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Occurrence, Monitoring and Risk Assessment of Toxic Substances in Sewage Water Treatment Plants: A Case Study, Great Cairo, Egypt.

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ABSTRACT

An evaluation process on the validity of wastewater treatment plants effluents for irrigation was done. Chemical and microbial pollutants were measured occasionally in five WWTPs spread in great Cairo, Egypt. The results revealed that WWTPs used secondary treatment (Chlorination) were had the capability to scrape much amount of microbial pollutants, while the units that have only primary treatments were unable to eliminate the microbial organisms. Although the processes used at WWTPs were unspecific for inorganic contaminants removal, metals were reduced in effluents to more than 50 % about the influents. This reduce was attributed to the adsorption of metals on activated sludge which used in aeration stage. In spite of low concentration values of heavy metals in the effluents, these values were conducted to cause hazard effects for aquatic organisms especially Cd, Cu, Pb and Zn based on predict no effect concentration criteria. Water quality index was calculated to identify the applicability of WWTPs effluents for sign in irrigation. The results cleared that the effluents of all units studied weren't applicable for irrigation purpose. These consequences can affect directly on biological cycles. Thus it seems that more consideration of bio conservation protocols is so important.

***Keywords**: Wastewater; Microbial pollutants; Heavy metals; Water quality index; Risk quotient.*

INTRODUCTION

Water is attractive an progressively scarce resource in arid and semi-arid regions, decision makers are forced to admit any source of water that might be used economically and efficiently to fill the deficit of water sources. Whenever good quality water is limited, water of marginal quality will have to be considered for usage in agriculture and groundwater recharge. During latest years, the policy for dealing the reuse of wastewater has moved from conventional disposal policies into value added goods. With the growth of wastewater reuse for different aims, attention over the environmental and health implications of this reuse has also raised. Reuse of treated sewage wastewater has become progressively essential in water resources supervision for both environmental and economic aims. Reuse of wastewater had been used from long time in Egypt. It has been used since 1930 in sandy soil zones such as Al Gabal Al Asfar and Abou Rawash, nearby Cairo. Concern in the reuse of treated wastewater, as a substitute for fresh water in agricultural purpose, has accelerated since 1980. Presently, 0.7 BCM/yr of treated wastewater is used in irrigation, of which 0.26 BCM has secondary treatment and 0.44 BCM has primary treatment (Abd el-wahab and Omar, 2011; MWRI water strategy, 2010). In general, reuse of treated wastewater is of terrific prospective significance for Egypt. The treatments process of wastewater in Egypt is generally divided into four steps. The first two steps are mainly employed for physical removal of big and fine solids. While other final two steps are employed for biological treatment and precipitation. The treatments of wastewater are mainly aims to reduce the concentration of pollutants to produce qualified water for the legal standards (Abdel-Shafy and Aly, 2002).

This study was aimed to monitoring and evaluates the applicability of sewage water treatment plants effluents for irrigation; study the efficiency of different processes used in WWTPs in great Cairo, Egypt for elimination of different pollutants. Also, designating the possible risks that might exist for aquatic organisms in all streams receives the effluents of these units.

MATERIALS AND METHODS

Site description

Cairo is the biggest governorate in Egypt contains the most urban and industrial areas, and its population around 25 millions at 2010. Cairo have many units for sewage water treatment, while there are five of them considered to be the biggest units in Cairo as shown in Figure 1 (AbuZeid, and Elrawady, 2014). All these plants use the same processes as shown in figure 2 and summarized as follows: (1) P4 using screening; discrete settling and primary sedimentation; (2) P5 and P3 using screening; discrete settling; primary sedimentation; aeration and secondary precipitation (3) P1 and P2 is using the same processes as mentioned at No. 3 in addition to chlorination.

