Zagazig Journal of Applied Microbiology and Biotechnology 849-860

Zagazig J. Agric. Res., Vol. 43 No. (3) 2016

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

EFFICIENCY OF WASTEWATER TREATMENT PLANT AT ZAGAZIG CITY FOR REMOVING MICROBIAL AND CHEMICAL POLLUTANTS (CASE STUDY)

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ABSTRACT

Biological urban wastewater treatment plants utilize microorganisms for wastewater treatment so that microbiological characterization of processes is very important. In addition, the removal of these microorganisms in the effluent for their reuse is important. This study aims to characterize the presence of microbial flora and chemical pollutants along the processes in Wastewater Treatment Plant (WTP) at Zagazig City. The removal efficiency of total bacterial counts was approximately 20 - 74% during all the periods of study from April 2011 up to January 2012. However, the average total *Enterobacteriaceae* count in the wastewater samples reduced in all the periods by 85% except in June and December 2011in which the reduction was varied between 29-37%. The results show a high level of coliforms, *Escherichia coli*, *Salmonella* and *Shigella* in the raw wastewater; although their total removal is not achieved (the removal efficiency was 11 to 83 %). *Candida* spp., which is a yeast indicator, although it is less usual than *E. coli*, is detected in raw wastewater as well as in treated wastewater. The maximum total yeasts and *Candida* counts in the wastewater samples were reduced by 64.29 and 95.24 %, respectively in August and October 2011. There was no difference in the physicochemical properties found in the treated wastewater during all the periods of the study in WTP. The maximum removal efficiency of biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), nitrate, sulphate and oil in the treated wastewater samples was 91.6, 89.8, 8.6, 45.4, 99.2 and 90.2 %, respectively

Key words: Wastewater, Coliforms, *E. coli*, *Salmonella*, BOD, COD, TDS.

INTRODUCTION

Wastewater is defined as any storm water runoff, as well as industrial, domestic or commercial sewage or any combination thereof carried by water. The type and volume of wastewater generated is determined by both, population numbers and the combination of surrounding domestic, recreational and industrial activities, all of which affect discharge patterns as well as the chemical status of the treated effluent (CIDWT, 2009).

In order to set up an efficient waste management system, proper identification and characterization of the influent entering a wastewater treatment plant is essential (Mara, 2004).This is based on the physical, chemical and biological characteristics of the influent; the immediate and downstream effect on the surrounding environment into which the wastewater will be discharged as well as the currently laid out environmental and discharge standards. Water-borne diseases are a major world-wide threat to public health, despite significant advances in water and wastewater treatment technology. Water borne disease is estimated to be responsible for 4.0% of all deaths and 5.7% of the total disease burden worldwide (Prüss *et al*., 2002). Though many of these infections occur in developing countries with lower levels of sanitation and less public. Communities across the world are facing the problem of water scarcity due to tremendously

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increased societal demands, drought, depletion and contamination of existing water resources (Tyagi *et al*., 2011). Water reclamation, recycling and reuse address these challenges by resolving water resource issue. Recent outbreak of water-borne diseases has raised public concerns regarding the safety of water supply and in specific, water reuse (Curriero *et al*., 2001).

In fact, one of the major barriers to water reclamation and reuse is concern regarding the health risk of exposing public to the wastewater. Out of all the contaminants in wastewater, pathogens are of major concern because of their ability to cause diseases in humans. Human pathogens are typically present in domestic sewage and their control is one of the fundamental reasons for wastewater treatment (Arias *et al*., 2003).

Wastewater treatment plants (WTPs) are usually designed to efficiently remove organic pollutants and nutrients but seldom have been planned specifically to remove pathogenic microorganisms from wastewater. It is therefore important to find technical methods to remove pathogens from domestic wastewater, so as to prevent pollution. Fewer studies have focused on the ability of different systems to reduce pathogens from wastewater, especially indicator microorganisms like the coliform group of bacteria *i.e.,* total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) (Reinoso *et al*., 2008). The effect of seasonal variations on treatment efficiency of vermifiltration for domestic wastewater for only two seasons was studied by Li *et al*. (2009). Temperature is an important factor for the growth and metabolic activity of microorganisms and diversity of microbial community changes with the variation of temperature (Nedwell, 1999). Arora *et al*. (2014) investigated that the microbial community diversity and antibacterial and enzymatic properties of microorganisms in a pilot-scale vermifiltration system during domestic wastewater treatment.

In context to Egypt, the study becomes more important as the weather conditions here are variable throughout the year. Egypt experiences variations of temperature to as low as 14-18^{o}C during winter to as high as 35-40^{o}C during summer. The studies on how temperature affects pathogen removal and microbial population are urgent during treatment wastewater. In addition, little is known about the effects of seasonal temperature on the treatment efficiency (BOD, COD, and TSS removal), pathogen removal efficacy, bacteria and yeast-molds removal efficiency (Mahgoub *et al.,* 2016).

