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Using a Conceptual Simultaneous Technique for the Optimisation of Mass Integration Networks

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Abstract

The design of the optimum wastewater interception network is presented in our research using LINGO Program. Minimising freshwater consumption and the total cost of freshwater usage, treatment of discharged wastewater and interception units are the objective functions in the optimisation model. In our research, we presented two models; the first model can use twelve sources and twelve sinks, each source can enter five techniques of treatment, and each technique has five probabilities to decrease the mass load of contaminants. The second model draws the wastewater interception network after transferring the results of the first model. This paper achieves the minimisation of freshwater consumption in the Kotchener Drain by obtaining the environmental impact of wastewater discharge. Three interception techniques are applied to decrease the chemical oxygen demand (COD) and biological oxygen demand (BOD) of the Segaaya source. Simultaneous linear equations are proposed to get the mass load which is removed with the cost of removing contaminant COD and BOD for other sources. A mathematical approach was applied to seek the two-objective functions, minimise the freshwater consumption as the first objective function and minimise the cost of fresh water, interception units and wastewater discharge in wastewater distribution as the second objective function in Kotchener Drain. Our technique is easy to apply in drains, fertilisers, and chemical plants.

Keywords: *Mathematical programming; Freshwater; Multiple contaminants; Wastewater; Interception techniques.*

1. Introduction

The importance of water usage in agriculture, industrial plants and human needs is worth the motivation to propose a mathematical model to optimise freshwater consumption by saving the cost of freshwater consumption, interception units and wastewater discharge treatment. That leads us to build a software technique consisting of twelve sources and twelve sinks with availability to treat each source with five treatment techniques. In each technique, there are five probabilities of decreasing the mass load of contaminants to comply with water quality and reuse it again in the wastewater network with the minimum cost of treatment. We presented Kotchener Drain as a case study with six sources and five sinks. We take a sample of the first source (Segaaya source), which has COD equal to 110 mg/L and BOD 65 mg/L, with applying three techniques two decrease the values of COD and BOD by different removal ratio by determining the cost of treatment in each trial.

In saving the cost of wastewater networks, many researchers presented an optimum design of wastewater networks. Debora *et al.* [3] presented a methodology to minimise the freshwater allocation in a wastewater network. Galan and Grossman [5] proposed a design for removing multiple contaminants (suspended solids, heavy metals, inorganic salts, organic contaminants unsuitable for biological treatment and organic contaminants suitable for biological treatment) of a wastewater network by using different technologies. Juan *et al.* [1] proposed a mixed integer non-linear program to design the wastewater treatment network using a case study from Mexico City. Kami Kaboosi [4] studied the physical and chemical characteristics of Bandargaz city by studying the suitable treatment for irrigation of the plants. Dakwala *et al.* [6] used water pinch technology to minimise the wastewater in the starch industry in the state of Gujarat, India. Farrag *et al.* [12] used composition driving forces with graphical design to minimise both the energy and mass load in different industries. Salari *et al.* [9] studied the quality assessment of physical and chemical parameters of total hardness (TH), dissolved oxygen (DO), turbidity (TU), alkalinity (ALK) and total dissolved solids (TDS) of the potable water in Michigan Bay in the US. Tuba *et al.* [11] proposed mathematical programming of the pinch method to minimise water and energy consumption in industrial processes. Kimmo *et al.* [13] presented a new way to minimise the concentrated volume of phosphorous in wastewater using two stages of a nanofiltration system. Nejad *et al.* [15] studied three contaminants in wastewater (Suspended solid, hardness and chemical oxygen demand) to minimise the fresh water and wastewater in the Tehran oil refinery using water pinch analysis. Amir *et al.* [7] presented a water supply and wastewater collection system in a closed-loop chain network by applying a case study in Iran. Galan and Grossmann [14] presented an optimum design of a wastewater network using a treatment unit; the objective function is decreasing the amount of fresh water in the network. Frederico *et al.* [17]] presented a simultaneous synthesis of wastewater reuse using interception units; their objective function is to minimise the cost of interception units and freshwater consumption. Gopal *et al.* [16] proposed an algebraic methodology to minimise wastewater treatment costs to satisfy environmental law limits. Joanna *et al.* [19] studied the cost-effective removal of chemical oxygen demand (COD) by using different coagulant doses to treat wastewater in the paper industry. Chin *et al.* [20] proposed a mathematical model that used a pinch-based method to optimise the total cost consumption in the water network design. Esther and Thokozani [18] presented a reverse osmosis membrane network to minimise freshwater consumption and wastewater discharge; freshwater reduction reached 28%, and wastewater discharge reached 80%. Ramkumar and Grossmann [21] proposed a Non-Linear Programming (NLP) of multiple contaminants by choosing different technologies and treatments. Hani *et al.* [2] presented a sustainable redesign of the wastewater network by using a water-energy approach and the construction of a power plant from biogas (anaerobic digestion) as a new treatment. Everton Hansen [10] proposed mass integration by mathematical programming to decrease freshwater consumption in the operations of petrochemical industries such as cooling systems, extraction, washing processes and distillation. Fangyou *et al.* [8] presented a Heat integrated water network synthesis (HIWNS) by using non-linear programming with considering the reuse and regeneration reuse in the network design.