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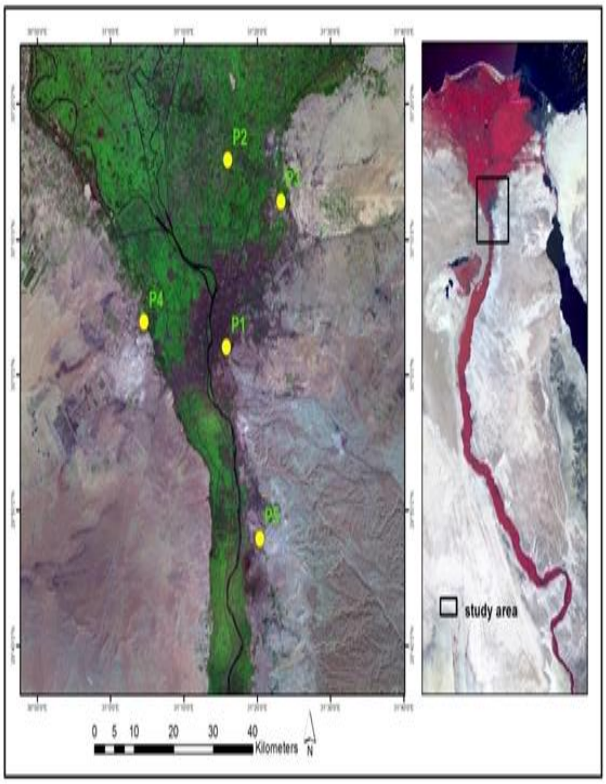

Figure 1. Location map of WWTPs spread in greater Cairo, Egypt.

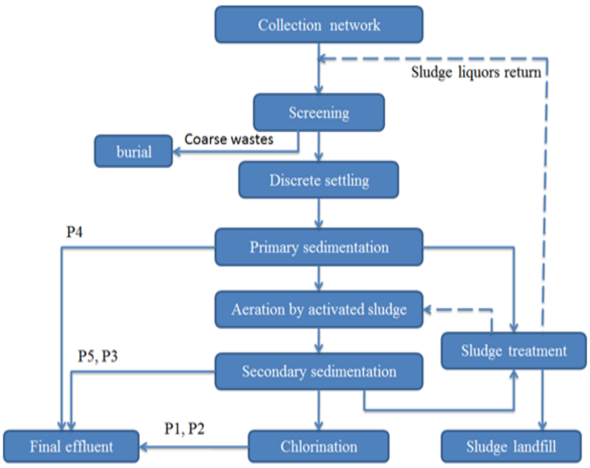

Figure 2. Schematic diagram of wastewater treatment processes used in studied units.

Water samples collection and preservation

Water samples were collected in pre-washed 4 L amber glass bottles along two seasons (winter and summer). Water samples were collected in glass bottles (4 L) that were pre-rinsed with tab water, deionized water and rinsed with sample water onsite. Water chemistries such as pH, DO and EC were measured onsite at the time of sampling. Samples, wrapped with aluminum foil, shipped on ice and delivered to the laboratory within 4 h. Samples were stored in air-tight condition in dark cold room until the analyses but no longer than two weeks.

Water estimates

Inorganic elements

The concentrations of B, Cd, Co, Cr, Cu, P, Pb, Mn, Ni and Zn in the filtrate were determined by using inductively coupled plasma. NO_3 and NH_4 were determined in fresh water using Kjeldahl method *(*Kacar and Inal, 2008)**.** Most of the chemicals used in this study were analytical grade, and mostly obtained from the Merck Company.

Microbial assessment

Chemical oxygen demand (COD) was determined using the method as described by Methods for Chemical Analysis of Water and Wastes (Standard methods for the examination of water and wastewater, 1982).

Biochemical Oxygen Demand (BOD) was determined using method described in the 5 days biochemical oxygen demand Methods for Chemical Analysis of Water and Wastes (Standard methods for the examination of water and wastewater, 1982).

