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Assessment of Waste Stabilization Ponds for The Treatment of Municipal Wastewater in Upper Egypt.

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Abstract: - Sewage can be defined as discharges from domestic and sanitary appliances or simply a complex mixture of materials from varied sources. This complex mixture contains both soluble and insoluble materials. Waste stabilization ponds are recognized as the solution to domestic wastewater treatment in developing countries. The use of such natural systems is considered to be very important. This is because it is cheap, easy to construct and they do not require high skilled laborite. In this study, samples were taken from the raw wastewater and effluents of treatment ponds of Elzaraby waste stabilization ponds over a period of one year. The treated effluent is either discharged into surface waters or reused for agricultural irrigation. The samples were analyzed according to the standard methods. The results obtained from the samples taken in different seasons showed the maximum wastewater temperature were in the influent (35^0C) in summer season, and the minimum were (18^0C) in winter season. The values of hydrogen power (pH) and dissolved oxygen (DO) is increased along the ponds series. The average annual overall removal efficiency of TSS and TDS were 70% and 26%, while the maximum overall efficiency of BOD_5 was in summer (88%) and minimum efficiency was (73%) in winter season.

I. INTRODUCTION

The increasing demands for domestic wastewater due to population growth, improvement in living standards and the growing industrial sector will increase the total amount of wastewater available for reuse as an important source. The major issues include public health and environmental hazards as well as technical, institutional, socio-cultural and sustainability aspects. Waste stabilization ponds (WSP) are large shallow basins enclosed by earth embankments in which raw wastewater is treated by entirely natural processes involving both algae and bacteria[1], WSPs are usually the most appropriate method for domestic and municipal wastewater treatment in developing countries, where the climate is most favorable for their operation. WSPs are low-cost, low-maintenance, highly efficient. The only energy they use is direct solar energy, so they do not need any electromechanical equipment, saving expenditure on electricity and more skilled operation. WSPs can be classified with respect to the types of biological activity occurring in a pond. Three types are distinguished; anaerobic, facultative and maturation ponds. Usually WSPs system comprises a single series of the aforementioned three ponds types or several such series in parallel [2].

Sanitation services in Egypt are less developed than water supply services. At present, there are more than 323 wastewater treatment plants in the country. The capacity of wastewater treatment plants has increased by 10 times in the last two decades. The existing capacity is 12 million m3/day. Length of wastewater collection networks / sanitation pipelines increased from 28,000 km in 2005 to 34,000 km in 2010 [3]. Urban coverage with improved sanitation gradually increased from 45% in 1993 to 56% in 2004, reaching 100% in urban and 40% in rural areas by the end of 2012. The low coverage in rural sanitation results in serious problems of water pollution and health conditions due to the discharge raw domestic wastewater directly into
the waterways [4].

The main objectives of this study is to evaluate the performance of waste stabilization ponds (WSPs) in Elzaraby village, Abutig, Assiut governorate Egypt. some physical and biological characteristics of the waste water through the treatment plant are investigated.

II. MATERIAL AND METHODS

2.1. Description of wastewater treatment plant

A recent full-scale system of WSPs was constructed in 2009 in Elzaraby village in Upper Egypt (Fig.1). Elzaraby WSPs are designed to treat domestic waste water from Abutig city, with mean daily design flow rate of 16500 m^3/day.

Fig. 1. Elzaraby Waste stabilization ponds.

The physical characteristics of the ponds are given in (Table. 1). The wastewater after screening is used to feed two parallel anaerobic ponds (A1~A2). The two effluent of the anaerobic ponds is used to feed two facultative ponds (F1~F2), the effluent from the facultative ponds passes through two parallel lines of maturation ponds. Each line comprising a first, second and third maturation pond, (M1~M6). The treated effluent is either discharged into surface water or reused for agriculture irrigation.

Table 1. Design basis for physical and operational characteristic of Elzaraby WSPs.

Ponds	Dimensions (m)of the water body				Design basis	
	Bottom/top Length (m)	Bottom/top Width (m)	Water Depth (m)	Water Volume (m3)	Flow rate (m3/day)	HRT (day)
A1-A2	146/163.6	45.4/63	4.4	37257	8250	4.5
F1-F2	277.8/288.8	154/164	2.5	112680	8250	14
M1-M2	158/164	104/110	1.5	25854	8250	3.0
M3-M4	158/164	104/110	1.5	25854	8250	3.0
M5-M6	158/164	104/110	1.5	25854	8250	3.0

2.2 Wastewater sampling

Wastewater samples were collected monthly from the plant through a period of one years, from Spt. 2011 to Aug. 2012 to study the seasonal removal efficiency of LAS in natural WSPs, Monthly-samples of raw wastewater after screening and effluents from each type ponds were collected (S1to S5) as shown in (Fig. 2) of the sampling points. The samples were collected in plastic containers of 2 liter capacity.