This paper proposes mathematical programming to design an optimum water-wastewater network that contains multiple contaminants with different treatment technologies. Two objective functions are presented in our research. The first objective function is minimising freshwater consumption, and the second is minimising the cost of freshwater consumption, wastewater interception treatment units and wastewater discharge treatment. The mathematical model is applied to the Kotchener drain to seek the two objective functions; the first objective function, which is the minimum freshwater consumption, is 72658.77 m^3, with decreasing of 58.5% of the original case, and the second objective, which is the minimum cost is decreased from 16064.98 to 9398.25 $. Our program is easy to use, and it has five treatment technologies for each source to get the optimum design of the water-wastewater network.

2. Problem statement

Two objective functions are presented in our research. The first objective function is to minimise freshwater consumption. The second objective function is to minimise the cost of three parameters-the first cost of fresh water consumption (C_{FW}). The second cost is for the treatment of wastewater interception units of multiple contaminants (CUIA, CUIB, CUIC), where CUIA is the cost of interception unit I of contaminant A, CUIB is the cost of interception unit I of contaminant B, CUIC is the cost of interception unit I of contaminant C, and the third cost is for treatment of wastewater discharge (C_{waste}).

Given sets of sources (reach to twelve sources), each source (n) has a flow rate (F_{sn}) with the concentration of multiple contaminants (X_{SnA}, X_{SnB}, X_{SnC}). Five technologies are applied in our research to decrease the concentration of contaminants; each technology has five probabilities of removal ratio (RuIA, RuIB and RuIC) with different costs (CUIA, CUIB and CUIC), where RuIA is the removal ratio of interception (I) of contaminant A, RuIB is removal ratio of interception (I) of contaminant B, RuIC is removal ratio of interception (I) of contaminant C, the number of interception units reach to 300 unit in the design of wastewater network; each interception unit has a flow rate W_I. Freshwater flow rate (F_W) has the availability to feed sinks with concentrations of multiple contaminants (X_{FWA}, X_{FWB} and X_{FWC}); a simple superstructure of the wastewater interception network of source 1 is presented in Figure 1.

Given sets of sinks (reach twelve sinks), each sink (m) has a flow rate (G_m) with a limiting concentration of multiple contaminants (Z_{mAin}, Z_{mBin} and Z_{mCin}). Wastewater discharge flow rate (G_{waste}) was collected from the flow rate of sources that did not enter the interception units ($W_{unint-n}$) and entered the wastewater discharge treatment with cost C_{waste}.

Two mathematical models are proposed in this paper; the first model is based on the LINGO program that leads to getting the optimum wastewater network with minimum freshwater consumption or with a minimum cost of freshwater consumption, cost of treatment of interception units and the cost of treatment of wastewater discharge. The second model is based on an Excel program which takes the resulting data from the LINGO program and draws the wastewater interception units network (WWIN).

