PRELIMINARY DESIGN AND COST ESTIMATION OF WASTE WATER TREATMENT UNIT

W. A. Aissa

Mechanical Power Department, High Insttitute of Energy, Aswan, Egypt
E-mail: walid_aniss@hotmail.com

ABSTRACT

The performance and initial cost of a waste water treatment unit are analyzed using both the fundamental laws of fluid mechanics and emperical data. Analysis is made for Kima waste water treatment unit (system 1) using the above mentioned analysis. Comparison was made with the data of Naga-Hamady waste water treatment unit (system 2). Amendments are made in system 2 to enhance its performance and minimize its drawback (system 3). Comparison is made for efficiency to cost ratio for the three systems.

KEYWORDS

Water treatment, Preliminary Design, Cost estimation.

1. INTRODUCTION

The development of the flush toilet, which produced large volumes of wastewater, induced people to use wastewater piping systems [1] to convey water borne domestic, commercial, or industrial wastes to a point of discharge and to treatment. Such systems are called sewer systems. Design of a wastewater piping system involves selection of pumps and piping diameters, materials and fittings. The design also includes estimation of pipe length, number of drop manholes and manholes, pipe slope, self cleaning velocity, loads imposed upon the pipes, friction losses and pumping requirement, in order to prevent environment from pollution.

The designed wastewater treatment unit [2], is divided into, primary and secondary. Primary treatment is done to remove the wastewater solids and grit materials, its components in the unit are, screen, grit chamber and primary sedimentation tanks. Then removing of colloidal matter by secondary treatment which activates the growth of bacteria to feed on colloidal and dissolved organic matter. The bacteria grow and multiply, thus the colloidal can be easily settled. This is performed by using aeration tank “surface aeration” and secondary sedimentation tanks where the waste water settle certain amount of time. This is called the method of activated sludge. The final stage is chlorination of waste water to increase the efficiency of the plant and make the water good for irrigation of the agricultural land. Also, there is a simple treatment system depending on primary settling and nearly aerated. The effluent of the unit is used to irrigate the land for growing some types of trees which are used to protect the city from winds. This system is modulated to increase the efficiency and reducing maintenance cost.

2. PIPELINES DESIGN

The design of waste water pipes includes the estimation of velocities and depth of flow. The flow in pipes are partially full , the velocity in pipe is in the range betwen 0.3 and 1.2 m/s and the recommended velocity is 0.6 m/s. the pipes are buried. So, the l oads on pipes must be calculated such as the weight of the earth and any superimposed loads. The design of piping system depends on Renolds number (laminar or turbulent flow) and , friction factor and local losses. The following eqations, tables and charts help in the design.

$$V = 83 R_h^{2/3} S^{1/2} \tag{1}$$

where, V is mean velocity of flow in pipe (m/s), R_h is hydraulic radius of pipe (m), S is pipe slope. The load on the pipe is calculated using the following formula

$$W = CwB^2 \tag{2}$$

where, W is load on pipe per unit length (kN/m), w is weight of soil per unit volume (kN/m^3), B is width of trench (m), C is coefficient which value depends upon type of soil and ratio of depth of cover to trench width.

$$B = 304.8 + \frac{3D}{2} \tag{3}$$

where, D is diameter of pipe (m). Equations (1,2,3) are sited in [2].

Tables 1, 2 and 3 give the values of C, w and S respectively.

Table 1 Values of C [3].

Ratio of depth to trench width	Sand and damp topsoil	Saturated topsoil	Damp clay	Saturated clay
0.5	0.46	0.46	0.47	0.47
1.0	0.85	0.86	0.88	0.90
2.0	1.46	1.50	1.56	1.62
3.0	1.90	1.98	2.08	2.20
4.0	2.22	2.33	2.49	2.66
5.0	2.45	2.59	2.80	3.03
6.0	2.61	2.78	3.04	3.33
7.0	2.73	2.93	3.22	3.57
8.0	2.81	3.03	3.37	3.76
9.0	2.88	3.11	3.48	3.92
10.0	2.92	3.17	3.56	4.04
11.0	2.95	3.21	3.63	4.14
12.0	2.97	3.24	3.68	4.22
13.0	2.99	3.27	3.72	4.29
14.0	3.00	3.28	3.75	4.34
15.0	3.01	3.30	3.77	4.38

Table 2 Weight of Ditch-Filling Materials [2].

Material	Weight of soil per unit volume KN/m^3
Dry sand	16
Ordinary(damp) sand	18
Wet sand	19
Damp clay	19
Saturated clay	20
Saturated topsoil	18
Sand and damp topsoil	16

Table 3 Slopes For Cast Iron Pipes [4].

Diameter; D (mm)	Slope; S	Diameter; D (mm)	Slope; S
130	1:75	600	1:700
150	1:100	700	1:800
180	1:135	800	1:900
230	1:200	850	1:1000
300	1:300	1000	1:1100
400	1:400	1200	1:1200
500	1:500	1300	1:1300

Head loss in pipes varies directly with pipe length and square of velocity, and inversly with pipe diameter. Using a dimensionless coefficient of propertionality; *f* called friction factor, Darcey, Weisbach, and others proposed equation in the form:

$$h_l = f \frac{L}{D} \frac{V^2}{2g} \tag{4}$$

where, h_l is head loss (m) ,g is gravitational accleration (m/s^2) and L is length of pipe (m). Friction factor; f depends on Reynolds number of flow and pipe relative roughness; e/D.

where, Re is Reynolds number based on diameter; D and it is defined by:

$$\mathrm{Re} = \frac{\rho V D}{\mu} \tag{5}$$

where, ρ is the density of the flowing fluid (kg/m^3) and μ is the viscosity of the flowing fluid (kg/m.s).

Friction factor can be evaluated from Moody charts shown in [1] based on the values of Reynolds number and the pipe relative roughness.

In addition to friction in pipes, local losses contribute also in head loss. These losses usually result from rather abrubt changes (in magnitude or direction) of velocity. Local losses incurred by change of cross section in pipes (sudden or conical enlargement), bends, elbows, valves, and fitting of all types. Local losses vary approximately with the square of velocity and led to the proposal of the basic equation:

$$h_l = k_l \frac{V^2}{2g} \tag{6}$$

where, k_1 is the loss coefficient. Values of k_l for various common fittings are tabulated by Street et. al. [1].

Equations (4,5,6) are listed by Street et. al. [1].

3. CONVENTIONAL WASTE WATER TREATMENT

3.1. Introduction

In general, the removal of organic pollutants in waste water may be divided into two stages. The first stage, which involves the removal of the waste water solids, is called primary treatment; figure 1-A. The second stage, which involves the removal of the colloids and the dissolved organic matter, in waste water, is called secondary treatment; figure 1-B. The secondary treatment of waste involves removing the "leftovers" from primary treatment. The leftovers are composed of colloidal and dissolved organic matters. Since these forms are colloidal and dissolved, they can no longer be removed by simple sedimentation. They must be transformed into solids that can then easily be settled. This transformation involves feeding them to micro organisms, mostly bacteria. As the bacteria feed on the colloidal and dissolved organic matters, they grow and multiply, thus converting those which were once colloidal and dissolved into solids that are capable of settling.