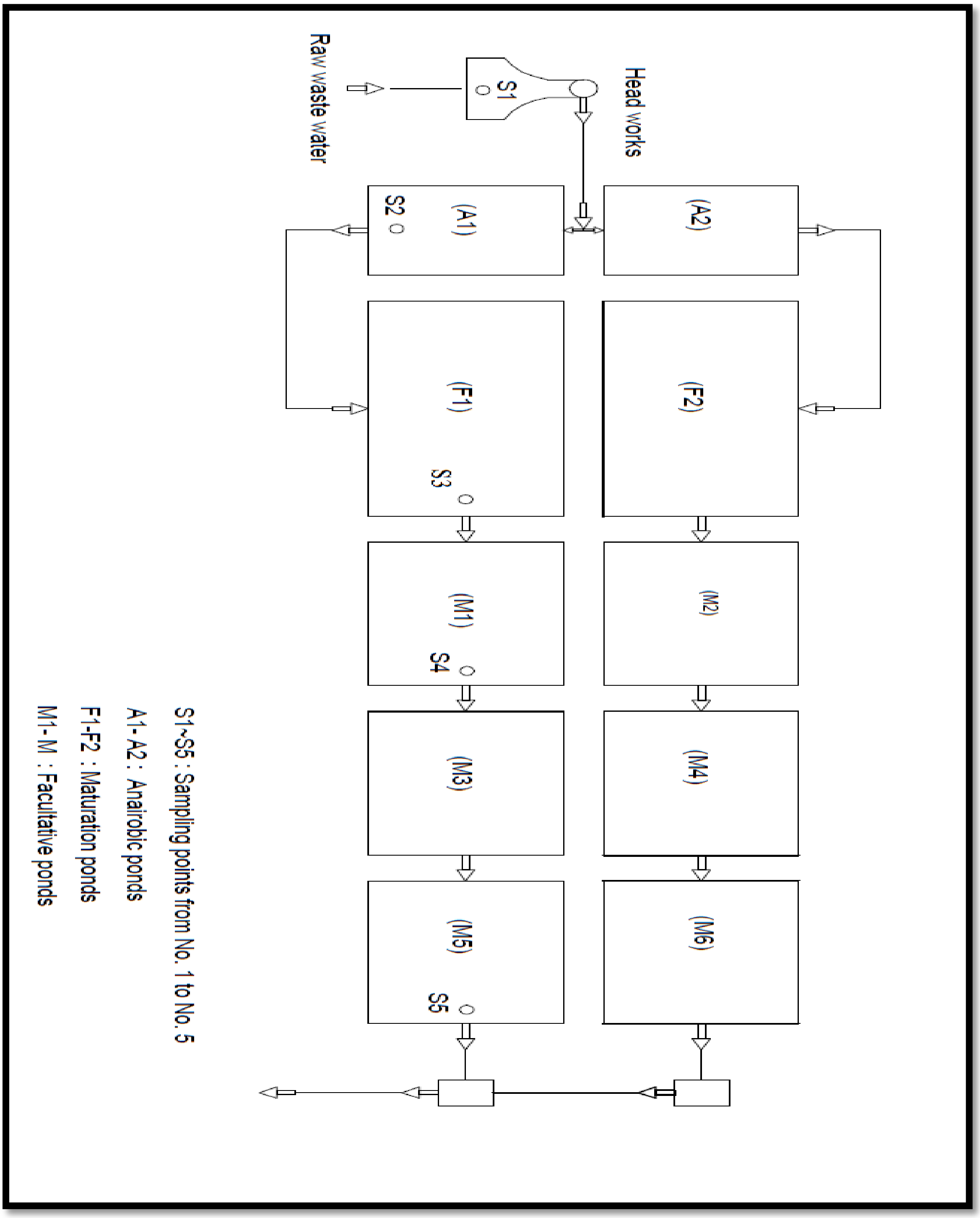

Fig. 2. The layout of Elzaraby WSPs

The following parameter were studied; water temperature (T), (pH) value, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), total suspended solid (T.S.S), total dissolved solids (T.D.S), electrical conductivity (EC),Turbidity(FTU)as in (table.2). All analysis have been carried out according to standard methods for examination of water and waste water (APHA, 2005) [5].

Table .2. Parameter and Instruments for wastewater sampling.

Parameter	Unit	Instruments Used
T	^0C	Thermometer
pH	----	Extech instruments pH meter
DO	Mg/l	DO meter AD610
TSS	Mg/l	HACH Spectrophotometer DR/2000
TDS	Mg/l	AD3000 TDS meter
BOD_5	Mg/l	Lovibond Oxidirect
EC	µs/cm	AD3000 EC meter
Tur	FTU	HACH Spectrophotometer DR/2000

III. RESULTS AND DISCUSSIONS

In this study, a complete one year monthly samples of wastewater were taken from WSPs of Elzaraby plant from locations S_1~S_5 totally 60 samples. The average seasonal values of T, pH, DO, TSS, TDS,EC, BOD_5 and Tur through the ponds were calculated.

