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Evaluation of Wastewater Treatment Plants in El-Gharbia Governorate, Egypt

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Abstract

The present study has been undertaken to evaluate performance efficiency of wastewater treatment plants in El-Gharbia governorate in Egypt. The wastewater treatment plants using different biological treatment techniques (conventional activated sludge, oxidation ditch, extended aeration, rotating biological contactors and aerated lagoons processes). Wastewater samples were collected from both influent and effluent of each plant and the wastewater quality were determined at central laboratory of Garbyia Water Co. The performance of each plant was estimated based on the treated wastewater quality data. Correlations between influent and effluent TSS, COD and BOD5 were developed. Kotour WWTP operates with the oxidation ditch technology exhibits the highest performance efficiency, while Tanta WWTP operates with conventional activated sludge technology exhibits the lowest one. The results show that, all collected samples from Tanta, and El Mehala El Kobra WWTPs were exceeding the Egyptian Permissible limits (COD: 80 mg/l) while the samples collected from Mehalet Marhom, Mehalet Menof, Kotour, El Santa, Shernak and Zefta were complying the Egyptian regulations.

Keywords: Wastewater treatment; WQI; Plants; Garbyia Governorate

Introduction

There is no truer sign of civilization and culture than good sanitation. A good drain reflects the culture as much as a beautiful statue [1,2]. Wastewater is essentially the water supply of the community after it has been fouled by a variety of uses. The water supplied to a community receives a range of chemical substances and microbial flora during its use such that the wastewater acquires a polluting potential and becomes a health and environmental hazard. Communicable diseases of the intestinal tract such as cholera, typhoid, dysenteries and water borne diseases like infectious hepatitis etc., can be spread from uncontrolled disposal of wastewater, and therefore prevention of communicable diseases and protecting public health attracts the primary objective of sanitary wastewater disposal [2,3].

The sites for disposal of wastewater have traditionally been natural watercourses, land and the coastal waters. One of the major sources of organic pollution is effluents from sewage treatment works. Prevention of pollution of natural resources such as land and water by the wastewater and adequate preparation or renovation of the wastewater before reuse, are further important considerations in formulating and designing appropriate wastewater disposal arrangements [3,4].

Given the characteristics of raw wastewater and the requirements of disposal or reuse, the wastewater usually requires some type of preparation or treatment before it is rendered fit for disposal or reuse. Generally, in many situations involving domestic wastewater, the treatment consists of removal of suspended solids and 5-day, 20°C BOD, which are the two usual parameters of prime interest. The degree of treatment provided to the wastewater will largely be based on the effluent standards prescribed by the regulatory agencies when the treated effluent is to be discharged into a watercourse or land. If the effluent is to be reused, the quality of the effluent required to support such reuse will indicate the degree of treatment necessary. The complete treatment of wastewater is brought by a sequential combination of various physical unit operations, and chemical and biological unit processes. The general yardstick of evaluating the performance of sewage treatment plant is the degree of reduction of BOD, and suspended solids, which constitute organic pollution. The performance efficiency of treatment plant depends not only on proper design and construction but also on good operation and maintenance [5,6].

Performance evaluation of existing treatment plants is required (1) to assess the existing effluent quality and/or to meet higher treatment requirements and, (2) to know about the treatment plants whether it is possible to handle higher hydraulic and organic loadings. Performance appraisal practice of existing treatment plants is effective in generation of additional data which also can be used in the improvement in the design procedures to be followed for design of these plants. Existing facilities can be made to handle higher hydraulic and organic loads by process modifications, whereas meeting higher treatment requirements usually requires significant expansion and/or modification of existing facilities [7,8].

One of the primary considerations in evaluating an existing wastewater treatment plants is in the area of plant operation and control. A major tool required for proper process control is frequent and accurate sampling and laboratory analysis [9,10].

In the current wastewater treatment process, microorganisms play a significant role in the treatment of domestic sewage. Many different organisms live within the wastewater itself, assisting in the breakdown of certain organic pollutants [11,12]. The basis for using these EM species of microorganisms is that they contain various organic acids

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due to the presence of lactic acid bacteria, which secrete organic acids, enzymes, antioxidants and metallic chelates. The creation of an antioxidant environment by EM assists in the enhancement of the solid-liquid separation, which is the foundation for cleaning water [13,14].

Poor conditions of sewerage system, improper design of the plant and organizational problems are important factors that cause treatment plant not to meet the effluent standards [14]. Overloading due to increase in population and water use, discharge of trade effluents are other reasons of recent times for the poor performance of wastewater treatment plants [15]. The treatment efficiency may be badly affected if the system is hydraulically under loaded [14-18].

The main aims of the present study are to study and evaluate the wastewater treatment plants efficiency in Garbyia Governorate.

Methodology

Case of the study

The study aimed to evaluate the performance and efficiency of the Wastewater Treatment Plants (WWTPs) in El-Gharbia Governorate, middle of Delta, Egypt as shown in Figure 1. The survey of present study covers more than 90% of the WWTPs in El-Gharbia governorate (17 WWTPs; Tanta, Mahalet Marhom, Fesha, Nawag, Nefia, Mahalet Menof, Berma, Basyoun, Mashal and Kom Elnagar, Kafr Elzayat, Kotour, Neshyl, Segen Elcoom, Elsanta, Zefta, Elmahala Elkobra, and Saft Trab). El-Gharbia Governorate WWTPs were designed and constructed in order to receive an average of 493500 m^3 of raw sewage wastewater per day aimed to manage it so as to minimize and/or remove organic matter, solids, nutrients, disease-causing organisms and other pollutants before it mixed with surface water bodies according to law No. 48 of 1982 and amendments. WQI were calculated as shown in Table 1.

Sampling

The collected samples were carried out during the study period (Jan. to Dec. 2016), collection and storage of samples were carried out according to APHA [19-21].

