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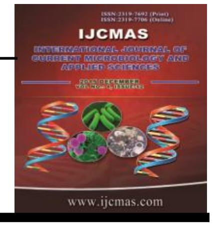

Original Research Article

Assessment the Viability of Wastewater Treatment's Different Technologies for Small Communities

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Keywords

Wastewater treatment, Technologies, performance, Effluent, evaluation

A B S T R A C T

The aim of this study is to evaluate the performance of wastewater treatment technologies in four governorates in Egypt, which are Kafr El-Sheikh, Al-Gharbia, El-Fayoum, and El-Sharqia. More than 25 full-scale wastewater treatment plants of discharges ranged between 978 and 6000m^3/day including oxidation ditches, oxidation ponds, aerated lagoons, extended aeration, conventional aeration, rotating biological contactors (RBC), upward-flow anaerobic sludge blanket reactor (UASB), and compact units were assessed. The assessment has been carried out to get the optimum wastewater treatment technology for small and rural communities; and also for the improvement of wastewater quality to provide safe wastewater reuse. The performance evaluation was done on the basis of removal efficiency of biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS).Experimental results indicated that the wastewater treatment compact unit achieved the highest removal efficiency in terms of BOD, COD, and TSS which were 96.42%, 96.59%, and 95.47%, respectively. On the other hand the oxidation ponds recorded the lowest removal efficiency of BOD, COD, and TSS were 57.99%, 74.17%, and 50.13% respectively.

Introduction

Wastewater treatment in Egyptian villages represents a dangerous challenge to environment and public health. A limited percentage of villages have recent facilities for safe collection and wastewater treatment. The number of rural wastewater treatment plants in operation may not exceed 500, while the total number of villages exceeds 5,500, so the number of desired sewer systems in villages is far greater than the number of established wastewater treatment plants.

Wastewater is sewage originates from household wastes, human and animal wastes, Industrial wastewaters, storm runoff, and groundwater infiltration (Metclaf, 2003).Wastewater treatment technologies varied according to design organic loading. Activated sludge technology has many modifications (El-Sayed, 2010). Oxidation ditch is a modified activated sludge biological treatment process that utilizes long solids retention times (SRTs) to remove biodegradable organics (EPA, 2000).

It consists of an aeration single or multi channel configuration within a ring, oval, or horseshoe-shaped basin with one or more rotating rotors for wastewater aeration (Bitton, 2005). Extended aeration is used primarily to treat wastewater flows from small residential communities. Process aeration is extended to 24 hours or more (Mackenzieand Davis, 2010). It is just one form of the conventional aeration system (Ukpong, 2013). In this system screened raw sewage are fed into the aeration tank without primary clarifiers and maintained for a period much longer than the case of the conventional process. The rate of return sludge is high. Oxidation ponds detention time is usually 5 to 30 days. The ponds receive no more pre-treatment than screening. The system is a symbiotic relationship between heterotrophic bacteria and algae. Organic matter in wastewater is decomposed by bacterial activities, including both aerobic and anaerobic. The ponds can be classified in to: aerobic, facultative, and anaerobic and maturation or tertiary ponds (Hegazy, 2010; Okafor, 2011). Facultative ponds are Ponds 1 to 2.5 m deep, which have an anaerobic lower zone, a facultative middle zone, and an aerobic upper zone maintained by photo synthesis and surface re-aeration. Anaerobic ponds are Deep ponds that receive high organic loadings used primarily as a pretreatment process and are particularly suited for the treatment of high-temperature, high-strength wastewater.

Maturation or tertiary ponds are used for polishing effluent from other biological processes. It receives wastewater effluent from secondary treatment systems Aerated lagoons are Ponds oxygenated through the action of surface or diffused air aeration. They are widely used for small rural communities up to populations of about 2,000 (Mackenzieand Davis, 2010). RBCs consist of a series of closely spaced discs (3 to 3.5 m in diameter) mounted on a horizontal shaft. The discs are rotated while about one-half of their surface area is immersed in wastewater (Sukumaran et al., 2015).The discs are typically constructed of lightweight plastic. It has been found that the biomass composition of the discs within the RBC plays a major role in the organic biodegradation (Cortez et al., 2008). The speed of rotation of the discs is adjustable. When the process is placed in operation, the microbes in the wastewater begin to adhere to the rotating surfaces and grow there until the entire surface area of the discs is covered with a 1 to 3mm layer of biological slime (Rongjun et al., 2015).

