Microbiological and Physico-chemical Characteristics of Municipal Wastewater at Treatment Plants, province Sharkia, Egypt (Case study)

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ABSTRACT

The present study was conducted to evaluate the microbiological and physico-chemical characteristics of effluent produced from 17 Wastewater Treatment Plants (WTPs) distributed in province Sharkia before discharge in the drainage to control the pollution and their disposal options. Total bacterial count (TBC), total yeasts & moulds count (TYMC), total *Candida* count (TCC), total coliform count (TCFC), *Escherichia coli* (EC), *Salmonella* and *Shigella* (SS) count) were analyzed for untreated wastewater (UW), aeration treatment wastewater (ATW), oxidation treatment wastewater (OTW), anaerobic treatment wastewater (ATW) and treated wastewater (TW). Physicochemical parameters (Temperature, pH, Total Suspended Solids (TSS), Total dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate (NO_3-), sulphite (SO_4-) and oil contents of UW and TW in the WTPs were examined in different seasons. The treatment plant received the municipal wastewater from various Sewage Pumping Stations being treated through different stages viz. primary (physical), secondary (chemical) and tertiary (disinfection) treatments. The results revealed that the wastewater was heavily contaminated with cultivable bacteria and inorganic & organic pollution. The coliform bacteria were correlated indicators of a reduction in pathogenic bacteria concentrations during the wastewater treatment, but were not correlated to *Candida* contamination of wastewater and drainage samples. The TBC, TYMC, TCC, TCFC, EC and SS were significantly ($p < 0.05$) decreased in treated water. The maximum removal of TBC (60%), TYMC (59 %), TCC (75 %), TCFC (77%), EC (75%) and SS (74%) of treated wastewater were observed after the finally treated. The TSS, TDS, BOD, COD, sulphite, nitrate and oil levels were significantly ($p < 0.05$) decreased in wastewater after the finally treated. The maximum removal of pH (6%), BOD (90%), COD (89%), TSS (88%), and SO_4- (86%), of treated wastewater were recorded after finally treatment. The results indicated that the treatment plants had a significant role in the control of pollution load from microbial, organic and inorganic pollution at province Sharkia, Egypt. The results conclude that microbiological parameters are essential to monitor the correct WTP operation and we propose quantification of *Candida* as indicator of wastewater microbiological quality.

Keywords: Microbiological, *Salmonella*, *Candida*, sewage water, TDS, BOD, COD.

1. Introduction

Actually, there remain major uncertainties about the implications of possible wastewater safety under a changing climate. Climate change can be expected to present a variety of new challenges in the area of wastewater treatment on middle and long-term timeline. Evidence of the impact of climate change on the transmission of waterborne diseases has become clear [1]. Climate change is a significant impact on land surface water availability, decreasing by 20% according to Mariotti et al., [2]. The Mediterranean is a ‘hot spot’ for climate change, an increase in the average annual temperature between +3.5 ˚C and +3.9 ˚C[3].The Intergovernmental Panel on Climate Change scenario, the average global air temperature should increase between 1.8 and 4.0 ˚C [4] during the 21st century and this increase might effect on wastewater treatment. Moreover, a drying tendency in summer is expected, particularly in subtropics, low and mid-latitudes, in addition with an extreme events increase in general. The vulnerability assessment of water resources in Egypt to climatic change in the Nile Basin was reported [5]. Irrigation of agricultural lands with wastewaters, following varying levels of treatment, is increasing around the world [6, 7, 8, 9].

Pollution from wastewater is currently the greatest threat to the sustainable use of surface and groundwater in the megacity. Household, commercial, and industrial effluents and raw untreated sewage are often discharged into the open and fresh-water sources such as the majority of villages and rural areas discharge their raw domestic wastewater directly into the waterways in the most of developing countries. 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 [10]. When point source pollution is reduced in many countries (even if wastewater treatment plants begin to reach their capacity limits), climate (global) change impacts could tend to increase the diffuse pollution with for example urban or agricultural runoff. The climate change determinants affecting water quality are mainly the ambient (air) temperature and the increase of extreme hydrological events. Soil drying-rewetting cycles and solar radiation increase may also be considered.