In Europe, the collection, treatment and discharge of urban wastewater are regulated by Directive 91/271/EEC, but it does not refer to the allowable limits for bacteria and parasites in the effluent (Marín *et al*., 2015).Where most bacteria and parasites from water are concentrated potential pathogens in wastewater and sewage sludge include various genera of bacteria, enterovirus, rotavirus, helminth eggs and protozoa, whose presence in output water and sludge may be harmful to health (García *et al*., 2013).

Therefore, the purpose of this work is to define the efficiency of each individual process in a urban wastewater treatment plant in the removal of microbial flora and chemical pollutants present in wastewater, with special emphasis on pathogenic microorganisms which may affect the human and animal health and they could be incorporated into environment as a result of the treated wastewater.

MATERIALS AND METHODS

Collection and Analysis of Sewage Water Samples

The samples of sewage water were collected from sewage water treatment plant located in Zagazig City, El-Sharkia Governorate, Egypt for microbiological examination. The samples were collected twice during every month from April 2011up to January 2012. The samples were collected from different sites during conventional treatment process stages *i.e.* Untreated Wastewater (UW), Pre-primary Treatment (PPT), Primary Treatment (PT), Secondary Treatment (ST) and Treated Wastewater (TW). At each sampling site, three samples were separately taken for microbiological analysis. The sewage water samples were taken randomly to a depth of 5-10 cm. The samples were placed in a container filled with ice, then transported to the microbiological laboratory, stored at 4^{o}C prior to analysis according to the procedures of APHA (2005).

Microbiological Analysis

Total bacteria and aerobic spore forming bacteria counts

Counting of total bacteria was carried out onto Plate Count Agar (PCA) using decimal dilution technique. For counting bacteria, dilutions were spread onto the surface of plate PCA medium and incubated at 30°C for 48 hr., after which colony forming units (CFU) of selected Petri dishes were counted. The aerobic spore forming bacteria were counted onto PCA agar after pasteurized decimal dilution at 80°C for 15 min then spread onto the surface of plate PCA medium and incubated at 30°C for 48 hr.

Enterobacteriaceae counts

The medium of Violet Red Bile Glucose Agar (VRBGA, Biolife, Italy) is used widely for enumeration of *Enterobacteriaceae* (ENT). Since glucose is fermented by all members of the *Enterobacteriaceae*, VRBGA enables the growth of all the key organisms of interest including *E. coli*, *Salmonella* and *Shigella* species. The inclusion of bile salts and crystal violet in the medium inhibits Gram positive and non-enteric organisms, while an overlay procedure ensures anaerobic conditions, suppressing the growth of non-fermentative Gram negative bacteria. Then incubated at 37°C for 48 hr., the number of red/purple colonies is counted, allowing calculation of the number of *Enterobacteriaceae* in the original sample.

Counts of total coliforms and *E. coli*

Coliform Agar is a selective chromogenic medium recommended for simultaneous detection of *Escherichia coli* and total coliforms in water and food samples. Sodium lauryl sulfate inhibits Gram-positive organisms. The chromogenic mixture contains two chromogenic substrates, Salmon-GAL and X-glucuronide. The enzyme â-D-galactosidase produced by coliforms cleaves Salmon-GAL, resulting in the salmon-to-red coloration of coliform colonies. The enzyme â-D-glucuronidase produced by *E. coli* cleaves X-glucuronide. *E. coli* forms dark blue-to-violet colored colonies due to cleavage of both Salmon-GAL and X-glucuronide. The addition of tryptophan improves the indole reaction, thereby increasing detection reliability in combination with the two chromogens. The plates were incubated at 37°C for 24 hr. To confirm *E. coli*, add a drop of Kovac's reagent (Catalog No. 60983) on the dark blue-to-violet colony. Formation of cherry-red color indicates the positive reaction.

Salmonella and *Shigella* counts

The basis for differentiation on *Salmonella and Shigella* Agar (SSA) depends on the fermentation of lactose and the absorption of neutral red as the bile salts precipitate in the acidic conditions. Neutral red turns red in the presence of an acidic pH, thus showing fermentation has occurred. The inclusion of bile salts, sodium citrate, and brilliant green serve to inhibit Gram-positive and coliform organisms. *Salmonella*, *Shigella* and other non-lactose-fermenting organisms appear as transparent or translucent colorless colonies on SS Agar. Sodium thiosulfate was added to the medium as a hydrogen sulfide source, and ferric citrate was added as an indicator for hydrogen sulfide production. The plates were incubated at 37°C for 24 hr.