Total coliforms bacteria were counted on Macconkey agar medium using the serial dilution poured plate method. The inoculated plates were inoculated plates incubated at 37C° for 24 hour according APHA (American Public Health Association, 1989). Fecal was counted using the same previous medium, but inoculated plates were incubated at 44.5 C° for 48 hour, according APHA (American Public Health Association, 1989). *Salmonella and Shigella* were counted using SS Agar medium using the serial dilution poured plate method. The inoculated plates were incubated at 33-37C° for 24 hour. Black centered or mirror colonies were counted as *salmonella* and *Shigella* microorganisms (Difco, manual Microbiological Laboratory Procedure, 1977). Parasites were determined according to Jirillo, *et al* (2014).

Data Analysis

Water quality index

A Water Quality Index (WQI) is a useful statistical tool for simplifying; reporting and interpreting complex information obtained from anybody number given by any WQI model explains the level of water contamination. WQI was used to summarize results from different physical, chemical and microbial measurements using computer program created by the national sanitation foundation, USA. The used parameters are: dissolved oxygen (DO), Fecal coliform (FC), pH, BOD, PO_4^{-3} and NO^{-3}. This index divide water quality into five categories: very bad water (0-25), bad (25-50), medium (50-75), good (70-90) and excellent (9-100) (Tyagi et al., 2013).

Risk assessment

The methodology used to predict exposure concentrations for various exposure routes is based upon European Commission Technical Guidance Document on Risk Assessment (TGD), part II, (European Commission, 2003). This document assists authorities in carrying out the environmental risk assessment of existing and new substances. The risk assessment is based on available Predicted No Effect Concentration (PNEC) values for the aquatic and terrestrial environment. The PNEC values from both the aquatic and terrestrial compartments are mainly adapted from EUs risk assessment reports.

The environmental risk posed by certain contaminants in aquatic ecosystems was assessed through the calculation of risk quotients (RQ) as described previously (Eriksen, 2009). RQ values for aquatic organisms were calculated from the measured environmental concentration (MEC) and the predicted no effect concentration (PNEC) of heavy metals under study.

A commonly used risk ranking criteria were applied: RQ < 0.1 means minimal risk, 0.1 ≤ RQ < 1 means median risk, and RQ≥1 means high risk (Hernando et al., 2006).

Statistical analysis

For statistical analysis of the data, three replicates of each plant were collected seasonally. Analysis of variance (ANOVA) was performed to test the significance of differences among season, plant, treatments conditions and their interaction**.** The SPSS statistical analysis package (SPSS Inc., ver. 16, Chicago, IL, USA) was used for data analysis. Data were first run for numerical normality test using the Shapiro–Wilk test, and then statistically analyzed using analysis of variance (ANOVA). Means of the main factors and their interaction were compared using the least significant difference (LSD) test at P ≤ 0.05 (Snedecor, and Cochran, 1980).

RESULTS AND DISCUSSION

Occurrence and removal of chemical pollutants

Occurrence and removal percentage of inorganic pollutants in influent and effluents of different WWTPs are showed in Table 1. The results revealed that the concentrations of inorganic pollutants were existing in trace amounts as compared with permissible limits according to different legislations (Egyptian code (501), 2005; FAO, 2007). Low concentration values of inorganic elements were attributed to the abscissions between municipal wastewater pipes and industrial wastewater influents, which considered the main source of inorganic pollutants. In general, the industrial activity is the main source of inorganic metals in wastewater, due to the discharge of metal laden effluents to the sewerage system. Thus, P5 showed higher concentration of heavy metals than other units, since this unit received effluents discharged from industrial units besides (fertilizers & chemicals factory, charcoal factory, iron and steel factory and many building bricks factories). Winter season showed low concentrations of heavy metals as compared with summer season. This was attributed to dilution effect, since rains are falls in winter season and discharged to the sewerage system during street sinks. Moreover, water consumption during winter is higher than summer seasons (Rathnayaka et al., 2015). While the capability of WWTPs were reduced during winter as compared with summer season (Fig. 3). This was attributed to excess of suspended solids during summer season which can adsorb much amounts of elements on its surface.

Table 1. Total content of chemical elements in municipal wastewater from selected wastewater treatment plants and standard of pollutants in water effluents for agricultural use in Egypt and other legislation (mg L^{-1}).