UASB operates as a suspended growth system where micro-organisms attach themselves to each other or to small particles of suspended matter to form agglomerates of highly settle able granules that form an active sludge blanket at the bottom of the reactor the gas formed causes sufficient agitation. To keep the bed fully mixed. In the UASB process, the waste to be treated is introduced in the bottom of the reactor (Ketan et al., 2014). The waste water flows upward through a sludge blanket composed of biologically formed granules or particles.

The gas, produced under anaerobic conditions, causes internal circulation which helps in the formation and maintenance of biological granules. The free gas and the particles attached with the attached gas rise to the top of the reactor (Pandya et al., 2011). The success of the UASB reactor is because of its high removal efficiency even at light loading rates and low temperature, low energy consumption, low sludge production, low space requirements and low nutrients compared to aerobic treatment (Kathikeyan and Kandasamy, 2010).

Materials and Methods

Egypt's governorates are enriched with various wastewater treatment facilities especially those of Kafr El-sheikh, El-Gharbia, El-Fayoum, and El-Sharqia which lie in the north and the middle Delta, Egypt. More than 25 full-scale wastewater treatment plants of discharges ranged between 978 and 6000m^3/day were assessed. The investigated WWTTs were distributed as follows: Four oxidation ponds (O.P.) WWTPs lied in El-Fayoum governorate. Two aerated lagoons (A.L.) WWTPs lied in El-fayoum and Kafr El-Sheikh. Ten oxidation ditches (O.D.) WWTPs lied in Kafr El-Sheikh governorates. Five extended aeration (Ext. Aer.) plants at El-Gharbia governorate. Two conventional aeration (Conv. Aer.) system WWTPs lied in El-Fayoum and EL-Gharbia governorates. Two RBC WWTPs at El-Gharbia governorate. Two UASB WWTPs located at El-Gharbia and El-Fayoum governorates, and one wastewater treatment compact unit (C.U.) at El-Sharqia governorate. This assessment of WWTTs had been carried out to get the optimum WWTT for small and rural communities and also for the improvement of the treated wastewater quality to provide safe wastewater reuse. The collected data include the description of each WWTP such as actual and designed discharges, main components with dimensions. The experimental study was conducted using collected samples from the influent and effluent flow of the WWTPs by the Holding Company of Water and Wastewater under the authority of the Holding Company of Sanitary Drainage in Cairo, supervised sampling, following and performing the chemical analyses, Operation, maintenance, and collecting the data in the laboratory of each WWTP. Samples were collected from the WWTPs in the months of summer and winter (S&W) which were February and September of the year 2013, the chemical parameters BOD, COD, and TSS were measured periodically.

Results and Discussion

The evaluation has been done through two branches; the first branch was the laboratory analyses that include the average summer and winter BOD, COD, and TSS concentrations and the average removal efficiency have been deduced for eight wastewater treatment technologies to be assessed. The second branch is evaluation the most economical alternative of the different wastewater treatment technologies. The value engineering was the used approach. The value engineering can be defined as the systematic application of recognized techniques which identify the function of a product or service, establish a value for that function, and provide the necessary function reliability at the least overall cost (Cooper and Slagmulder, 1997). Some chemical parameters were taken for comparison because of their high selectivity as point of efficiency of treatment.

Effect of Sewage Plant Variation on BOD_5 Concentration

Figure (1) represents the concentrations of BOD_5 in the raw and treated wastewater for the eight WWTTs. The average concentrations of BOD_5 of the raw wastewater ranged from 275.125 to 629 mg/l. After treatment, wastewater treatment compact unit secured an average of 22.5 mg/l O.D. Plants secured 23.31 mg/l, while A. L. treatment plants secured 41.6 mg/l. the 4th group of RBC secured an average of 48.5 mg/l.