3.1 Wastewater temperatures in the ponds

The wastewater temperature for the four season of the year from (Spt. 2011 to Aug. 2012) through the water pass in WSPs are illustrated in (Fig. 3). Measured temperatures of wastewater through the ponds were ranged between 18 ^{0}C and 35 ^{0}C. The maximum wastewater temperature in anaerobic ponds was 31.8 ^{0}C in summer season while the minimum was 22.1 ^{0}C in winter season. In facultative ponds, the temperature were ranged between 20.1 ^{0}C to 30.6 ^{0}C in winter and summer, respectively. In the last maturation ponds the minimum and maximum temperature were 18 ^{0}C in winter and 27 ^{0}C in summer season.

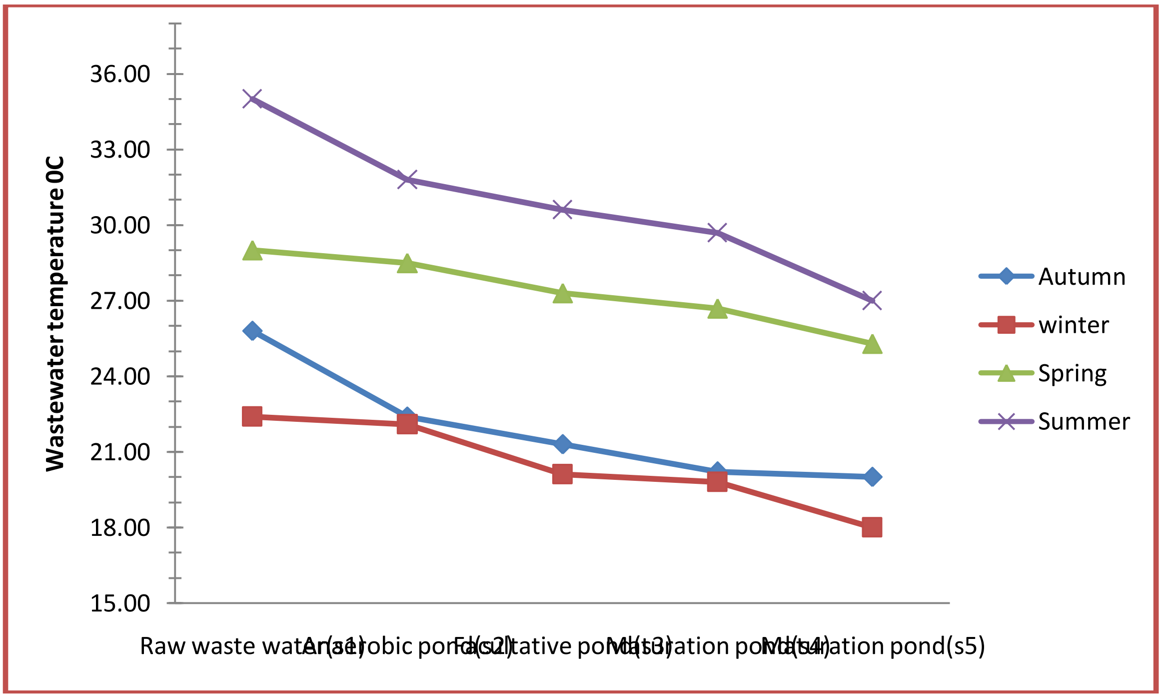

Fig. 3. Wastewater temperature for different season through the wastewater pass in Elzaraby WSPs.

As shown in (Fig. 3), it is clear that the wastewater temperature decreases along the pass of the ponds and maximum temperature occurs in summer season[6]. The decreasing rate is find to be much higher in the summer season (8^0C) than that in the winter season (4.4^0C), this due to the higher evaporation rate from the surface of the ponds which accomplished with higher latent heat in summer compared with that in winter season.

3.2 pH variations along the pond series

The average seasonal variation of the measured pH value for the raw sewage and effluent from each type of ponds in the period from Spt. 2011 to Aug. 2012 are presented in (Fig. 4). The average pH value of raw wastewater ranged between 6.63~7.4, while increased in anaerobic ponds to be 6.75 and 7.8 as minimum and maximum values in winter and summer seasons, respectively. In maturation ponds the measured pH recorded a maximum value in summer 8.8 and a minimum value in winter was 7.7. As shown in Figure, the pH values of the ponds' wastewater has it's higher values in the summer season, and it increases along the wastewater pass with the highest values in the last maturation ponds. The increased of pH value in maturation ponds is due to rapid photosynthesis by the pond algae, which consumes Carbon dioxide (CO_2)faster than it can be replaced by bacterial respiration; as a result carbonate and bicarbonate ions dissociate. Algae fix the resulting CO_2 from the dissociation while hydroxyl ions (OH^-) accumulate so raising the pH value. Similar results were found by[7].

3.3 DO concentration along the ponds series

From (Fig -5) it is clear that the DO average concentration values for four season along Elzaraby WSPs series were increased along the ponds and recorded a maximum values in summer season and minimum values in winter season (ranged from 0.0 to 6 mg/l), while the mean values in the ponds during autumn and spring season are located in the intermediate range between summer and winter season. It is clear that the value of DO in the summer season increases relative to the winter season, because the rate of algae photosynthesis and the cellular metabolism of microorganisms in the ponds are enhanced by high temperatures and retarded by low temperatures. Algal oxygen production is directly related to photosynthesis, which depends on temperature variations. From the figure [8].