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 [11]. Coliform load in a tidal embayment was studied and shown that storm water coming from the surrounding watershed is a primary source of coliform [12]. Moreover, higher water temperatures will probably lead to a pathogen survival increase in the environment, although there is still no clear evidence [13]. Half of the waterborne disease outbreaks in the US during the last half century followed a period of extreme rainfall [14]. Even though the risk of diseases outbreaks linked to mains drinking waters is low in developed countries, private supplies would be at risk [13], and even properly constructed onsite wastewater treatment systems may cause a waterborne outbreak [15]. In addition, an increase in temperature threats water quality with regard to waterborne diseases especially cholera disease in Asia, Africa and South America [13]. Lastly, it was shown that with increased UV radiation due to ozone layer depletion, NOM trap higher levels of UV energy and breaks down to more bioavailable organic compounds, minerals and micronutrients. All these processes could stimulate bacterial activity in aquatic ecosystems [16].The prevalence of pathogenic microbes in treated wastewater has raised concerns about the capacities of existing treatment to remove theses microbes [17]. In Egypt, according to FAO [18], at present, wastewater is estimated at 4930 billion m^3/yr. However, the total capacity of the installed treatment plants amounts to about 1.752 billion m^3/yr. The whole wastewater reuse in agriculture is about 0.2 billion m3/year [19]. At present, there are more than 239 wastewater treatment plants (WTPs) in Egypt in 2012 and 35 WTPs of the total in province Sharkia. Urban coverage with improved sanitation gradually increased from 45% in 1993 to 56% in 2004. The WTPs are treating an average of 10.1 million cubic meters per day [20], serving more than 18 million people. The number has increased 10 times between 1985 and 2005 [21]. The amount of water which is released into the Nile is 3.8 billion m^3 per year, out of which only 35% was treated properly as of 2004.

Recently, the average log removals after treated wastewater by three different pilot-scale sand filters were 2.2-3.5for 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 at removing nutrients [22]. Thus, this study assessed the performance of 17 Wastewater Treatment Plants (WTPs) in cold and hot climate over a one-year period from April 2012 to March 2013 in province Sharkia, Egypt. The WTPs, traditionally, rural household wastewater has been treated by two or three separate septic tanks that provide primary treatment, secondary treatments and a soil absorption field for further treatment. The main purpose was to examine the changes in physical, chemical and microbiological quality in wastewater during treatment operations. The function of the systems evaluated in terms of their ability to remove nutrients, organic and microbial loads. The second aim was to evaluate the quality of wastewater in drainages that discharges from the WTPs.

2. Materials and methods

2.1. Study area

The area of case study is located in Sharkia governorate, Egypt. The Sharkia area locates at latitude 30.7 °N and 31.63 °E longitudinal at an evaluation of 10 m above the mean sea level. The TW discharges into the Belbeis Drain (BD) and then into Bahr El Baqar Drain (BEBD), which in turn drains to Lake Manzala 170 km away from Cairo. The drain and Lake Manzala had been identified as "black spots" by the Egyptian Environmental Action Plan back in 1992.

2.2. Water sampling

The study was conducted in 17 WTPs located in the megacities in Sharkia, Egypt. They served about 6.884.000 populations, receive about 387.000 m^3/y and indirect discharge about 138.000 m^3/y. Other 10 sites, the wastewater samples were collected from BEBD located in Sharkia, Egypt during seasons of 2012-2013.The samples were collected each month at the same location between 8 am and 11 am in a sterile Schott glass bottle from the TMW, BD and BEBD at the same point. Water was obtained from areas of fast flow at a depth half that of the total in order to avoid debris and collecting exclusively surface water. The samples were placed in a container filled with ice, then transported to the microbiological laboratory, and stored at 4 ˚C prior to analysis.

2.3. Microbiological analysis

Wastewater samples (10 ml) were aseptically pipetted into a sterile Erlenmeyer flask and diluted tenfold by adding 90 ml of in sterile buffered peptone water (BPW: peptone 1 g/l, pH 7.4) followed by subsequent decimal dilution (up to 10^{-7}) using the BPW. Total bacterial counts (TBC) for wastewater samples were conducted in triplicate according to the American Public Health Association [23]. using plate count agar and incubated at 30 ˚C for 48 h. Results are expressed as the mean ($\log_{10}$) with the calculated standard error indicated. Total coliforms, 1.0 ml from dilution sample was poured in sterile Petri dish then poured 10 ml of Violet Red Bile Dextrose Agar (Biolife 402188). After solidifying media, a 10 ml overlay of the same molten medium was added. The incubation was carried out at 37 ˚C for 24 h. For *Escherichia coli*, the detection was done by using the selective Chromo Cult Coliform agar (Merck KGaA, Germany) according to the manufacturer's instructions and confirmed with Kovac's indole reagent. Yeasts and moulds were detected onto Rose Bengal Chloramphenicol Agar (Lab M, 36, supplemented with chloramphenicol, X009) at 25 ºC for 5 days; *Candida* counts were counted on *Candida* Agar (Biolife, 4012802, Milano, Italy) by spreading 0.1 ml of sample onto media and incubated at 37 ˚C for 48 h. All plates were examined for typical colony types and morphological characteristics associated to each culture medium. *Salmonella* and *Shigella* were counted on *Salmonella* & *Shigella* Agar (SS Agar, LAB052, UK) after incubation for 24 h at 37 ˚C.

