Stable Performance of the Oxidation Ditch Process in Egypt

Ashmawy, M.A[1], Khalil. K.H[2], Aly, O.H[2] and Metwally, M.F[2]

[1]Civil Department, Faculty of Engineering, Helwan University
[2]Civil Department, Higher Institute of Engineering – El-Shorouk Academy
mashmawy95@yahoo.com

Abstract: Egypt is deeply suffering from the lack of proper wastewater collection and treatment facilities especially in rural areas. Several factors have been responsible for the relatively slow progress rate in implementation of waste water collection and treatment units. The most important one is the escalating cost of providing the needed services. The continuous discussions and comparisons along the last twenty years between the centralization against the de- centralization wastewater systems did not lead to fixed conclusion due to the wide range of parameters those changes from one location to another. Not only the huge initial construction cost of the centralized waste water treatment plants and the area required are the only governing factors, but the operation and maintenance, power requirements and roots for sewage force mains from the different villages in the cluster also has to be deeply investigated. Optimization of the application of wastewater treatment techniques in their different categories primary, secondary and tertiary is a must for the strategic planning of the country. The main objective of this research is to assess the performance of the oxidation ditch technology as a treatment process applied in Delta, Egypt. Four wastewater treatment plants with different design capacities ranging between two thousand to 12000 m³/d were selected for assessment where the oxidation ditches were found to be highly recommended for the treatment of discharges less than 12000 m^3/day.
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1. Introduction

Egypt is deeply suffering from the lack of proper wastewater collection and treatment facilities especially in rural areas. More than 40 % of the Egyptian rural areas are not served that represents about 4000 Egyptian villages with a population ranging from 1,000 to 20,000 capita suffering from the lack of wastewater collection and treatment facilities. In general the gap remains remarkable between what is required and what has been attained in that field [1].Several factors have been responsible for the relatively slow progress rate. The most important one is the escalating cost of providing the needed facilities. Implementation of centralized wastewater systems is considered an obstacle for the Egyptian government due to high operation, structure and maintenance costs. Optimization of the application of wastewater treatment techniques in their different categories primary, secondary and tertiary is highly recommended for the strategic planning of the country, future feasibility studies, design purposes and implementation [1].

The principal objective of waste water treatment is generally to allow domestic and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. Conventional systems such as oxidation ditch, activated sludge, trickling filter and aerated lagoons used for sewage treatment are based on the electrical power and use of chlorine for disinfection, civil constructions directed processes such as oxidation ponds is considered a nonconventional system, where the treatment plants works with minimum need for electrical power, chlorine and operators[2].

The oxidation ditch is a type of equipment used for a long-term aeration. It consists of a long channel of an elliptical or circular shape equipped with aeration equipment called a rotor for generation of water flow and stirring water in the channel to supply oxygen. Although the process requires a relatively large area; it has a simple structure and can be easily operated as well as being able to remove nitrogen within the process and this is why it has been widely used in Delta Egypt recently [3].

In 2004, Abdel Ghaly and Ashley Thistle studied the effect of various design and operation parameters on the oxygenation capacity of the oxidation ditch system. A bench scale oxidation ditch system equipped with a disc aerator was used to gain better understanding of the phenomena of oxygen transfer and to study the effects of whole diameter, number of holes per disc, disc thickness, disc speed, immersion depth and number of discs on the oxygenation capacity of the system. The unsteady state method with sulphite oxidation was used to deoxygenate the water. The test involved chemical removal of dissolved oxygen from water followed by oxygenation. The power consumed was measured,

the oxygen transfer coefficient was determined and both the oxygenation capacity and oxygenation efficiency were calculated. According to the result of this bench scale the use of sodium sulphite with cobalt chloride for de oxygenation of the water via the oxidation ditch was effective and the results were very consistent and repeatable. The system is anticipated to provide a broad range of oxygen transfer rates under actual conditions (23-164 mgO2/L-h) to meet varying process demands encountered in aerobic treatment systems. [4]

Shen Lian-feng el al.,[2011], studied the efficiency of the Wu Long Kou sewage treatment plant in nitrogen and phosphorus removal using an improved oxidation ditch process where they found out that the processes was able to overcome the contradictions in the traditional nitrogen and phosphorus removal process. In a two years evaluation period the plant has effectively controlled the operation problems achieving stable operation, good water quality and high efficiency of nitrogen and phosphorus removal with a minimum footprint and very low investing expenses and operating cost. [5]

M. A. Ashmawy el al., [2014] compared between different types of waste water treatment processes where they concluded that the oxidation ditch process was suitable for application in treatment of the Egyptian villages with capability of achieving removal efficiencies up to 94.3 %, 94.3 % and 89.4 % for BOD, COD and TSS respectively.[6]

The main objective of this research is to assess the performance of the oxidation ditch technology as a treatment process wildly applied in Delta, Egypt.