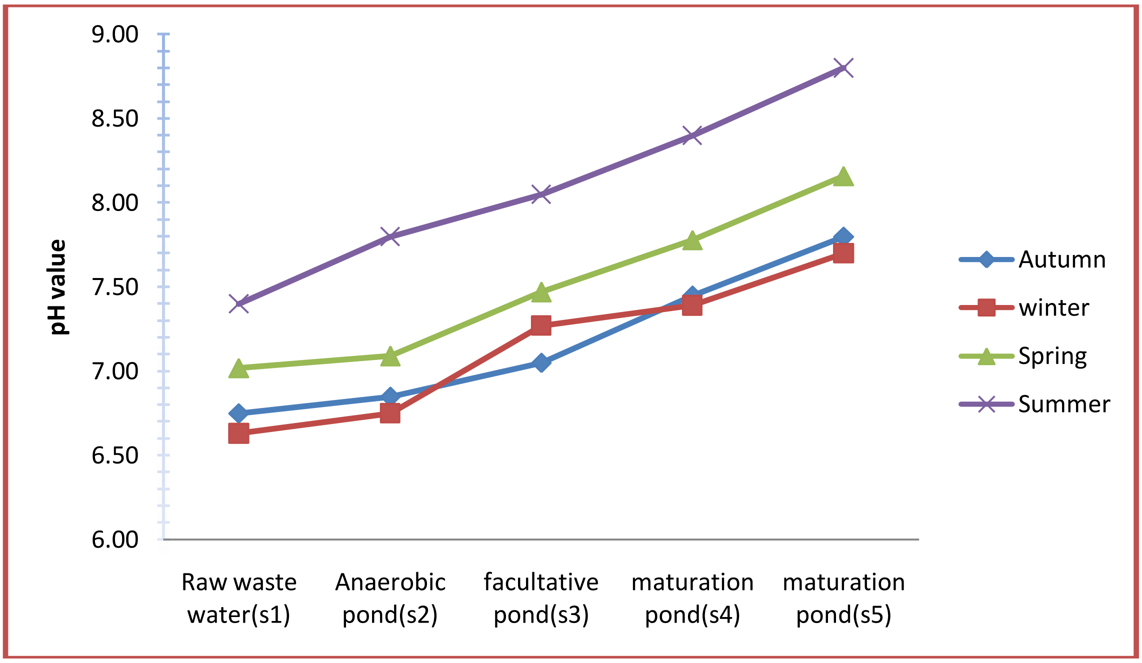

Fig. 4. Seasonal variation of pH value measured along Elzaraby WSPs.

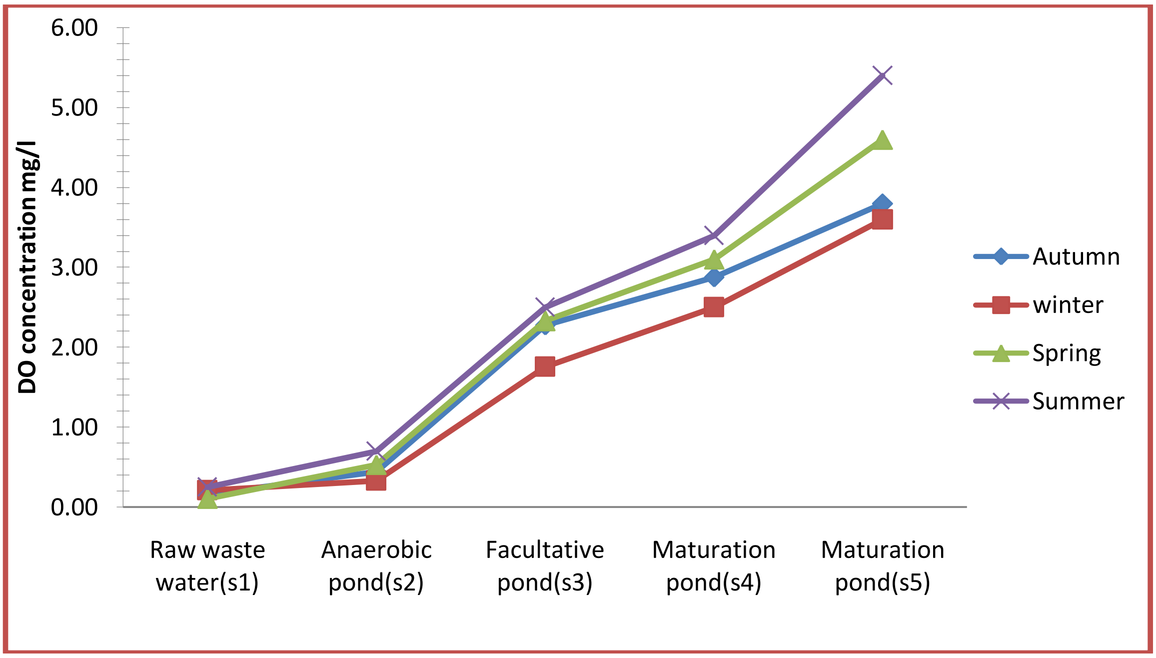

Fig. 5. Seasonal concentration value of DO measured along Elzaraby WSPs.