Figure (2) showed that the highest BOD removal was obtained from the wastewater treatment compact unit plants with about

96.42%.This reflects an excellent performance during all the treatment stages. This might be attributed to the post tertiary treatment using ultra filtration, moderate organic loading, and sufficient follow-up. While O.D. achieved high BOD removal efficiency equal 95.02%.This performance was higher than expected according to other studied case histories that recorded 94.9 % average removal efficiency of BOD_5 (Hegazy, 2010). A. L. achieved a reasonable BOD removal equal to 88.84% despite the high organic loading in some plants like El-Hasafa. RBC technology achieved a high BOD removal equal to 88.84% when compared with Rongjun et al., (2015) who investigated that RBC achieves BOD removal efficiency equal to 85%. Ext. Aer. technology gives a moderate evidence for its performance and secured BOD removal efficiency equal to 86.71%, so the removal efficiency of BOD was lower than expected according to other case histories that recorded (92-97.7%) average removal of BOD, demonstrated in (Hegazy, 2010; Al-Sa'ed and Tomaleh, 2012). Conv. Aer. System Showed unexpected performance of BOD removal efficiency which was 80.40%, this was lower than that reported in the literature that showed BOD% ranged between 85 and 97 %, as mentioned in (Metcalf, 2003; Silvia et al., 2011). The UASB system gives removal efficiency of BOD equal to 62.62%. This result showed that BOD removal efficiency of UASB system was within the limits of BOD% which ranges between 60 and 75 %, as it was mentioned in (Metcalf, 2003; Silvia et al., 2011). Finally O.P. achieved the worst BOD removal efficiency which was57.99%.

Effect of Sewage Plant Variation on COD Concentration

Figure (3) illustrates the concentrations of COD in the raw and treated sewage in the 8WWTTs. The average concentrations of COD of the raw sewage ranged from 674 to 915 mg/l. Compact unit plants secured an average of 29 mg/l in the treated sewage. O.D plants secured 42.42 mg/l, while A. L. and RBC treatment plants secured 73 mg/l. the 8th group of O.P secured an average of 145 mg/l.

Figure (4) showed that the best COD removal efficiency was obtained from the compact unit plants with about 96.59%.This reflects an excellent performance during all the treatment stages. While O.D. achieved high COD removal efficiency equal to 93.98%.This performance was higher than expected according to other studied case histories that recorded 85.60 % average removal efficiency of COD (Metcalf, 2003). A. L. achieved a reasonable COD removal equal to 92.04% despite the high organic loading in some plants like El-Hasafa. RBC achieved a high COD removal equal to 89.23% when compared with (Rongjun et al., 2015) who investigated that RBC achieves COD removal efficiency ranged between 60 and 80%%. Ext. Aer. Technology gives a good performance and secured COD removal efficiency equal to 87.91%, so the removal efficiency of COD was within the limits according to other case histories that ranged between 85.5 and 91%average removal of COD, demonstrated in (Hegazy, 2010; Al-Sa'ed and Tomaleh, 2012). Conv. Aer. System showed a low COD removal efficiency equal to 83.19%, unlike it was higher than the BOD removal efficiency, this value of COD removal was lower than that reported in the literature that showed COD % ranged between 87 and 93 %, as mentioned in (Metcalf, 2003; Silvia et al., 2011). O.P. achieved COD removal efficiency equal to74.17%, so the COD removal efficiency was higher than that of BOD removal efficiency. Finally, the UASB system gives the lowest removal efficiency of COD that was equal to 72.41%.Although this result showed that COD removal efficiency of UASB system was within the limits of COD % which ranges between 60 and 75 %, as it was mentioned in (Metcalf, 2003; Silvia et al., 2011).

Effect of Sewage Plant Variation on TSS Concentration

Figure (5) showed the concentrations of COD in the raw and treated sewage in the 8WWTTs. The average concentrations of COD of the raw sewage ranged from 221.31 to 435 mg/l. After treatment, compact unit plants secured an average of 21.5 mg/l. O.D plants secured 26.64 mg/l, while A. L. treatment plants secured 40.5 mg/l. RBC secured an average of 46.75 mg/l.