Counts of total yeasts and *Candida*

Total yeasts were counted on Rose Bengal Chloramphenicol Agar (RBCA) according to the method described by Yarrow (1998), where the plates were incubated at 30°C for 24 hr. While *Candida* was counted onto *Candida* Agar (Biolife, Milano, Italy) and the plates were incubated at 35°C for 24 hr.

Physicochemical Analysis

The physicochemical data were routinely collected each week by the regional Holding Company of Water and Wastewater Management, used to evaluate the treated wastewater quality. These parameters include: temperature, pH, total suspended solids (TSS), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen Demand (COD), nitrate (NO_3^-), sulphate (SO_4^-) and oil (APHA, 2005). Wastewater quality data interpretations of this station and drain were conducted in a period of ten months from April 2011 to January 2012.

Statistical Analysis

Data from microbiological analyses were entered into Excel and transformed to log_{10} values. All presented values are the averages of three replicates plus the standard deviation. The removal efficiency of each treated wastewater sample in the wastewater treatment plant was calculated as [(Untreated wastewater- Treated wastewater)/Untreated wastewater x 100].

RESULTS AND DISCUSSION

Microbiological Properties of Wastewater and Treated Wastewater

The initial total bacterial count (TBC) in UW ranged from 6.3 to 8.3 Log CFU/ml (Table 1). The results reveale that there are variations in TBC not only for the sample type, but also at the different sampling periods of the study (APHA, 2005). Meanwhile the TBC decreased in August, November 2011 and January 2012, while in May, June, July and December 2011, the bacterial population increased and reached the maximum levels up to ~ 8.0 Log CFU/ml. The results also indicated that there was a reduction in the total bacterial counts at treated wastewater after disinfection of wastewater. The population of bacteria was reduced by about 4 Log CFU/ml. The removal efficiency of total bacterial was approximately 20 -74% (Table 2). Disinfection efficiency is still currently evaluated on the basis of the decrease in microbial counts after treatment, which is measured by traditional plates enumerating total heterotrophic bacteria or total coliform or fecal coliform indicators (Salgot *et al.,* 2001). Bacteria provide the largest component of the microbial community in all biological wastewater treatment processes and numbers in the range of 10^6 CFU/ml of wastewater are frequently encountered (Horan, 1990). Chlorination can remove over 90% of bacterial population from sewage water; however, the removal of bacteria is much more varied. In this study the maximum bacterial removal was about 74% (Table 2).

Aerobic spore-formers counts (ASC) ranged from 5.1-7.3 and 2.0-5.5 Log CFU/ml in UW and TW, respectively (Table 1). Meanwhile the ASC decreased in September, October 2011 and January 2012 and reached at level 5.5 Log CFU/ml, while in April, May, June, July and December 2011, the ASC increased and reached the maximum levels up to ~ 7.0 Log CFU/ml in UW. The results also indicated that the population of ASC was reduced by about 3 Log CFU/ml after disinfection treatment. The removal efficiency of ASC was approximately 8 -73% (Table 2). Several authors suggested bacterial groups other than coliforms which included aerobic spore-formers, *Staphylococcus aureus, Salmonella* and *Shigella*, *Enterobacterieaceae etc*. may be employed in assessing sewage water quality (Araujo *et al*., 2004; Ashbolt *et al*., 2007; Cabral, 2010).

A wide range of densities of *Enterobacteriaceae* counts (ENT) was found from a minimum value to a maximum value *i.e.,* 6.0-7.8 and 1.0-5.5 Log CFU/ml in UW and TW, respectively (Table 1). The average ENT in the wastewater samples reduced in all the periods by 85% except in June and December 2011in which the reduction was varied between 29-37% (Table 2).

Generally, the coliform counts (CF) showed a similar trend as described for total bacteria and *Enterobacterieaceae c*ounts. The CF ranged from 2.9-6.2 and 1.0-4.5 Log CFU/ml in UW and TW, respectively (Table 1). The higher densities of CF were found in raw wastewater and the least for treated wastewater. Also, the highest numbers occurred in April, June, July and September months compared with November, December and January months. Moreover, a variation in total numbers of bacterial counts was observed at the different sampling periods of this study. The maximum total coliforms and *E. coli* (EC) counts in the wastewater samples were reduced to 83 and 81%, respectively in April and October 2011 (Table 2). However, the minimum reduction in total coliforms and *E. coli* counts in treated wastewater was reduced 4 and 13%, respectively in August 2011. Microbiological water analysis is mainly based on the concept of fecal indicator bacteria. According to the American legislation, total coliforms are the routine parameter to be determined in water. Only when these determinations are repeatedly positive, it is mandatory to assess fecal coliforms (Hecq *et al*., 2006). *E. coli* is a natural and essential part of the bacterial flora in the gut of humans and animals. Most *E. coli* strains are nonpathogenic