2.4. Data collection and statistical analysis

In this research, some physicochemical and bacteriological data, routinely experimented each week by Holding Company for Water and Wastewater that used to evaluate the treated wastewater quality at the Wastewater treatment plants. These parameters include: Temperature, pH, Total Suspended Solids (TSS), Turbidity, Total dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate (NO_3-), sulphite (SO_4-) and oil [24]. Holding Company for Water and Wastewater have established 35 stations along the entire megacity e.g. Zagazig city has 3 stations. Wastewater quality data interpretations of these stations and drains were conducted in a period of one year from April 2012 to March 2013. The removal efficiency of each treated wastewater sample in the wastewater treatment plants was calculated as [(influent- effluent)/influent x 100]

All analyses were performed in three replicates. The results were expressed by the mean of the two samples plus the standard error. Data were statistically analyzed using ANOVA through the general linear models (GLM) procedure of the statistical analysis system software (SAS version 9.1, SAS Institute, Inc., 2003). Least significant differences were used to separate means at $p < 0.05$.

3. Results and discussions

3.1. Influent, effluent characteristics and microbial indicators removal efficiency

The level of total bacterial count (TBC), total yeasts & moulds count (TYMC), total *Candida* count (TCC), total coliform count (TCFC), *Escherichia coli* (EC), *Salmonella* and *Shigella* (SS) counts in wastewater samples collected from different treatment processes in 17 WTPs are presented in Figs 1&2 and Tables 1&2. The pathogenic bacteria and microbial indicators are used to evaluate WTPs through one year 2012-2013.The results revealed that the influent in the WTPs was heavily contaminated with cultivable bacteria and yeasts. The TBC, TYMC, TCC, TCFC, EC and SS were significantly ($p <0.05$) decreased in the TW during all the period of study. Among the many kinds of wastewater disinfection, chlorination has gained wide acceptance commercially, because of its simple application and moderate cost [25]. However, the counts were varying from a minimum of 3.1 log CFU/ml to maximum 9.2 log/CFU/ml, from 2.1 to 5.76 log CFU/ml, from 1.0 to 4.47 log CFU/ml, from 1.2 to 5.86 log CFU/ml, from 1.2 to 5.1 log CFU/ml and from 1.5 to 5.71 log CFU/ml (Figs. 1&2), respectively. The average log removals after treated wastewater by WTP systems were 4.71 (58.08%), 2.87 (56%), 3.20 (57.87%), 2.33 (49.44%), 3.55 (66.03) and 1.97 (59.51%) log CFU/ml for TBC, TYMC, TCFC, EC, SS and TCC counts, respectively (Table, 1). The maximum removal of TBC was (60%), TYMC (59 %), TCC (75 %), TCFC (77%), EC (75%) and SS (74%) of TW in August, October and September 2012. Coliforms, *E. coli* and *Salmonella* spp. have been accepted as contamination indicator bacteria in treated wastewater [26]. Moreover, seasonal conditions appear to have a clear effect on purification efficiencies, emphasising the strongest of these systems especially in hot climates [22]. However, the capacity of wastewater treatment plants has not enough to counteract increased of domestic wastewater. The reduction in microbial groups may have been influenced by the seasonal changes and the volume of receiving stream [27]. The average log removals after treated wastewater by three different pilot-scale sand filters were 4.6-5.4 log CFU/ml for bacteria. The system that effectively removed microbes was also efficient at removing nutrients. The coliform bacteria were correlated ($r= 0.83$) indicators of a reduction in pathogenic bacteria concentrations during the wastewater treatment, but were not correlated ($r= -0.33$) to *Candida* contamination of wastewater (Table, 2). Total coliforms load in a tidal embayment was studied and shown that storm water coming from the surrounding watershed is a primary source of coliform [28]. The presence of coliforms is usually assumed to indicate the potential presence of other fecal pathogens such as *Salmonella* spp., *Shigella* spp. or pathogenic strains of *Escherichia coli* [29].These organisms can cause gastroenteric illnesses via the fecal/oral route through the consumption of raw produce irrigated with contaminated water. Moreover, higher water temperatures will probably lead to a pathogen survival increase in the environment, although there is still no clear evidence [13]. Its logic after tertiary treatment, the pathogens could be absent but in this study the wastewater treatment received domestic water more than its capacity and the conventional tertiary treatment do not applied correctly. In Europe, *Salmonella* spp. was more rarely detected (16.3%) of the reclaimed wastewater and *Campylobacter* cells were only found in 2% of samples [30].