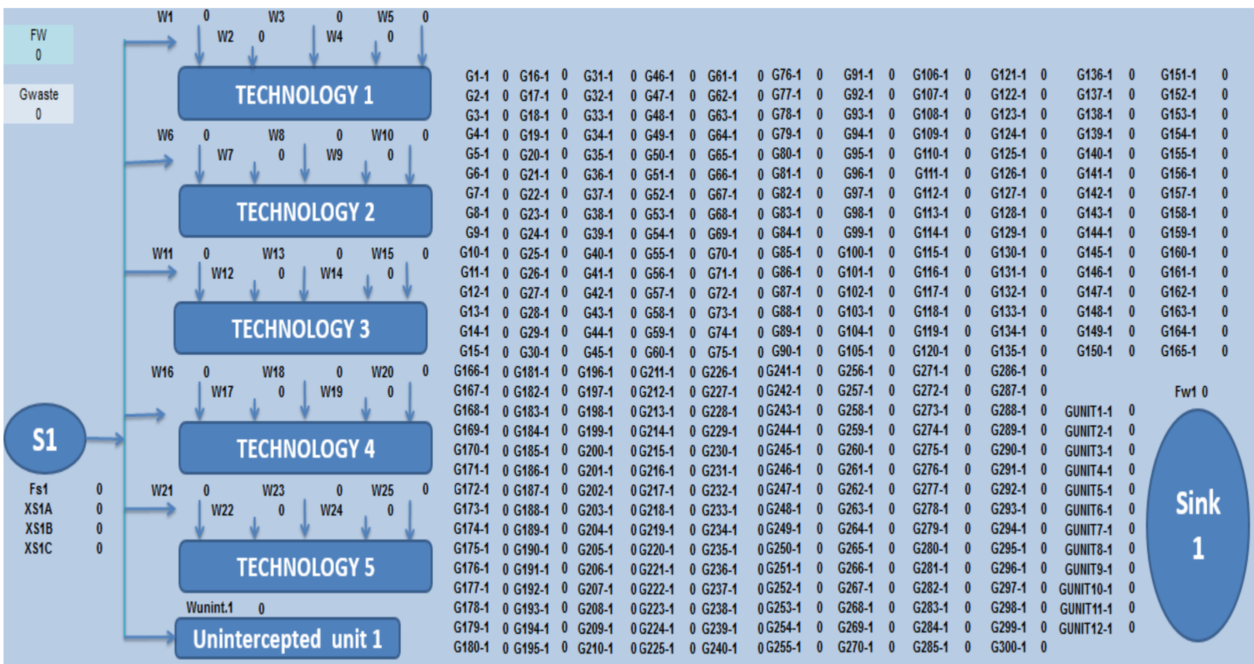

Figure1. Simple superstructure of wastewater interception network of source 1

Figure 2 illustrates the procedure of the designing of the wastewater interception network; overall mass balance is applied on each source which feeds the interception units by flow rate W_i and the un-interception units by flow rate $W_{unint-n}$; overall mass balance is also applied on each interception unit which feeds the sinks by flow rate g_{i-m} and the waste by flow rate $W_{i-waste}$, component material balance is applied on each interception unit for three contaminants A, B and C. Overall material balance is applied for each un interception unit Wunint-n which feeds the sinks by flow rate $g_{unpoint\ n-m}$ and waste by flow rate $g_{unpoint\ n-waste}$.

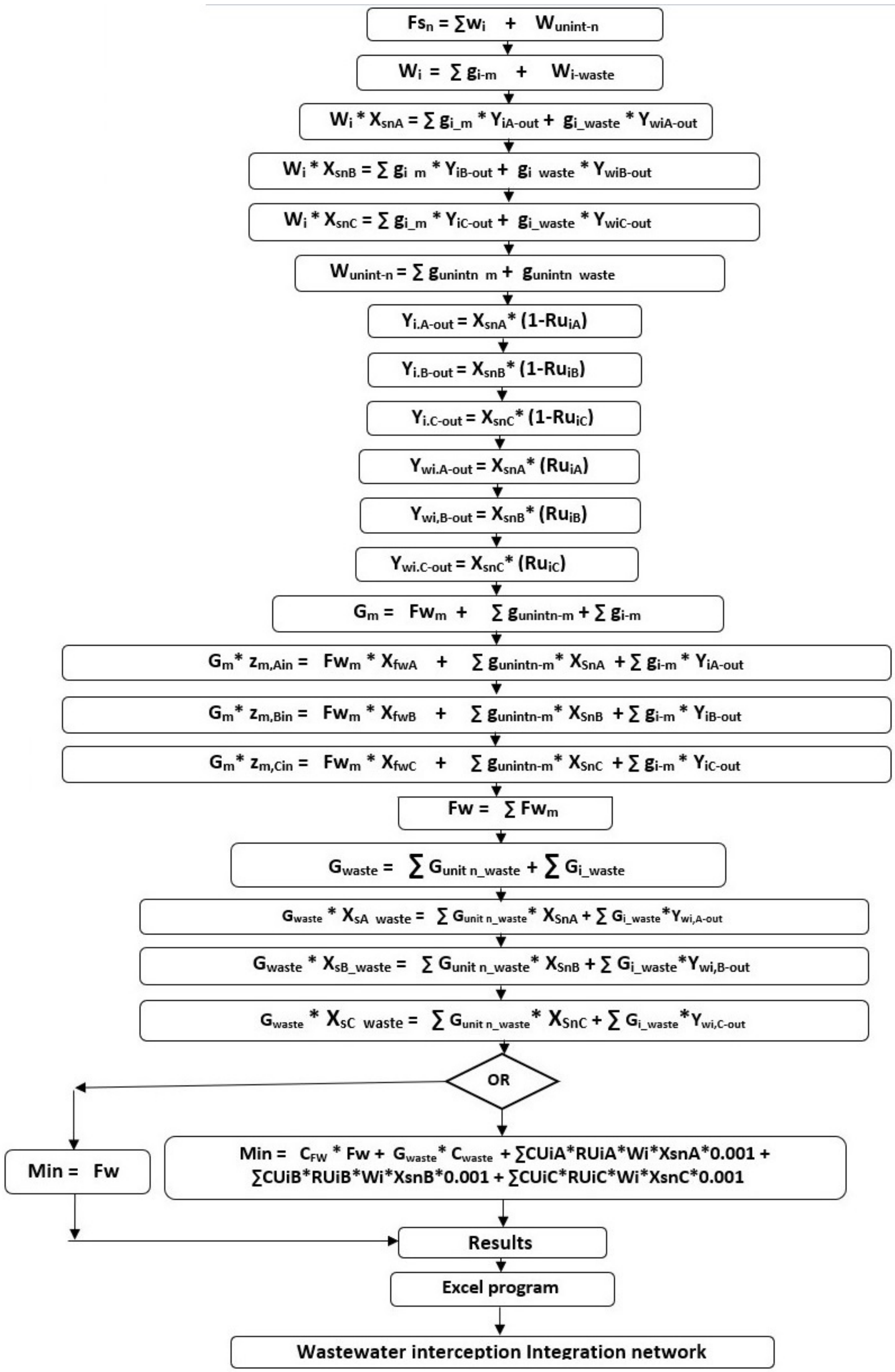

Figure 2. The procedure for designing the Wastewater interception Integration network

The outlet concentration of each interception unit of contaminant A, B and C are $Y_{i.A\text{-}out}$, $Y_{i.B\text{-}out}$ and $Y_{i.C\text{-}out}$, respectively; these concentrations depend on the outlet concentration of each source X_{snA}, X_{snB}, X_{snC} and the removal ratio of each interception unit for the three contaminants R_{uiA}, R_{uiB} and R_{uiC}. Outlet concentration from the interception units feeds the waste for three contaminants: $Yw_{i.A\text{-}out}$, $Yw_{i.B\text{-}out}$ and $Yw_{i.C\text{-}out}$ are calculated from the R_{uiA}, R_{uiB} and R_{uiC} removal ratios.