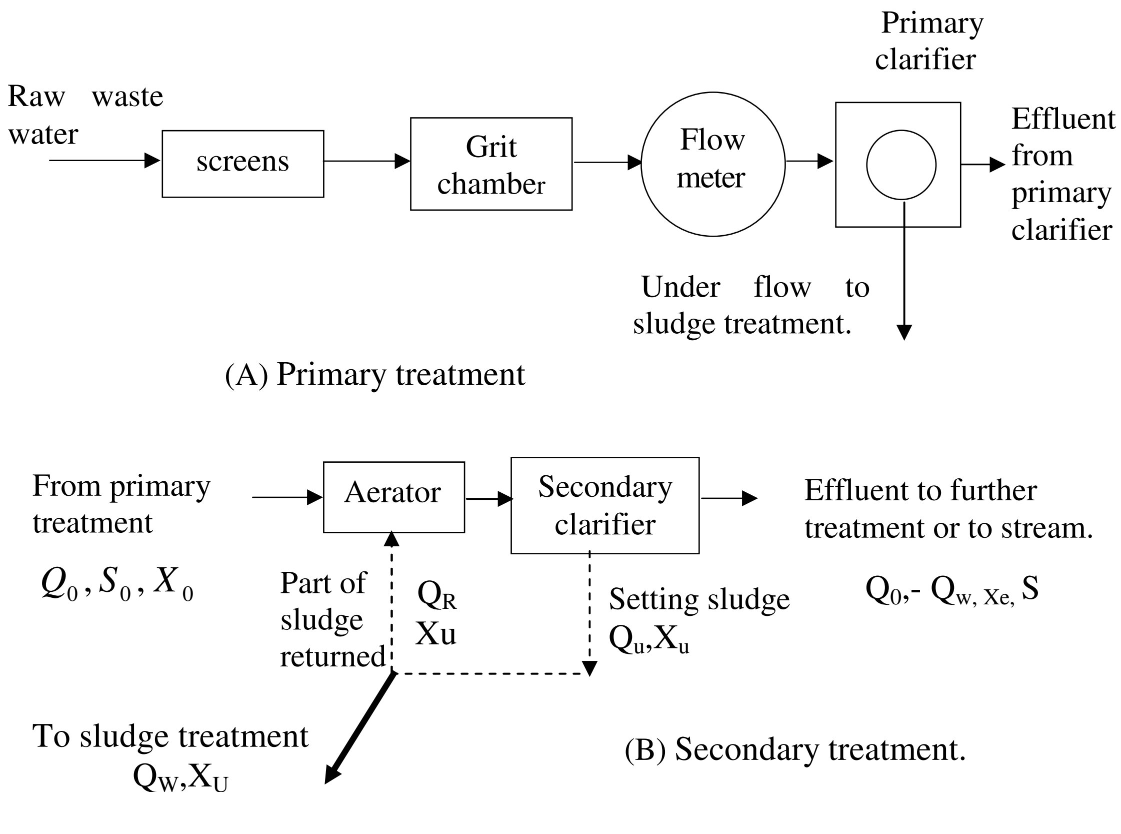


Figure 1 Schematic drawing of two stages of treatment [3].

3.2. Compenents of Waste Water Treatment

3.2.1. Screens

A screen is a device with openings, generally of uniform size, that is used to retain the coarse solids found in waste water. Equation (7) is used to determine the head loss through them [5].

$$h_l = \frac{1}{0.7}\left(\frac{V^2 - v^2}{2g}\right) \tag{7}$$

where, v is approach velocity in up stream channel (m/s), V is velocity of flow through the opening of the bar rack (m/s), 0.7 is an empirical discharge coefficient to account for turbulence and eddy losses.

3.2.2. Grit chamber

Grit chamber is a long channel designed mainly to settle grits, sand , stone and seeds. The flow velocity through this channel is 0.3 m/s , the retention time is about 1 min and the over flow rate changes according to the volume of grits. The ratio of settled grits is 10 to 30% of the flow rate its width is about 18 to 20 m. It has parabolic cross section. Proportional flow weir can be installed at the end of grit channel in order to prevent increasing and decreasing in flow rate. The flow area [3] of the proportional flow weir in orifice is given by:

$$Q=KWH^{1/2} \tag{8}$$

Where, Q is the flow through an orifice, K is the orifice constant, W is the width of over the weir and H *is* the head over the weir crest.

3.2.3. Primary sedimentation tanks

It is circular or rectangular tank. The flow settles in it about 1.5 to 2.5 hr. Its efficiency reaches 60%. The depth of tank settling sludge zone is a design constraint. It is about 1m. A smaller overflow rate produces a longer detention time. In primary sedimentation tanks, settling detention time is short. Although longer detention time tends to produce more solid removal in water treatment, longer time causes septic conditions because of formation of gasses. septicity makes solids rise, resulting in inefficiency of tank. Efficiency of tank is defined as the ability of settling more quantity of solids in lower time.

The equation which relates the overflow rate to the flow rate and the surface area [3] is:

$$A = \frac{Q}{O} \tag{9}$$

where, A is the surface area (m^2), Q is the flow rate (m^3/s), O is the over flow rate (m/day), where the flow rate is proportional to tank area, A_t and the tank outflow velocity, i.e.

$$Q = A_t . V_t \tag{10}$$

Design criteria for primary sedimentation tanks is tabulated in table 4.

Table 4 Design criteria for primary sedimentation tanks [3].

Parameter	Value	
	range	Typical
Detention time (hr)	1.5-2.5	2
Over flow rate (m/day)		
Average flow	30-50	____
Peak flow	80-120	90
Weir loading (m^3/m^2-day)	120-450	200
Dimensions (m)		
Rectangular		
depth	2-6	3.5
length	15-100	30
width	3-30	10
Sludge scraper speed (m/min)	0.5-1.5	1
Circular		
depth	3-5	4.5
diameter	3-60	30
Bottom slope (min/m)	60-160	80
Sludge scraper speed(r.p.m)	0.02-0.05	0.03

Figure 2 is used to determine the percentage of suspended solids in waste water coated with the over flow rate to determine the area of the tank to obtain its dimensions such as (diameter, depth). BOD_5 is a very important parameter in the design of waste water treatment plant. It is a waste strength which represents the amount of oxygen that will be consumed in 5 days at a given temperature. The normal temperature at BOD_5 is 20°C.

