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QUALITY OF SECONDARY WASTEWATER TREATMENT AT ZENIEN WASTE WATER TREATMENT PLANT

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ABSTRACT

Zenien waste water treatment plant (WWTP) consists of flow measurement device, screens, pre-aeration unit, primary sedimentation tanks, grit chamber, activated sludge tanks which were supported with diffused aeration system, final sedimentation tanks, and chlorine contact chamber. Firstly, the wastewater passes through screen for large objects removal and is pre-aerated in pre-aerated unit, which is operated at retention time of 30 min., for oil and grease separation. The plant is operated at retention time of 2 h in the primary sedimentation tank, while the activated unit is operated at retention of 4 h. The secondary sedimentation tank is performed at retention time of 2 h and thirty min. The plant was designed for receiving a wastewater flow rate of 330,000 m^3/d. The aim of this research is to evaluate the potential efficiencies of a secondary WWTP under Egyptian conditions in comparison with Egyptian code of wastewater reuse or disposal of to waterways.

Results showed that the overall removal percentages of Zenien WWTP in respect to TS and TSS were 31.9 and 95.2%, respectively, meanwhile the overall removal percentages of COD and BOD_5 were 91.6 and 95.3 %, respectively. The removal efficiencies of ammonia after the primary and secondary treatment were 27.9 and 48.7 %, respectively. The overall removal percentage of NH_4^+-N was 63 %. Nitrate showed continual increases after the primary and secondary treatment. The increase percentages were 70 and 133.3 %, respectively. Total and fecal coliforms bacteria were removed at percentages of 99.99% after chlorination.

INTRODUCTION

The principal objective of wastewater 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. Biological processes are used to convert the finely divided and dissolved organic matter in wastewater into flocculent settleable inorganic solids that can be removed in final sedimentation tanks. This process is called "secondary treatment" and is employed in conjunction with physical and chemical processes that are used for the preliminary and primary treatment of wastewater (Metcalf and Eddy, 2003).

In Egypt, the interest of use treated wastewater, as a substitute for fresh water in irrigation, has accelerated since 1980. Currently, 0.7 BCM/yr of treated wastewater is being used in irrigation, of which 0.26 BCM is undergoing secondary treatment and 0.44 BCM undergoing primary treatment (Abdel-Gawad, 2008). Sanitation services are less developed than those for water supply. At present, there are more than 200 wastewater treatment plants. Urban coverage with improved sanitation gradually increased from 45% in 1993 to 56% in 2004. In contrast, rural sanitation coverage remains incredibly low at 4%. The low coverage, in combination with a sub-optimal treatment, results in serious problems of water pollution and degradation of health conditions because the majority of villages and rural areas discharge their raw domestic wastewater directly into the waterways. The discharges are increasing year after year due to the population growth as well as the rapid implementation of water supply networks in many villages without the parallel construction of sewage systems. Delays in achieving sufficient sanitation services are due to financial constraints. The capacity of wastewater treatment plants has increased by 10 times in the last two decades. The existing capacity of 11 million m^3/day serves about 18 million people in mainly urban areas. The plan is to reach a total available capacity of 16 million m^3/day by 2007, serving all urban areas (Abedel Gawad *et al*, 2004).

Greater Cairo has 6 essential wastewater treatment plants (WWTPs). They are Gabal El-Asfar, El-Zenien, Helwan, Berka, Shoubra El-Kheima and Abu-Rawash WWTPs. The first five WWTPs are secondary treatment plants. Only Abu-Rawash WWTP is primary treatment plant. They receive wastewater from east and west banks at quantities of 3.0×10^6, 330×10^3, 350×10^3, 500×10^3, 600×10^3 and 400×10^3 cubic meters, respectively.

The aim of this research is to evaluate the potential efficiencies of a secondary WWTP under Egyptian conditions in comparison with Egyptian code of wastewater reuse or disposal of to waterways.