Table 1. Average microbial counts (Log_{10} CFU /ml) of wastewater from wastewater treatment plant at Zagazig City between April 2011 and January 2012

Time	Untreated wastewater(UW)								Treated wastewater(TW)							
	TBC	ASC	ENT	CF	EC	SSC	TYC	CA	TBC	ASC	ENT	CF	EC	SSC	TYC	CA
Apr-11	7.80	7.30	6.90	6.00	5.90	3.90	4.00	3.00	3.50	2.00	1.00	1.00	1.00	2.00	2.00	2.00
Apr-11	7.40	7.30	6.90	5.40	5.40	3.70	5.10	3.00	3.50	3.10	1.00	1.00	1.00	2.00	2.00	2.00
May-11	7.90	7.30	6.90	5.40	5.40	5.70	2.00	2.00	3.50	3.20	1.00	1.00	1.00	2.00	2.00	2.00
May-11	8.00	7.30	7.80	5.40	5.40	5.70	4.40	3.00	4.70	3.20	1.00	1.00	1.00	2.00	2.00	2.00
Jun-11	8.00	7.30	7.80	4.00	6.00	5.70	5.80	3.20	6.40	5.20	4.90	1.00	4.50	3.30	3.20	2.50
Jun-11	8.00	6.00	7.10	6.20	6.00	3.80	2.00	2.00	6.20	5.50	4.70	4.50	4.50	1.30	2.00	2.00
Jul-11	8.30	7.30	7.80	6.20	6.00	5.70	5.80	3.50	5.00	4.80	5.50	4.50	4.50	3.30	3.50	2.30
Jul-11	7.50	7.30	6.90	5.60	4.30	5.50	5.00	4.30	5.30	3.10	1.00	3.50	1.00	3.40	2.00	3.20
Aug-11	6.30	6.30	6.90	5.40	5.40	2.80	4.90	2.00	4.00	2.00	1.00	1.00	1.00	1.30	3.90	2.00
Aug-11	6.30	6.10	6.20	4.90	5.50	4.40	5.60	2.70	5.30	3.10	1.00	4.70	4.80	2.00	2.00	2.30
Sep-11	7.50	5.10	6.90	5.30	4.50	3.60	4.40	3.90	3.10	2.10	1.00	1.00	1.00	1.60	2.00	2.00
Sep-11	6.60	5.70	6.00	6.20	6.00	5.70	2.00	2.00	5.30	3.10	1.00	4.50	4.50	2.00	2.00	2.00
Oct-11	7.80	7.30	7.00	5.90	5.40	2.10	4.40	2.10	2.0	5.20	1.00	1.00	1.00	2.00	2.00	2.00
Oct-11	7.30	5.90	6.30	5.90	5.40	5.70	2.00	3.00	2.0	5.20	1.00	1.00	1.00	3.30	2.10	2.00
Nov-11	7.50	6.40	6.90	2.90	4.30	2.80	3.00	2.50	2.50	3.10	1.00	2.50	3.20	1.30	2.00	2.00
Nov-11	6.70	6.00	6.20	5.40	5.40	5.70	2.00	2.00	5.40	5.20	1.00	1.00	1.00	3.30	2.00	2.00
Dec-11	8.00	7.30	7.80	5.40	5.40	3.60	3.10	2.50	6.40	5.20	4.90	1.00	1.00	2.00	2.00	2.00
Dec-11	8.00	7.20	7.10	3.60	4.30	2.80	2.00	2.00	6.40	5.20	4.90	1.00	1.00	1.30	2.00	2.00
Jan-12	6.70	5.80	7.40	4.60	3.00	3.80	3.60	2.90	2.0	2.00	1.00	1.50	1.00	1.30	2.90	2.00
Jan-12	6.70	5.80	7.40	4.60	3.00	2.80	2.00	2.00	2.0	2.00	1.00	1.50	1.00	1.30	2.00	2.00

TBC: total bacterial count, ASC: aerobic Spore-forming bacteria count, ENT: *Enterobacteriaceae* family, CF: coliforms, EC: *E. coli*, SSC: *Salmonella* and *Shigella* count, TYC: total yeasts count, CA: *Candida* agar for total *Candida.*

Table 2. The removal efficiency of each microbial group from wastewater treatment plant at Zagazig City between April 2011 and January 2012