We applied overall mass balance on each sink which has an outlet flow rate G_m that depends on the flow rate of freshwater flow rate Fw_m, summation of un interception units flow rates $g_{unpoint\ n\text{-}m}$ and the summation of flow rates coming from each interception unit $g_{i\text{-}m}$. Component mass balance is applied on each sink of three contaminants A, B and C, entering the concentrations of freshwater X_{fwA}, X_{fwB} and X_{fwC} in our calculations.

Overall mass balance is applied to the total freshwater consumption F_w and wastewater discharge G_{waste}. We applied the component mass balance for each contaminant on the sinks by entering in our calculations the concentrations of wastewater discharge X_{SA_waste}, X_{SB_waste} and X_{SC_waste}.

Two objective functions are presented to minimise the consumption of freshwater flow rate F_w or minimise the cost of freshwater C_{fw}, cost of treatment of wastewater discharge and the cost of treatment in each interception for the three contaminants (C_{UiA}, C_{UiB}, C_{UiC}) with removal ratios R_{uiA}, R_{uiB} and R_{uiC}.

We entered all these equations into the LINGO Program by choosing the required objective function; the results were entered into the second model in the Excel program to draw the wastewater interception integration network (WWIN).

3. Case study

The mathematical model applied to the Kotchener drain case study which has three key contaminants; total hardness (TDS), chemical oxygen demand (COD) and biological oxygen demand (BOD), six wastewater sources (Segaaya, Samaty, Lumana, El-Tshween, Ebshan and Hafir) presented in our case study with flow rates and limiting concentrations of three contaminants as shown in Table 1, five sinks (Botita canal, El-Batalah Canal, Al-Wasta Canal, El-Nile Canal and Bahr terra Canal) flow rates and their limiting concentrations are shown in Table 2.

Table 1. Flow rates and concentrations of sources

Source	Segaaya	Samaty	Lumana	El-Tshween	Ebshan	Hafir
Flow rate (m^3/hr)	36000	54000	36000	81000	36000	43000
TDS (mg/L)	1109.8	834.6	821.1	1090.6	1159.7	3000
COD (mg/L)	110	76	82	64	84	60
BOD (mg/L)	65	40	33	36	49	40

Table 2. Data given on sinks

Sinks	Botita canal	El-Batalah canal	Al-Wasta Canal	El-Nile Canal	Bahr terra Canal
Flow rate (m^3/hr)	35000	60000	20000	65000	30000
TDS (mg/L)	970	980	960	990	920
COD (mg/L)	48	49	46	45	48
BOD (mg/L)	28	28	26	28	28

Two objective functions are applied in our case study; the first objective function is to minimise fresh water consumption; we entered the flow rates of sources and sinks with their limiting concentrations only to our mathematical modelling of the LINGO Program; the results are entered to Excel program for the design of wastewater network.

The second objective function is to minimise the cost of designing the wastewater network by decreasing the cost of freshwater consumption, interception units, and wastewater discharge treatment.

We made a cost study by taking a sample from the Segaaya source with a limiting concentration that is shown in Table 1, then applied three techniques of treatment for chemical oxygen demand (COD) and biological oxygen demand (BOD) to decrease their values; the first technique used sodium hypochlorite with aluminium sulfate ($Al_2(SO_4)_3.18H_2O$), the second technique used sodium hypochlorite with ferric chloride ($FeCl_3$) and the third technique used sodium hypochlorite with ferrous sulfate ($FeSO_4$).

A simulation model is presented to determine the cost of removal ratio of contaminants in the interception units for the other sources; then entered, this data is sent to the LINGO Program, which gives the optimum cost of the wastewater network; then we pass this result to the Excel program to get the design of wastewater interception network.

4. Results and discussions

By applying the first objective function, which targets minimise freshwater consumption, the flow rate of freshwater consumption is reduced to 72658.77 m^3/hr; this value decreased by 58.5% of the original case. The flow rates from sources to sinks, wastewater flow rate and freshwater flow rate for each sink are shown in Table 3.

