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Evaluating the Efficiency of Wastewater Treatment Plants in Sharkia Governorate, Egypt

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Abstract – *A survey was conducted to report on the efficiencies of various treatment technologies being used at major wastewater treatment plants (WWTPs) in Sharkia governorate, Egypt. Twelve, full-scale wastewater treatment facilities with a design capacity varied from 15,000 to 40,000(m^3/d) were evaluated. Analysis data for two months was obtained from plants operation companies. Influent and effluent five-day Biochemical Oxygen Demand(BOD_5), total suspended solids (TSS), Chemical oxygen demand (COD), total dissolved solids (TSS), and effluent concentration of dissolved oxygen (DO) were evaluated and compared to Environmental standards for the treated sewage and discharge limit for law 48/1982, analysis shows that almost 75% of the WWTP meets the required treatment standards while 25% of the facilities reported some violations.*

Key Words: plant performance, secondary, treatment, wastewater.

1.INTRODUCTION

Wastewater is the collective term for all used water contaminated to the extent that, for most purposes, it cannot be used without treatment. Accumulating amounts of wastewater quickly become a hazard as the contaminants commonly create both health risks – spreading pathogenic deceases and environmental problems to both natural waters eutrophication and toxicity and air by greenhouse gas (GHG) emissions [1].

The “per capita” (cap) municipal water use in the world ranges from below 50 to over 500 l/capita/day and there is a clear correlation between economic wealth (i.e. gross domestic product) and water use [2]. In developed communities and cities, the water use lies between 150 and 250 l/capita/day, with major cities in The United States at over 400 l/capita/day. Egypt has on an average water consumption of 220 l/capita/day [3, 4],

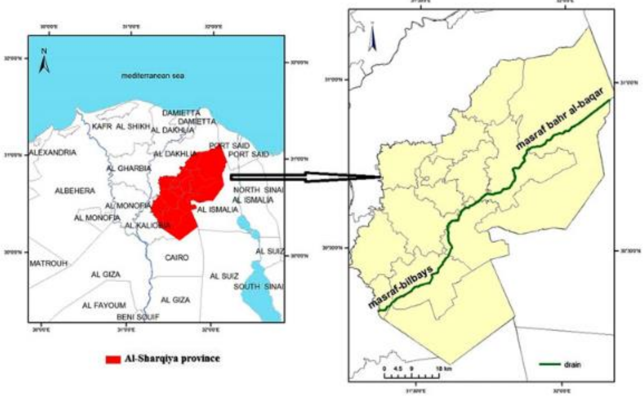
Pollution from wastewater is currently the greatest threat to the sustainable use of surface and groundwater in megacities. Today, household, commercial, and industrial effluents and raw untreated sewage are often discharged into the surface freshwater sources, while untreated wastewaters from villages and rural areas in the most of developing countries are often discharged directly into the waterways. The wastewater eventually percolates or is washed into the water bodies by rainstorms. The stagnating pools of wastewater in the open gutters and on the roads often provide the breeding grounds for mosquitoes and habitat for several bacteria and viruses. In addition, wastewater pools contain hazardous contaminants such as oil and grease, pesticides, ammonia and heavy metals [5]. When point source pollution is reduced in many countries (even if wastewater treatment plants (WTPs) begin to reach their capacity limits), climate (global) change impacts could increase the diffuse pollution due to urban or agricultural run-off. The climate change parameters affecting water quality include mainly the ambient (air) temperature and the increase of extreme hydrological events; in addition, soil drying–rewetting cycles and solar radiation increase should be considered. By the end of the 21st century, projected future climate change would lead to an increased portion of treated wastewater in rivers due to reduced discharges during low-flow situations [6]. Waterborne pathogens could be spread within the freshwater after a contamination by animal or human waste due to heavy rainfall discharge in combined sewer systems (CSS). When the flow exceeds the CSS capacity, the sewers overflow directly into surface water body [7]. Coliform load in a tidal embayment was studied, and it was shown that storm water coming from the surrounding watershed represented a primary source of coliform [8]. Moreover, higher water temperatures will probably lead to a pathogen survival increase in the environment, although there is still no clear evidence [9]. Half of the waterborne disease outbreaks in the US during the last half century followed a period of extreme rainfall [10]. Even though the risk of diseases outbreak linked to mains drinking waters is low in developing countries, private supplies would be at risk [9], andeven properly constructed onsite wastewater treatment systems may cause a waterborne outbreak [11]. In addition, an increase in temperature may worsen water quality with regard to waterborne diseases especially cholera disease in Asia, Africa and South America [9]. At last, it was shown that by increased UV radiation due to ozone layer depletion, natural organic substances might trap higher levels of UV energy resulting to their breakdown to more bioavailable organic compounds, minerals and micronutrients. All these processes could stimulate bacterial activity in aquatic ecosystems [12]. The prevalence of pathogenic microbes in treated wastewater has raised concerns about the capacities of existing treatment to remove theses microbes [13]. Recently, the average log removals rates in effluents by three different pilot-scale sand filters were 2.2–3.5 for pathogenic human noro- and adenoviruses and 4.3–5.2 and 4.6–5.4 log CFU/ml for indicator viruses and bacteria, respectively. The system that effectively removed microbes was also efficient for removing nutrients [14].