2. Materials and Methods

Oxidation ditch system is one of the widely applied systems in Delta, Egypt especially in the cities and big villages. In Kafr Elshaikh governorate the oxidation ditch process is applied in different capacities to serve both moderate and small population in cities and villages. A wide range of oxidation ditch capacities are already in use ranging from two thousands m³/d up to12000 m³/d. Four plants were selected for evaluation of the processes with different design capacities named El-Riad, Sanhur Al-Madina, Sidi Ghazi and Shabas Al-Malh, located at Kafr Elshaikh governorate, Egypt.

Work Plan:

To conduct the desired evaluation a list of factors and analyses was prepared and results from the different laboratories operated by the governmental operation companies where collected for TSS, BOD and COD. Tables [1] to [4] show the characteristics of the influent and effluent flow for each plant.

Table (1): EL Riad WWTP Influent Characterization & Removal Efficiency (Design flow 10000 m³/d /-Actual flow 6000 m³/d)

	Time	September 2012	October 2012	November 2012	December 2012	January 2013	February 2013	Average
Influent	BOD (mg/l)	248	177	200	237	220	223	217.50
	COD (mg/l)	538	415	430	456	460	540	473.17
	TSS (mg/l)	246	169.8	148.4	136.2	156.6	161.08	169.68
Treatment Efficiency	% BOD Rem.	87.1	91.5	86.5	91.9	89.5	91.03	89.59
	% COD Rem.	92	92.5	89.7	91.45	92.4	94.3	92.06
	% TSS Rem.	85.7	89.4	85.8	86.05	84	83.85	85.80

Table (2):Sanhur Al-madina WWTP Influent Characterization & Removal Efficiency (Design flow 6000 m³/d -Actual flow 4600 m³/d)

	Time	September 2012	October 2012	November 2012	December 2012	January 2013	February 2013	Average
Influent	BOD (mg/l)	285	355	365	375	353	373	351.00
	COD (mg/l)	432	538	828	845	815	808	711.00
	TSS (mg/l)	137	151	155	191	223	262	186.50
Treatment Efficiency	% BOD Rem.	90.5	91.8	96.4	96.8	96	95.4	94.48
	% COD Rem.	90.5	92	94.2	94.4	94	94.5	93.27
	% TSS Rem.	71.5	76.8	84.5	87.4	90.5	93.5	84.03

Table (3): Sidi Ghazi WWTP Influent Characterization & Removal Efficiency (Design flow 3000 m³/d-Actual flow 2100 m³/d)

	Time	September 2012	October 2012	November 2012	December 2012	January 2013	February 2013	Average
Influent	BOD (mg/l)	290	220	282	247	360	372	295.17
	COD (mg/l)	450	352	445	450	550	455	450.33
	TSS (mg/l)	203	182	223	206	300	310	237.33
Treatment Efficiency	% BOD Rem.	81	84	84	80.6	96.7	97.3	87.27
	% COD Rem.	83.1	83	84.3	82.9	90.9	90.1	85.72
	% TSS Rem.	82.2	85	83.7	81.6	97	97.7	87.87

Table (4): Shabas Al-malh WWTP Influent Characterization & Removal Efficiency (Design flow 2000 m³/d-Actual flow (1450 m³/d)

	Time	September 2012	October 2012	November 2012	December 2012	January 2013	February 2013	Average
Influent	BOD (mg/l)	320	350	360	380	370	310	348.33
	COD (mg/l)	728	525	612	620	640	510	605.83
	TSS (mg/l)	345	112	122	187	170	140	179.33
Treatment Efficiency	% BOD Rem.	91.2	93.5	95	95.8	94	89.7	93.20
	% COD Rem.	89.3	94	93.13	93.5	92.6	90	92.09
	% TSS Rem.	88	89.3	78.7	88.2	87.6	86.4	86.37