Figure (6) demonstrated that compact unit plants recorded the highest TSS removal about 95.47%.While O.D. achieved high TSS removal efficiency equal to 91.24%.This performance was higher than expected according to other studied case histories that recorded 85.6 %average removal efficiency of TSS (Hegazy, 2010). A. L. recorded a reasonable TSS removal equal to 90.62%.While Ext. Aer. technology secured TSS removal efficiency equal to 87.40%, so the removal efficiency of TSS were lower than expected according to other case histories that recorded94.8 %, as mentioned in (Hegazy, 2010; Al-Sa'ed and Tomaleh, 2012). RBC technology achieved a good TSS removal equal to 87.21%.Conv. Aer. System Showed unexpected performance of TSS removal efficiency which was 72.95%, this was lower than that reported in the literature that showed TSS% ranged between 80 and 93 %, as mentioned in (Metcalf, 2003; Silvia et al., 2011). The UASB system gives removal efficiency of TSS equal to 71.69%. This result showed that TSS removal efficiency of UASB system was within the limits of TSS% which ranges between 65 and 80 %, as it was mentioned in (Metcalf, 2003; Silvia et al., 2011). Finally O.P. achieved the worst TSS removal efficiency which was50.13%.

Effect of Sewage Plant Variation on Total Average Removal Efficiencies of BOD, COD, and TSS

Table (I) and figure (7) summarize, in a similar way, the hall applied technologies. The average influent, effluent concentrations and the removal ratio percentage in terms of BOD, COD, and TSS parameters have been evaluated. It was recognized that compact unit WWTP recorded the highest total percent removal which was 96.16%. This might be attributed to the post tertiary treatment using ultra filtration, availability of chemicals and spare parts to ensure ideal operational conditions and regular maintenance period. On the other hand, the oxidation ditches WWTPs have enjoyed consistently good results insofar as reliability and performance are concerned. The total percent removal recorded 93.41%.This might be due to the long solids retention times (SRTs) to remove biodegradable organics. Meanwhile, Oxidation ditches have typically complete mix systems and constant water level. This technology has a continuous discharge which lowers the weir overflow rate and eliminates the periodic effluent surge (EPA, 2000). Aerated lagoons technology significantly gives expected values for total percent removal which were 90.50%. This technology contains El-Hasafa WWTP which has been excluded due to its high organic loading, which significantly affected its performance. This can be explained by the high organic loading of the raw water influent that contains animal's wastes with very large quantities. This high organic loading produces high rates of Ammonia, heavy metals, H_2S. As a result, the plant consumes high quantities of Chlorine. This leads to the presence of high levels of Ammonia in effluent. On the other hand, the surface aerators do not generate oxygen with sufficient quantities to complete mixing in the aeration tank and complete the biological process (Fawzy, 2014). After that rotating biological contactors system achieves considerable total percent removal that is equal to 88.41%. It was reported that RBC performance may be due to Proper thickness that should be about 2 mm. If too thick, there may be loss of adhesion of the bio-films which may cause them to separate from the bio-discs then loss of biomass in basin, the sludge age was roughly 28–35 days so this resulting in slow treatment rate. Other factors such as the spinning speed of the bio-discs should be 1 rpm, and the bio-discs material should be noncorrosive materials. Hydraulic retention time, high temperature increase the bio-degradation by the bacteria, no. of stages and hydraulic loading also influence the treatment effectiveness (Tawfik et al., 2006; Cortez et al., 2008; Rongjun et al., 2015).