MATERIALS AND METHODS

Sampling procedure:

Samples were taken from three points: influent of Zenien Wastewater Treatment Plant (WWTP) and after the primary and secondary settling tanks. Over a 24-h period, one 22- liter composite sample (916 ml during 15 min every hour) was taken at 4th, 8th, 12th, 16th, 20th, 24th and 28th day every month for one year starting from Jan. to Dec., 2005. Samples were immediately transported to the laboratory in ice box, at 4 to 6°C and submitted to analysis within 6 h after sampling. Samples for heavy metals were collected and determined every three months, *i.e.*, January, April, July and October.

Zenien WWTP consists of screens, grit chamber, pre-aeration unit, primary sedimentation tanks, activated sludge tanks which were supported with diffused aeration system, secondary sedimentation tanks, and chlorine contact chamber. The plant was designed for receiving a wastewater flow rate of 330,000 m^3/d. Firstly, the wastewater passes through screen for large objects removal and is pre-aerated for 30min. in pre-aerated unit for oil and grease separation. The plant is operated at retention time of 2 hours for the primary sedimentation tank, while the activated unit is operated at retention of 4 hours. The secondary sedimentation tank is performed at retention time of 2 hours and thirty minutes.

Determinations:

The flow rate of the wastewater was measured with a flowmeter and it ranged between 300,500 and 345,770 m^3/day with an average of 320,700 m^3/day. Biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total solids (TS), NH_4, NO_3, heavy metals and pathogenic indicators (Total and fecal coliforms bacteria) were measured according to Standard Methods (APHA, 1989), and the results are expressed in milligrams per liter for BOD, COD, TSS, TS, NH_4 and NO_3 or as MPN/100ml for total and fecal coliforms bacteria.

RESULTS AND DISCUSSION

Physical characteristics:

Data of TS, TSS and TDS for influent (raw sewage) and effluents after primary and secondary treatments are shown in Figs. (1, 2 and 3) while data summaries and average removal percentages are presented in Tables (1, 2 and 3).

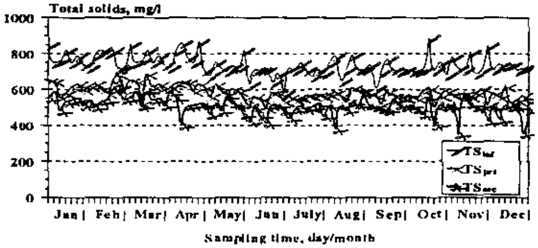


Fig. (1): Values of TS of Zenien WWTP influent and effluents drained from primary and secondary sedimentation tanks for a period from Jan. to Dec., 2005.

Table (1): Minimum, maximum and average values of TS for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	580	890	739.3 (±57.1)	0
Primary	492	685	582.2 (±39.3)	21.3
Secondary	350	620	503.8 (± 50.7)	13.4 (31.9)

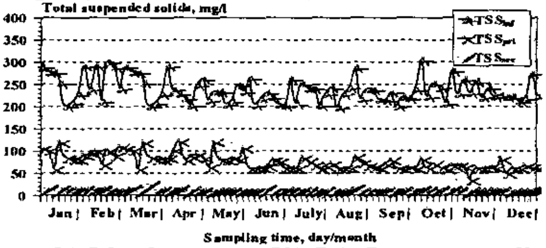


Fig. (2): Values of TSS of Zenien WWTP influent and effluents drained from primary and secondary sedimentation tanks for a period from Jan. to Dec., 2005.

Table (2): Minimum, maximum and average values of TSS for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	200	306	239.3 (± 27.8)	0
Primary	35.7	122	76.9 (± 17.7)	67.9
Secondary	5.2	26	11.4 (± 3.0)	85.2 (95.2)

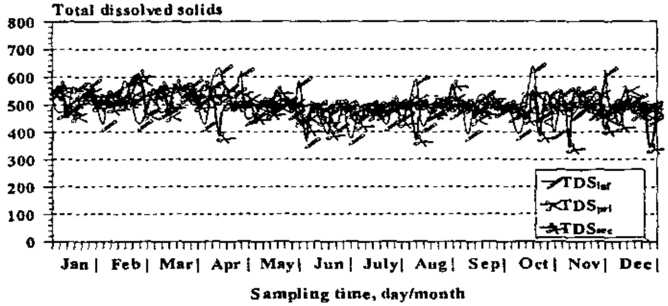


Fig. (3): Values of TDS of Zenien WWTP influent and effluents drained from primary and secondary sedimentation tanks for a period from Jan. to Dec., 2005.