3.2. Microbial indicators in drainages

The levels of bacterial indicators in 10 sites on BEBD located in Sharkia were more less varying from a minimum of 6.8 log CFU/ml to maximum 9.7 log/CFU/ml, from 4.6 to 6.06 log CFU/ml, from 4.0 to 5.49 log CFU/ml, from 4.52 to 5.66 log CFU/ml, from 4.32 to 5.46 log CFU/ml and from 5.15 to 5.85 log CFU/ml, respectively (data not shown).This high levels of microbes resulted in 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. In Egypt, the increasing population, urbanization and industrialization has resulted in a large proportion of mostly rural communities lacking adequate sanitation, waste disposal and access to safety wastewater. When the flow exceeds the combined sewer systems capacity, the sewers overflow directly into surface water body [11].

3.2. Influent, effluent characteristics and nutrients removal efficiency

The concentrations of COD, BOD and TSS contents in the wastewater samples collected from different treatment processes in the WTPs are shown in Fig. 3. All targeted parameters were detected in influent and effluent samples during at least two of the sampling months throughout the year which they showed higher concentrations in cold seasons than hot seasons. In the stage for treating aeration caused a significantly ($p<0.05$) reduction of COD and BOD contents between influent and effluent. The targeted parameters (minimum to maximum, mg/l: COD (441 to 541), BOD (367 to 421) and TSS (289 to 320) were detected in all influent samples (Fig. 3). These targeted parameters were decreased significantly ($p<0.05$) in all effluent samples, mg/l: COD (56-62), BOD (34- 46) and TSS (52- 82). The removal efficiency was of COD (86.95- 89.22%)), BOD (88.83-91.56%) and TSS (74.83- 82.73%). These results indicated that the elimination of organic compounds in WTPs was incomplete and that more than of effluent are discharge to waterways. It was shown that with increased UV radiation due to ozone layer depletion, NOM trap higher levels of UV energy and breaks down to more bioavailable organic compounds, minerals and micronutrients in water. All these processes could stimulate bacterial activity in aquatic ecosystems [16].

The concentrations of temperature, pH, TDS, nitrate (NO_3^-), sulphite (SO_4^-) and oil contents in the wastewater samples collected from different treatment processes in the WTPs are shown in Table 3. These values were used to assess treated wastewater characteristics before discharge in waterways. Seasonal trends in mass removals were observed for all parameters. Monthly average influent temperature and pH ranged from 18 to 29 °C and 7.6 to 7.9, while average effluent temperature ranged from 17 to 28 °C and 7.4 to 7.6, respectively (Table 3). There was no significant difference ($p>0.05$) in the level of TDS and NO_3- in influent compared to the initial values recorded during all the period of study. However, the slight decrease in the NO^-_3 and TDS levels in effluent and this might be WTPs are lack to the efficiency of removal nitrate and TDS during tertiary treatments. The SO^-_4 and oil levels were significantly ($p<0.05$) decreased in treated wastewater. The maximum removal of pH (3.02%), TDS (2.76%), NO-$_3$ (2%) and SO_4- (89.85%) of treated wastewater compared to the initial values. Seasonal differences were observed in effluent NO_3- rates and COD, with the highest values in cold calamite than hot climate. The targeted removal rate efficiencies greater than 75%were achieved for TSS, COD, BOD, SO_4- and oil levels. The efficiency of aeration on total carbon conversion rates depends on the bioavailability of easily degradable organic substances, on the abundance, composition and activity of microbial groups involved in degradation processes and on pre-existing environmental conditions such as oxygen supply, pH, temperature, water and nutrient concentrations. A higher carbon conversion rate under aerated than anaerobic conditions is attributed to aerobic microbial groups being able to convert semi-degradable and hardly-degradable organic substances such as lignin which are resistant to anaerobic microbial break-downs [31].