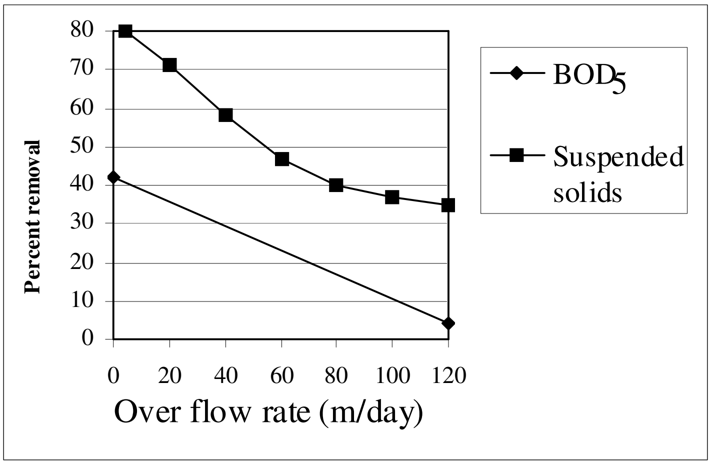


Figure 2 Suspended solids and BOD_5 overflow rate removal as a function of over flow rate [3].

3.2.4. Aeration tanks

Surface mechanical aerators are used in this tank. Mixing in waste water process usually occures in the regime of turbulent flow. Surface aerators may be obtained in sizes from 1 to 150 hp (0.75 to 100 KW). The power requirement for mixing [5] can be calculated using equation 11.

$$P = K\rho n^3 D^5 \tag{11}$$

where, P is power requirement (W), K is constant D is diameter of impeller (m) and N is aerator speed (rev/s).

The aerator size is selected according to tank dimensions as specified in table 5.

Table 5 Typical aeration tank dimensions for mechanical surface aerators [5].

Aerator size, hp	Tank dimensions, ft	
	Depth	Width
10	10-12	30-40
20	12-14	35-50
30	13-15	40-60
40	12-17	45-65
50	15-18	45-75
75	15-20	50-85
100	15-20	60-80

3.2.5. Archimedean screw pump

The screw pump; figure 3 is used to raise the setelled sludge in the secondary sedimentation tanks to the aeration tanks. The advanteges of screw pump are long life due to low wear, can be used in lower heads, mechanical efficiency is almost constant, even on part load, continuous performance with sudden fluctuations in output, thus ensuring efficient treatment of the effluent which is particularly important when handling activated sludge, continuously pumping even when the liquid is very low, the pump will handle effluent containing solids as large as the blade pitch, stringy and fibrous material cannot clog the pump, highly efficient, low noise, low speed, low maintenance cost, low energy costs, low building costs. Overall efficiency lies some where in between 70 to 80 percent. Equation (12) can be used to calculate the pump power. Selection charts illustrated below in figures 4 and 5 are used to estimate head, diameter of helix and R.P.M.

$$P = \frac{\rho g H Q}{1000\eta} \tag{12}$$

where, P is power requirement (KW), H is maximum head of fluid (m), and η is pump efficiency. By knowing the flowrate, figures 4 and 5 are used to determine the head, diameter of helix and RPM respectively.

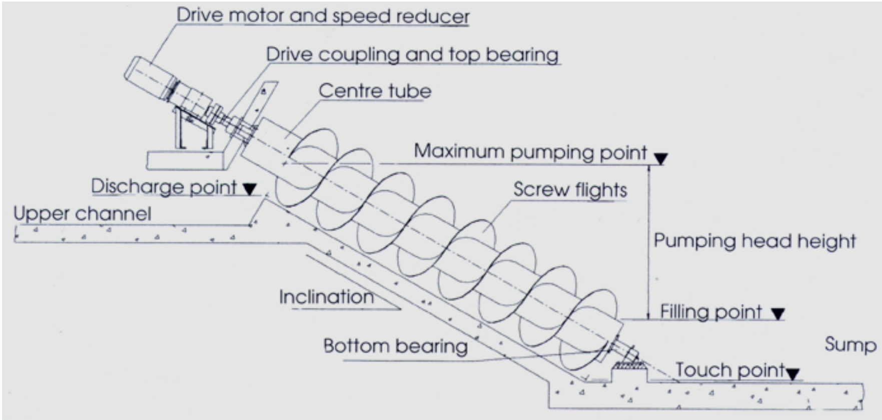


Figure 3 Schematic of Archmedian screw pump.

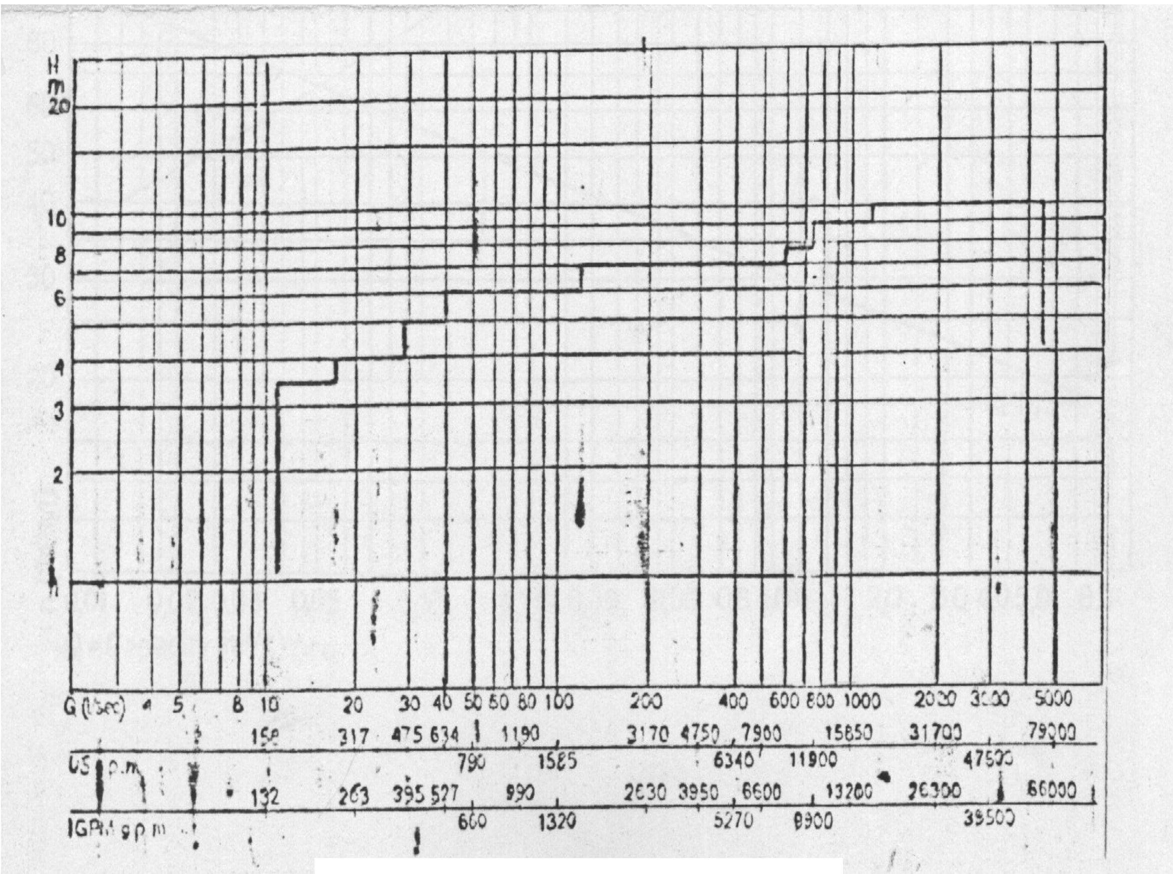


Figure 4 Head capacity curve [6].