3. Results and Discussion

The study resulted in a comparison between the four oxidation ditches wastewater treatment plants for the removal efficiency of BOD, COD and TSS. Figures (1) to (3) shows the plotting of the results, where in general the ratio between the BOD and COD concentrations was in the rational range and figures represented typical values for the Egyptian Cities. However it should be noted that for Sanhur Al-Madina WWTP where the values recorded for COD were higher than the average values for the rest of the plants and this was referred to the direct discharge of raw animal wastes to the collecting sewers system. It should be also noted that Egypt has suffered from interrupted power supply and routine failure in electricity along the country during the period of study and this has caused some non-homogeneous records of the performance of the four plants.

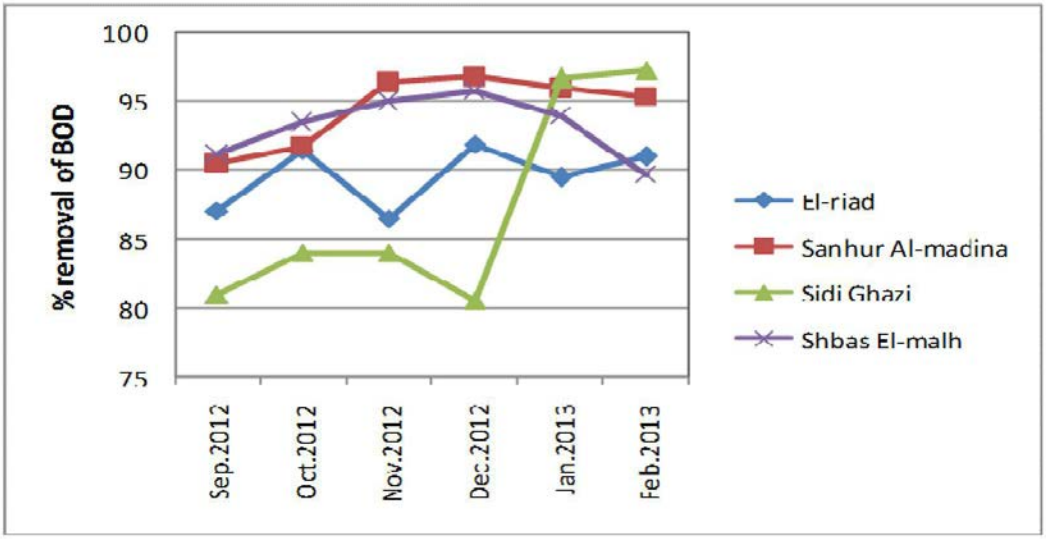

Fig (1): BOD Removal Efficiency

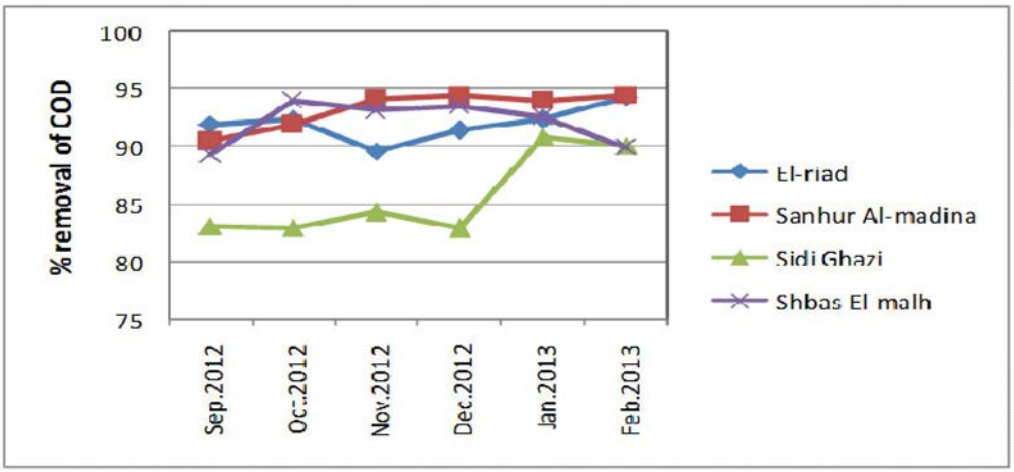

Fig (2): COD Removal Efficiency

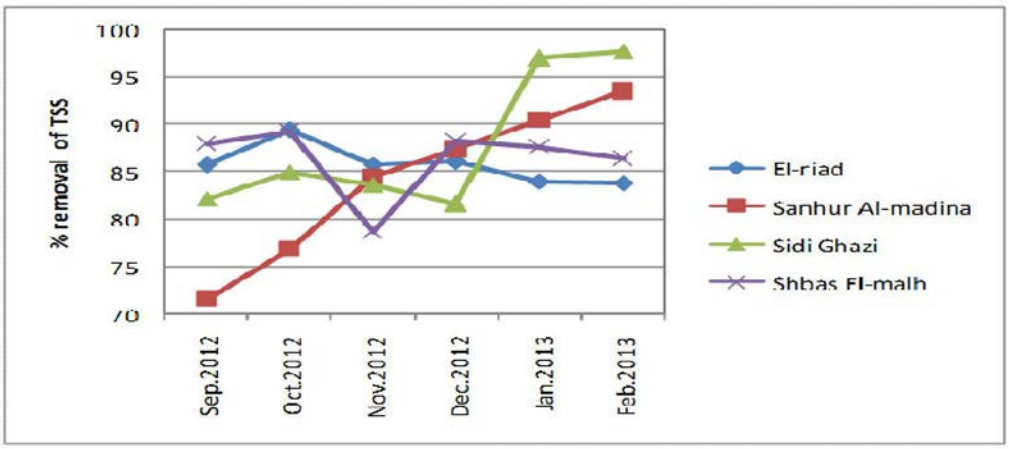

Fig (3): TSS Removal Efficiency

As shown in figures (10 to (3) the influent TSS for El Riad WWTP ranged from 136 to 246 mg/l, while the influent BOD ranged from 177 mg/l to 248mg/l and COD ranged from 415 to 540 mg/l. Results showed high removal efficiency for the three parameters where removal efficiency of BOD ranged from 87% to 92%, while for the TSS ranged from 84% to 89% and for the COD ranged from 90% to 94%. It was noticed that oxidation ditch process applied in this plant proved stable efficiency despite suffering from interrupted power supply and lake of skilled labors.