The Excel program automatically takes the results from LINGO Program and designs the wastewater network. As shown in Figure 3, the first source (Segaaya source) feeds sink 4 (EL-Nile canal) with a flow rate 9326.76 m^3/hr, and it is wastewater discharge flow rate 26673.25 m^3/hr, the flow rate of second source (Samaty) feeds the sink 3 (Al-wasta canal) by flow rate 4411.34 m^3/hr, and it is wastewater discharge flow rate is 49588.6 m^3/hr, the third source (Lumana) feeds the sink 2 (El-Batalah Canal), sink 3 (Al-Wasta Canal) by flow rates 1916.55 m^3/hr, 1087.88 m^3/hr respectively, and it is wastewater discharge 32995.56 m^3/hr. The fourth source (El-Tshween) feeds the four sinks, Botita Canal, El-Batalah Canal, Al-wasta Canal and Bahr terra canal by flow rates 20922.51 m3/hr, 38833.71 m^3/hr, 4812.51m^3/hr and 16431.27 m^3/hr respectively, the fifth source (Ebshan) feed the three sinks, Botita Canal, El-Nile Canal and Bahr terra canal by flow rates 1945.88 m^3/hr, 13470.26 m^3/hr and 3203.59 m^3/hr respectively and it is wastewater discharge 17380.27 m^3/hr. The sixth source (Hafir source) feeds the five sinks, Botita Canal, El-Batalah Canal, Al-wasta Canal, El-Nile Canal and Bahr terra Canal by flow rates 2303.19 m^3/hr, 3937.26 m^3/hr, 2656.73 m^3/hr, 10691.82 m^3/hr and 1389.93 m^3/hr respectively and it is wastewater discharge 22021 m^3/hr. The freshwater is distributed to the five sinks, Botita Canal, El-Batalah Canal, Al-wasta Canal, El-Nile Canal and Bahr terra Canal, by flow rates 9828.4 m^3/hr, 15312.48 m^3/hr, 7031.52 m^3/hr, 31511.15 m^3/hr and 8975.2 m^3/hr respectively.

Table 3. Flow rates of wastewater network of Kotchener drain case study

Stream	Flow rate (m^3/h)	Stream	Flow rate (m^3/h)
Fw	72658.77	Gunit3-3	1087.89
Gwaste	148658.8	Gunit4-3	4812.52
Fw1	9828.41	Gunit6-3	2656.73
Wunint.1	36000	Wunint.4	81000
Gunit4-1	20922.5	Fw4	31511.2
Gunit5-1	1945.88	Gunit1-4	9326.77
Gunit6-1	2303.2	Gunit5-4	13470.3
Wunint.2	54000	Gunit6-4	10691.8
Fw2	15312.5	Wunint.5	36000
Gunit3-2	1916.55	Fw5	8975.2
Gunit4-2	38833.7	Gunit4-5	16431.3
Gunit6-2	3937.26	Gunit5-5	3203.59
Wunint.3	36000	Gunit6-5	1389.94
Fw3	7031.52	Wunint.6	43000
Gunit2-3	4411.34		