3-4 T.S.S values along the ponds series

For a comparison between the mean values of the measured T.S.S in the different four seasons of the year are plotted as shown in (Fig. 6). The average T.S.S values in raw wastewater recorded 202, 153, 227 and 326 mg/l in Autumn, winter, Spring and summer seasons respectively, while they recorded in the effluent in last maturation ponds 74,75, 105 and 110 mg/l in Autumn, winter, Spring and summer seasons respectively. From the figure it is clear that T.S.S concentration values increased in hot seasons and decreased in cold seasons. The reason of these phenomena is that high wastewater in hot season accomplished with high photosynthesis and evaporation rates. High rate of photosynthesis generates many new cells of algae which increases the values of the T.S.S in the ponds. Also, a high evaporation rate in the summer tends to increase the T.S.S concentration in the ponds and T.S.S concentration values is decreased along the ponds series [9].

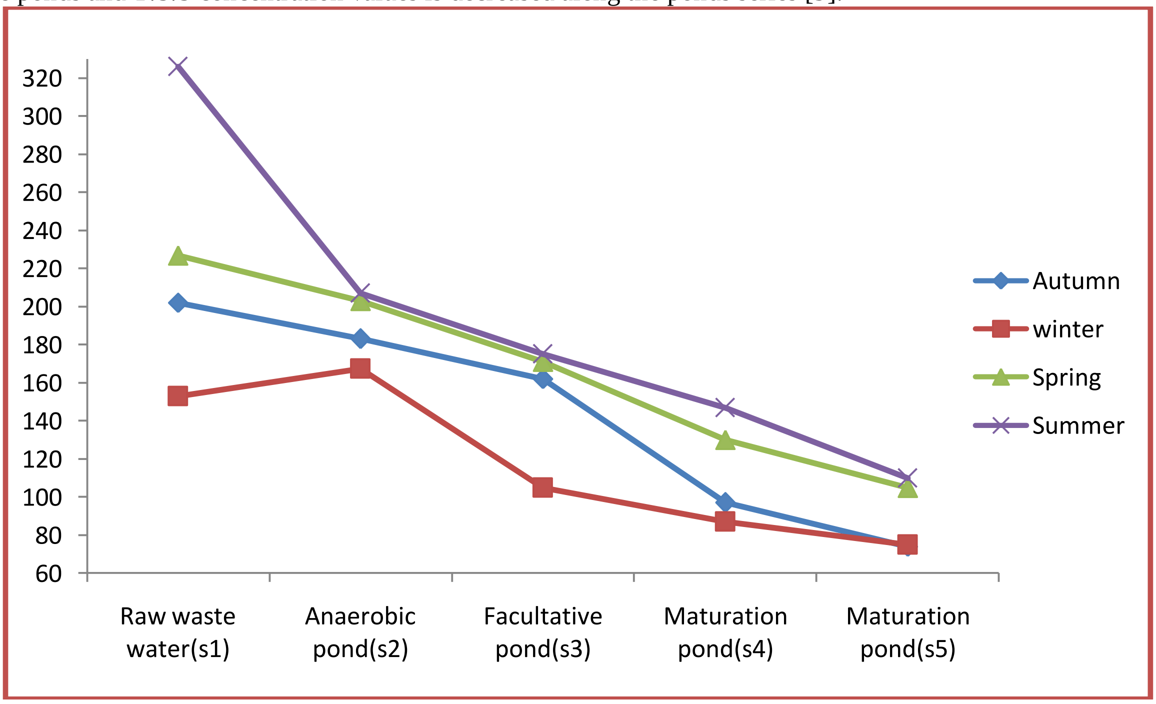

Fig. 6. Average Seasonal variation values of measured T.S.S along the ponds series at Elzaraby WSPs.

3-5 T.D.S values along the ponds series

For comparison the mean annual values of the measured T.D.S in the different four seasons of the year are plotted as shown in (Fig. 7), from the figure it is clear that T.D.S concentration values decreased along the ponds series [10]. From the it is clear that the overall removal efficiency of T.D.S increased in hot seasons and decreased in cold seasons. The reason of these phenomena is that high wastewater temperature in hot season accomplished with high photosynthesis and high evaporation rates, the result showed higher removal efficiency of TDS than other study in Ethiopia the avarege annual removal efficiency of the ponds was 26%.