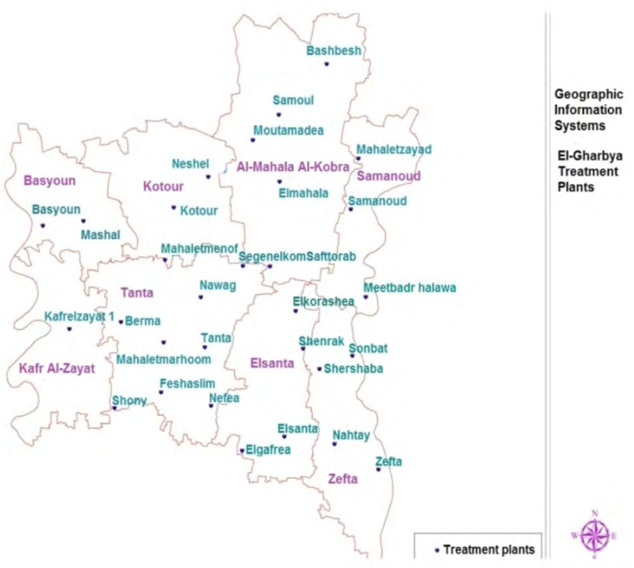

Figure 1: Sampling sites, El-Gharbia Governorate.

Performance appraisal has been carried out by comparing the concentrations of pollutants at the influent and effluent of the investigated treatment plants. The grab and composite samples were collected at the influent and effluent of the investigated treatment plants in clean polyethylene bottles. Composite samples were collected over 12 hours at a rate of one sample each hour. Residual chlorine ($R.Cl_2$) was measured on site during sampling time. The composite samples were analysed for various parameters like BOD_5, COD and TSS. The samples were analysed as outlined in the standard methods for the examination of water and wastewater APHA, Depending on the results, performance of each plant was evaluated. By regression analysis correlations between TSS, COD and BOD_5 were established to improve treatment plants control and operation.

Results and Discussion

The evaluation of performance (pollutant removal efficiency) of the investigated wastewater treatment plants was undertaken in terms of effluent quality. The evaluation was based on measurements of TSS, BOD_5, COD, $R.Cl_2$, plant TSS removal efficiency (TSS%), plant BOD_5 removal efficiency (BOD_5%), and influent COD/BOD_5 ratio. These parameters were estimated on monthly basis for the raw untreated wastewater (influent) and treated wastewater (effluent) for the period of 12 months from January to December, 2016.

TSS, BOD_5 and COD

TSS, BOD_5 and COD are indirect indicators for total suspended solids, fermentable and non-fermentable organic content. The obtained data show that, the physical (TSS), chemical (COD) and biochemical (BOD_5) properties of the influent exhibits insignificant variations among the different investigated WWTPs. This variation trend was also detected for the single plant at different times. This variation may attribute to the different social, economic, geographic and climatic conditions in the studied communities. Significant variations of physical, chemical and biochemical properties of the different investigated WWTPs effluent were observed. This variation can be ascribed to the nature of incoming organic loading, the type of the operational conditions and mainly the difference in the efficiency of the treatment process.

The observed variability of the effluent concentrations and the removal efficiencies within all treatment plants operates with different technologies, considering all the analyzed constituents can be visualized in the data presented in the present study. These results are in agreement with the results obtained by Oliveira and Von Sperling.

The present results demonstrate that, Kotour WWTP operates with the oxidation ditch technology exhibits the highest performance efficiency, while Tanta WWTP operates with conventional activated sludge technology exhibits the lowest one.

TSS and TSS removal efficiency

TSS: The data of TSS are recorded in Tables 2 and 3. For the investigated WWTPs the average influent values of TSS are ranged from 253.167 mg/L at Mahalet Menof WWTP to 111.250 mg/L at El Mehala El Kobra WWTP. The average effluent values of TSS are ranged from 24.583 mg/L at Kotour WWTP to 144.583 mg/L at Tanta WWTP. These results reveal that the influent of the investigated WWTPs presents means of TSS significantly higher than that presented by the effluent. As well as the present results indicate that there is no significant variation in the influent mean TSS values while there is a significant variation in those presented by the effluent. A poor performance was observed for Tanta, Nefia, and Elmahala Elkobra, WWTPs. On the other hand,

WQI				
Factor	**Weight**	**Data**	**WQI**	**WQI**
DO (mg/l)	0.17			
FC (CFU/100 ml)	0.16			
pH	0.11			
BOD (mg/l)	0.11			
COD (mg/l)	0.15			
ΔT (°C)	0.1			
TP (mg/l)	0.1			
NO_3 (mg/l)	0.1			
Treated water WQI				

Table 1: Water Quality Index (WQI) weights and calculation.

Wastewater treatment plants	IN/E	January	February	March	April	May	June	July	August	September	October	November	December	Mean	SD
Tanta	IN	312	244	290	234	394	310	252	340	342	362	270	298	304.00	49.45
	E	164	64	208	192	122	150	149	240	98	92	152	104	144.58	51.73
Mahalet Marhom	IN	252	420	304	322	224	314	298	304	254	297	402	245	303.00	59.27
	E	24	43	24	30	26	28	29	29	31	33	39	24	30.00	5.95
Nawag	IN	216	294	262	308	296	188	236	310	342	218	222	262	262.83	47.48
	E	45	91	42	85	36	63	36	69	56	25	28	22	49.83	23.05
Nefia	IN	296	234	316	202	302	208	234	218	488	352	360	290	291.67	82.40
	E	43	47	39	102	30	45	21	35	93	45	84	64	54.00	25.95
Mahalet Menof	IN	202	274	210	236	258	282	212	294	412	208	236	214	253.17	59.18
	E	19	21	20	31	36	30	24	28	25	24	22	22	25.17	5.11
Berma	IN	238	212	312	292	226	282	301	448	360	324	248	242	290.42	66.50
	E	29	20	88	25	24	24	27	39	31	36	25	44	34.33	18.30
Basyoun	IN	208	392	284	304	308	436	432	208	259	308	412	214	313.75	85.85
	E	20	31	22	31	26	24	26	32	24	37	37	62	31.00	11.22
Mashal and Kom Elnagar	IN	280	264	322	308	270	214	452	296	364	216	354	226	297.17	69.48
	E	32	38	102	27	30	24	35	36	21	33	27	25	35.83	21.48
Kafr Elzayat	IN	236	389	330	306	268	216	368	306	270	268	318	288	296.92	50.43
	E	34	22	21	43	27	30	66	30	25	28	41	24	32.58	12.58
Kotour	IN	392	312	316	336	242	238	230	290	328	326	310	198	293.17	55.41
	E	32	31	29	28	20	17	23	18	27	24	20	26	24.58	5.05
Neshyl	IN	376	320	232	373	374	286	364	270	221	298	282	228	302.00	59.16
	E	36	65	66	32	27	22	28	20	36	41	24	30	35.58	15.25
Segen Elcoom	IN	164	196	294	372	254	232	220	330	300	216	230	302	259.17	60.70
	E	28	68	78	26	24	34	29	54	35	24	25	20	37.08	19.02
Elsanta	IN	315	272	324	205	248	254	228	284	328	215	256	230	263.25	42.11
	E	38	35	21	28	25	29	21	28	23	29	23	22	26.83	5.46
Shenrak	IN	258	316	316	270	288	202	268	256	220	230	358	298	273.33	44.74
	E	27	25	23	27	27	23	25	26	25	21	35	28	26.00	3.49
Zefta	IN	268	320	246	216	240	272	236	238	262	267	396	326	273.92	50.44
	E	22	34	28	35	26	19	22	22	29	36	24	28	27.08	5.63
Elmahala Elkobra	IN	288	306	288	254	328	242	260	224	384	346	248	348	293.00	50.05
	E	99	130	80	131	134	106	106	94	103	110	92	142	110.58	19.35
Saft Trab and Elhyatem	IN	275	338	276	302	295	280	202	206	282	262	214	302	269.50	42.12
	E	20	126	32	21	21	43	25	32	24	31	78	22	39.58	31.60