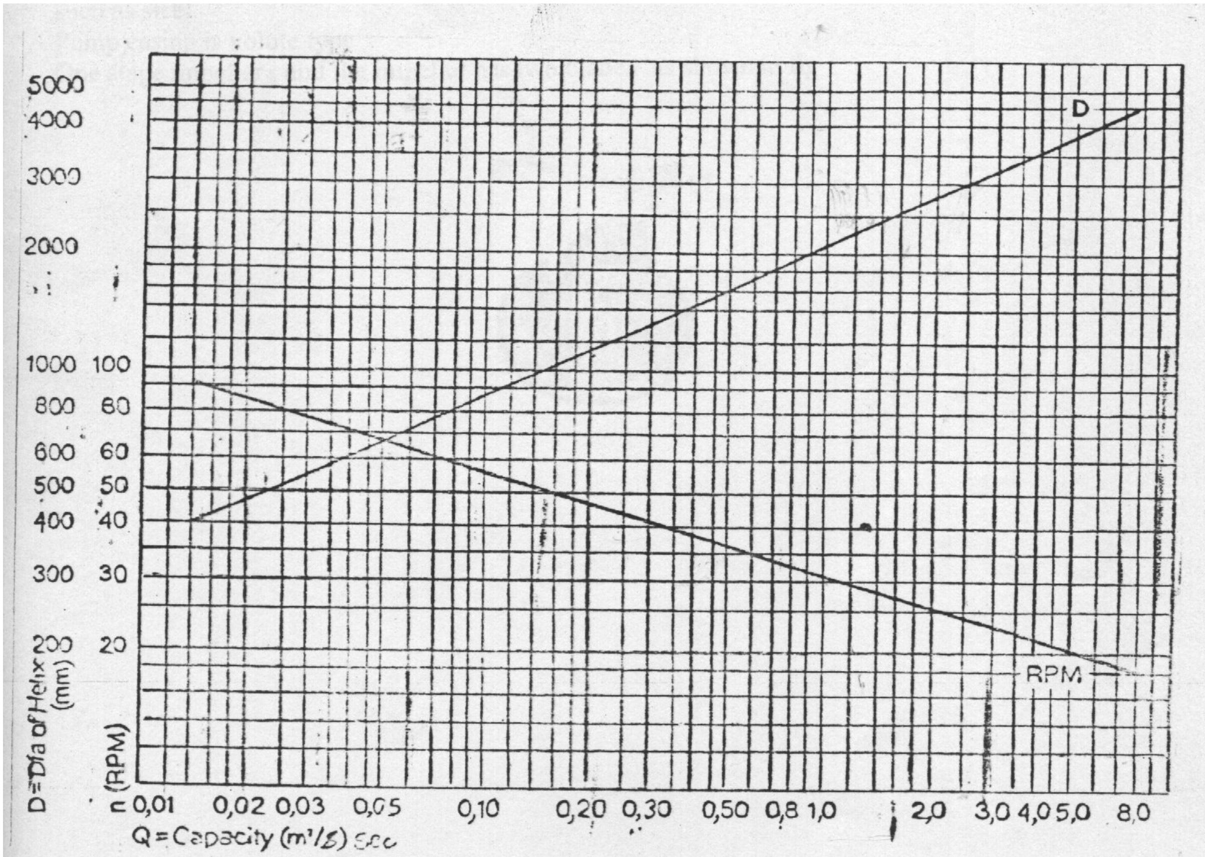


Figure 5 Diameter of helix and RPM capacity curve [6].

3.2.6. Secondary sedimentation tanks

In these tanks, removing the left overs from primary setlling and the volume of the tank depend on retention time of water. Equations. (12) and (13) are used in the design of secondary sedimentation tanks to estimate the quantity of setlled sludge in the tank [3].

$$[X] = \frac{\theta_c Y([S_0]-[S])}{\theta(1+k_d\theta_c)} \tag{13}$$

$$\theta_C = \frac{V[X]}{Q_W[X_U]+(Q_0-Q_W)[X_e]-Q_0[X_0]} \tag{14}$$

where, [X] is mixed population of microrganisms utilizing the organic waste, $[X_e]$ is Effluent biomass concentration, $[X_0]$ is Effluent biomass concentration, $[X_U]$ is underflow concentration, [S] is the concentration of a limiting substrate or nutrient, $[S_0]$ is the inflow concentration of substrate, Q_0 is influent to secondary tank, Q_w is sludge waste rate, Y is specific yeild of organisms "mass of organisms produced", K_d