Location (L)	Treatment (T)	NO_3			NH_4			P			B			Ca		
		Season (S)			Season (S)			Season (S)			Season (S)			Season (S)		
		Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean
P1	Influent	7.69	7.71	7.7	21.95	18.21	20.08	1.36	2.07	1.715	0.048	0.047	0.0475	195.9	44.69	120.295
	effluent	N.d	1.04	0.52	9.95	8.88	9.41	0.23	0.5	0.365	0.047	0.043	0.045	42.39	10.69	26.54
P2	Influent	N.d	N.d	N.d	15.59	13.59	14.59	2.09	2.76	2.425	0.084	0.082	0.083	62.58	24.57	43.575
	effluent	N.d	N.d	N.d	2.1	4.2	3.15	0.35	2.72	1.535	0.074	0.046	0.06	53.57	8.55	31.06
P3	Influent	5.77	4.79	5.28	18.54	15.41	16.97	17.52	3.29	10.405	0.087	3.55	1.8185	76.05	22.66	49.355
	effluent	N.d	N.d	N.d	2.01	5.95	6.95	0.54	1.45	0.995	N.d	0.44	0.22	20.25	20.21	20.23
P4	Influent	N.d	N.d	N.d	25.35	23.11	24.23	2.61	2.62	2.615	0.027	1.68	0.8535	84.33	30.75	57.54
	effluent	N.d	N.d	N.d	19..27	18.48	18.87	2.06	0.58	1.32	0.02	0.78	0.4	26.25	28.14	27.195
P5	Influent	4.2	4.2	4.2	22.53	20.58	21.55	3.04	0.94	1.99	0.093	0.14	0.1165	126.42	38.68	82.55
	effluent	N.d	N.d	N.d	18.54	12.94	15.74	1.25	0.73	0.99	0.091	0.125	0.108	19.49	4.41	11.95
Mean		1.77	1.77	1.77	15.17	14.13	14.86	3.1	1.76	2.4	0.057	0.69	0.3752	70.72	23.33	47.029
L.S.D. (P ≤ 0.05)		L = 0.125 T = 0.08 S – 0.08 L×S =0.177 L×T = 0.177 S×T = 0.112 L×T×S = 0.25			L = 1.93 T = 1.22 S – 1.22 L×S = 2.73 L×T = 2.73 S×T = 1.73 L×T×S = 3.86			L = 0.24 T = 0.15 S – 0.15 L×S = 0.0016 L×T = 0.0016 S×T = 0.001 L×T×S = 0.002			L = 0.05 T = 0.031 S – 0.031 L×S = 0.34 L×T = 0.34 S×T = 0.21 L×T×S = 0.48			L = 1.4 T = 0.9 S – 0.9 L×S = 2.03 L×T = 2.03 S×T = 1.28 L×T×S = 2.86		
Irrigation water (FAO 2007)		10.0			5.0			2.0			2.0			20.0		