The most common treatment streams in Egypt are using Activated sludge or trickling filters, the activated sludge process is a two-step sequential process consisting of substrate utilization in the aeration basin, followed by solids-liquid separation in the secondary clarifier. In well operated activated sludge systems treating domestic wastewater at a solids retention time (SRT) of 4 days or longer, the effluent soluble BOD is generally <3mg/l and effluent TSS concentrations range from 5–15 mg/l [1, 15 and 16].

Trickling filters (TF) are attached biological growth systems wherein wastewater is applied to rock or plastic media. Microorganisms growing on the TF media oxidize and synthesize organics in the wastewater. Insignificant quantities of nitrogen and phosphorus are removed through synthesis of biomass. Traditionally, rock or slag is used for TF media, while plastic is used for biotowers. Trickling filters generally produce an effluent with BOD and TSS values ranging from 15–30 mg/l or that equivalent to secondary treatment [1, 15 and 16]

The demand for water in Sharkia governorate has increased over the last several decades. According to the CAPMATH Census [4]Sharkia population has increased from 5,283,317 to 7,192,355 capita from 2006 to 2017. They are served by a water treatment plants with capacity up to 1.0 M.m3/d while the wastewater treatment capacity does not exceed 0.4 M.m3/d. Wastewater effluent should be considered as a precious resource; one to be recycled and reused for irrigation, groundwater or aquifer recharge, cooling water, and ultimately as a source of drinking water, therefore effluent from wastewater treatment facilities must be properly treated before discharging back into the environment.

Fig - 1: Sharkia governorate location [17].



The purpose of this study was to assess the performance of major wastewater treatment plants (WWTPs) in Sharkia governorate and to report on the efficiencies of various treatment technologies being used. The significance of this study lies in the development of probability plots showing the concentration of various effluent parameters with the Environmental standards for the treated sewage and discharge limit for law 48/1982 Table 1. The study also identifies which facilities are meeting permit requirements and those that have incurred minor violations.

Table -1: Environmental standards for the treated sewage and discharge limit for law 48/1982

Treatment degree	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	DO (mg/l)	TDS (mg/l)
Primary treatment	300	600	350	----	2,500
Secondary treatment	40	80	40	>4	2,000
Tertiary treatment	30	40	20	>4	2,000
Discharge limit to drains	60	80	50	>4	2,000
Discharge limit to River Nile	30	40	30	>4	2,000

2. EXPERIMENTAL TESTS

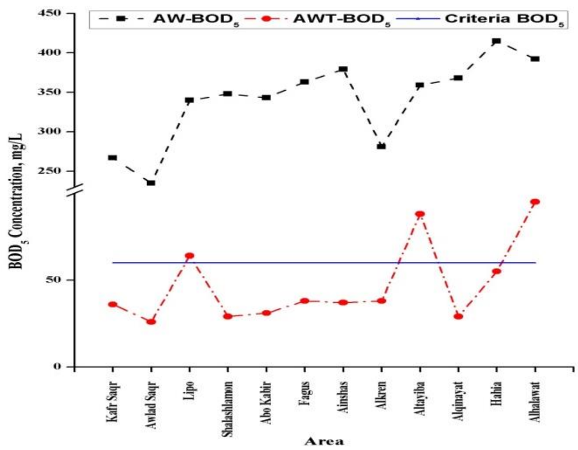
Two months of operating data was obtained from WWTP's operation companies, and data evaluated included: influent and effluent 5-day biochemical oxygen demand (BOD_5) influent and effluent total suspended solids (TSS), influent and effluent Chemical oxygen demand (COD), influent and effluent total dissolved solids (TSS), and effluent dissolved oxygen (DO). All these parameters were measured according to [18]