The extended aeration system comes after that in the arrangement gives a moderate evidence for its performance and secured a total percent removal equal to 87.84%. This performance may be attributed to the low mixed liquor suspended solids (MLSS) which should be within the range of 31000mg/l. the solids retention time (SRT) and the oxygen concentrations in the aeration tank also may be the reason for the low performance where SRT ranges from 24-30hrs.Conventional Aeration system performance was unexpected. The total percent removal recorded 78.85%.This type of treatment achieved low performance because it was represented with two WWTPs named Zawyat El-Karadsa at El-Fayoum governorate and El-Moatamadia at El-Gharbia governorate. Those plants have not worked satisfactorily. This problem may be attributed to problems in this plants' operation. Where there was a malfunction or damage in two from six mechanical surface aerators of the aeration tank. This absolutely leads to non contact and a less diffusion between the air oxygen and the water surfaces to give the chance to the bacteria to degrade the organic constituents on the aeration tank. On the other hand, there was a low influent flow that was equal to 1280m^3/day for Zawyat El- Karadsa and 2000m^3/day for El-Moatamadia. This actual flow was lower than the designed one. It was equal to 3000m^3/day Zawyat El-Karadsa and 4000m^3/day for El-Moatamadia. These problems make achieving of high removal efficiencies more difficult. This low performance can be due to the Biological foams or scums, formed on the liquid surface of activated sludge plants. The stable foam is grey to cream-brown in color, quite heavy in consistency and up to 30cm deep. The scum or foams appear on the aeration tank and then eventually cover most of the liquid surfaces including that of the final effluent from the plant (Mackenzie and Davis, 2010). Activated sludge is highly recommended for treatment of big discharges produced from large cities (Fawzy, 2014). During this study, it was observed that the system of UASB WWTT gives total percent removal equal to 64.28%. Meanwhile, Oxidation ponds recorded the lowest total percent removal that is equal to 60.76%; so this was the worst technology among the all applied systems for small communities in Egypt. These results may be attributed to the improper cleaning of the pond's surfaces and the over flow at some plants like El-Lahon and Kotta. This over flow means high organic loading more than the designed one. This also means achieving a low performance and so bad results.

Table.1 Mean BOD, COD, and TSS Removal Efficiencies, According to the Treatment Technologies

Item No	WWTT	BOD removal %	COD removal %	TSS removal %	Total average Removal efficiencies	order of the system
1	C. U.	96.42	96.59	95.47	96.16	**1**
2	O. D.	95.02	93.98	91.24	93.41	**2**
3	A. L.	88.84	92.04	90.62	90.50	**3**
4	RBC	88.78	89.23	87.21	88.41	**4**
5	Ext. Aer.	86.71	87.91	87.40	87.34	**5**
6	Conv. Aer.	80.40	83.19	72.95	78.85	**6**
7	UASB	62.62	58.53	71.69	64.28	**7**
8	O. P.	57.99	74.17	50.13	60.76	**8**

Table.2 Values of Points of Comparison

Point of Comparison	**Code**	**Alternatives**							
		O. D.	**O. P.**	**A. L.**	**Ext. Aer.**	**Conv. Aer.**	**RBC**	**UASB**	**C. U.**
Electricity Consumption (kW/h/m^3)	A	**0.412**	**0.155**	**0.310**	**0.440**	**0.314**	**0.0785**	**0.5**	**0.08**
Required Area (m^2/m^3)	B	**6.839**	**25.437**	**28.225**	**3.671**	**4.55**	**2.273**	**12.18**	**0.167**
Labor Productivity (m^3/Worker)	C	**210**	**1566**	**342**	**240**	**338**	**333.33**	**333.33**	**50**

Table.3 The Weight of the Desired Criteria

	A	B	C
A		A-2	A
B			C-2
C			

Table.4 The Normalized Weight of each Point in Percentage

Point of Comparison	Raw Weight	Normalized Weight
Electricity (A)	3	60.00 %
Area (B)	0	0.00 %
Productivity (C)	2	40.00 %
Total	5	100 %

Table.5 Ranks of Points of Comparison

Point of Comparison	Code	Alternatives							
		Oxidation Ditches	Oxidation Ponds	Aerated Lagoons	Extended Aeration	Conventional Aeration	RBC	UASB	Compact Unit
Electricity Consumption ($KW/h/M^3$)	A	**1.91**	**5.06**	**2.53**	**1.78**	**2.50**	**10.00**	**1.57**	**9.81**
Required Area (M^2/M^3)	B	**0.24**	**0.07**	**0.06**	**0.45**	**0.37**	**0.73**	**0.14**	**10.00**
Labor Productivity (M^3/Worker)	C	**1.34**	**10.00**	**2.18**	**1.53**	**2.16**	**2.13**	**2.13**	**0.32**