Table 1. Continued

Location (L)	Treatment (T)	Mg			Fe			Mn			Cu			Zn		
		Season (S)			Season (S)			Season (S)			Season (S)			Season (S)		
		Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean
P1	Influent	29.22	13.61	21.415	0.112	0.015	0.0635	0.084	0.001	0.0425	0.034	0.005	0.0195	0.078	0.01	0.044
	effluent	27.38	13.08	20.23	0.043	0.005	0.024	0.077	N.d	0.0385	0.022	0.002	0.012	0.025	0.002	0.013
P2	Influent	33.4	15.52	24.46	0.071	0.006	0.0385	0.172	0.035	0.1035	0.043	0.001	0.022	0.015	0.007	0.011
	effluent	29.63	14.36	21.995	0.023	0.002	0.0125	0.008	0.01	0.009	0.005	N.d	0.0025	N.d	N.d	N.d
P3	Influent	39.05	21.43	30.24	0.157	0.016	0.0865	0.222	0.001	0.1115	0.014	0.006	0.01	N.d	0.005	0.005
	effluent	34.01	20.67	27.34	0.043	0.002	0.0225	0.045	N.d	0.0225	N.d	0.004	0.002	N.d	0.004	0.002
P4	Influent	35.2	15.32	25.26	N.d	0.021	0.0105	0.033	0.005	0.019	0.024	0.005	0.0145	0.024	0.003	0.013
	effluent	32.54	3.56	18.05	N.d	0.015	0.0075	0.01	0.001	0.0055	0.022	0.001	0.0115	0.005	0.001	0.003
P5	Influent	41.78	19.57	30.675	0.034	0.084	0.059	0.047	0.195	0.121	0.057	0.23	0.1435	0.128	0.087	0.107
	effluent	28.92	18.7	23.81	N.d	0.046	0.023	0.006	0.067	0.0365	0.016	N.d	0.008	0.23	N.d	0.115
Mean		33.113	15.582	24.3475	0.0483	0.021	0.0347	0.0704	0.0315	0.0509	0.0237	0.0254	0.02455	0.0505	0.0119	0.03
L.S.D. (P ≤ 0.05)		L = 1.23 T = 0.77 S – 0.77 L×S = 1.7 L×T = 1.7 S×T = 1.09 L×T×S = 2.45			L = 0.017 T = 0.011 S – 0.01 L×S = 0.024 L×T = 0.024 S×T = 0.015 L×T×S = 0.035			L = 0.002 T = 0.003 S – 0.002 L×S = 0.005 L×T = 0.005 S×T = 0.003 L×T×S = 0.007			L = 0.002 T = 0.002 S – 0.0016 L×S = 0.0035 L×T = 0.0035 S×T = 0.0022 L×T×S = 0.0049			L = 0.002 T = 0.001 S – 0.001 L×S = 0.003 L×T = 0.003 S×T = 0.001 L×T×S = 0.004		
Irrigation water (FAO 2007)		5.0			5.0			0.2			0.2			2.0		

Table 1. Continued

Location (L)	Treatment (T)	Cd			Co			Cr			Ni			Pb		
		Season (S)			Season (S)			Season (S)			Season (S)			Season (S)		
		Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean	Summer	Winter	Mean
P1	Influent	0.001	N.d	0.0005	0.006	0.004	0.005	0.003	0.001	0.002	0.002	N.d	0.001	0.007	N.d	0.0035
	effluent	N.d	N.d	0.00	N.d	N.d	0.00	0.0026	0.001	0.0018	N.d	N.d	0.00	0.002	N.d	0.001
P2	Influent	0.001	N.d	0.0005	N.d	N.d	0.000	0.016	0.001	0.008	0.021	0.006	0.013	0.0034	N.d	0.0017
	effluent	N.d	N.d	0.00	N.d	N.d	0.00	0.002	N.d	0.001	0.003	0.002	0.0025	0.001	N.d	0.00005
P3	Influent	0.001	N.d	0.0005	0.001	N.d	0.0005	0.004	0.004	0.004	0.004	0.005	0.0045	0.005	N.d	0.0025
	effluent	N.d	N.d	0.00	N.d	N.d	0.00	0.002	0.003	0.002	N.d	0.003	0.0015	N.d	N.d	0.00
P4	Influent	N.d	N.d	0.00	N.d	0.001	0.0005	N.d	0.002	0.001	N.d	N.d	0.00	0.076	N.d	0.038
	effluent	N.d	N.d	0.00	N.d	N.d	0.00	N.d	N.d	0.00	N.d	N.d	0.00	0.073	N.d	0.036
P5	Influent	0.013	N.d	0.0065	N.d	N.d	0.00	0.006	0.003	0.004	N.d	0.017	0.0085	0.077	0.011	0.038
	effluent	N.d	N.d	0.00	N.d	N.d	0.00	0.004	0.001	0.0025	N.d	0.002	0.001	0.075	N.d	0.037
Mean		0.0016	0.00	0.0008	0.0008	0.0004	0.0006	0.0039	0.0018	0.0028	0.0055	0.001	0.0032	0.021	0.017	0.019
L.S.D. (P ≤ 0.05)		L = 0.00037 T = 0.00023 S – 0.0002 L×S = 0.00025 L×T = 0.0005 S×T = 0.0003 L×T×S = 0.0007			L = 0.0004 T = 0.00025 S – 0.0002 L×S = 0.0.00057 L×T = 0.00057 S×T = 0.00036 L×T×S = 0.0008			L = 0.0011 T = 0.0007 S – 0.0007 L×S = 0.0016 L×T = 0.0016 S×T = 0.001 L×T×S = 0.002			L = 0.0007 T = 0.0004 S – 0.0004 L×S = 0.001 L×T = 0.001 S×T = 0.006 L×T×S = 0.001			L = 0.0001 T = 0.0008 S – 0.0008 L×S = 0.0018 L×T = 0.0018 S×T = 0.0011 L×T×S = 0.0025		
Irrigation water (FAO 2007)		0.01			0.05			0.1			0.2			5.0		