Table (3): Minimum, maximum and average values of TDS for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	364	636	500.0 (± 57.1)	0
Primary	426	592	505 (± 30.8)	+1.0
Secondary	343.5	610	492.5 (± 50.2)	-1.5

Concentrations of TS, TSS and TDS of raw sewage influent pumped to Zenien WWTP ranged from 580 to 890mg/l, 200 to 306mg/l and from 364 to 636mg/l, respectively. The average concentration of TS, TSS and TDS were 739.3 (±57.1), 239.3 (±27.8) and 500.0 (± 57.1) mg/l, respectively. The primary effluent showed lower concentration values of TS and TSS. Their concentration values ranged from 492 to 685 and from 35.7 to 122 mg/l, respectively. The average values of TS and TSS were 582.2 (±39.3) and 76.9 (± 17.7) mg/l, respectively. The primary treatment was able to purify the wastewater at removal percentages of 21.3 % and 67.9 % for TS and TSS, respectively. The primary effluent TDS showed values ranged between 426 and 592 mg/l, with an average of 505 (± 30.8), which is slightly higher than average of the raw wastewater. This may be referred to the water evaporation or to increase the percentage of colloid substances. The average increase percentage of TDS of the primary effluent was 1%.

Primary sedimentation tanks may provide the principal degree of wastewater treatment, or they may be used as a preliminary step in the further processing of the wastewater. Casey (1997) reported that the efficiently designed and operated primary sedimentation tanks should remove from 50 to 70 % of the suspended solids.

The secondary treated effluent contained the lowest values of TS and TSS which, they ranged from 350 to 620 and from 5.2 to 26 mg/l, respectively. The average values of TS and TSS were 503.8 (±50.7) and 11.4(±3.0) mg/l. The removal percentage of both TS and TSS was 13.4 and 85.2 %, respectively. The overall removal percentages of Zenien WWTP in respect to TS and TSS were 31.9 and 95.2%, respectively. Value of TDS for secondary treated effluent ranged from 343.5 to 610 mg/l with an average of 492.5 mg/l. This may be referred to the high efficiency of secondary sedimentation tank in removing flocculants.

Chemical characteristics:

1. Chemical and Biochemical oxygen demand:

Results of COD and BOD_5 for influent (raw sewage) and effluents after primary and secondary treatments are shown in Figs. (4 and 5) while data summaries and average removal percentages are presented in Tables (4 and 5).

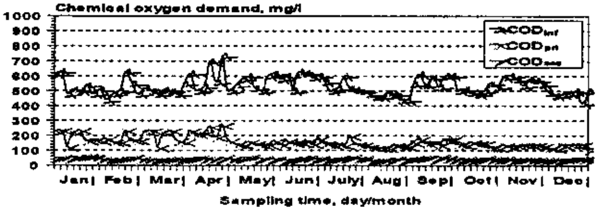


Fig. (4): Values of COD of Zenien WWTP influent and effluents drained from primary and secondary sedimentation tanks for a period from Jan. to Dec., 2005.

Table (4): Minimum, maximum and average values of COD for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	420	736	536 (± 60)	0
Primary	108	270	162.1 (± 36.6)	69.8
Secondary	30	60	45.3 (± 6.9)	72.1 (91.6)

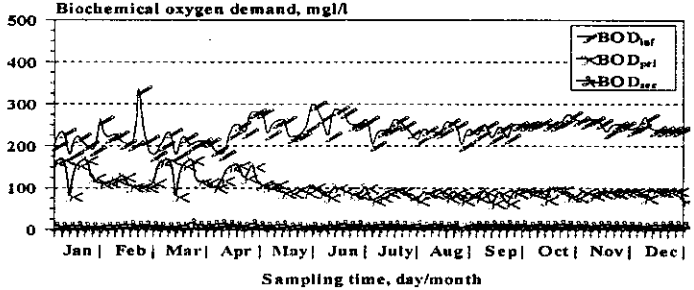


Fig. (5): Values of BOD of Zenien WWTP influent and effluents drained from primary and secondary sedimentation tanks for a period from Jan. to Dec., 2005.