Table.6 Score of Alternatives

Points of comp.	Weight	Alternatives															
		Oxidation Ditches		Oxidation Ponds		Aerated Lagoons		Extended Aeration		Conventional Aeration		RBC		UASB		Compact Unit	
		Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Elec.	60.00%	1.91	114.3	5.06	303.87	2.53	151.93	1.78	107.04	2.50	150	10.00	600	1.57	94.2	9.81	588.7
Area	0.00%	0.24	0	0.07	0	0.06	0	0.45	0	0.37	0	0.73	0	0.14	0	10.00	0
Labor Prod.	40.00%	1.34	53.64	10.0	400	2.18	87.356	1.53	61.30	2.16	86.33	2.13	85.14	2.13	85.14	0.32	12.77
Total	100.00%		**167.96**		**703.87**		**239.29**		**168.34**		**236.33**		**685.14**		**179.3**		**601.5**

Fig. 1 Effect of Sewage Plant Variation on BOD5 Concentration

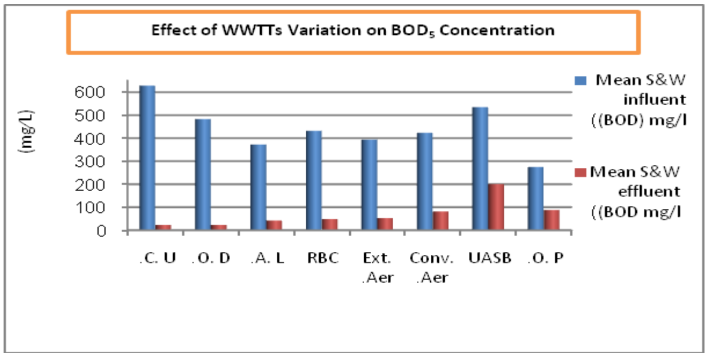


Fig.2 BOD5 Removal Efficiency of Different Technologies

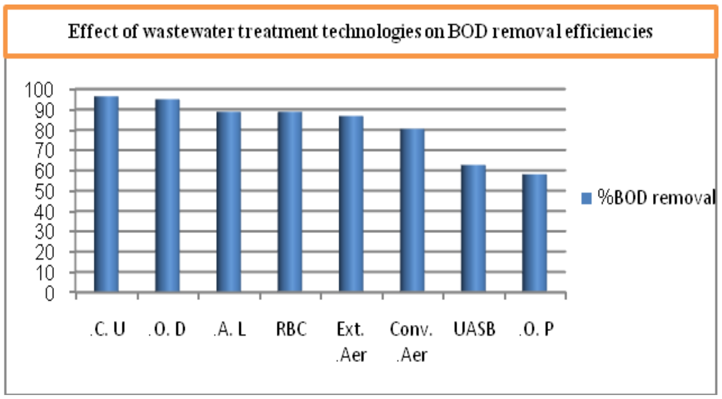


Fig.3 Effect of Sewage Plant Variation on COD Concentration

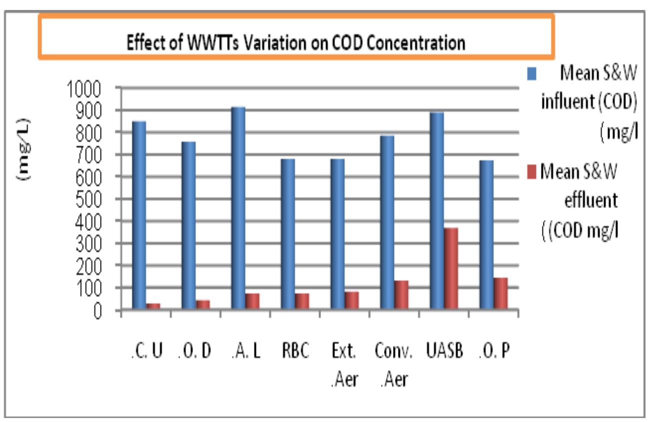


Fig.4 COD Removal Efficiency of Different Technologies

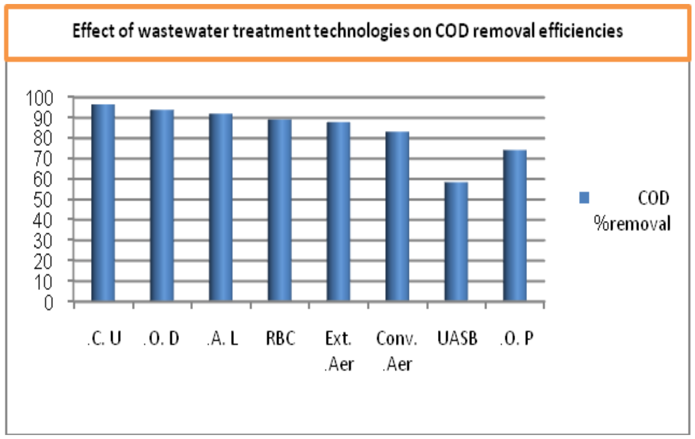


Fig. 5 Effect of Sewage Plant Variation on TSS Concentration

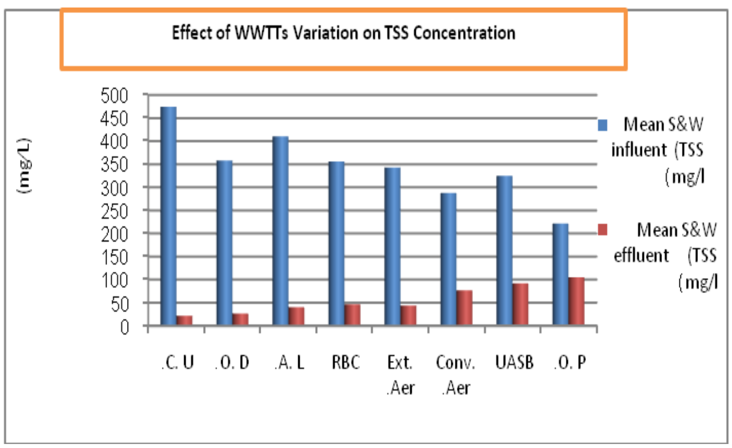


Fig.6 TSS Removal Efficiency of Different Technologies

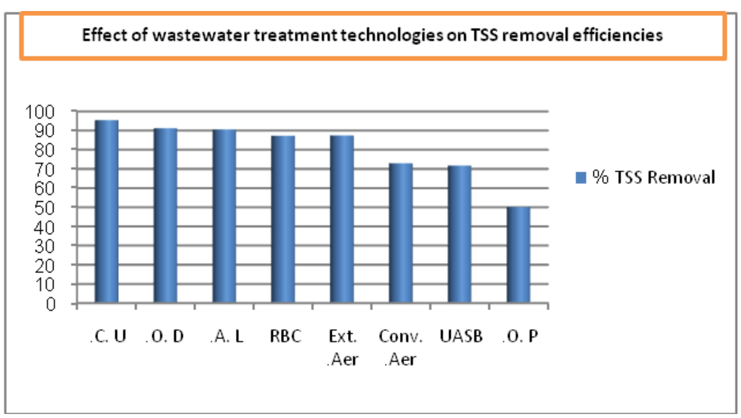
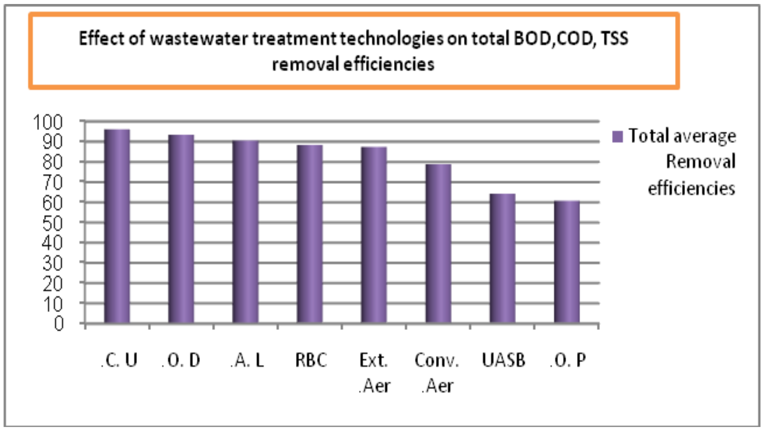


Fig.7 Effect of Different WWTTs Variations on total BOD, COD, and TSS Removal Efficiencies