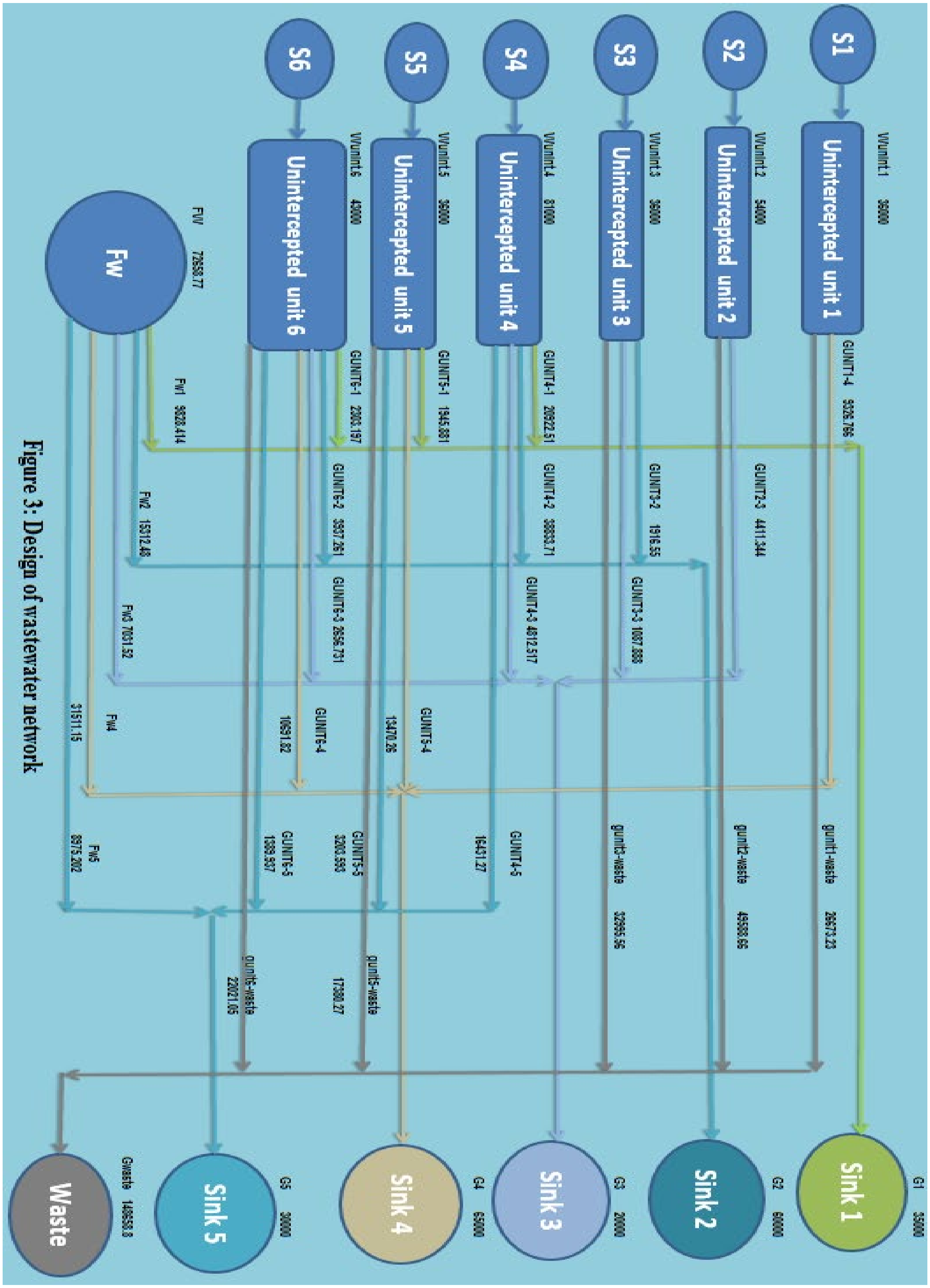

Figure 3: Design of wastewater network

We applied treatment of interception unit of COD and BOD in laboratory scale for Segaaya source with different removal ratios by three techniques; the first technique used Sodium hypochlorite with Aluminum sulfate, the second technique used Sodium hypochlorite with ferric chloride, and the third technique used Sodium hypochlorite with ferrous sulfate.

The relation between the removing mass load of COD and the cost of removing for technique 1, technique 2 and technique 3 are shown in Table 4, and the cost calculations of decreasing the mass load of contaminant BOD with different removal ratios are shown in Table 5.

Table 4. Results of the mass load for COD were removed by three techniques with the cost of removing for Segaaya source.

Technique 1			Technique 2			Technique 3		
Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)
0.75	2.97	1.62	0.50	1.98	1.55	0.33	1.39	1.30
0.77	3.05	1.66	0.53	2.10	1.70	0.38	1.50	1.90
0.8	3.17	1.80	0.58	2.30	2.20	0.42	1.66	2.30
0.84	3.33	2.20	0.61	2.42	2.60	0.46	1.82	2.80

Table 5. Results of the mass load for BOD, which was removed by three techniques with the cost of removing for Segaaya source

Technique 1			Technique 2			Technique 3		
Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)
0.80	1.87	2.38	0.55	2.18	3.50	0.4	0.94	2.88
0.83	1.94	2.45	0.57	2.26	3.60	0.43	1.01	3.00
0.85	1.99	2.60	0.59	2.34	3.70	0.48	1.12	3.40
0.86	2.01	2.90	0.62	2.45	3.90	0.52	1.22	3.70

We applied a simulation technique to get the cost of decreasing the COD and BOD for the other sources by proposing linear equations from the relation between the mass load of removing contaminants and the cost of decreasing them from sources, as shown in Figures 4, 5, 6, 7, 8 and 9.

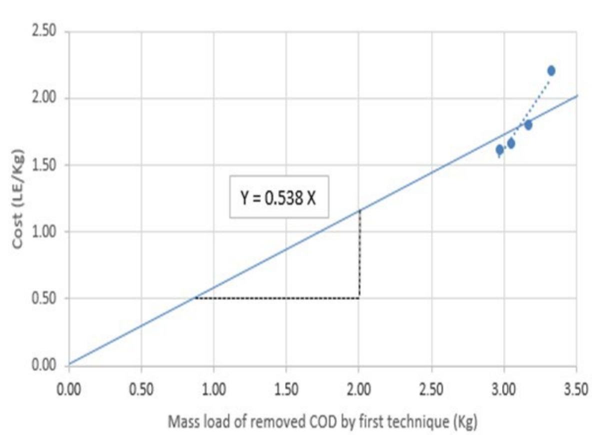

Figure 4. Graphical representation between the removing mass load of COD and the treatment cost for technique 1.

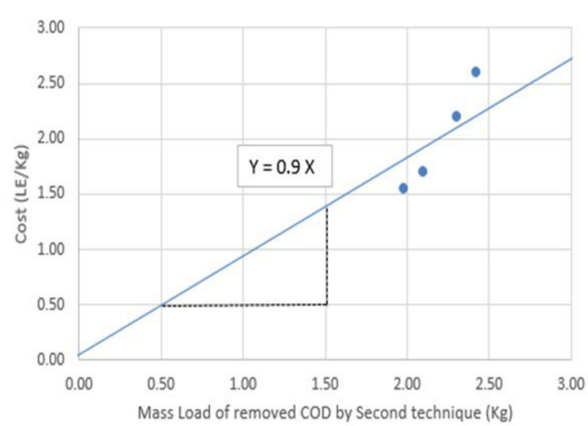

Figure 5. Graphical representation between the removing mass load of COD and the treatment cost for technique 2

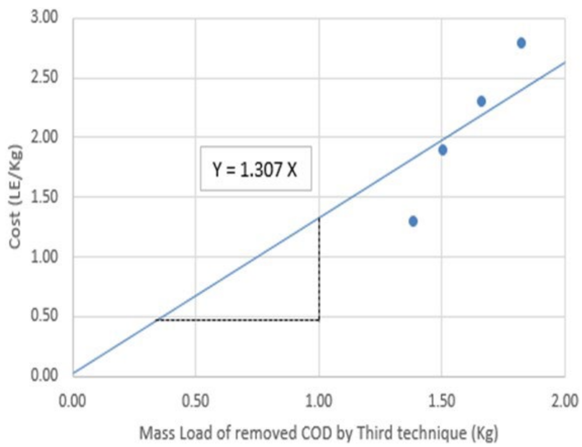

Figure 6. Graphical representation between the removing mass load of COD and the treatment cost for technique 3.