Table 2: TSS data (mg/L) of the influent and effluent of the WWTPs. All data represents means of five replicates ± Stander Deviation (SD), TSS: Total suspended solids, IN: Influent (untreated raw wastewater) and E: Effluent (treated wastewater).

Wastewater treatment plants (WWTPs)		TSS removal efficiency (%)	
		%Range	Mean ± SD
Tanta		17.9-94.5	51.1 ± 19.7
Mahalet Marhom		87.8-92.1	90 ± 1.2
Nawag		66.5-91.6	81 ± 8.1
Nefia		49.5-91	8.7 ± 11
Mahalet Menof		86-93.9	89.8 ± 2.2
Berma		71.8-91.5	88.1 ± 5.1
Basyoun		71-94.5	89.2 ± 6.3
Mashal and Kom Elnagar		68.3-94.2	87.6 ± 6.7
Kafr Elzayat		82.1-94.3	88.9 ± 3.6
Kotour		86.9-93.8	91.5± 1.9
Neshyl		71.6-92.8	87.6 ± 6.5
Segen Elcoom		65.3-93.4	85.1 ± 8.2
Elsanta		86.3-93.5	89.6 ± 2.4
Shenrak		88.6-92.7	90.4 ± 1.2
Zefta		83.8-93.9	89.8 ± 2.8
Elmahala Elkobra		48.4-73.2	61.7 ± 7.1
Saft Trab and Elhyatem		62.7-93	85.2 ± 10.8
ANOVA	F	23.548	
	P-value	<0.001*	

Table 3: Mean TSS removal efficiency of the thirty investigated WWTPs. All data represents means of 12 replicates per year ± Standard Deviation (SD), TSS: Total suspended solids, IN: Influent (untreated raw wastewater), E: Effluent (treated wastewater) and *: Significant variation.

a good performance was detected for Mahalet Marhom, Fesha Sleem, Mahalet Menof, Berma, Basyoun, and Kom Elnagar, Kafr Elzayat, Kotour, Neshyl, Elsanta, and Elkorashia, Shenrak, Elgafaria, Zefta, Nawag, Saft Trab and Elhyatem WWTPs.

The results show that, all collected samples from Tanta, El Mehala El Kobra and Nawag WWTPs were exceeding the Egyptian Permissible limits (TSS: 40 mg/l) while the samples collected from Mehalet Menof, Kotour, El Santa, Shernak and Zefta were complying the Egyptian regulations as indicated in Table 10.

Horan et al. defined the activated sludge process as a suspended growth system comprising a mass of microorganisms constantly supplied with organic matter and oxygen. This process is widely used worldwide for the treatment of domestic and industrial wastewater, in situations where high effluent quality is necessary [22,23]. According to Francioso et al. a number of AS processes and design configuration have evolved due to new regulations for effluent quality, technological advances, better understanding of microbial processes and to reduce costs. We can have complete-mix activated sludge (CMAS), plug-flow (conventional, high-rate aeration, step feed, contact stabilization, two-sludge, high-purity oxygen, Kraus process, conventional extended aeration), extended aeration (oxidation ditch, orbal, countercurrent aeration system, biolac process) and the sequentially operated systems such as sequentially batch reactor (SBR), cyclic activated sludge system (CAAS), Batch decant reactor- intermittent cycle extended aeration system (ICEAS) (Figures 2 and 3).

TSS removal efficiency

The data obtained for the TSS removal efficiency in Tables 3 and 4 illustrate that the average removal of TSS is ranged from 51.1% to 91.5% for Tanta and Kotour WWTPs respectively. Kotour WWTP is more efficient than Tanta WWTP in TSS removal by 40.38%. Poor efficiency for TSS removal is detected for Tanta, Nawag, Nefia, and Elmahala Elkobra, WWTPs. These results reveal a significant variation in the mean TSS removal efficiency for all investigated WWTPs.

BOD_5 and BOD_5 removal efficiency

BOD_5: Table 4 presents the BOD_5 values (mg/L) for the influent and effluent of the investigated WWTPs. Table 5 shows the mean BOD_5 values (mg/L) for the influent and effluent of the thirty investigated WWTPs. For the investigated WWTPs, the average influent values of BOD_5 are ranged from 330.833 mg/L to 399.167 mg/L for Segen Elcoom and El Moutamadia WWTPs respectively. The average effluent values are ranged from 34.833 mg/L to 181.500 mg/L for Shenrak and Tanta stage 2 WWTPs respectively. These results indicate poor performance for Tanta, and Elmahala Elkobra WWTPs. A good performance is detected for Mahalet Marhom, Fesha Sleem, Mahalet Menof, Berma, Basyoun Mashal and Kom Elnagar, Kafr Elzayat, Kotour, Neshyl, Elsanta, Shenrak, and Zefta, WWTPs.

