198*COD_{in} + 20.466$ ... Eq. (3)

$\% Error = (R.R_{actual} - R.R_{calc.}) / R.R_{actual}$ … Eq. (2)

Allow with 10% error

$10\% = (43.69 - R.R_{calc}) / 43.69$, get $R.R_{calc} = 39.321$

$\% R.R = (0.00062*COD^2_{in} - 0.198*COD_{in} + 20.466) *K_2$

Where K_2 is a factor related to interval/ depth, Get K_2 =0.056

By trial and error and apply with readings in equation get new K_2 = 0.059 and the new equation is

$\% R.R = 0.000036*COD_{in}^2 - 0.011*COD_{in} + 1.207$... Eq. (4)

Apply equation (4) for COD data results to check its validity with this study.

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Table 3: COD calculations due to inlet concentrations

Week	Day	COD_{in}	COD_{out}	$\%R.R_{actual}$	$\%R.R_{calc.}$	% Error
1	1	1200	712	40.67	39.86	1.97
	2	1190	712	40.17	39.11	2.64
	3	1190	712	40.17	39.11	2.64
	4	1190	712	40.17	39.11	2.64
	5	1190	712	40.17	39.11	2.64
	6	1180	712	39.66	38.36	3.29
2	1	1180	695	41.10	38.36	6.68
	2	1180	695	41.10	38.36	6.68
	3	1200	695	42.08	39.86	5.27
	4	1220	695	43.03	41.40	3.79
	5	1210	695	42.56	40.63	4.54
	6	1200	695	42.08	39.86	5.27
3	1	1200	687	42.75	39.86	6.75
	2	1190	687	42.27	39.11	7.48
	3	1190	687	42.27	39.11	7.48
	4	1190	687	42.27	39.11	7.48
	5	1190	687	42.27	39.11	7.48
	6	1180	687	41.78	38.36	8.19
4	1	1200	687	42.75	39.86	6.75
	2	1200	687	42.75	39.86	6.75
	3	1200	687	42.75	39.86	6.75
	4	1220	687	43.69	41.40	5.24
	5	1210	687	43.22	40.63	6.00
	6	1200	687	42.75	39.86	6.75

The errors are varied between 1.97 & 8.19 % which is good range for simulation purpose and the equation is convenient to this work and it can be applied to other parameters and check its validity.

V. MODEL VERIFICATION

The verification for the produced models is done here using the experimental results produced during the study field work at the last two weeks of the run for agriculture wastewater to determine the validity of the model due to the application of the mentioned result inside it and present error less than + 10% for COD.

Application of initial concentrations of COD of the last two weeks from the agriculture wastewater run in the new produced model equation,

$$\% R.R = 0.000036*COD_{in}^{2} - 0.011*COD_{in} + 1.207 \quad \text{... Eq. (4)}$$

To get the error between the actual and calculated results as illustrated in table (4).

Table 4: COD Model Verification Result

Week	Day	COD_{in}	COD_{out}	$\% R.R_{actual}$	$\% R.R_{calc.}$	% Error
5	1	1200	712	40.67	39.86	1.97
	2	1210	712	41.16	40.63	1.28
	3	1220	712	41.64	41.40	0.57
	4	1180	712	39.66	38.36	3.29
	5	1200	712	40.67	39.86	1.97
	6	1220	712	41.64	41.40	0.57

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6	1	1170	717	38.72	37.61	2.85
	2	1160	717	38.19	36.88	3.43
	3	1170	717	38.72	37.61	2.85
	4	1170	717	38.72	37.61	2.85
	5	1180	717	39.24	38.36	2.24
	6	1170	717	38.72	37.61	2.85

From table (4) the error range between the field results and the produce model results varied between +0.57% & +3.43% which is small error that led to make this model valid for determine the removal efficiency of the COD due to the application of the Polyethylene strips curtain as inside stream treatment for agriculture wastewater.

VI. CONCLUSION

The produced simulation model for the effect of applying the polyethylene curtains strips as bio media reactor in stream for enhancing the agriculture drains wastewater was done using the experimental results determined during the study field work for Faqous agriculture drain wastewater by developing Abdel Moemen equation and modified it to determine the validity of the model due to the application of the mentioned results inside it with error less than+10 % with the final shape for the performance simulation form as follows:

$$\% R.R = 0.000036*COD_{in}^2 - 0.011*COD_{in} + 1.207$$

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