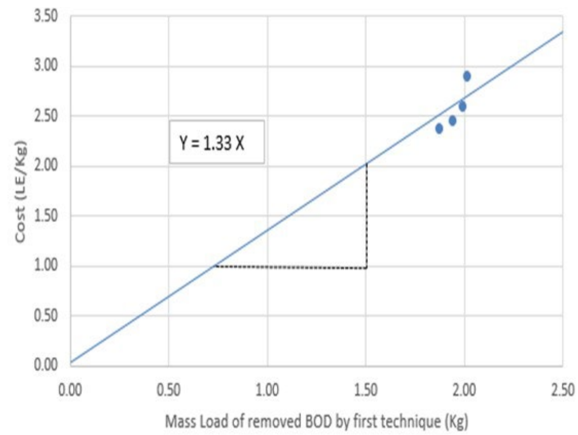

Figure 7. Graphical representation between the removing mass load of BOD and the treatment cost for technique 1

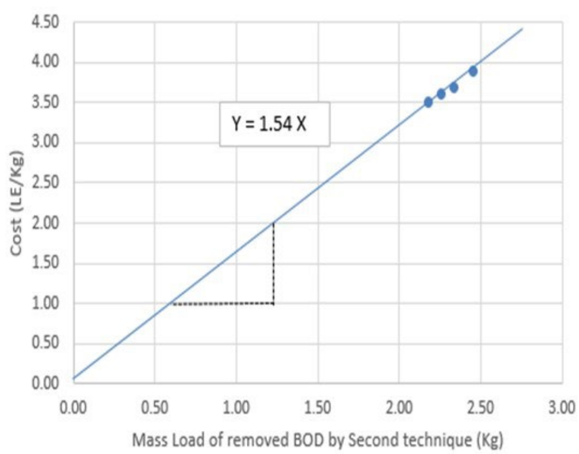

Figure 8. Graphical representation between the removing mass load of BOD and the treatment cost for technique 2

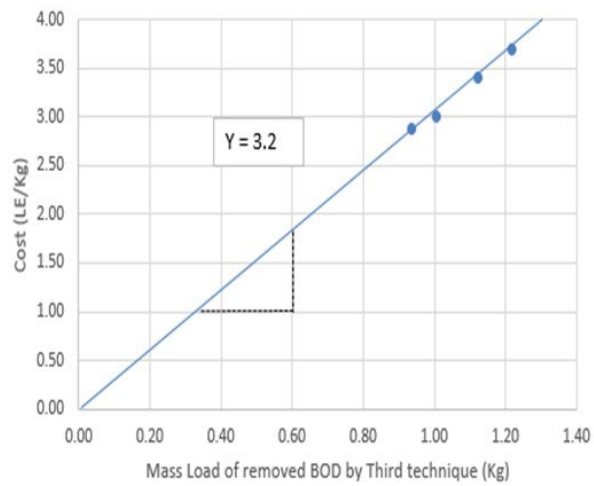

Figure 9. Graphical representation between the removing mass load of BOD and the treatment cost for technique 3

According to these linear equations, we estimated the cost of interception treatment for other sources with different removal ratios and different mass loads of removing contaminants COD and BOD by the three techniques; these values are shown in Table 6 and Table 7, respectively.

Table 6. Results of the mass load for COD, which was removed by three techniques with the cost of removing for sources Samaty, Lumana, El-Tshween, Ebshan and Hafir

Sources	Technique 1			Technique 2			Technique 3		
	Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contaminant COD	Cost (LE)
Samaty	0.75	3.08	1.66	0.50	2.05	1.85	0.33	1.44	1.88
	0.77	3.16	1.70	0.53	2.18	1.96	0.38	1.56	2.04
	0.8	3.28	1.77	0.58	2.38	2.14	0.42	1.72	2.25
	0.84	3.45	1.85	0.61	2.50	2.25	0.46	1.89	2.47
Lumana	0.75	2.21	1.19	0.50	1.48	1.33	0.33	1.03	1.35