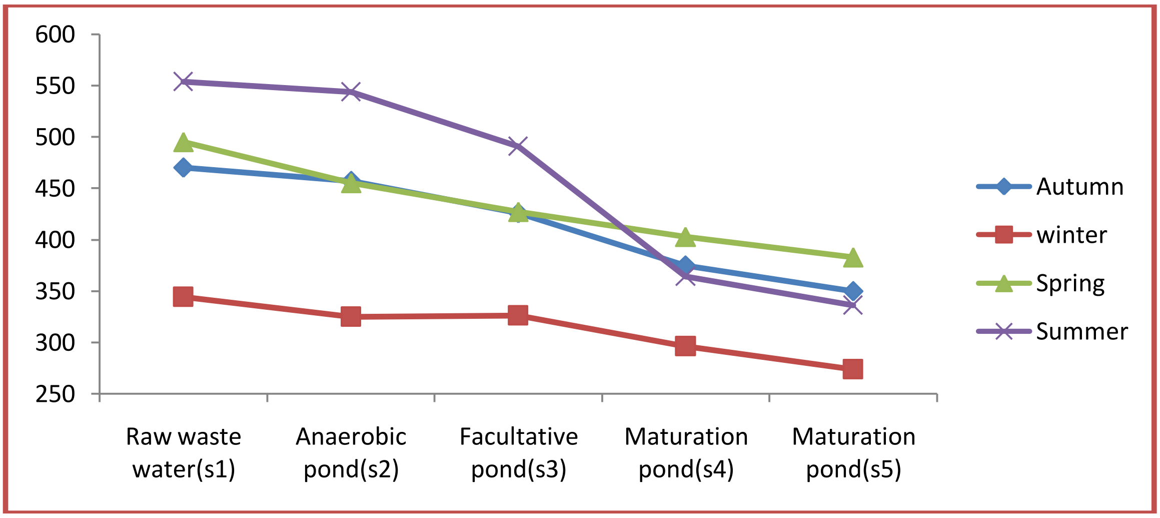

Fig. 7. Average Seasonal variation values of measured T.D.S along the ponds series at Elzaraby WSPs.

3-6 Average Turbidity values along the ponds series.

As shown in (Fig.8), in the period of investigation turbidity concentration values increased in hot seasons and decreased in cold seasons, and the overall removal efficiency of turbidity from Elzaraby WSPs in summer menthes is higher than other menthes. The reason of these phenomena is that high wastewater temperature in hot season [11] .

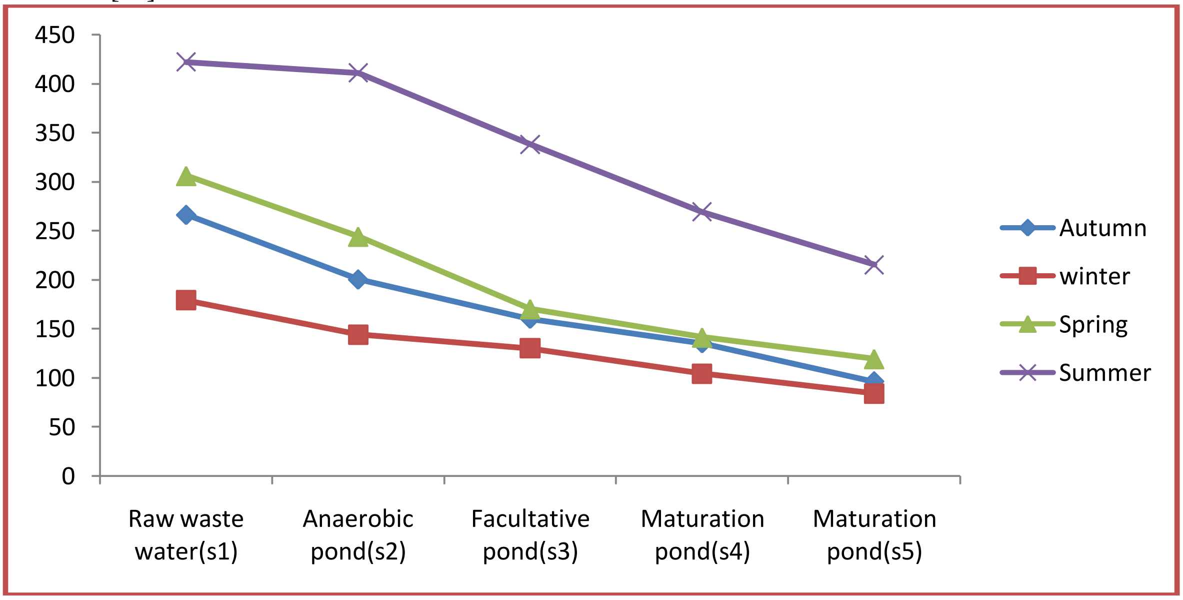

Fig. 8. Average Seasonal variation values of measured Turbidity along the ponds series at Elzaraby WSPs.

3-7 Average values of measured conductivity along the ponds series for the four seasons.

For comparison the mean values of the measured EC in different four seasons of the year are plotted as shown in (Fig. 9). The average EC values in raw wastewater recorded 1260, 1169, 1285 and 1553 µs/cm in Autumn, winter, Spring and summer seasons respectively, while they recorded in the effluent in last maturation ponds 1070, 855, 1121 and 1249 µs/cm in Autumn, winter, Spring and summer seasons respectively. From the figuer It is clear that the maximum EC values occur in the summer season, while the minimum EC values are in the winter season because high air and water temperature and high evaporation rate occurs in summer season relative to other seasons[8].