Table (5): Minimum, maximum and average values of BOD_5 for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (± SD) in mg/l	Average removal efficiency (%)
Influent	180	336	238.9 (± 27.9)	0
Primary	66	168	102.5 (± 26.2)	56.9
Secondary	7.2	16.5	11.2 (± 2.0)	89.1 (95.3)

Concentrations of COD and BOD_5 of raw sewage influent ranged from 420 to 736 mg/l, and from 180 to 360 mg/l, respectively. The average concentration of COD and BOD_5 were 536 (±60) and 238.9 (± 27.9) mg/l, respectively. The primary effluent showed reductions in its COD and BOD_5 values. Their concentration values ranged from 108 to 270 and from 66 to 168 mg/l, respectively. The average COD and BOD_5 values were 162.1 (±36.6) and 102.5 (± 26.2) mg/l, respectively. The primary treatment was able to remove COD and BOD_5 at percentages of 69.76 % and 56.9 %, respectively. Concentrations of COD and BOD_5 in secondary effluent ranged from 30 to 60 and from 7.2 to 16.5 mg/l, respectively. The average COD and BOD_5 concentrations in the secondary effluent COD and BOD were 45.3 (±6.9) and 11.2 (± 2.0), respectively. The secondary treatment was able to remove COD and BOD_5 at percentages of 72.1 and 89.1 %, respectively. The overall removal percentages of COD and BOD_5 of Zenien WWTP were 91.6 and 95.3 %, respectively. Casey (1997) reported that the efficiently designed and operated primary sedimentation tanks should remove from 25 to 40 % of BOD_5.

The objective of secondary treatment is the further treatment of the effluent from primary treatment to remove the residual organics and suspended solids. In most cases, secondary treatment follows primary treatment and involves the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment processes. The activated sludge process is an aeration tank containing a suspension of the wastewater and microorganisms, the mixed liquor. The contents of the aeration tank are mixed vigorously by aeration devices which also supply oxygen to the biological suspension. This process activates the degradation of the organic solids and leads to high reduction in COD, BOD_5 and suspended solids. Following the aeration step, the microorganisms are separated from the liquid by sedimentation and the clarified liquid is secondary effluent. A portion of the biological sludge is recycled to the aeration basin to maintain a high mixed-liquor suspended solids level. The remainder is removed from the process and sent to sludge processing to maintain a relatively constant concentration of microorganisms in the system. Activated sludge procedures are used extensively for coagulating and removing nonsettleable colloidal solids, as well as to stabilize organic matter. Kenneth and Bush (1980) reported removal efficiencies of 80-99% for BOD_5, 50-95% for COD, and 60-85% for suspended solids. Thus, a high quality effluent is obtainable from a properly designed and operated activated sludge system

2. Ammoniacal and nitrate nitrogen:

Data of ammoniacal nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) for influent (raw sewage) and effluents after primary and secondary treatments are shown in Figs. (6 and 7) while data summaries and average removal or increase percentages are presented in Tables (6 and 7).

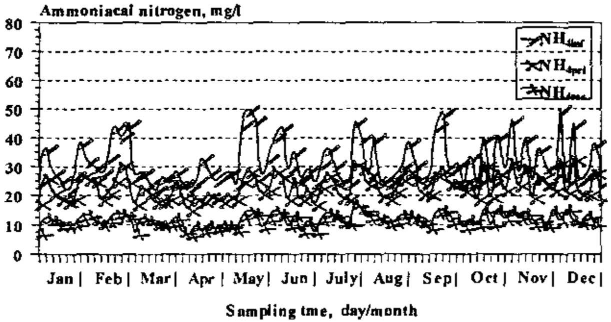


Fig. (6): Values of NH_4^+-N of Zenien WWTP influent and effluents drained from primary and secondary sedimentation tanks for a period from Jan. to Dec., 2005.