It is obvious that the influent of the investigated WWTPs presents means of BOD_5 significantly higher than that presented by the effluent. No significant variation in the influent mean BOD_5 values can be detected while there is a significant variation in those presented by the effluent.

The results show that, all collected samples from Tanta, and El Mehala El Kobra WWTPs were exceeding the Egyptian Permissible limits (BOD: 60 mg/l) while the samples collected from Mehalet Menof, Nawag, Menof, Kotour, El Santa, Shernak and Zefta were complying the Egyptian regulations as indicated in Table 12.

BOD_5 removal efficiency

Table 5 presents the BOD_5 removal efficiency (%) of the investigated WWTPs. Table 6 presents the mean BOD_5 removal efficiency of the thirty studied WWTPs. The average values of BOD_5 removal efficiency are ranged from 52.3% to 90.1% for Tanta and Kotour WWTPs respectively. Kotour WWTP is more efficient than Tanta WWTP in BOD_5 removal by 37.72%. Poor BOD_5 removal efficiency is observed for Tanta, Nawag, Nefia, Elmahala Elkobra, Saft Trab and Elhyatem WWTPs. A significant variation in the mean BOD_5 removal efficiency for the investigated WWTPs is observed (Figures 4 and 5).

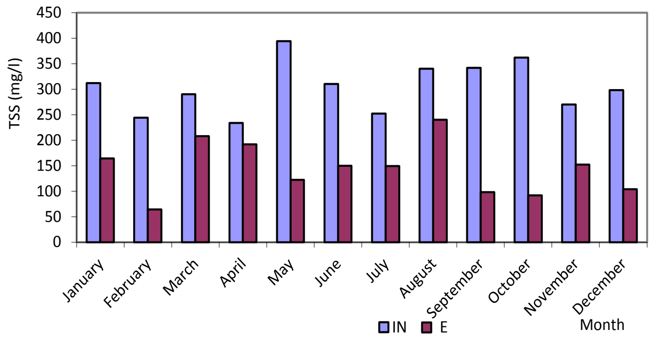

Figure 2: TSS of Tanta WWTP during the present study.

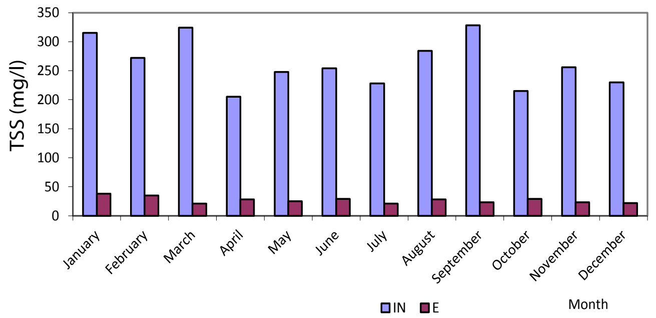

Figure 3: TSS of Elsanta WWTP during the present study.

Dissolved organics are generally treated with biological processes. The more common systems are aerobic (with oxygen) and include aerobic or facultative pond, biofilm reactor, and activated sludge processes. All these processes rely on the ability of microorganisms to convert organic wastes into stabilized, low-energy compounds [15].

COD of the investigated WWTPs

Table 6 shows the influent and effluent COD values (mg/L) of the investigated WWTPs. Table 6 reports the mean influent and effluent COD values (mg/L) of the investigated WWTPs. The average values of the influent COD are ranged from 657.42 mg/L to 663.08 mg/L for Tanta and Neshyl WWTPs respectively. The average effluent values are ranged from 57.417 mg/L to 253.333 mg/L for Shenrak and Elmahala Elkobra WWTPs respectively.

These results show a poor performance for Tanta, Nefia, Elmahala Elkobra, Nawag, Saft Trab WWTPs. A good performance is detected for Mahalet Marhom, Fesha Sleem, Mahalet Menof, Berma, Basyoun Mashal and Kom Elnagar, Kafr Elzayat, Kotour, Neshyl, Elsanta, Shenrak, and Zefta, WWTPs.

The present results illustrate that the influent of the investigated WWTPs presents means of COD significantly higher than that presented by the effluent. No significant variation in the influent mean COD values is observed, while there is a significant variation in those presented by the effluent.

The results show that, all collected samples from Tanta, and El Mehala El Kobra WWTPs were exceeding the Egyptian Permissible limits (COD: 80 mg/l) while the samples collected from Mehalet Marhom, Mehalet Menof, Kotour, El Santa, Shernak and Zefta were complying the Egyptian regulations as indicated in Table 11.

Chemical oxygen demand (COD) is a measure of the amount of oxygen required to chemically oxidize reduced minerals and organic matter [22,23]. Higher levels of COD were observed in influent but were reduced, with a mean percentage removal efficiency of 38.9 (± 62.22) % in effluent in average. This explains the significant difference between influent and effluent values of BOD as a result of plants performance ($P>0.05$). Furthermore, COD effluent concentrations were above the recommend EPA standard of 250 mg/L despite high percentage removal efficiency. This is due to very low algal populations to cause chemical activity that will reduce the COD [24,25] (Figures 6 and 7).

Residual chlorine ($R.Cl_2$)

Table 7 reveals the effluent $R.Cl_2$ values (mg/L) of the investigated WWTPs. Data in Table 8 provides the mean values of the effluent $R.Cl_2$ (mg/L) of the investigated WWTPs. Mean effluent $R.Cl_2$ values below the reference value is observed for Tanta, Kom Elnagar, Neshyl, Shenrak, and Saft Trab WWTPs. A significant difference in the effluent $R.Cl_2$ values of the investigated WWTPs were noticed.