Twelve, full-scale wastewater treatment facilities with a design capacity varied from 15,000 to 40,000(m^3/d) were evaluated, all these plants contain secondary treatment process, 10 plants operated with Activated sludge and only 2 had trickling filter units.

3. RESULTS AND DISCUSSIONS

Figure 2shows the concentration of influent, effluent and standard limit of $BOD_{5,}$ the influent concentration varied from 235 mg/l to 415 mg/l while the effluent concentration varied from 25 mg/l to 90 mg/l, 3 out of the 12 recorded plants are not complying with the criteria of environmental standard.

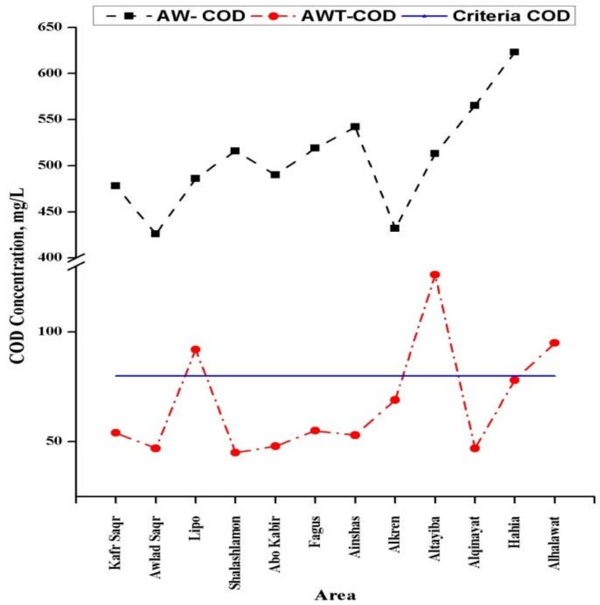
Fig - 2: BOD_5 concentration for influent (AW), effluent (AWT) and standard limit.



Removal efficiency of the complying plants ranged between 85 to 95%, data of the influent concentrations and removal efficiency complies with [1, 15 and 16].

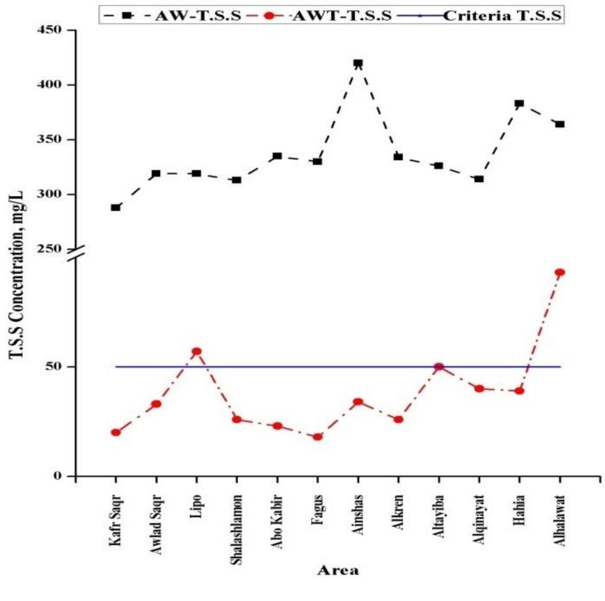
Figure 3 shows the concentration of influent, effluent and standard limit of $COD_,$ the influent concentration varied from 420 mg/l to 630 mg/l while the effluent concentration varied from 35 mg/l to 160 mg/l, also the same 3 plants which does not comply with the BOD criteria also does not comply with COD criteria this is due to the interconnection between the two parameters especially for the same wastewater source.