Economical Evaluation of Different Plant Groups

The points of comparison are the average electrical power consumed to treat 1 m^3 of wastewater in kW/hr, the average required land space in m^2 to treat 1 m^3/d of wastewater, and the labor daily productivity of treated wastewater in m^3/worker. The values are shown in table (II). The evaluation methods steps are the weight of the desired criteria and the analysis of the desired criteria. In the first step, the weight of the desired criteria has been extracted from Table (III), in which the mutual weight factors of each point of comparison against the others are presented. From Table (III), it was concluded that the element (A) which is the electricity consumption has a weight factor that is two times superior to that of element (B), which is the area of land. This means that the running cost of the electricity consumption is more important than initial cost of the land, based on rough estimate of the initial and running cost during the whole design period of the project. Also, the element (A) which is the electricity consumption has a weight factor that is one time superior to that of element (C) which is the labor productivity. On the other hand, element (C), which is the labor productivity has a weight factor that is two times superior to that of element (B) which is the area of land. The total weight factor of each item depends on the total number of times that it was mentioned in the Table (IV). This means that the raw weight of element (A) is 3, the raw weight of element (B) is 0, and the raw weight of element (C) is 2. In Table (IV), the normalized weight of each point in percentage has been introduced. Sources: (Cortez et al., 2008; Hegazy, 2010; Fawzy, 2014).

In the second step, the average values of each element are transformed to rank based on the ratios between values presented in Table (II). And these ranks are presented in Table (V). The analysis completes by calculating the total score of each alternative, which equals the summation of the normalized weight multiplied by the rank of each element of comparison, as presented in Table (VI). The alternative that gets the highest score should be the best alternative under the normal conditions. From Table (VI), the oxidation ponds, rotating biological contactors and compact unit systems have the highest scores. Under the normal conditions, the oxidation ponds and rotating biological contactors systems are the most appropriate alternative at the least cost, while the oxidation ditch is the most expensive appropriate system. It was expected that variations in the treatment, construction, and design in the sewage plants may lead to a difference in quality of treated wastewater. Also, irregular timing and operation of pump stations that introduce wastewater to the plants may create over flow and create problems in the treatment. Most of the results for the treated sewage showed a high efficiency treatment with high percentage of removal of organic matter and suspended solids. The change in type and design of plant have nearly no effect on the final effluent. The efficiency may increase by a good trained staff, good management and availability of spare parts to ensure a good operation and regular maintenance period (Hegazy, 2010).

In conclusion, the study indicates that all major pollutants were reduced in the wastewater after treatment to the BOD, COD and TSS. Hence study concludes: The performance of the wastewater treatment compact unit WWTT was the best one for the discharges below 500m3/d. the overall removal efficiencies of BOD was 96.42%; COD was 96.59% and TSS was 95.47%. This technology is applied for the packaged plants. The oxidation ditch technology has been proved a great performance for different contaminants. The average removal efficiency of BOD was 95.02%; COD was 93.98, and TSS was 91.24 %. The performance of the aerated lagoons was reasonable. The average removal efficiencies were BOD was 88.84%; COD was 92.04%, and TSS was 90.62%.The rotating biological contactors showed a good performance in terms of BOD, COD, and TSS removal, with significant percentages equal to 88.78%, 89.23%, and 87.21%, respectively. The performance of extended aeration technology was moderate and secured a BOD equal to 86.71%, COD equal to 87.91% and 87.40% for TSS removal efficiency. This performance was lower than expected. The performance presented by the conventional aeration plants, considering organic matter removal, was significantly un expected among the evaluated systems, this system recorded removal efficiencies for BOD equal to 80.40%; COD equal to 83.19%, and 72.95% for TSS removal efficiency. The UASB reactors showed low BOD and COD removal efficiencies and a poor performance regarding TSS. The performance achieved by the UASB reactors was equal to 72.41% for BOD average removal efficiency; 72.33% for COD, and 47.78% for TSS average removal efficiency. UASB process provides a suitable method to treat wastewater with high concentration of suspended solids. The oxidation ponds have achieved the worst performance among all the studied technologies with a removal values equal to 59.99% for BOD; 74.17% for COD, and 50.13% for TSS. But it is more suitable and applicable for the villages with slightly high temperatures.

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