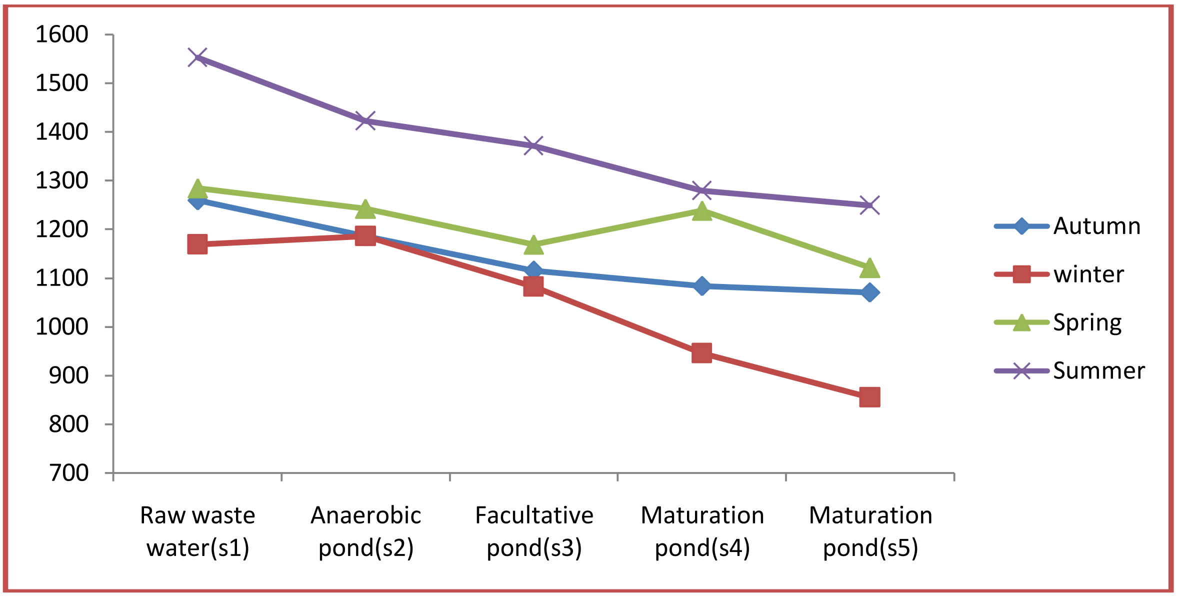

Fig. 9. Average Seasonal variation values of measured EC along the ponds series at Elzaraby WSPs.

3-8 BOD average seasonal concentration value

For comparison the mean values of the measured unfiltered BOD_5 in different four seasons of the year are plotted as shown in (Fig. 10). The average concentration of BOD_5 values in raw wastewater were ranged between 426.3 mg /l to 305 mg/l in summer and winter seasons respectively, while they recorded in anaerobic ponds 314~167.5 mg/l as a maximum and a minimum values. In facultative ponds BOD_5 concentrations were found to be ranged between 275~111 mg/l, while the effluent of the last maturation ponds has BOD_5 concentrations of 43.5, 51.5, 55 and 73.3 mg/l in autumn, winter, spring and summer seasons, respectively.

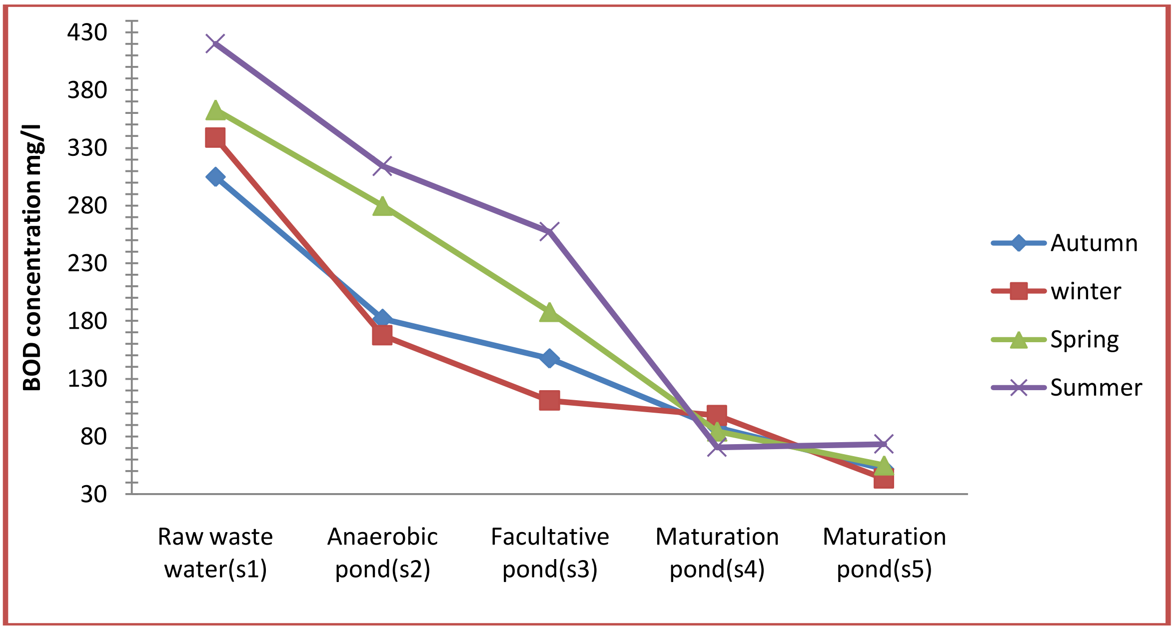

Fig. 10. Seasonal concentration value of BOD measured along Elzaraby WSPs.