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Caption of Figures and Tables

Fig. 1 Microbiological changes (total bacterial count (TBC), total yeasts and moulds count (TYC) and *Candida* counts (TCC)) of wastewater in Sewage treatment plant during one year 2012-2013.
Fig. 2 Microbiological changes (total coliform count (TCFC), total *E. coli* (TEC) and total *Salmonella* and *Shigella* counts (TSS)) of wastewater in Sewage treatment plant during one year 2012-2013.
Fig.3 : Total Suspended Solids (TSS, mg/l), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) of Untreated Wastewater (UW) and Treated Wastewater (TW) in Sewage Water Treatment Plants (SWTPs) during one year 2012-2013.
Table 1: Removal efficiency (RE) of total bacterial count (TBC), total yeasts & moulds count (TYMC), total Candida count (TCC), total coliform count (TCFC), *Escherichia coli* (EC), *Salmonella* and *Shigella* (SS) count) in Sewage Water Treatment Plant during 2012-2013.
Table 2: Correlations between microbial groups (total bacterial count (TBC), total yeasts & moulds count (TYMC), total *Candida* count (TCC), total coliform count (TCFC), *Escherichia coli* (EC), *Salmonella* and *Shigella* (SS) count) in Sewage Water Treatment Plant during 2012-2013

Table 3: Temperature, pH, Total Dissolved Solids (TDS, mg/l), SO^{-}_{4}, NO^{-}_{3} and oil levels of Untreated Wastewater (UW) and Treated Wastewater (TW) in Sewage Water Treatment Plants (SWTPs) during one year 2012-2013