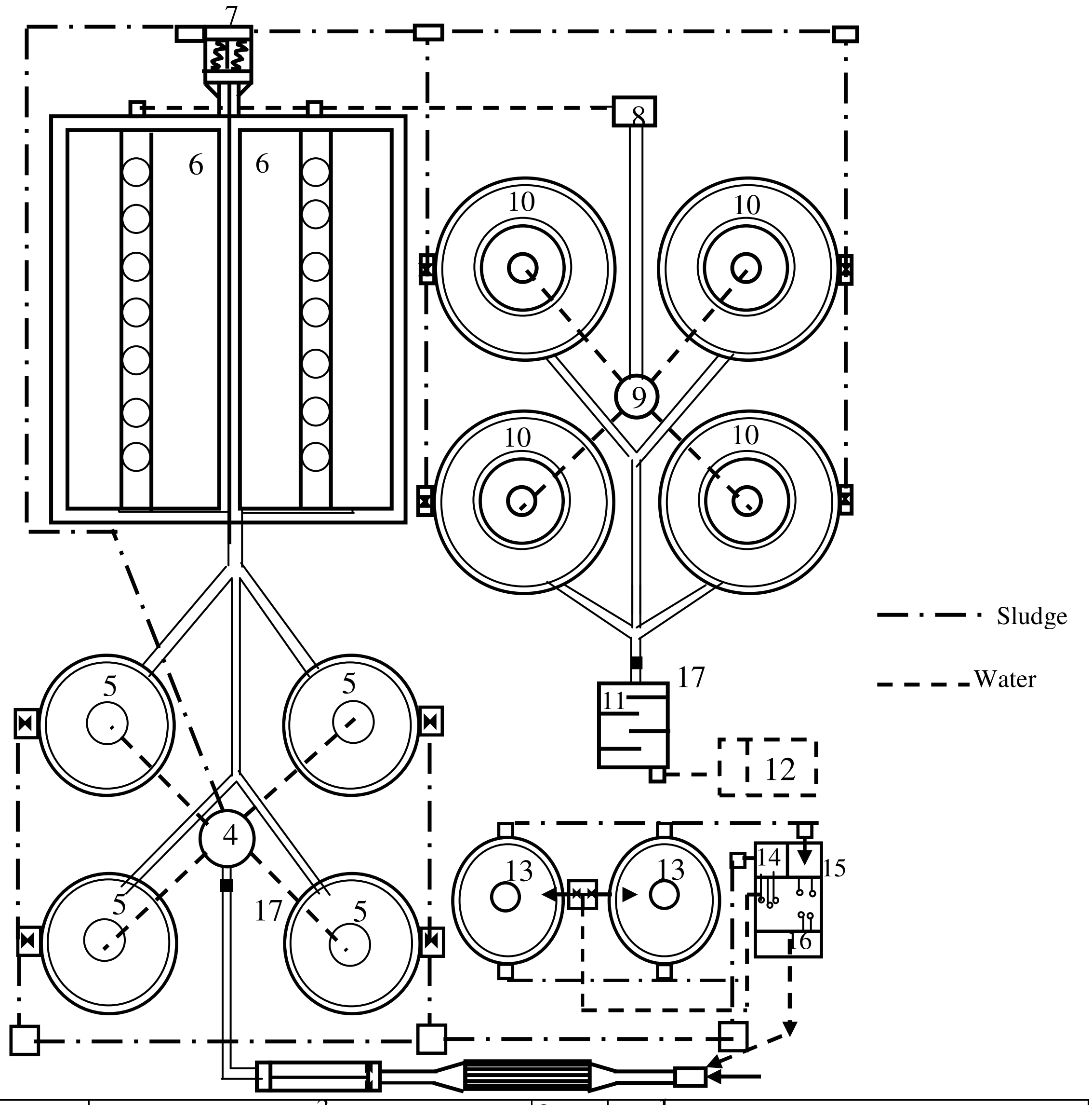
is the rate of decay, θ is nominal hydraulic retention time and θ_c is is mean cell residue time. A complete analysis of secondary treatment is shown by Sincero [3].

3.3. Kima Waste Water Treatment Unit (System 1)

The flow of 35000 m^3/day; figure 6, pass through entrance chamber with 0.6 m/s velocity to screening chamber to remove coarses, then to grit chamber to settle grit, bones , and great particles. It has 1 min. retention time and 0.3 m/s velocity, then flows to P.S.T through distribution chamber; D.C. P.S.T are four tanks which are used to settle the suspended solids of the waste, the retention time is 1hr, efficiency of tank is 60%. Surface aerator and method of activated sludge in aeration tanks are used to remove colloidal matter by activating the growth of bacteria to feed on colloidal and dissolved organic matter. They grow and multiply then easily settle in the S.S.T. The flow moves from secondary settling tanks to mixing color baisns, which are designed in order to prevent any bacteria in water, then to effluent water pumping station. The flow rate is measured by flow meter before treatment process at entrance to distribution chamber and before entrance to mixing color tanks. The sludge which settled in the P.S.T is collected and raised to thickner tanks by pumping station, then to drying beds. The rest liquid in drying bedes is pumped to entrance chamber. The sludge settled in S.S.T is raised by archimedean screw pump to aeration tank and the rest to D.C. to P.S.T.

3.4. Naga-Hamady Waste Water Treatment Unit (System 2)

It is a simple unit; figure 7, and it has low efficiency. It depends on primary settling only. The aeration which is the last stage of treatment is performed by using ponds. They are earthen basins which have rectangular shape, its depth is 1m. The supply of oxygen is provided through photosynthesis. Retention time is from 21 to 30 days. They have special building style in order to increase the exposure of the flow path to oxygen. This system is applied at large areas. This system has proplems which are, the impeller of centrifugal pump at the entrance of the plant wears out after peroid of 9 months and has to be replaced, which leads to the increase of maintenance cost. Moreover, the pipe lines of oxidation ponds *II*, *III* and *IV* exhibit proplems in peroids of maintenance.



NO	Unit	NO	Unit
1	Entrance chamber	10	S.S.T- Four 38m diameter, water depth 4.5m
2	Screening chamber	11	Chlorination tanks
3	Grit chamber	12	Effluent water pumping station
4	Distribution chamber to P.S.T	13	Thickner tanks diameter = 22m
5	P.S.T-Four 28m diameter, water depth 3.25m	14	Sludge P.S to thickners
6	Aeration tanks L=112m, W=26m, depth=4.4m	15	Sludge P.S to drying beds
7	Returned and excess pumping station (screw pump)	16	Supernatent P.S of drying beds and thickners
8	Collection chamber	17	Flow meter
9	Distribution chamber to S.S.T		

Figure 6 Schematic drawing of system 1.