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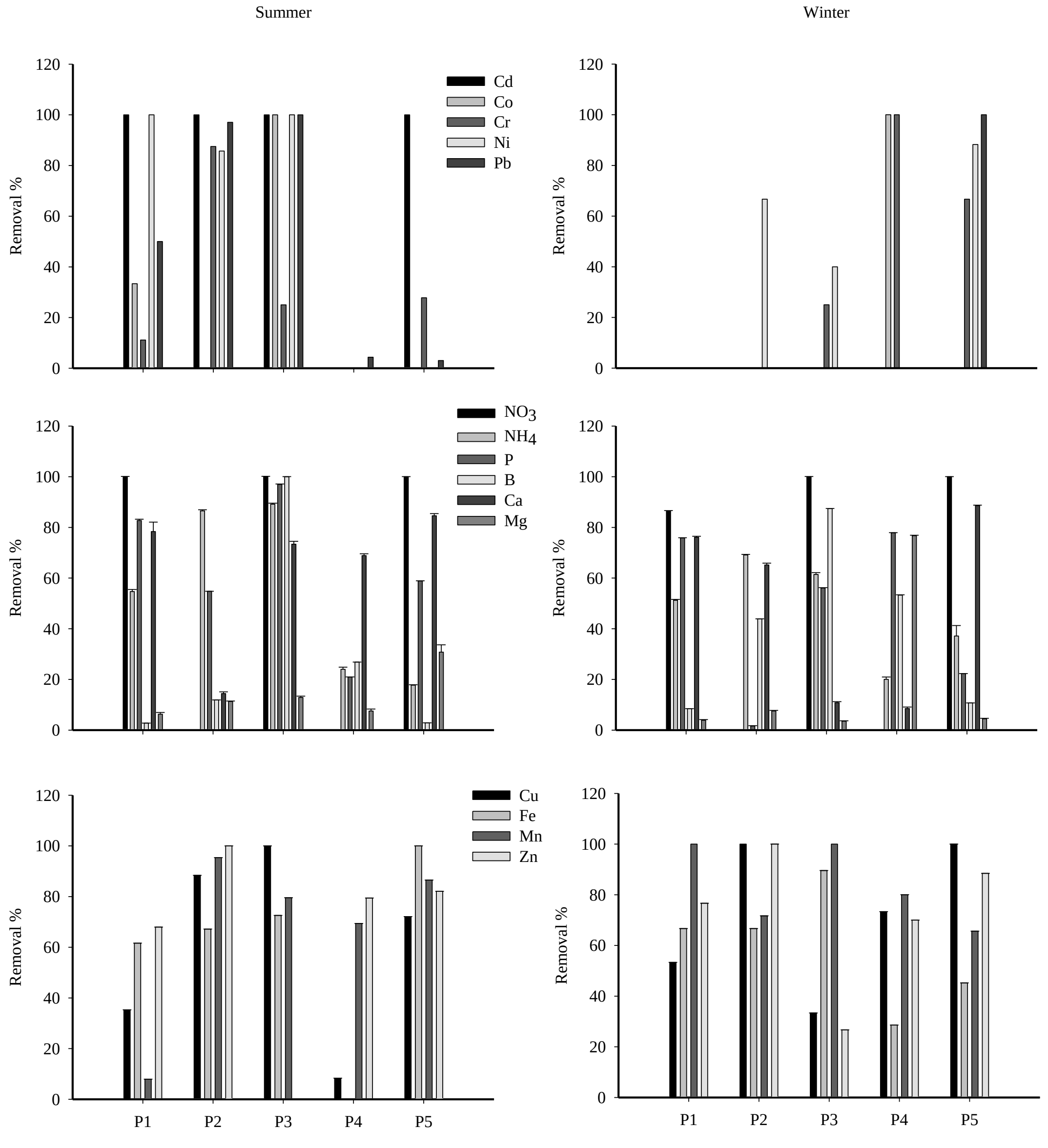