Time	TBC (%)	ASC(%)	ENT(%)	CF(%)	EC(%)	SSC(%)	TYC(%)	CA(%)
Apr-11	55.13	72.60	85.51	83.33	83.05	48.72	50.00	66.67
Apr-11	52.70	57.53	85.51	81.48	81.48	45.95	60.78	66.67
May-11	55.70	56.16	85.51	81.48	81.48	64.91	0.00	0.00
May-11	41.25	56.16	87.18	81.48	81.48	64.91	54.55	66.67
Jun-11	20.00	28.77	37.18	75.00	25.00	42.11	44.83	78.13
Jun-11	22.50	8.33	33.80	27.42	25.00	65.79	0.00	0.00
Jul-11	39.76	34.25	29.49	27.42	25.00	42.11	39.66	65.71
Jul-11	29.33	57.53	85.51	37.50	76.74	38.18	60.00	74.42
Aug-11	36.51	68.25	85.51	81.48	81.48	53.57	20.41	0.00
Aug-11	15.87	49.18	83.87	4.08	12.73	54.55	64.29	85.19
Sep-11	58.67	58.82	85.51	81.13	77.78	55.56	54.55	51.28
Sep-11	19.70	45.61	83.33	27.42	25.00	64.91	0.00	0.00
Oct-11	74.36	28.77	85.71	83.05	81.48	4.76	54.55	95.24
Oct-11	72.60	11.86	84.13	83.05	81.48	42.11	30.00	0.00
Nov-11	66.67	51.56	85.51	13.79	25.58	53.57	33.33	80.00
Nov-11	19.40	13.33	83.87	81.48	81.48	42.11	0.00	0.00
Dec-11	20.00	28.77	37.18	81.48	81.48	44.44	35.48	80.00
Dec-11	20.00	27.78	30.99	72.22	76.74	53.57	0.00	0.00
Jan-12	70.15	65.52	86.49	67.39	66.67	65.79	19.44	68.97
Jan-12	70.15	65.52	86.49	67.39	66.67	53.57	0.00	0.00

TBC: total bacterial count, ASC: aerobic Spore-forming bacteria count, ENT: *Enterobacteriaceae* family, CF: coliforms, EC: *E. coli*, SSC: *Salmonella* and *Shigella* count, TYC: total yeasts count, CA: total *Candida* and reside harmlessly in the colon. However, certain serotypes do play a role in intestinal and extra-intestinal diseases, such as urinary tract infections (Scheutz *et al*., 2005). Pathogens removal during primary treatment is highly varied with various removal rates reported for different organisms (Gray, 1989). Experimental evidence indicates that, the pathogenic bacteria generally have shorter survival times in the environment than coliforms, whereas viruses tend to survive longer. The efficiency of disinfection of sewage is generally estimated by the extent of removal of total coliform organisms (Sebastian and Nair, 1984). Many municipal wastewater treatment plants (WWTPs) discharge treated effluent with substantial concentrations of fecal indicator bacteria (Rose *et al*., 1996). This study is in agreement with Kay *et al.* (2008) who reported that in a study of 12 WWTPs across the United Kingdom; in the primary clarification stage was not statistically significant elimination of fecal coliform (FC) and total count (TC). Urban wastewater has high levels of microbiological contamination. These microorganisms are involved in the purifying water process, and become the treatment plant into a unique ecosystem. During the treatment, these microorganisms are not removed totally, so they are incorporated in the natural ecosystems through the treated water discharge, where the natural processes of self-purifying of water continue. Nevertheless, some of them may be potentially pathogenic to human health and animals.

As a whole, *Salmonella* and *Shigella* counts (SSC) achieved the lowest averages when compared with any of the examined microbial flora linked to pollution bio- indicators and pathogens. The SSC ranged between 2.1-5.7 and 1.3-3.4 Log CFU/ml in UW and TW, respectively (Table 1). The maximum total *Salmonella* and *Shigella* counts in the wastewater samples were reduced by 65.79 and 64.91% in (June 2011 and January 2012) and (May and September 2011), respectively (Table 2). However, the minimum reduction in *Salmonella* and *Shigella* counts in treated wastewater was reduced 4.76 % in October 2011.The principal habitat of *Salmonella* is the intestinal tract of humans and animals (Le, 2003). Salmonellae are constantly found in environmental samples, because they are excreted by humans, pets, farm animals, and wild life. Municipal sewage, agriculture pollution, and storm water runoff are the main sources of these pathogens in natural waters (Arvanitidou *et al*., 2005). Salmonellae do not seem to multiply significantly in the natural environment, but they can survive several weeks in water and in soil if conditions of temperature, humidity, and pH are favorable (Le, 2003). Salmonellae isolated from environmental sources are predominantly non-typhi or paratyphi serovars. Arvanitidou *et al*. (2005) carried out comparative study in Rivers Aliakmon and Axios, in Northern Greece, during a 1-year period, from May 2002 to April 2003. A total of 29 *Salmonella* species were recovered from the water samples. Many of the isolated *Salmonella* serovars were of non-human animal origin such as Mbantaka, Virchow, Hadar, Infantis and Senftenberg, commonly isolated from poultry farm. Unlike cholera, humans infected with *Salmonella* can carry the bacteria in the gut without signs of disease. Infected humans can harbor the bacteria for considerable periods of time.