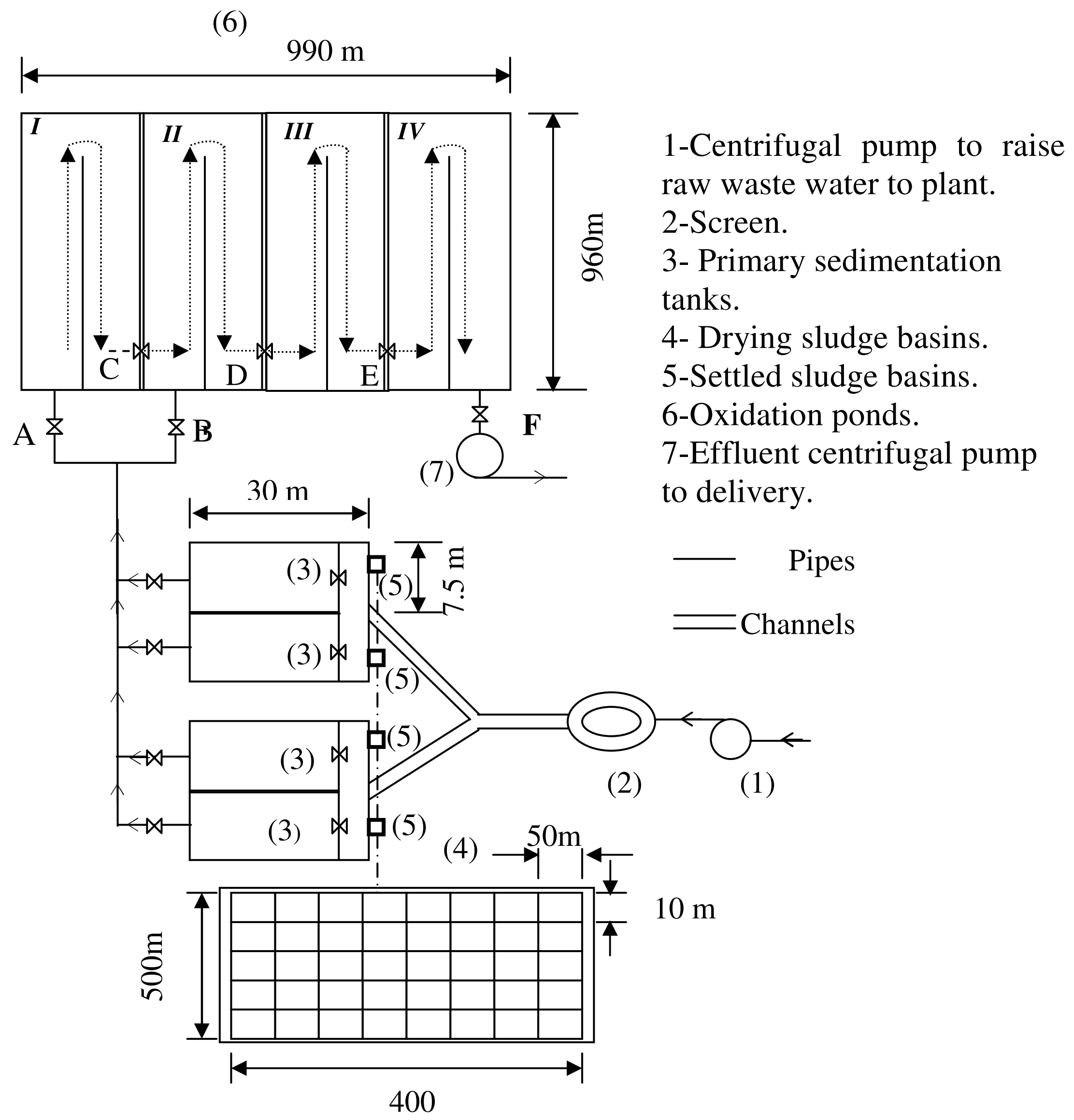


Figure 7 Schematic drawing of system 2.

3.5. Ammended Naga-Hamady Waste Water Treatment Unit (System 3)

Jet pump; figure 8 which has the advantage of no moving parts is used instead of centrifugal pump to reduce maintenance cost. Grit chamber is used in order to increase the efficiency of treatment process. The suggested solution of piping system problem while maintinance is illustrated in figure 9.

4. RESULTS AND DISCUSSION

The specification of the three systems is tabulated in Appendix A. The cost of construction of waste water treatment unit involves both civil and mechanical costs. The civil cost includes the cost of all excavation, filling up and construction works. It is not included in this study.

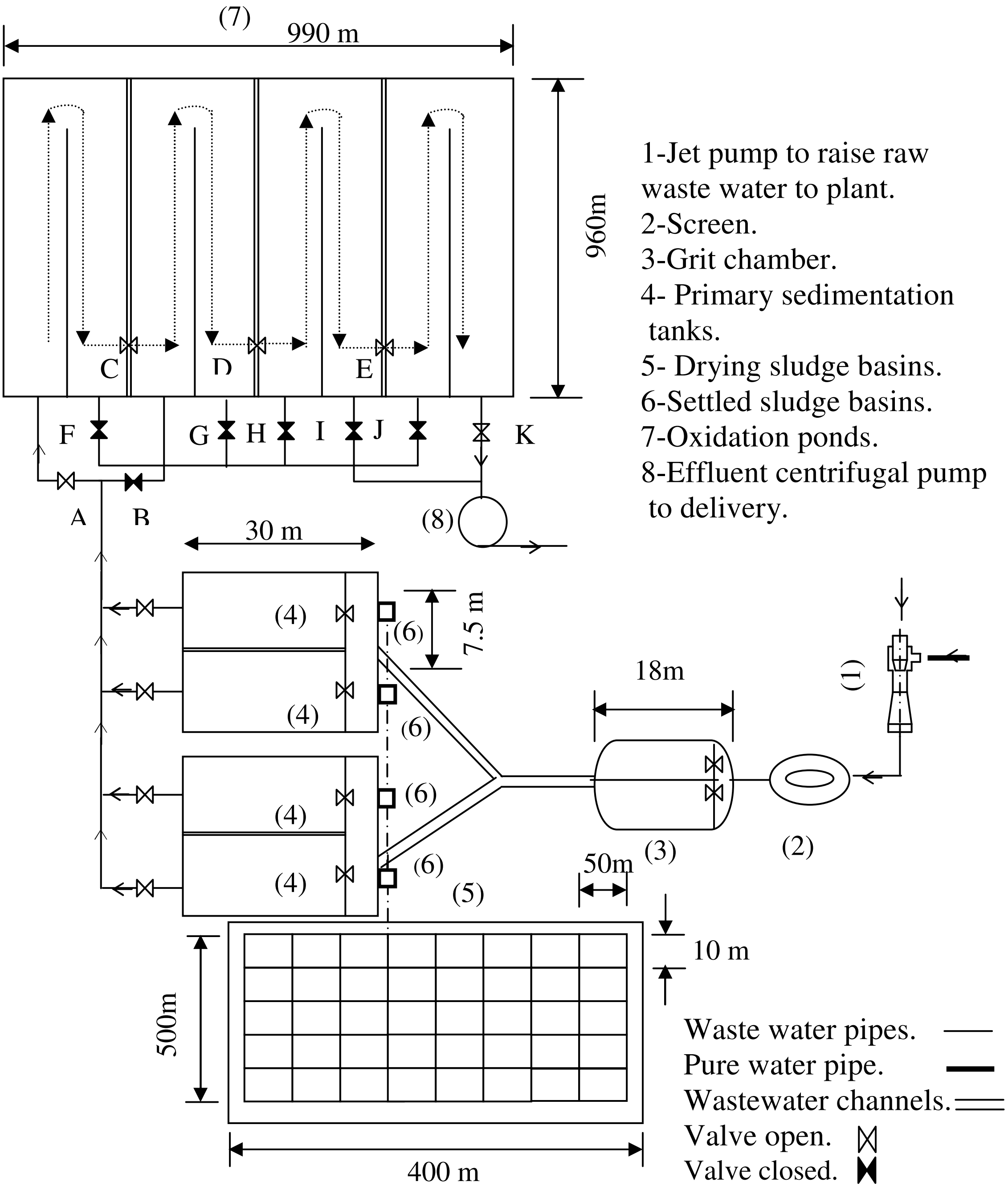
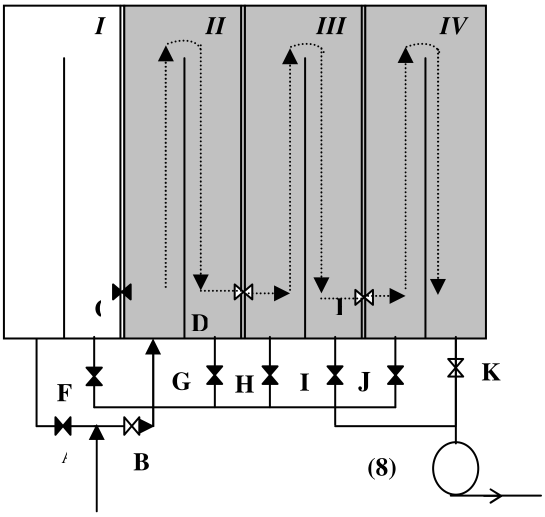
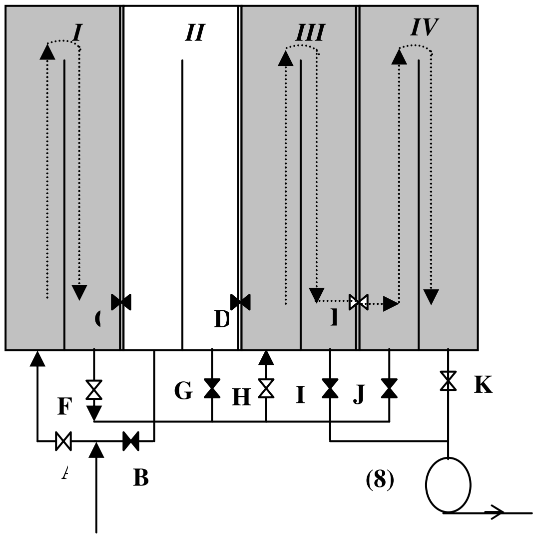