Fig - 3: COD concentration for influent (AW), effluent (AWT) and standard limit.



Removal efficiency of the complying plants ranged between 84 to 92%, data of the influent concentrations and removal efficiency also complies with [1, 15 and 16].

Fig - 4: TSS concentration for influent (AW), effluent (AWT) and standard limit.



Regarding TSS, 10 out of the 12 plants were complying with the standard and only 2 were violating the standard, the influent concentration varied from 280 mg/l to 400 mg/l while the effluent concentration varied from 20 mg/l to 100 mg/l (figure 4), Removal efficiency of the complying plants ranged between 88 to 96%, data of the influent concentrations and removal efficiency also complies with [1, 15 and 16].

Regarding the TDS and as the influent concentrations were already less than the limit all plants comply with the required standard (Figure 5).

Fig - 5: TDS concentration for influent (AW), effluent (AWT) and standard limit.

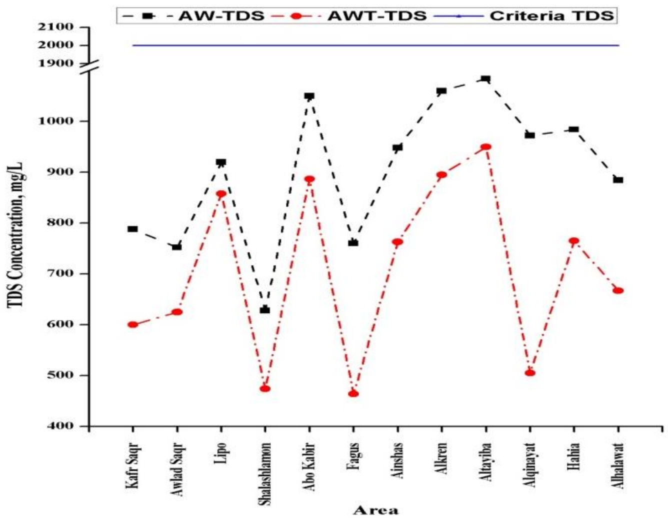
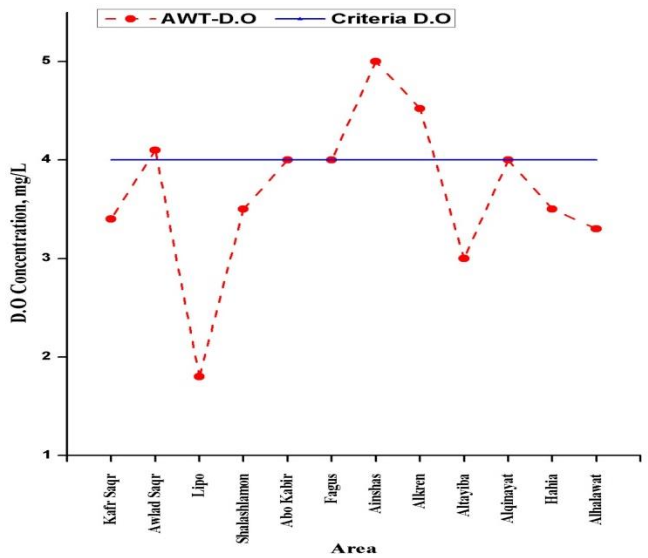


Fig - 6: DO concentration for effluent (AWT) and standard limit.



Dissolved oxygen is one of the most important factors in order to maintain the aqua systems in equilibrium [19], as shown in figure 6 only 3 plants complying with the required criteria, 3 are just on the edge of the limit while 6 are violating the standard.

4. CONCLUSIONS

The main conclusion from this work can be summarized as follows;

- Generally, influent concentrations of BOD_5, COD, TSS and TDS are complying with municipal wastewater characteristics.
- Removal efficiency of tested parameters complying with the standard performance of WWTP technologies.
- 75% of the WWTP are complying with the BOD_5 standard.
- 75% of the WWTP are complying with the COD standard.
- 83% of the WWTP are complying with the TSS standard.
- 100% of the WWTP are complying with the TDS standard.
- 50% of the WWTP are complying with the effluent DO standard.

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