Influent COD/BOD_5 ratio: Table 8 presents the influent COD/BOD_5 ratio of the investigated WWTPs. Data in Table 9 reports the mean influent COD/BOD_5 ratio of the investigated WWTPs. The values of the influent COD/BOD_5 ratio of the investigated WWTPs are within the normal range and does not exceeded the upper reference value reported by Wentzel et al. [11] (1.25-2.5). This indicates that the incoming influents to these investigated WWTPs are human wastes in nature and is not industrial wastes. Industrial wastes are characterized by the presence of slowly biodegradable organic suspended solids or refractory substances for biodegradation or both of them. These results indicate a non-significant variation in the mean influent COD/BOD_5 ratio of the studied WWTPs.

It can be observed that, the influent COD/BOD_5 ratio are lower than 3. This indicates that these influent wastewaters can usually be successfully treated with biological processes because of their high biodegradability and this meets the data reported by Ng Wun [25].

Correlations developed between TSS, COD and BOD_5: Establishment of constant relationships among the various measures of organic content depends primarily on the nature of the wastewater and its source. Variations of both influent and effluent BOD_5 with the influent and effluent TSS and COD were achieved using regression analysis (Table 9). As the experimental determination of BOD_5 requires relatively long time (5 days), this theoretical correlation gives a fast expectation for the corresponding BOD_5 values. Once the correlation has been established, TSS and COD measurements can be used to provide a good advantage for treatment plant control and operation. This will improve the performance efficiency of the investigated WWTPs [26,27].

Treated water quality index and data analysis: Table 13 and Figure 8 show the calculated values of WQI for treated wastewater of the investigated WWTPs in the Garbyia Governorate. The values of WQI ranged from 69 (Neshyl WWTP) to 143 (Mehala El Kobra WWTP).

Data Analysis

Tables 10-12 shows the number of collected samples and didn't comply with Egyptian guidelines values for TSS, BOD and COD (Figure 8).

Conclusion

The performance studies on the investigated sewage treatment plants located in El-Gharbia governorate in Egypt conducted for a period of 12 months reveal that the overall performance achieved by

Wastewater treatment plants	IN/E	January	February	March	April	May	June	July	August	September	October	November	December	Mean	SD
Tanta	IN	405	410	320	360	465	390	340	420	460	420	350	340	390.00	48.01
	E	200	90	250	220	169	190	150	280	115	154	210	150	181.50	54.60
Mahalet Marhom	IN	310	495	370	390	375	370	340	460	340	380	470	320	385.00	59.89
	E	35	51	34	39	38	34	39	37	46	42	45	36	39.67	5.33
Fesha Sleem	IN	345	390	390	390	395	320	280	390	280	290	330	350	345.83	45.67
	E	39	30	38	50	42	40	42	35	38	36	39	36	38.75	4.83
Nawag	IN	285	395	330	380	410	280	290	410	450	280	290	310	342.50	62.29
	E	55	130	50	115	55	70	42	105	78	45	42	40	68.92	31.40
Nefia	IN	390	395	380	310	465	310	290	300	510	420	420	320	375.83	70.93
	E	55	56	46	125	45	70	33	50	110	49	90	85	67.83	28.64
Mahalet Menof	IN	250	320	250	430	372	360	290	320	570	260	310	330	338.50	90.10
	E	30	27	33	39	42	48	39	39	30	31	39	39	36.33	6.11
Berma	IN	330	320	430	390	310	350	380	510	480	520	360	275	387.92	80.72
	E	38	39	96	38	39	40	39	46	45	43	41	54	46.50	16.26
Basyoun	IN	300	465	320	380	495	510	510	270	310	370	450	290	389.17	92.12
	E	32	41	28	40	39	38	39	42	38	46	42	83	42.33	13.64
Mashal and Kom Elnagar	IN	310	330	360	380	355	340	490	380	415	280	410	310	363.33	57.06
	E	39	52	110	45	40	35	41	50	32	46	39	34	46.92	20.80
Kafr Elzayat	IN	335	445	360	390	310	310	420	340	360	310	510	360	370.83	61.31
	E	44	30	31	58	40	42	86	48	42	36	52	39	45.67	15.03
Kotour	IN	495	375	395	380	380	330	270	380	390	430	370	270	372.08	61.88
	E	48	38	39	39	35	29	30	26	44	39	37	35	36.58	6.20
Neshyl	IN	485	410	310	460	425	340	410	370	420	420	310	350	392.50	56.39
	E	50	80	73	45	46	28	36	31	52	52	35	44	47.67	15.71
Segen Elcoom	IN	205	245	380	430	390	280	290	410	380	320	290	350	330.83	70.09
	E	48	82	105	42	45	38	35	70	46	38	38	36	51.92	22.09
Elsanta	IN	465	365	390	380	355	320	280	350	390	310	290	310	350.42	52.37
	E	49	40	29	42	36	35	32	32	39	39	39	39	37.58	5.30
Shenrak	IN	390	345	380	380	325	270	290	290	280	290	400	370	334.17	48.66
	E	36	30	29	38	40	25	36	29	36	37	44	38	34.83	5.46
Elgafaria	IN	355	435	310	380	410	430	310	290	370	390	440	290	367.50	56.39
	E	41	45	42	58	38	42	39	53	54	38	45	36	44.25	7.11
Zefta	IN	385	415	360	360	395	310	270	290	350	320	430	380	355.42	49.66
	E	29	48	38	44	30	26	30	38	34	45	38	34	36.17	6.94
Elmahala Elkobra	IN	395	380	320	290	435	380	350	260	420	460	350	390	369.17	58.65
	E	105	160	100	160	100	160	140	180	190	150	170	190	150.42	32.92
Saft	IN	325	390	290	470	340	390	250	280	345	370	290	370	342.50	60.73
	E	29	160	51	39	40	48	48	39	55	48	130	38	60.42	40.63

Table 4: Influent and effluent BOD_5 values (mg/L) of the thirty investigated WWTPs. All data represents means of five replicates ± Stander Deviation (SD), BOD_5: Biochemical oxygen.