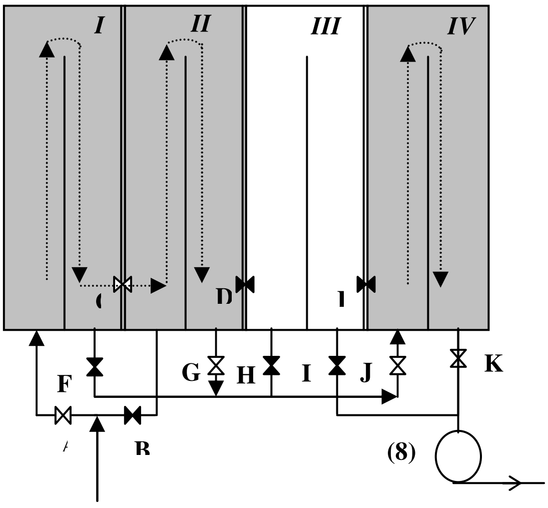
Figure 8 Schematic drawing of system 3.



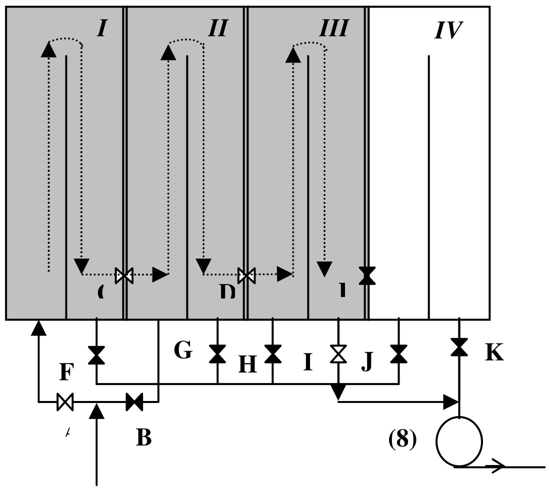
Position (1): Ponds *II*,*III*,*IV* are full
Valves B,D,E and K are open.
Valves A,C, F, G,H,I and J are closed.



Position (2): Ponds *I*,*III*,*IV* are full
Valves A,E, F,H and K are open.
Valves B,C,D,G,I and J are closed.



Position (3): Pond *I*,*II*,*IV* are full
Valves A,C,G,J,K are open.
Valves B,D,E, F, H and I are closed.



Position (4): Ponds *I*,*II*,*III* are full
Valves A,C,D,I are open.
Valves B,E, F,G,H,J and K are closed.

Figure 9 Recommended solution of piping system.

The mechanical cost includes the prices and the cost of all mechanical works (pumps, piping, valves,…etc.). Approximate estimaton of mechanical cost of the three systems is shown in table 6. The efficiency of a system is a measure of the purification of water. The efficiency of the three systems are evaluated depeding on the classification of efficiency of various waste water treatment systems described by Eladwy [4]. Table 6 shows the efficiency of the three systems which lies in the range between 0.8 and 1.0.

Table 6 Efficiency and cost for the three systems.

	System 1	System 2	System 3
Efficiency %	100	80	90
Cost (LE)	1004356	242076	234876
Efficiency to cost ratio (%/LE)	$9.96*10^{-5}$	$3.3*10^{-4}$	$3.83*10^{-4}$

Waste water in System 1 is subjected to final treatment and this is achieved by Chlorination process. So, efficiency of treatment of water which is manifested by water purity approaches unity. However, not only Chlorination remarkably increases treatment cost but it also consumes organic substances completely which implies a great amount of fertilizers. System 2 does not finally treat water. Hence, its quality is about 80%. However, in system 3, waste water is sucked by jet pumps using pure water. So, both types of water are mixed leading to increasing the purity of water while keeping some of organic substances which are useful to soil and cultivated crops. So, it has a moderate treatment efficiency; about 90%.

Hence, although systems 2 and 3 have less water purity compared to system 1. However, they keep some of organic substances which increase the productivity of crops that are irrigated with treated waste water compared to that irrigated with fresh water and fertilized using chemical fertilizers.

Constituents in waste water enhances the structure of soil particles which leads to the improvement of soil performance (irrigation, plant nutrition,…….) and converting lands to agriculture lands just by irrigation with treated waste water.

It may be noticed that although system 1 has the highest efficiency, it has the lowest efficiency to cost ratio. This is due to its high mechanical cost. Moreover systems 2 and 3 has advantage compared to system 1 is that the organic matters and some of natural chemical substances are left in waste water which is very important for cultivating some trees.

Although system 3; which represents modified system 2, has higher cost compared to system 2, however, it has the highest efficiency to mechanical cost ratio. Another parameter, which is not included in this study is maintenance cost. It is expected that system 3 has low maintenance compared to the other systems due to the modification of piping system illustrated earlier; Fig. 9, and the the incorporation of jet pump. However, system 3 requires large area compared to system 1.

So, it may be concluded from this study, that system 3 is recommended compared to the other two systems.

5. CONCLUSIONS

An analytical analysis has been made for the design of waste water treatment unit using both fundamental laws of fluid mechanics and imperical data. The design includes a system comparable to kima system; system 1, system comparable to Naga-Hamady waste water treatment unit; system 2 and system 3 which represents modified system 2. Comparison has been made for the performance and the mechanical cost of three systems. The study showed that although system 1 has the highest efficiency, it has the lowest efficiency to cost ratio due to its high mechanical cost. Moreover, system 3 has the highest efficiency to cost ratio. In addition, It is expected to have a low maintenance cost compared to the other systems due to its simplicity and modifications performed. However, system 3 requires large area compared to system 1. Hence, it may be concluded that system 3 is recommended when compared to the other systems.