Table (6): Minimum, maximum and average values of the NH_4^+-N for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	22.1	50	31.9 (± 7.7)	0
Primary	15.4	32.6	23.0 (± 4.2)	27.9
Secondary	7.0	17.2	11.8 (± 2.2)	48.7 (63.0)

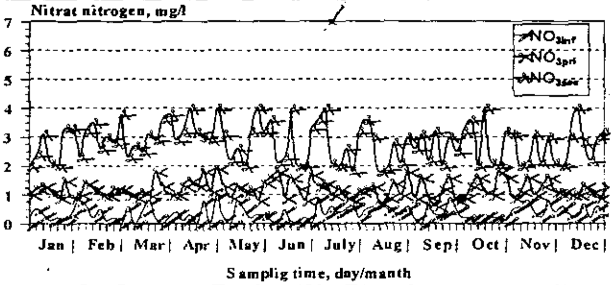


Fig. (7): Values of NO_3^--N of Zenien WWTP influent and effluents drained from primary and secondary sedimentation tanks for a period from Jan. to Dec., 2005.

Table (7): Minimum, maximum and average values of NO_3^--N for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	0.0	1.0	0.36 (± 0.36)	0
Primary	0.6	1.9	1.2 (± 0.3)	70
Secondary	1.8	4.0	2.8 (± 0.7)	133.3 (677.8)

Concentrations of NH_4^+-N and NO_3^--N of raw sewage influent ranged from 22.1 to 50 mg/l and from 0 to 1.0 mg/l, respectively. The average concentration of NH_4^+-N and NO_3^-N were 31.9 (±7.7) and 0.36 (±26) mg/l, respectively. The primary and secondary effluents showed continuous reductions in their contents of NH_4^+-N and increases in NO_3^--N. Ammoniacal nitrogen content for primary and secondary effluents ranged from 15.4 to 32.6 and from 7.0 to 17.2 mg/l, respectively. The average values of ammoniacal nitrogen for the primary and secondary effluents were 23.0 (±4.2) and 11.8 (±2.2) mg/l, respectively. The removal efficiencies of ammonia after the primary and secondary treatment were calculated to be 27.9 and 48.7 %. The overall removal percentage of NH_4^+-N was 63 %. Nitrate contents for primary and secondary effluents ranged from 0.6 to 1.9 and from 1.8 to 4.0 mg/l, respectively. The average values of nitrate for the primary and secondary effluents were 1.2 (±0.3) and 2.8 (±0.7) mg/l, respectively. The increase percentages of nitrate after the primary and secondary treatment were calculated to be 70 and 133.3 %, respectively. The overall increase percentage of NO_3^-N was 677.8 %. Reduction of ammonia is referred to the oxidation of ammonia to nitrite then to nitrate by oxygen in two tanks, *i.e.*, pre aerating tank and activated sludge tank. Autotrophic bacteria, *Nitrosomonas* sp. and *Nitrobacter* are performing the nitrification process (Gray, 1992).

3. Total heavy metals:

Data summaries of total heavy metals of influent (raw sewage) and effluents after primary and secondary treatments are shown in Table (8).

Table (8): Minimum, maximum and average values of some heavy metals for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

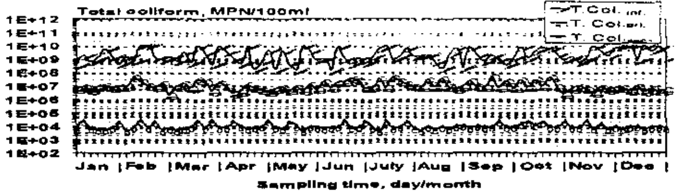
Sample type		Heavy metals, mg/l							
		Fe	Cu	Zn	Mn	Cd	Cr	Pb	Ni
Raw influent	Min	0.032	0.014	0.060.	0.015	0.000	0.040	0.055	0.018
	Max.	1.250	1.012	0.670	1.035	0.300	0.440	0.742	0.162
	Avg.	0.877	0.385	0.244	0.792	0.071	0.200	0.178	0.079
Primary effluent	Min	0.020	0.024	0.040	0.010	0.00	0.007	0.008	0.006
	Max.	0.852	0.895	0.380	0.800	0.088	0.157	0.500	0.112
	Avg.	0.540	0.266	0.170	0.490	0.034	0.121	0.135	0.041
Average removal (%)		38.43	30.91	30.00	38.13	52.11	39.50	24.16	48.10
Secondary effluent	Min	0.028	0.006	0.015	0.025	0.00	0.009	0.014	0.005
	Max.	0.745	0.095	0.440	0.302	0.020	0.070	0.190	0.090
	Avg.	0.348	0.058	0.099	0.117	0.007	0.028	0.069	0.025
Average removal (%)		35.56	78.20	41.76	76.12	79.41	82.64	48.89	39.02
Overall removal %		60.32	84.94	59.43	85.23	90.14	86.00	61.24	68.35