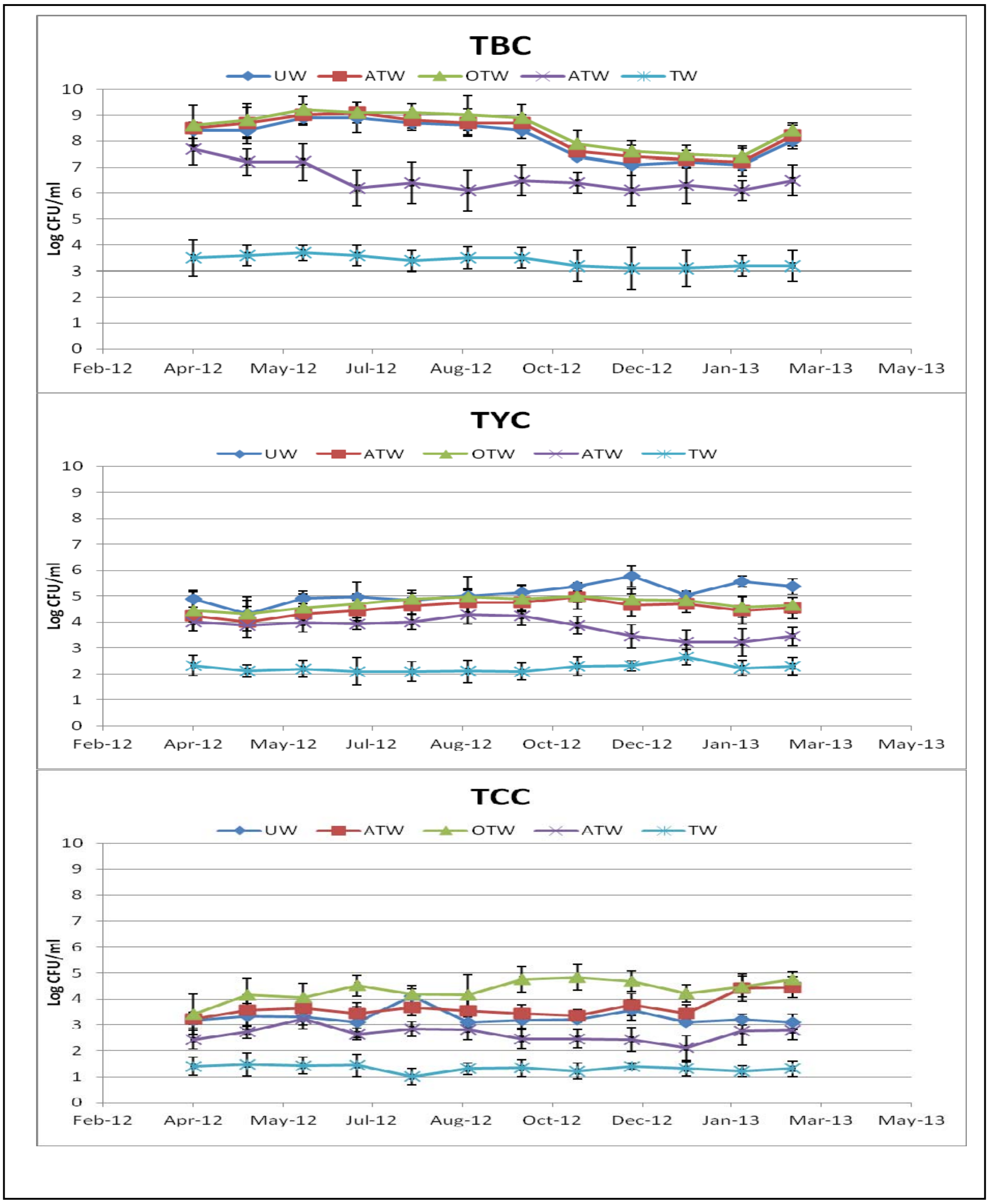

Fig. 1 Microbiological changes (total bacterial count (TBC), total yeasts and moulds count (TYC) and *Candida* counts (TCC)) of wastewater in Sewage treatment plant during one year 2012-2013.