APPENDIX A

SPECIFICATIONS OF SYSTEMS 1 , 2 & 3

Item	System 1	System 2	System 3
1- Flow rate	35000 m^3/day, flow comming into plant by gravity and cleanning velocities are (0.3,0.6) m/s	35000 m^3/day, flow coming to plant by gravity and pressurized by centrifugal pump at the first of plant. Cleanning velocities are (0.3,0.6) m/s.	Effluent from plant = 35000 m^3/day. Flow coming to plant by gravity and pressurized by jet pump at the first of plant. Cleanning velocities are (0.3,0.6) m/s.
2- Inlet chamber	Chamber with H=20m, 1inlet pipe diameter; d= 0.927 m.	1 inlet pipe to centrifugal pump with H=5m. P=40 KW	2 inlet pipes, 1waste water pipe Dia=927 mm, 1 pure water pipe (d =0.625m) to jet pump with nozzle diameter =0.158m, throat diameter= 0.347 m.
3- Screens	Automatic screens L=6.5, W=1m.	Normal screen to remove big grains of grits	
4- Grit chamber	L=20m, W=0.85m, d=1.2m.	There is no grit chamber	L=18m, W=1.4m , d=0.97m.
5- Pumping station of grits	Submerged pump Q=25.5 m^3/hr, H=4m, P=3KW.	There is no pumping station	It is taken by its weight
6- Collection grit tanks	3 tanks, D =2.5 m, V=1.5 m^3.	There is no collection grit tanks.	3 tanks, D =1.7m , V= 1.5 m^3.

Item	System 1	System 2	System 3
7- Channels in the system.	-1 channel between grit chamber to D.C with W=1.34m, d=0.99m. - 4 channels take water from P.S.T with W=0.7m, d=0.67m. -1 channel collect from two channels take from P.S.Twith W=1.4m, d=0.67m.	-1channel with W=1.1m, d=1.2m is divided into two channels, each one for two baisns, each one has the dimensions, W=0.55m, d =1.2m.	-1channel with W=1.1m, d=1.2m is divided into two channels, each one for two baisns, each one has dimensions, W=0.55m, d=1.2m.
		System 2	System 3
	-1 channel collect from 4 channels to aeration tanks with W=1.6m, d=0.74m. 1- channel between collection chamber to D.C with W=1.9m, d=1.24m.-4 channels take water from S.S.T with W=0.7m, d=0.76m.	-1 channel collect from 4 channels to color baisns with W=1.6m, d=0.74m.	
8- P.S.T	-4 circular tanks with inlet D =28m, d =3.25m.	-4 rectangular tanks, with L=30m, W=7.5m, d=2.8m.	
9- Aeration	In aeration tanks using the activated sludge process and oxygen using mechanical aerators	In oxidation ponds depends on atmospheric oxygen where the depth =1m to enable the flow exposing to natural oxygen .	
10- Pumping station for returned and excess sludge.	Archimedean screw pump H= 6m, P=10 KW, R.P.M=60. Submerged pump (excess sludge) H=9m, P=14 KW.	There is no pumping station for returned and excess sludge .	
11- S.S.T	4 circular tanks, D =38m, d=3.5m.	The oxidation pond acts as secondary treatment with L= 990 m, W=960 m, d= 1m.	
12- Effluent pump	4 centrifugal pumps, H= 102 m, P=155 KW.	4 centrifugal pumps, H=80 m, P=123 KW.	

Item	System 1	System 2	System 3
13- Drying beds	Small baisns divided into small areas A = 9600m^2 Depth of filtration layer = 0.6 m (0.2 m layer of grit, 0.05 m layer of coarse, 0.05 m layer of bigger coarse, 0.3 m layer of more bigger coarse). Depth of sludge = 0.7 m.	Small baisns divided into small areas. A = 20000m^2 Small area =500m^2 with W=10m, L=50m. The thickness layer of sludge = 0.7 m.	
14- Type of treatment	Final treatment	Secondary treatment	
15- Mechanical cost	Very high, because it has large number of special pump (sludge, grits) and color adding apparatus is very expensive.	Moderate cost	
16- Building cost	High, because, it has tanks at great diameters and depths, large number of channels.	Moderate cost, because, P.S.Tat low depth, oxidation pond at 1m depth only, small number of channels.	
17- Maintenance cost	Very high	High	Low
18- The cost of treatment process.	Very high	Low	
19- Area used	Large area	Very large area	
20- Efficiency of performance.	100%	80%	90%

REFERENCES

1 Street, R. L., Watters, G. Z., and Vennard, J.K., "Elementary Fluid Mechanics", John Wiley and Son's. 7th Edition, 1996.

2 Nayyar, M. L., "Piping Hand Book", McGraw-Hill, Inc, 6th Edition, 1992.

3 Sincero, A. L., and Sincero, G.A., "Environmental Engineering" Prentice Hall, 1996.

4 Eladwy, M. S., "Sewage Engineering,", Sadek Publishing Co., Alexandria, Egypt, 1990. (written in Arabic)
5 Hammer, M. J. and Hammer Jr., M. J. "Water and Wastewater Technology," Fourth Edition, Prentice-Hall of India Private Limited, New Delhi-110 001, India, 2002.
6 Archimedian Screw pump (Ritz Atro pumpwerk sbau GmbH vertriebsgesells chaft Nurnberge Thomas Mann / Max- Bord- StraBe 8500 Nurnberge-Langwasser. Tel.(0911) 86608-09-00, Telex 0623010.

NOMENCLATURE

A	Area	v	Approach velocity
C	Coefficient	V	Velocity, Volume
d	Depth	w	Weight of soil per unit volume
D	Diameter	W	Load on pipe per unit length, Width
f	Friction factor	[X]	Mixed population of microrganisms utilizing the organic waste
g	Gravitational accleration	[X_e]	Effluent biomass concentration
h_l	Head loss	[X_U]	Underflow concentration
H	Head	[X_0]	Effluent biomass concentration
K	Orifice constant, Constant	Y	Specific yeild of organisms
K_d	Rate of decay	η	Efficiency
K_l	Loss coefficient	θ	Nominal hydraulic retention time
L	Length	θ_c	Mean cell residue time
N	Speed	μ	Viscosity
O	Over flow rate	ρ	Desity
P	Power	Abbreviations	
Q	Flow rate	BOD	Biochemical oxygen demand
Q_w	Sludge waste rate	D.C	Distribution chamber
Q_0	Influent to secondary tank	P.S.T	Primary sedimentation tank
Re	Reynolds number	S.S.T	Secondary sedimentation tank
R_h	Hydraulic radius	Temp.	Temperature
S	Slope		
[S]	Concentration of a limiting substrate or nutrient	Subscripts	
[S_0]	Inflow concentration of substrate	t	Tank