Shigella is typically an inhabitant of the intestinal tract of humans and other primates (Strockbine and Maurelli, 2005). It is typically spread by fecal-contaminated water or food, or by direct contact with an infected person. In water, *Shigella* can survive for at least six months at room temperature, and this high survival favors transmission through water. Flies have been implicated on the transmission of *Shigella* cells from human feces to foods. The hand is an important vehicle for transmission of shigellosis, since *S. dysenteriae* serotype 1 cells survives for up to one hour on a human's skin and a very small inoculum is required to unchain infection and disease. Indeed, studies on American volunteers experimentally infected with *Shigella* have shown that as few as one hundred *Shigella* cells given orally cause the disease in 25–50% of the cases. Resistance of *Shigella* to gastric juice certainly accounts, although not exclusively, for this high infectivity (Chompook *et al*., 2006). Asymptomatic and inappropriately-treated patients with shigellosis can harbor the bacteria in the gut and these appear to be the main reservoirs of the bacteria in the environment (Faruque *et al*., 2002).

Variation in total yeasts count (TYC) and *Candida* counts (CA) was observed not only for the sample location, but also at the different sampling periods of the study. A wide range of densities of TYC was found from a minimum value to a maximum value *i.e.,* 2.0-5.8 and <2.0-3.9 Log CFU/ml in UW and TW, respectively (Table 1). However, a wide range of densities of CA was found from a minimum value to a maximum value *i.e.,* 2.0-4.3 and <2.0 -3.2 Log CFU/ml in UW and TW, respectively. The maximum total yeasts and *Candida* counts in the wastewater samples was reduced by 64.29 and 95.29%, respectively in August and October 2011 (Table 2). Unfortunately, yeast ecology in wastewater treatment systems has long been neglected compared to bacteria or other microbial populations possibly because they occupy only a minor part of microorganisms present in activated sludge. Therefore, investigating the natural existence and ecological roles of yeasts in various existed full-scale wastewater treatment systems will be helpful for understanding the yeast ecology but also will provide important information for application of yeast technologies in wastewater treatment. Few studies have investigated how yeasts are distributed in different wastewater treatment systems. Process operating conditions play a role in shaping yeast community composition, with anoxic–anaerobic–aerobic systems harboring more diverse communities than anoxic–aerobic systems (Liu *et al*., 2007; Yang *et al.,* 2011; Mahgoub *et al*., 2015 a,b).

Physicochemical Properties of Wastewater and Treated Wastewater

The physicochemical properties of the wastewater before and after treated during the period of study from April 2011 to January 2012 were determined (Tables 3 and 4) to evaluate the physicochemical quality of treated wastewater. The minimum and maximum temperature ranged from 18-29°C. The values of pH in untreated and treated wastewater ranged from 7.6 to 7.9 (Table 3). These conditions are considered suitable for mesophilic bacteria growth. The highest temperature was obtained in July where more bacterial growth (8.5 Log CFU/ml) was expected, while the lower temperature in January which affects bacterial growth (6.70 Log CFU/ml). The total dissolved solids (TDS) in untreated and treated wastewater ranged from 1106-1197 $mg.1^{-1}$ and 1087-1193 $mg.1^{-1}$, respectively (Table 3).

The biological oxygen demand (BOD) represents the quantity of the gas required by water microflora to metabolize the readily-decomposable compounds in water course in a specific period. The BOD in untreated wastewater with variable values ranged from 329-441 $mg.1^{-1}$. The highly polluted samples were distributed along the period of study. The difference between high and low polluted samples were not also big and decreased after treatment to reach 34-51 $mg.1^{-1}$ in the treated wastewater (Table, 3).The amount of organic matter in domestic wastes determines the degree of biological treatment required, and the major objective of domestic waste treatment is the reduction of BOD, which may be either in the form of solides (suspended matter) or soluble (Gerba and Pepper, 2009). Also Graczyk, *et.al* (2009) revealed that primary treatment is used to physically remove floating and settleable materials. Because of removal of these materials, there is an appreciable reduction in biochemical oxygen demond (BOD), total suspended solids (TSSs), total organic carbon (TOC), and some metals associated with TSSs.