Wastewater treatment plants	January	February	March	April	May	June	July	August	September	October	November	December	Mean	SD
Tanta	51	78	22	39	64	51	56	33	75	63	40	56	52	17
Mahalet Marhom	89	90	91	90	90	91	89	92	86	89	90	89	90	1
Fesha Sleem	89	92	90	87	89	88	85	91	86	88	88	90	89	2
Nawag	81	67	85	70	87	75	86	74	83	84	86	87	80	7
Nefia	86	86	88	60	90	77	89	83	78	88	79	73	81	9
Mahalet Menof	88	92	87	91	89	87	87	88	95	88	87	88	89	2
Berma	88	88	78	90	87	89	90	91	91	92	89	80	88	4
Basyoun	89	91	91	89	92	93	92	84	88	88	91	71	88	6
Mashal and Kom Elnagar	87	84	69	88	89	90	92	87	92	84	90	89	87	6
Kafr Elzayat	87	93	91	85	87	86	80	86	88	88	90	89	88	3
Kotour	90	90	90	90	91	91	89	93	89	91	90	87	90.1	1.5
Neshyl	90	80	76	90	89	92	91	92	88	88	89	87	88	5
Segen Elcoom	77	67	72	90	88	86	88	83	88	88	87	90	84	8
Elsanta	89	89	93	89	90	89	89	91	90	87	87	87	89	2
Met Yazed and Elkorashia	91	91	91	89	91	91	91	81	89	89	86	89	89	3
Shenrak	91	91	92	90	88	91	88	90	87	87	89	90	89	2
Elgafaria	88	90	86	85	91	90	87	82	85	90	90	88	88	3
Zefta	92	88	89	88	92	92	89	87	90	86	91	91	90	2
Shershaba	93	87	89	81	92	89	84	88	83	83	90	81	87	4
Elmahala Elkobra	73	58	69	45	77	58	60	31	55	67	51	51	58	13
Saft Trab	91	59	82	92	88	88	81	86	84	87	55	90	82	12

Table 5: BOD_5 removal efficiency (%) of the thirty investigated WWTPs. All data represents means of five replicates ± Stander Deviation (SD), BOD_5: Biochemical oxygen demand after five days, IN: Influent (untreated raw wastewater) and E: Effluent (treated wastewater).

Wastewater treatment plants	IN/E	January	February	March	April	May	June	July	August	September	October	November	December	Mean	SD
Tanta	IN	524	632	653	708	633	690	675	899	651	622	630	572	657.42	90.80
	E	239	168	330	285	220	239	177	378	159	198	271	198	238.50	67.25
Mahalet Marhom	IN	475	795	731	623	416	616	547	762	578	776	783	704	650.50	127.80
	E	67	74	68	74	65	68	68	67	74	66	61	60	67.67	4.62
Nawag	IN	422	695	575	597	694	556	625	550	742	517	464	514	579.25	96.77
	E	74	176	73	173	71	110	63	143	122	68	61	61	99.58	43.92
Nefia	IN	564	725	716	687	717	665	618	677	752	761	593	422	658.08	96.48
	E	76	75	70	163	63	106	80	71	144	62	107	127	95.33	33.86
Mahalet Menof	IN	468	479	522	689	523	510	520	451	870	524	634	642	569.33	120.23
	E	50	69	54	54	61	60	55	60	65	57	60	62	58.92	5.25
Berma	IN	667	527	690	598	620	652	563	722	876	849	636	550	662.50	109.70
	E	68	55	112	65	69	67	61	66	66	70	69	75	70.25	14.03
Basyoun	IN	599	778	625	682	664	737	734	499	683	546	613	584	645.33	82.92
	E	50	67	66	79	64	74	66	60	51	79	63	118	69.75	17.76
Mashal and Kom Elnagar	IN	525	714	662	677	467	550	885	741	572	574	656	500	626.92	118.93
	E	65	64	192	78	66	66	69	66	66	69	65	68	77.83	36.14
Kafr Elzayat	IN	426	616	761	632	440	693	659	505	692	656	781	502	613.58	119.08
	E	69	51	62	71	71	69	121	71	68	67	76	63	71.58	16.78

Kotour	IN	716	465	764	673	742	758	536	578	731	649	528	536	639.67	105.99
	E	72	55	62	74	60	66	43	60	57	67	59	53	60.67	8.51
Neshyl	IN	752	598	681	795	602	723	656	607	779	638	489	637	663.08	88.13
	E	71	128	96	78	77	65	60	55	66	69	52	72	74.08	20.56
Segen Elcoom	IN	329	382	764	730	624	561	676	639	872	559	662	500	608.17	154.59
	E	79	125	156	75	74	63	58	98	64	66	56	56	80.83	30.98
Elsanta	IN	775	654	638	749	427	564	424	605	532	750	459	637	601.17	123.50
	E	72	64	65	70	64	68	67	65	77	65	60	53	65.83	5.98
Shenrak	IN	678	686	664	627	459	528	409	535	639	716	552	588	590.08	95.50
	E	58	54	51	62	70	53	59	57	55	55	63	52	57.42	5.45
Elgafaria	IN	525	790	756	613	664	872	663	592	899	627	560	527	674.00	127.81
	E	59	57	64	68	68	63	68	76	80	62	71	76	67.67	7.13
Zefta	IN	647	700	752	642	580	509	528	627	626	643	630	500	615.33	75.24
	E	45	69	66	62	61	46	61	63	67	58	60	56	59.50	7.50
Elmahala Elkobra	IN	684	631	611	638	767	634	713	539	686	646	482	522	629.42	82.16
	E	146	225	167	238	196	418	202	371	328	222	259	268	253.33	81.85
Saft Trab	IN	540	727	595	722	684	620	475	645	589	624	459	614	607.83	85.16
	E	52	207	71	78	64	78	68	59	79	63	197	67	90.25	52.86

Table 6: Influent and effluent COD values (mg/L) of the thirty investigated WWTPs. All data represents means of five replicates ± Stander Deviation (SD), COD: Chemical oxygen demand, IN: Influent (untreated raw wastewater) and E: Effluent (treated wastewater).