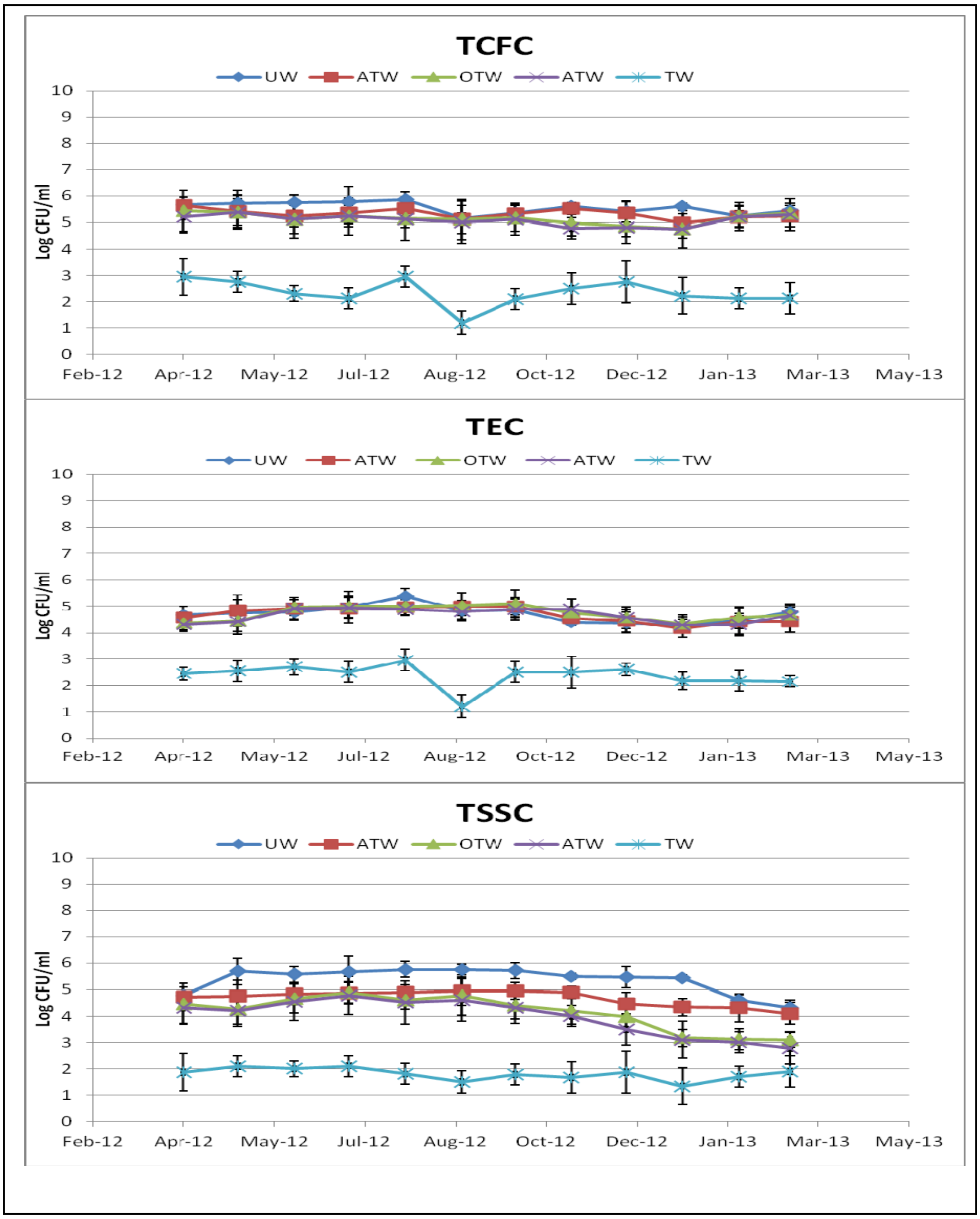

Fig. 2 Microbiological changes (total coliform count (TCFC), total *E. coli* (TEC) and total *Salmonella* and *Shigella* counts (TSS)) of wastewater in Sewage treatment plant during one year 2012-2013.

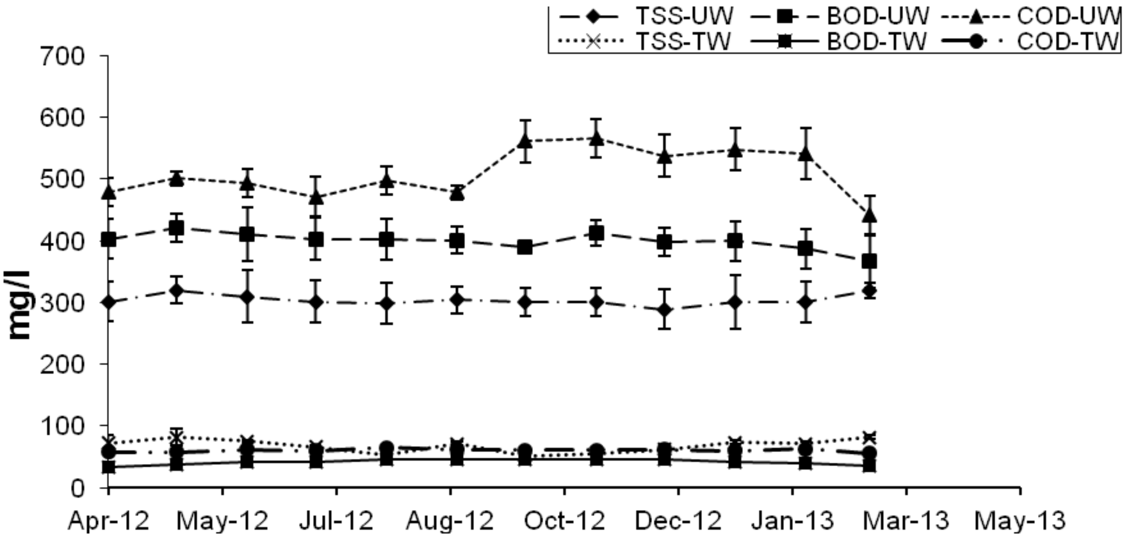

Fig.3 : Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) of Untreated Wastewater (UW) and Treated Wastewater (TW) in Sewage Water Treatment Plants (SWTPs) during one year 2012-2013.

Table 1: Removal efficiency (RE) of total bacterial count (TBC), total yeasts & moulds count (TYC), total *Candida* count (TCC), total coliform count (TCFC), *Escherichia coli* (EC), *Salmonella* and *Shigella* (SS) count) of wastewater in Sewage Water Treatment Plant during 2012-2013.

Time (month)	RE-TBC	RE-TYC	RE-CFC	RE-EC	RE-SS	RE-TCC
Apr-12	58.33	52.46	47.88	47.65	60.96	55.66
May-12	57.14	51.27	51.75	46.11	63.09	55.86
Jun-12	58.43	55.19	59.83	43.31	64.09	56.80
Jul-12	59.55	57.66	63.26	49.40	62.79	53.70
Aug-12	60.92	56.52	49.66	44.96	68.75	75.61
Sep-12	59.30	57.97	76.70	75.21	73.91	57.88
Oct-12	58.33	59.14	60.63	48.25	68.83	57.86
Nov-12	56.76	57.33	55.26	43.05	69.58	62.31
Dec-12	56.34	59.90	48.98	40.27	65.81	60.50
Jan-13	56.94	47.52	60.43	49.30	75.37	57.88
Feb-13	54.93	59.89	59.46	51.12	63.20	62.19
Mar-13	60.00	57.17	60.59	54.72	55.92	57.88
Total mean of log removals CFU/ml	4.71	2.87	3.20	2.33	3.55	1.97
Total mean of *RE %	58.08	56.00	57.87	49.44	66.03	59.51