The COD is dependent upon the occurrence of certain compounds that can be readily oxidized by chemical oxidants at a certain concentration and at a specific period. Therefore, it is always higher than the BOD. Table 3 shows the difference between BOD and COD for untreated and treated sewage water. The COD values are higher than BOD either before or after sewage treatment. The COD values in untreated and treated wastewater ranged between 433-588 $mg.1^{-1}$ and 58-65 $mg.1^{-1}$, respectively. Table 3 shows the level of nitrate, sulphate and oil in untreated and treated sewage water. The level of nitrate and sulphate in untreated and treated wastewater ranged between 10.0 to 13.0 $mg.1^{-1}$ and 0.6-1.3 $mg.1^{-1}$, respectively. While the level of oil in untreated and treated was about 55 and 77 $mg.1^{-1}$ and 4.3-

Table 3. Physicochemical characteristics (Temperature, pH, BOD, COD, TDS, Nitrate, Sulphate and oil mg/l) of wastewater from wastewater treatment plant at Zagazig City between April 2011 and January 2012

Time	Untreated Wastewater(UW)								Treated wastewater(TW)							
	Tem.	pH	BOD	COD	TDS	Nitrate	Sulphate	Oil	Tem.	pH	BOD	COD	TDS	Nitrate	Sulphate	Oil
	°C		mg O_2/ml	mg/l	mg/l	mg/l	mg/l	mg/l	°C		mg O_2/ml	mg/l	mg/l	mg/l	mg/l	mg/l
Apr-11	28	7.6	401	499	1179	10	71	66	28	7.6	34	58	1108	7	0.6	7.3
May-11	29	7.6	441	571	1190	11	75	62	29	7.6	37	58	1087	7.2	0.7	7.2
Jun-11	29	7.7	329	433	1166	11	66	69	29	7.7	51	62	1149	7.2	0.7	7.4
Jul-11	28	7.8	404	451	1156	12	67	70	28	7.8	42	60	1148	7.1	0.7	7.4
Aug-11	27	7.8	405	488	1194	12	70	55	27	7.8	50	65	1193	7.4	0.8	7.3
Sep-11	27	7.8	339	488	1197	13	77	75	27	7.8	46	62	1190	7.9	1.3	4.3
Oct-11	27	7.9	402	561	1107	12	75	70	27	7.9	45	61	1118	7.3	0.8	7.7
Nov-11	27	7.7	405	546	1190	11	75	74	27	7.7	46	61	1144	7.3	0.8	7.8
Dec-11	22	7.7	391	588	1106	10	75	74	22	7.7	45	62	1143	7	0.8	8.1
Jan-12	18	7.7	402	588	1190	13	75	77	18	7.7	41	60	1162	7.1	0.6	7.5

Tem.: Temperature, COD: chemical oxygen demand, BOD: biological oxygen demand, TDS: total dissolved solids.

Table 4. The removal efficiency of each chemical pollutant from wastewater treatment plant at Zagazig City between April 2011 and January 2012

Time	Tem. (%)	pH (%)	BOD (%)	COD (%)	TDS (%)	Nitrate (%)	Sulphate (%)	Oil (%)
Apr-11	0.0	0.0	91.5	88.3	6.1	30	99.1	88.9
May-11	0.0	0.0	91.6	89.8	8.6	34.5	99.1	88.3
Jun-11	0.0	0.0	88.1	89.1	1.4	34.5	98.9	89.2
Jul-11	0.0	0.0	89.6	89.1	0.6	40.8	98.9	89.4
Aug-11	0.0	0.0	87.6	88.9	0.1	38.3	98.8	89.7
Sep-11	0.0	0.0	89.5	89.4	0.5	39.2	98.3	94.2
Oct-11	0.0	0.0	88.8	89.1	0.9	39.2	98.9	89
Nov-11	0.0	0.0	88.6	88.8	3.8	33.6	98.9	89.4
Dec-11	0.0	0.0	88.4	89.4	3.3	30	98.9	89.1
Jan-12	0.0	0.0	89.8	89.7	2.3	45.4	99.2	90.2

Tem.: Temperature, COD: chemical oxygen demand, BOD: biological oxygen demand, TDS: total dissolved solids.