Concentrations of Fe, Cu, Zn, Mn, Cd, Cr, Pb and Ni in raw sewage influent ranged from 0.032 to 1.250, 0.014 to 1.012, 0.060 to 0.670, 0.015 to1.035, 0.0 to 0.300, 0.040 to 0.440, 0.055 to 0.742 and from 0.018 to 0.162 mg/l, with an average concentrations of 0.877, 0.385, 0.244, 0.792, 0.071, 0.200, 0.171 and 0.079 mg/l, respectively. The primary effluent showed reductions in its heavy metals contents. The concentration values ranged from 0.020 to 0.852, 0.024 to 0.895, 0.040 to 0.380, 0.010 to 0.800, 0.0 to 0.088, 0.007 to 0.157, 0.008 to 0.500 and 0.006 to 0.112 mg/l for Fe, Cu, Zn, Mn, Cd, Cr, Pb and Ni, with an average values of 0.540, 0.266, 0.170, 0.490, 0.034, 0.121, 0.135 and 0.041 mg/l, respectively. The primary treatment was able to remove all studied heavy metals at percentages of 38.43, 30.91, 30.00, 38.13, 52.11, 39.50, 24.16 and 48.10 % for Fe, Cu, Zn, Mn, Cd, Cr, Pb and Ni, respectively. The secondary treated effluent contained the lowest values of all determined heavy metals as shown in Table (8). The average values were 0.348, 0.058, 0.099, 0117, 0.007, 0.028, 0.069 and 0.025 mg/l for Fe, Cu, Zn, Mn, Cd, Cr, Pb and Ni, respectively. The secondary treatment process was able to remove all studied heavy metals at percentages of 35.56, 78.20, 41.76, 76.12, 79.41, 82.64, 48.89 and 39.02 % for Fe, Cu, Zn, Mn, Cd, Cr, Pb and Ni, respectively. The overall removal percentages of Zenien WWTP were 60.32, 84.94, 59.43, 85.23, 90.14, 86.00, 61.24 and 68.35 for Fe, Cu, Zn, Mn, Cd, Cr, Pb and Ni, respectively. The results showed that wastewater characteristics were within the acceptable range for reuse, normally according to the Egyptian decree for wastewater reuse (DECREE 44, 2000). Abd El Lateef *et al.* (2006) determined the concentrations of some heavy metals in the secondary treated effluents of Gabal El Asfar and El Berka WWTPs and found approximately similar concentrations.

Heavy metals are removed from raw sewage in physical and chemical treatment processes such as sedimentation with suspended solids and activated sludge flocs, co-precipitation by organic compounds and chemical precipitation, as well as in microbiological processes. Contribution of various processes in heavy metals removal depends on: applied technology of wastewater treatment, type and concentration and oxidation state of metal, composition and pH of wastewater, type of microorganisms (Neyman and Prejzner, 1975) and mechanism of metal removal (Brierley, 1990). Heavy metals can be actively bound by living microorganisms by means of the following mechanisms: intracellular accumulation, extracellular precipitation and chemical transformations catalyzed by these microorganisms, such as oxidation, reduction, methylation and demethylation. Passive mechanisms of metal binding are as follows: extracellular complexation of metal by substances excreted by cells and biosorption-binding of heavy metals to active groups of chemical compounds of cell walls and membranes (Tobin *et al*, 1990)

4. Microbial pathogenic indicators

Densities of total and faecal coliforms bacteria for influent (raw sewage) and effluents after primary and secondary treatments are shown in Figs (8 and 9) while data summaries and average removal percentages are presented in Tables (9 and 10).