*RE, Removal Efficiency = [(influent-effluent)/influentx100]

Table 2: Correlations between microbial groups (total bacterial count (TBC), total yeasts & moulds count (TYMC), total *Candida* count (TCC), total coliform count (TCFC), *Escherichia*

coli (EC), *Salmonella* and *Shigella* (SS) count) of wastewater in Sewage Water Treatment Plant during 2012-2013

	TBC	TYMC	TCFC	EC	TSSC	TCC
TBC		0.020189*	0.188167*	0.283812*	-0.10849	0.19645*
TYMC			0.188741*	0.110162*	-0.19269	0.225603*
TCFC				0.833005*	0.341162*	-0.32795
EC					0.252595*	-0.19008
TSSC						0.243344*

*****$P < 0.05$

Table 3: Temperature, pH, Total Dissolved Solids (TDS, mg/l), SO-4, NO-3 and oil levels of Untreated Wastewater (UW) and Treated Wastewater (TW) in Sewage

	Untreated Wastewater (UW)						**Treated Wastewater (TW)**					
Time (Month)	Temp.-UW	pH- UW	TDS-UW	SO4--UW	NO3-UW	Oil-UW	Temp.-TW	pH- TW	TDS-TW	SO4--TW	NO3-TW	Oil-TW
Apr-12	23±3.1	7.6±0.08	1179±31.2	71±3.9	10±1.5	66±6.1	23±3.5	7.4±0.14	1108±37.2	6.7±0.41	7.9±0.77	7.3±0.31
May-12	26±3.2	7.6±0.08	1190±32.3	75±3.8	11±1.9	62±6.4	26±3.5	7.5±0.13	1087±33.1	6.7±0.31	8.6±0.72	7.2±0.36
Jun-12	28±3.3	7.7±0.07	1166±34.1	66±3.7	11±1.8	69±6.5	28±3.3	7.5±0.12	1149±43.1	6.7±0.41	8.7±0.73	7.4±0.35
Jul-12	29±3.5	7.7±0.07	1156±23.9	67±3.9	12±1.3	70±6.4	27±3.2	7.4±0.13	1148±34.3	6.8±0.41	9.5±0.76	7.4±0.37
Aug-12	24±3.2	7.8±0.07	1194±23.7	70±3.9	12±1.5	55±6.3	24±3.3	7.5±0.14	1193±43.3	7.8±0.43	9.6±0.75	7.3±0.38
Sep-12	27±3.2	7.8±0.09	1197±31.5	77±3.8	13±1.4	75±6.3	27±3.2	7.4±0.12	1190±34.3	7.3±0.32	10.3±0.71	7.4±0.38
Oct-12	27±3.6	7.9±0.09	1107±34.1	75±3.7	12±1.6	70±6.1	27±3.2	7.6±0.15	1118±32.1	7.8±0.33	10.1±0.74	7.7±0.37
Nov-12	22±3.4	7.7±0.07	1190±23.7	75±3.8	11±1.7	74±6.7	22±3.2	7.4±0.14	1144±34.3	7.8±0.31	8.4±0.77	7.8±0.35
Dec-12	18±3.2	7.7±0.08	1106±32.9	75±3.8	10±1.7	74±6.1	18±3.6	7.5±0.18	1143±34.1	7.6±0.34	7.8±0.74	8.1±0.33
Jan-13	19±3.4	7.7±0.08	1190±22.8	75±3.8	13±1.4	77±6.4	17±3.6	7.6±0.19	1162±32.1	7.7±0.45	10.2±0.75	7.5±0.32
Feb-13	19±3.3	7.8±0.09	1184±34.6	75±3.9	13±1.4	70±6.3	19±3.7	7.4±0.11	1061±33.4	7.7±0.43	9.5±0.77	6.6±0.34
Mar-13	24±3.2	7.7±0.06	1177±32.7	70±3.9	12±1.3	71±6.2	24±3.1	7.4±0.21	1146±34.2	7.8±0.31	9.8±0.72	7.2±0.34
Average	23.67	7.73	1169.67	72.58	11.67	69.42	23.67	7.49	1137.42	7.37	9.19	7.41
***RE**								3.02	2.76	89.85	2.00	89.33

*RE, Removal Efficiency = [(influent-effluent)/influentx100]