Wastewater treatment plants	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Mean**	**SD**
Tanta	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Mahalet Marhom	1	0.6	1	3	0.6	0.6	0.7	0.8	0.8	0.6	0.5	0	0.85	0.73
Fesha Sleem	1	2	1.5	1.3	0.8	0.8	0.5	1	0.8	3	0.2	2	1.24	0.78
Nawag	0	0.2	0.6	0.6	1	1	0.8	0	0.9	0	1	0	0.51	0.44
Nefia	1	0.8	1	0.7	0.5	0.6	0.6	0.5	0.6	0.5	1	0	0.65	0.28
Mahalet Menof	0.5	0.5	0.6	0.5	0.6	1	0.9	0.2	3	0.5	0.5	0.8	0.80	0.72
Berma	3	0.5	0	0	1	0	0	1.5	2	2.5	0.8	0	0.94	1.08
Basyoun	0.8	0.8	1	0.5	0.6	0	0.6	0.8	0	0.8	2	0.7	0.72	0.51
Mashal	0.5	0	0	0.5	0.1	0.5	0.7	0.5	0.5	0.6	0.6	0.3	0.40	0.24
Kafr Elzayat	0	0	0.8	0.5	0.5	0.6	0.4	0.8	1	0.8	1	0.6	0.58	0.33
Kotour	0	4	1.5	0.5	2.5	0.5	0.1	3.3	0.5	0.7	0.5	0.8	1.24	1.32
Neshyl	0	0.6	0	0	0.6	0.5	0.5	0.3	0.5	1.7	0	0.5	0.43	0.47
Segen Elcoom	0.3	0	0	0	0	0	0	0	0.1	1.3	1.5	0	0.27	0.54
Elsanta	0.2	1	3	0.8	0.5	0.6	0.6	2.5	0.6	0.5	0.8	0.2	0.94	0.88
Met Yazed	0.5	3	0.6	0.5	0	0.5	0.6	0.5	2	0.7	1.5	2	1.03	0.89
Shenrak	0.6	0.6	0.6	0.5	0.5	0.7	0.1	0.5	0.5	0.6	0	0	0.43	0.25
Elgafaria	0.8	0	0.6	0.8	1	0.6	0.5	0.8	0.5	0.5	0.6	0.78	0.62	0.25
Zefta	1.5	0.5	0.6	0.5	0.5	1.5	0.8	0.8	0.6	1.6	3.4	1.2	1.13	0.83
Shershaba	0.8	1	1.5	0.8	1.2	0.7	0.9	1	0.8	0.5	1.3	0.8	0.94	0.28
Elmahala Elkobra	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Saft Trab	0.8	0.8	0.8	0	0.8	0.8	0.6	0	0	0	0	0	0.38	0.40

Table 7: Effluent $R.Cl_2$ values (mg/L) of the thirty investigated WWTPs. All data represents means of five replicates ± Stander Deviation (SD), $R.Cl_2$: Residual chlorine, IN: Influent (untreated raw wastewater) and E: Effluent (treated wastewater).

Wastewater treatment plants (WWTPs)		Influent COD/BOD_5 ratio	
		Range	Mean
Tanta		1.3-2.14	1.708 ± 0.287
Mahalet Marhom		1.11-2.2	1.695 ± 0.28
Fesha Sleem		1.5-2.5	1.807 ± 0366
Nawag		1.34 -2.16	1.709 ± 0.218
Nefia		1.32-2.26	1.785 ± 0.35
Mahalet Menof		1.41-2.09	1.719 ± 0.27
Berma		1.42 -2.02	1.733 ± 0.211
Basyoun		1.34-2.2	1.712 ± 0.294
Mashal and Kom Elnagar		1.32-2.16	1.735 ± 0.251
Kafr Elzayat		1.3-2.24	1.674 ± 0.332
Kotour		1.24-2.3	1.742 ± 0.316
Neshyl		1.42-2.2	1.713 ± 0.248
Segen Elcoom		1.43-2.33	1.843 ± 0.325
Elsanta		1.2-2.42	1.726 ± 0.322
Met Yazed		1.54-2.16	1.763 ± 0.217
Shenrak		1.38-2.47	1.786 ± 0.344
Elgafaria		1.27-2.44	1.861 ± 0.365
Zefta		1.32-2.16	1.757 ± 0.262
Shershaba		1.38-2.47	1.805 ± 0.368
Elmahala Elkobra		1.34-2.2	1.728 ± 0.278
Saft Trab		1.54-2.3	1.791 ± 0.235
ANOVA	**F**	0.495	
	P-value	0.988	

Table 8: Mean influent COD/BOD_5 ratio of the thirty investigated WWTPs.All data represents means of 12 replicates per year ± Standard Deviation (SD), BOD_5: Biochemical oxygen demand after five days, COD: Chemical oxygen demand, IN: Influent (untreated raw wastewater).

Correlation between	Expression	Correlation coefficient
Variation of influent BOD_5 with the influent TSS and COD	X=52.876+(0.755) Y+(0.154) Z X: influent BOD_5, Y: influent TSS and Z: influent COD	R Square=69.7% or =0.697
Variation of effluent BOD_5 with the effluent TSS and COD	X=-0.700+(0.698) Y+(0.324) Z X: effluent BOD_5, Y: effluent TSS and Z: effluent COD	R Square=97.4% or =0.974

Table 9: Correlations developed between TSS, COD and BOD_5 of the thirty investigated WWTPs. TSS: Total suspended solids, BOD_5: Biochemical oxygen demand after five days, COD: Chemical oxygen demand and R Square: Coefficient of determination.

Wastewater Treatment Plant	Number of non-comply Samples from 12 collected samples	%
Tanta	12	100.0
Marhom	1	8.3
Nawag	7	58.3
Nefia	8	66.7
Mahalet Menof	0	0.0
Berma	2	16.7
Basyoun	1	8.3
Kom Elnagar	1	8.3
Kafr Elzayat	3	25.0
Kotour	0	0.0
Neshyl	3	25.0
Segen Elcoom	3	25.0
Elsanta	0	0.0
Shenrak	0	0.0
Zefta	0	0.0
Elmahala	12	100.0

Table 10: TSS data analysis.

Wastewater Treatment Plant	Number of non-comply Samples from 12 collected samples	%
Tanta	12	100.0
Marhom	0	0.0
Nawag	5	41.7
Nefia	4	33.3
Mahalet Menof	0	0.0
Berma	1	8.3
Basyoun	1	8.3
Kom Elnagar	1	8.3
Kafr Elzayat	1	8.3
Kotour	0	0.0
Neshyl	2	16.7
Segen Elcoom	3	25.0
Elsanta	0	0.0
Shenrak	0	0.0
Zefta	0	0.0
Elmahala	12	100.0

Table 11: COD data analysis.