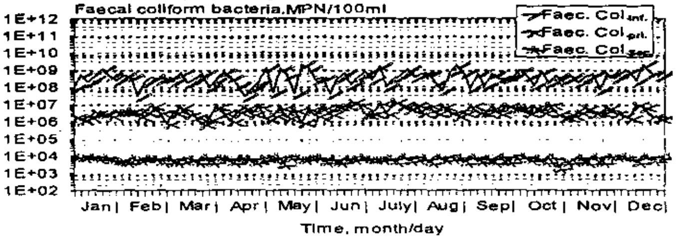


Fig, (8): Total coliform bacteria (MPN/100ml) for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate.

Table (9): Minimum, maximum and average number of total coliform bacteria (MPN/100ml) for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	1.3 x 10^8	1.0 x 10^{10}	3.1 x 10^9	0
Primary	2.2 x 10^6	4.8 x 10^7	1.3 x 10^7	.99.58
Secondary	4.0 x 10^3	2.4 x 10^4	1.1 x 10^4	99.91 (99.99)

Densities of total and faecal coliforms bacteria (pathogenic bacterial indicators) in raw sewage influent were ranged from 1.3x10^8 to 1x10^{10} and from 2.7x10^7 to 2.1x10^9 MPN/100ml, respectively. The average numbers of total and faecal coliforms bacteria were 3.1x10^9 and 4.8x10^8 MPN/100ml, respectively. The primary effluent showed high reductions in densities of total and faecal coliforms bacteria. Their numbers ranged from 2.2x10^6 to 4.8 x10^7 and 7x10^5 to 1.4x10^7 MPN/100ml, respectively. The average numbers of both pathogenic bacterial indicators in the primary effluent were 1.3 x 10^7 and 4.3x10^6 MPN/100ml, respectively.



Fig, (9): Faecal coliform bacteria (MPN/100ml) for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate.

Table (10): Minimum, maximum and average number of faecal coliform bacteria (MPN/100ml) for wastewater influent, primary and secondary effluents of Zenien WWTP, Giza governorate

Treatment step	Minimum value (mg/l)	Maximum value (mg/l)	Average value (±SD) in mg/l	Average removal efficiency (%)
Influent	2.7 x 10^7	2.1 x 10^9	4.8 x 10^8	0
Primary	7.0 x 10^5	1.4 x 10^7	4.3 x 10^6	99.10
Secondary	2.0 x 10^3	9.8 x 10^3	6.6 x 10^3	99.85 (99.99)

The primary treatment was able to remove both pathogenic bacterial indicators at percentages of 99.58 and 99.10 % for total and faecal coliforms bacteria, respectively. The secondary treated effluent (after chlorination Step) contained the lowest densities of total and faecal coliforms bacteria; their counts ranged from 4x10^3 to 2.4x10^4 and 2x10^3 to 9.8x10^3 MPN/100ml, respectively. The average numbers of both pathogenic bacterial indicators in the secondary effluent were 1.1x10^4 and 6.6x10^3 MPN/100ml, respectively. The secondary treatment was able to remove both pathogenic bacterial indicators at percentages of 99.91 and 99.85 % for total and faecal coliforms bacteria, respectively. The overall removal percentages of Zenien WWTP were 99.99 % for both pathogenic indicators. The results obtained are similarly to the findings by El-Hawaary *et al.* (1997) where they found a range from 10^7 to 10^{11} at 13 different wastewater treatment plants. The percentages of faecal coliform to total coliform bacteria for sewage influent, primary and secondary effluents were 15.48, 33.08 and 60 %, respectively. This indicates that faecal coliform is more tolerant to die off in comparison with total coliform bacteria.