From (Fig. 10). It is clear that the maximum BOD_5 values occur in the summer season, while the minimum BOD_5 values are in the winter season. The reason of this phenomenon is that high air and water temperature and sun light intensity occurs in summer season relative to other seasons, which increased algal grow [12].

IV. CONCLUSION

1- The wastewater temperatures of the plant were decreased along the ponds series and recorded 35^0C as a higher values in anaerobic ponds in sumer season, while recorded 18^0C as minimum values in winter season in the last maturation ponds.

2- The average variation values of measured pH of Elzaraby WSPs is increased along the ponds series from 6.36 (minimum values occurred in raw wastewater) to 8.8 as a maximum values in the last maturation ponds, so faecal bacteria die very quickly and the photosynthesis activity of algae becomes less. Also, the high pH values occurred in ponds leads to high efficiency removed of heavy metal.

3- Concentration values of measured DO is increased along the pond series and recorded maximum values in summer season in the last maturation ponds.

4- The electrical conductivity EC is recorded variation values and changed seasonally along the ponds series, the values of EC increased in summer season relative to other months.

5- The maximum overall removal efficiency of measured T.S.S was 70% in summer season and recorded 48% as minimum values in winter season, furthermore the average over all removal efficiency of T.S.S from the ponds series along the study period was 59%. The average concentration values of the last maturation ponds T.S.S was 85 mg/l so, the treated wastewater allow to be reused in agriculture in grade (C) as in Egyptian Code for the Use of Treated Wastewater in Agriculture.

6- The maximum overall removal efficiency of BOD_5 was in summer (88%) and minimum efficiency was (73%) in winter season, while The average values of measured BOD_5 in the last maturation ponds was 60 mg/l which allow to be reused in agriculture in grade (B,C) as in Egyptian Code for the Use of Treated Wastewater in Agriculture

REFERENCE

[1] Mara, D. D. "Domestic Wastewater Treatment in Developing Countries", Earth scan, London , Sterling, VA, 2004

[2] Ramadan, H., Ponce, V. "Design and Performance of Waste Stabilization Ponds".info@virginglobe.com Version 081218, 2011

[3] Abdel- Kader, A.M., Abdel-Rassoul, S.M. (2010)., Prospects of water conservation in Egypt(special reference to wastewater reuse).Fourteenth international water technology conference, 25-27 March 2010.

[4] MWRI/USAID (2000): Policies and procedures for improved urban wastewater discharge and reuse. Appendix 2: Health impact and water quality standards in wastewater irrigation. Report No.34, Egyptian Ministry of Water Resources and Irrigation and US Agency for International Development, available online at http://pdf.usaid. gov/pdf_docs/PNACS687.pdf (last accessed 3 January 2013).

[5] APHA (2005). Standard methods for the examination of water and wastewater, 20th and 21st ed. American Public Health Association, Washington, DC.

[6] Haydeh Hayati1, Mohammadreza Doosti1, Mohammadhossein Sayadi., Performance evaluation of waste stabilization pond in Birjand, Iran for the

[7] treatment of municipal sewage . Civil and Environmental Engineering Department, University of Birjand, Birjand, Iran., 2013

[8] Bastawey. M.A. (2010). Diurnal variation of some physical – chemical parameters in natural waste stabilization ponds in upper Egypt.

[9] Nasr. F.A., El-Ashmawy. A., Eltaweel. G., El-Shafai. S.A. (2007). Waste Stabilization Ponds for Wastewater Treatment and Reuse in Egypt. Environmental Sciences Division, Department of Water Pollution Research

[10] Ebrahimi, A., Ehrampoosh, M., Samaie, M., Ghelmani, S., Talebi, P., Dehghan, M., Honardoost, A., Shahsavani, E., 2010. Removal Efficiency of Linear Alkyl Benzene Sulfonate (LAS) in Yazd Stabilization Pond. Scientific Information Database, Iran.

[11] Hasan, A.' Program of Water and Environmental Engineering 461652, Spring 2011 Natural WWT, 2-WSP.

[12] Ram Kumar Kushwah, Avinash Bajpai, Suman Malik and Archana Singh, Assessment of Some Physicochemical Parameters in Influent and Effluent and Water from Sewage Treatment Plant at Bhopal, M.P. (India) Water Research & Development Vol. 1 | No.1 | 59-62 | January-April | 2011

[13] Gad, A., Ali, A., 2005. The pereformance of an existing system of waste stabilization ponds in upper Egypt. In: First Ain Shams University International Conference on Environmental Engineering.