8.1 $mg.l^{-1}$, respectively. The maximum removal efficiency of BOD, COD, TDS, nitrate, sulphate and oil in the treated wastewater samples was 91.6, 89.8, 8.6, 45.4, 99.2 and 90.2%, respectively (Table 4). Horan (1990) reported that pollution of wastewater may be manifested in three broad categories, namely organic materials, inorganic materials in addition to microbial contents. The organic compounds of wastewater comprise a large number of compounds, which all have at least one carbon atom. These carbon atoms may be oxidized both chemically and biologically to yield carbon dioxide. If biological oxidation is employed the test is termed the Biochemical Oxygen Demand (BOD), whereas for chemical oxidation, the test is termed Chemical Oxygen Demand (COD). In other words, BOD exploits the ability of microorganisms to oxidise organic material to carbon dioxide and water using molecular oxygen as an oxidizing agent. Therefore, biochemical oxygen demand is a measure of the respiratory demand of bacteria metabolizing the organic matter present in wastewater. Excess BOD can deplete the dissolved oxygen of receiving water leading to fish kills and anaerobiosis, hence its removal is a primary aim of wastewater treatment.

Conclusion

This study could be followed by a side-by-side field comparison of identical systems treating municipal wastewater to detect the effect of treating these wastewaters simultaneously. Because co-treatment systems could be used to treat waste streams in communities, it would be useful to track specific fecal indicator coliform bacteria through this system. Additionally, alternative microbiological laboratory techniques, such as direct viability counts, may better estimate the viability of fecal indicator coliform bacteria and pathogens in this study. Results suggest that environmental discharge considerations: A potential problem associated with disposal of wastewater without disinfection to natural waterways is a high turbidity. The levels of indicator and pathogenic bacteria in the wastewater in this study were well in excess of the thresholds for environmental protection compared with other study in developed countries. This suggests that overall the treatment of wastewater process is not adding chlorine at the final treatment of the water. In situation the wastewater is not discharged directly to a waterway. There are no Egyptian guidelines for acceptable concentrations of these kinds of microorganisms in the environment. Generally, wastewater from the Zagazig Wastewater Treatment Plant is not in a suitable quality to be reused for irrigation. Moreover, it is not managed appropriately especially with respect to risks posed by human pathogens. Some form of disinfection may be required to minimize the risk of plant and/or human infections, but further trials need to be conducted to confirm this.

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كفاءة محطة معالجة ميـاه الصـــرف الصحي بمدينة الزقازيق لإزالة الملوثات الميكـروبية والكيميائية

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تستفيد محطات المعالجة البيولوجية لمياه البلدية من الميكروبات لتنقية مياه الصرف الصحي حيث أن الخصائص الميكروبيولوجية لتلك المعالجات على درجة كبيرة من الأهمية، بالإضافة إلى ذلك فأن عملية إزالتها من المياه المتدفقة من المحطة لا عادة استخدمها تكون مهمة، وتهدف هذه الدراسة إلى توصيف وجود الفللورا الميكروبية والملوثات الكيميائية علي التوازي مع مراحل عمليات معالجة مياه الصرف الصحي بمحطة المعالجة بمدينة الزقازيق، لقد كانت كفاءة الإزالة للأعداد الكلية البكتيرية تتراوح ما بين ٢٠-٧٤% خلال مراحل الدراسة وفي نفس الوقت كان متوسط الانخفاض في المعدل الكلي لبكتريا عائلة *Enterobacteriaceae* في عينات مياه الصرف الصحي خلال فترة الدراسة ٨٥% باستثناء شهر يونيه و ديسمبر من عام ٢٠١١ م حيث كان الانخفاض ما بين ٢٩-٣٧% وتشير النتائج إلى ارتفاع مستوى الأعداد الكلية لبكتريا coliforms, *Escherichia coli*, *Salmonella* and *Shigella* في عينات مياه الصرف الصحي الخام ومع أن الازالة الكاملة لأعداد تلك الميكروبات لم يتم انجازها فأن الانخفاض كان بنسبة ما بين ١١-٨٣% في أعداد تلك الميكروبات الكاشفة و قد تم تحقيقها على امتداد خط المعالجة في المحطة، وتعتبر خميرة الـ *Candida* spp., والتي تستخدم في العادة ككاشف حيوي عن الخميرة وهي اقل في الاستخدام من بكتيريا *E.coli* وقد تم اكتشافها في مياه الصرف الخام والمعالجة، ولقد تم تسجيل اقصي انخفاض في الأعداد الكلية للخمائر وخميرة الـ *Candida* spp. في عينات الصرف الصحي بنسبة ٦٤,٢٩ و ٩٥,٢٩% على التوالي في شهر أغسطس وأكتوبر من عام ٢٠١١م، وسجلت النتائج عدم وجود فرق في الخصائص الكيموفيزيائية في مياه الصرف الصحي المعالجة خلال كل فترات الدراسة، وقد كانت أعلي كفاءة لإزالة كل من BOD وCOD والمواد الذائبة الكلية والنترات والسلفات والزيوت بنسب ٩١,٦ و ٨٩,٨ و ٨,٦ و ٤٥,٤ و ٩٩,٢ و٩٠,٢% على التوالي.

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