In developed countries, reuse of wastewater is strictly controlled in order to minimize the spread of excreta-related disease. This entails treating the wastewater to a defined microbiological quality before it can be reused. However, in most developing countries reuse is carried out with untreated wastewater with little or no consideration for associated health risks. This is especially hazardous when salad vegetables are cultivated, also it can lead to contamination of groundwater and potable water supplies (Niedrum, *et al.*, 1991). The WHO (1989) and ECP-501 (2005) guidelines set microbiological quality criteria for wastewater use in the irrigation of crops to be eaten cooked or eaten raw, sports fields, public parks, cereal crops, industrial crops, fodder crops and trees. The guidelines required that treated wastewater should contain less than 1000 faecal coliforms per 100 ml for vegetables eaten raw. The numbers of faecal coliforms found in both primary and secondary treated effluents are higher than that permissible guideline. It is preferred to use this type of treated wastewater for forest irrigation.

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نوعية مياه الصرف الصحي المعالجة ثانويا في محطة زنين لمعالجة مياه الصرف الصحي

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تحتوى محطة زنين لمعالجة مياه الصرف الصحي على مقياس لمياه الصرف الصحي الداخلة ومناخل لتصفيه المياه الخام ووحدة التهوية الأولية وأحواض الترسيب الأولية.كذلك تحتوى على وحدة لسحب الرمال وأحواض الحماة النشطة مزودة بنظام للتهوية وأحواض الترسيب الثانوية أو النهائية وفى النهاية أحواض التلامس مع الكلورين، في البداية تمر مياه الصرف الصحي الخام على المناخل لفصل الأجسام غير العضوية كبيرة الحجم ثم تمر على التهوية الأولية لمدة مكوث مقدرها ٣٠ دقيقه في وحدة التهوية الأولية لفصل الزيوت والشحوم. كما يتم تشغيل أحواض الترسيب الأولية بالمحطة على مدة مكوث مقدرها ساعتان بينما وحدة تنشيط الحماة على مدة مكوث مقدرها أربع ساعات أما أحواض الترسيب الثانوية فيتم تشغيلها على مدة مكوث مقدرها ساعتان ونصف الساعة. وقد صممت المحطة لاستقبال ٣٣٠٠٠٠ م^{٣} / يوم.

والغرض من هذا البحث هو تقييم نظام المعالجة الثانوية بطريقة الحماة المنشطه ومعرفة مواصفات المياه المعالجة الخارجه من هذا النظام مقارنه بالكود المصري لإعادة استخدام مياه الصرف الصحي في الزراعة.

تم سحب العينات من ثلاث مواقع وهى المياه الداخلة وبعد المعالجة الأولية وبعد المعالجة الثانوية وبمعدل ٧ مرات كل شهر ولمدة عام كامل خلال ٢٠٠٥ وذلك لإجراء التقديرات اللازمة للحكم على كفاءة المعالجة وجودة المياه الخارجة، أما بالنسبة للعناصر الثقيلة فأخذت العينات مرة كل ٣ أشهر لمدة عام أيضا.

وقد أشارت النتائج إلى أن كفاءة المحطة في المعالجة تتراوح بين ٣١,٩ و ٩٥,٢% بالنسبة للمادة الصلبة الكلية والمواد العالقة الكلية على التوالي وبالنسبة لإزالة الكربون اللازم لأكسدة المادة العضوية كيماويا (COD) والكربون اللازم لأكسدة المادة العضوية بيولوجيا (BOD_5) فكانت الإزالة تتراوح بين ٩١,٦ و ٩٥,٣% على التوالي.

كفاءة التخلص من الأمونيا بعد المعالجة الأولية والثانوية كانت ٢٧,٩ و ٤٨,٧% على التوالي بمحصله نهائيه ٦٣% أما النترات فزادت بنسبة ٧٠ و ١٣٣,٣% بعد المعالجة الأولية والثانوية على التوالي.

بالنسبة لدلائل البكتريا الممرضة مثل بكتريا القولون الكلية وبكتريا القولون البرازيه فكانت كفاءة الازاله ٩٩,٩٩% بعد وحدة التلامس مع الكلورين.