For Sanhuar El Madina WWTP influent TSS ranged from 137 to 262 mg/l, while the influent BOD ranged from 285 mg/l to 375 mg/l and COD ranged from 432 to 845 mg/l. Results showed that removal efficiency of BOD ranged from 90% to 96%, while for the TSS ranged from 71% to 94% and for the COD ranged from 90% to 94% even with the relative high values of the influent COD.

For Sidi Ghazi WWTP influent T.S.S ranged from 182 to 310 mg/l, while the influent BOD ranged from 220 mg/l to 372mg/l and COD ranged from 352 to 550 mg/l. Results showed high removal efficiency for the three parameters. The removal efficiency of both TSS and BOD ranged between 80% and 98%, and for the COD ranged from 82% to 91%.

For Shabbas Al-malh WWTP, influent T.S.S ranged from 112 to 345 mg/l, while the influent BOD ranged from 310 mg/l to 380 mg/l and COD ranged from 510 to 728 mg/l. Results showed high removal efficiency for the three parameters where removal efficiency of BOD ranged from 90% to 96%, while for the TSSremoval efficiency ranged from 79% to 90% and finally for the COD it was found to range from 90% to 94%.

In general, the oxidation ditch process proved excellent removal efficiency and stable performance under different weather and operation conditions with average removal efficiency of 91%,92% and 86% for BOD, COD and TSS respectively in addition, the

direct discharge of animal wastes to the collection system accompanied by high concentrations of COD did not affect the processes efficiency.

Conclusion and Recommendation

The oxidation ditch process is highly recommended for application in the wastewater treatment of the Egyptian cities and villages dealing with capacities up to12000 m3/ day. The recorded removal efficiency for normal operating conditions reaches to 91% BOD removal, 92% COD removal and 86% TSS removal, with relatively reduced footprint and better space utilization.

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