Sources	Technique 1			Technique 2			Technique 3		
	Removal ratio (RR)	Mass load (removed) of contam-inant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contam-inant COD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contam-inant COD	Cost (LE)
	0.77	2.27	1.22	0.53	1.56	1.41	0.38	1.12	1.47
	0.8	2.36	1.27	0.58	1.71	1.54	0.42	1.24	1.62
	0.84	2.48	1.33	0.61	1.80	1.62	0.46	1.36	1.77
El-Tshween	0.75	3.89	2.09	0.50	2.59	2.33	0.33	1.81	2.37
	0.77	3.99	2.15	0.53	2.75	2.47	0.38	1.97	2.57
	0.8	4.15	2.23	0.58	3.01	2.71	0.42	2.18	2.85
	0.84	4.35	2.34	0.61	3.16	2.85	0.46	2.38	3.12
Ebshan	0.75	2.27	1.22	0.50	1.51	1.36	0.33	1.06	1.38
	0.77	2.33	1.25	0.53	1.60	1.44	0.38	1.15	1.50
	0.8	2.42	1.30	0.58	1.75	1.58	0.42	1.27	1.66
	0.84	2.54	1.37	0.61	1.84	1.66	0.46	1.39	1.82
Hafir	0.75	1.94	1.04	0.50	1.29	1.16	0.33	0.90	1.18
	0.77	1.99	1.07	0.53	1.37	1.23	0.38	0.98	1.28
	0.8	2.06	1.11	0.58	1.50	1.35	0.42	1.08	1.42
	0.84	2.17	1.17	0.61	1.57	1.42	0.46	1.19	1.55

Table 7. Results of the mass load for BOD, which was removed by three techniques with the cost of removing for sources Samaty, Lumana, El-Tshween, Ebshan and Hafir

Sources	Technique 1			Technique 2			Technique 3		
	Removal ratio (RR)	Mass load (removed) of contam-inant BOD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contam-inant BOD	Cost (LE)	Removal ratio (RR)	Mass load (removed) of contam-inant BOD	Cost (LE)
Samaty	0.80	1.73	2.30	0.55	2.28	3.51	0.40	0.86	2.76
	0.83	1.79	2.38	0.57	2.34	3.60	0.43	0.93	2.97
	0.85	1.84	2.44	0.59	2.42	3.73	0.48	1.04	3.32
	0.88	1.86	2.47	0.62	2.54	3.91	0.52	1.12	3.59
Lumana	0.80	0.95	1.26	0.55	1.62	2.49	0.40	0.48	1.52
	0.83	0.99	1.31	0.57	1.68	2.59	0.43	0.51	1.63
	0.85	1.01	1.34	0.59	1.74	2.68	0.48	0.57	1.82
	0.88	1.02	1.36	0.62	1.83	2.82	0.52	0.62	1.98
El-Tshween	0.80	2.33	3.10	0.55	2.85	4.39	0.40	1.17	3.73
	0.83	2.42	3.22	0.57	2.95	4.54	0.43	1.25	4.01
	0.85	2.48	3.30	0.59	3.06	4.71	0.48	1.40	4.48
	0.88	2.51	3.34	0.62	3.21	4.94	0.52	1.52	4.85
Ebshan	0.80	1.41	1.88	0.55	1.66	2.56	0.40	0.71	2.26
	0.83	1.46	1.95	0.57	1.72	2.65	0.43	0.76	2.43
	0.85	1.50	1.99	0.59	1.78	2.74	0.48	0.85	2.71
	0.88	1.52	2.02	0.62	1.87	2.88	0.52	0.92	2.94
Hafir	0.80	1.38	1.83	0.55	1.42	2.19	0.40	0.69	2.20
	0.83	1.43	1.90	0.57	1.47	2.26	0.43	0.74	2.37
	0.85	1.46	1.94	0.59	1.52	2.34	0.48	0.83	2.64
	0.88	1.48	1.97	0.62	1.60	2.46	0.52	0.89	2.86

The data in Tables 4, 5, 6 and 7 are applied in the first mathematical model by taking the objective function to minimise the cost of freshwater consumption, the treatment cost of interception units and the treatment cost of wastewater discharge.

The results show that the optimum solution is to mix the sinks with the minimum amount of fresh water to reach the limiting concentrations of each sink; the cost of interception unit is higher than the cost of fresh water with the large amount of flow rate of sources that we need to enter it to the interception units, the estimated cost decrease from 16064.98 $ to 9398.25 $.

The results are entered from LINGO Program into the Excel program to design the wastewater interception network, the resulting design of the wastewater interception network is the same design which gets in the first objective function in Figure 3.

5. Conclusion

Two models are presented in our research to seek two objective functions; the first is to minimise freshwater consumption, and the second is to minimise the estimated cost of freshwater consumption and treatment of interception units and wastewater discharge. The first mathematical model is based on the LINGO Program, which can use twelve sources and sinks with five treatment techniques for each source; the second model is based on the Excel program. That is used to draw the optimum wastewater network. Kotchener Drain is presented as a case study which has six sources and five sinks; we applied three interception techniques in the laboratory scale to decrease the mass load of COD and BOD for the Segaaya source with estimating the cost of removal mass load of each contaminant. We simulated linear equations between the removal of the mass load of COD and BOD to estimate the cost of removal of mass load for other sources. By applying the first objective function in LINGO Program, we get the minimum consumption of fresh water of 72658.77 m^3/hr, which is decreased by 58.5% of the original case. When applying the second objective function, the optimum cost is decreased from 496800 in the original case to 290635 LE in the resulting network. The proposed mathematical models are easy to use and more effective in different fields, fertiliser industries, cement industry, paper industry, food industry and wastewater distribution in drains.

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