Wastewater Treatment Plant	Number of non-comply Samples from 12 collected samples	%
Tanta	12	100.0
Marhom	0	0.0
Nawag	0	0.0
Nefia	5	41.7
Mahalet Menof	0	0.0
Berma	1	8.3
Basyoun	1	8.3
Kom Elnagar	1	8.3
Kafr Elzayat	1	8.3
Kotour	0	0.0
Neshyl	2	16.7
Segen Elcoom	3	25.0
Elsanta	0	0.0
Shenrak	0	0.0
Zefta	0	0.0
Elmahala	12	100.0

Table 12: BOD data analysis.

Wastewater treatment plants	WQI	Notes
Tanta	151	-
Marhom	88	-
Nawag	112	-
Nefia	106	-
Mahalet Menof	82	-
Berma	91	-
Basyoun	84	-
Kom Elnagar	81	-
Kafr Elzayat	77	-
Kotour	74	-
Neshyl	69	-
Segen Elcoom	98	-
Elsanta	79	-
Shenrak	82	-
Zefta	83	-
Elmahala	143	-
Saft Trab	96	-

Table 13: WQI for WWTPs.

Citation: Ramadan AEMM, Rahman AAA, Abdullah AM, Eltawab OA (2017) Evaluation of Wastewater Treatment Plants in El-Gharbia Governorate, Egypt. Organic Chem Curr Res 6: 184. doi: 10.4172/2161-0401.1000184

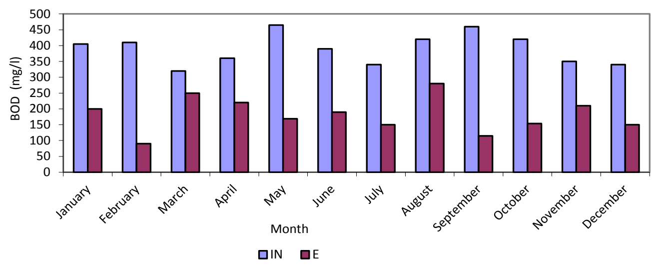

Figure 4: BOD of Tanta WWTP during the present study.

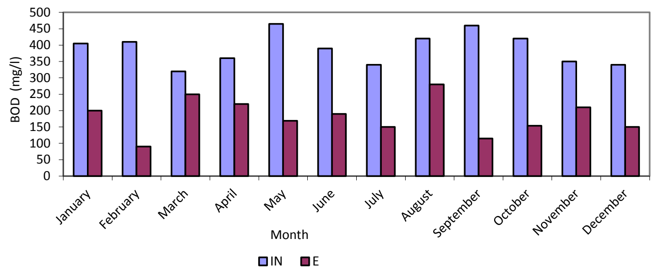

Figure 5: BOD of Elsanta WWTP during the present study.

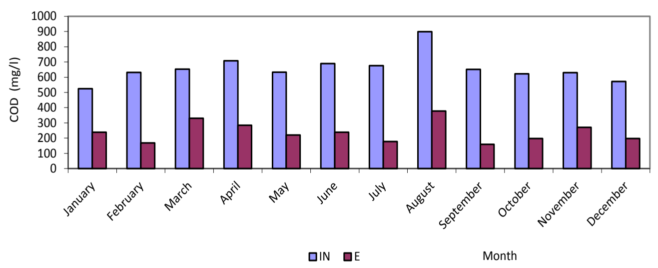

Figure 6: COD of Elsanta WWTP during the present study.

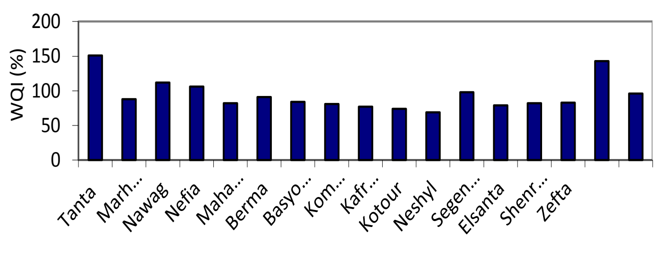

Figure 7: COD of Elsanta WWTP during the present study.

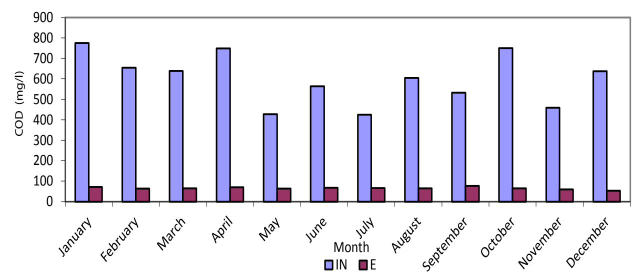

Figure 8: WQI for WWTPs.

some of the investigated plants is lower than the expected performance. This shows that improvements in the current situation are possible, thus serving as an incentive to designers and plant operators. Non-significant variation in the influent's mean TSS, BOD_5, COD and COD/BOD_5 ratios are observed. While significant variations in the removal efficiencies and the effluent concentrations considering all the analyzed constituents are obtained during the experimental period within all investigated treatment plants. The influents of the investigated WWTPs are human wastes in nature and can usually be successfully treated with biological processes because of their high biodegradability. Theoretical correlations between influents and effluents TSS, COD and BOD_5 were determined. These correlations can be used to provide a good advantage for treatment plant control and operation. A probabilistic model has been used for determining achievable effluent BOD_5, COD and TSS concentrations. This probabilistic approach provides a theoretical basis for the analysis of reliability. The reliability measures are expressed in probability terms, that is, the probability of success or adequate performance as a function of mean values and effluent variability. The effluent variability has been described by the coefficient of variation. The performance variability in some WWTPs are observed, this is because there are many factors that affect wastewater treatment plant performance (reliability). Flow variability and their characteristics, the inherent variability of the behavior of wastewater treatment processes (inherent reliability), the variability caused by failures, in addition the lack of experience of the wastewater treatment plant operators especially in the developing countries.

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