Figure 3. Capability of different WWTPs under study for inorganic compounds removal during different seasons.

WWTP efficacy for elimination of inorganic metals

Effect of different processes used at wastewater treatment plants for the removal of chemical pollutants are shown in Fig. 4. Although wastewater treatment processes used were unspecific for the elimination of heavy metals, large amount of these metals were eliminated due to adsorption on the sludge fraction. These results were in agreement with those obtained by Chipasa (2003) and Qdais and Moussa (2004). As a result, their presence in effluents wastewater is largely infrequent. The water quality of effluents for farmland irrigation is generally poor, where these waters were only primary treated. In addition, the municipal wastewater and industrial wastewater are not well separated in many cases. Same results were got by Yi *et al*., (2011). As a result, heavy metal pollution problems were occasionally noticed in agricultural soils irrigated with the reclaimed water (Xiong et al., 2003; Liu et al., 2005). While the efficacy of different processes used for the removal of salinity was insignificant, since these treatment strategies are not recognized for salinity removal. Many pollutants (B, Ca, Mg, Fe, Zn, Mn, Cu and heavy metals…..) were increased after aeration process due to absorption on to sludge fraction, which used as a source of organic matter for nitrifying bacteria. Therefore, the concentration values of these metals were decreased after secondary precipitation which removes sludge fractions and metals immobilized. NH_4 were significantly reduced to the extent that can be used for irrigation by secondary treatment. NO_3 was also under the permissible limits in the effluents, but the primary and secondary treatments showed insignificant removal efficiency for NO_3. This was attributed to the absence of tertiary treatment which has the ability to eliminate the chargeable elements. pH was markedly reduced by chlorination process due to acidity effect of chlore ion.

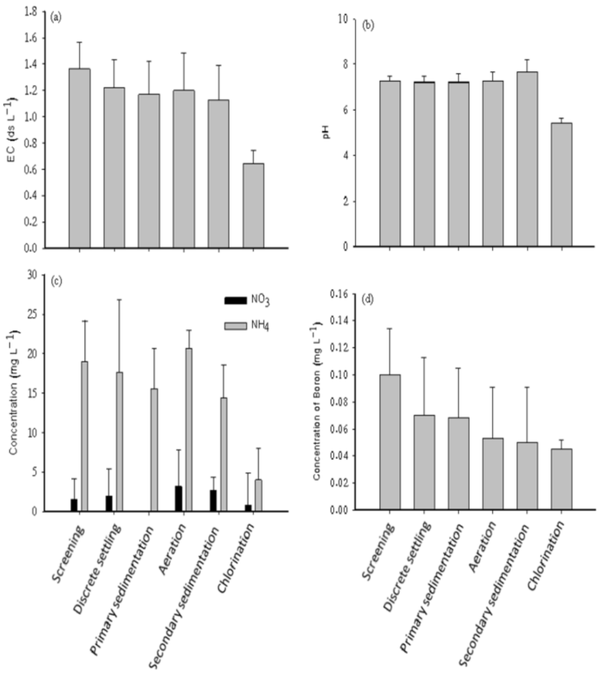

Fig. 4. Efficacy of different processes used at wastewater treatment plants for the removal of salinity (a), acidity (b), NO_3 & NH_4 (c) and B (d).

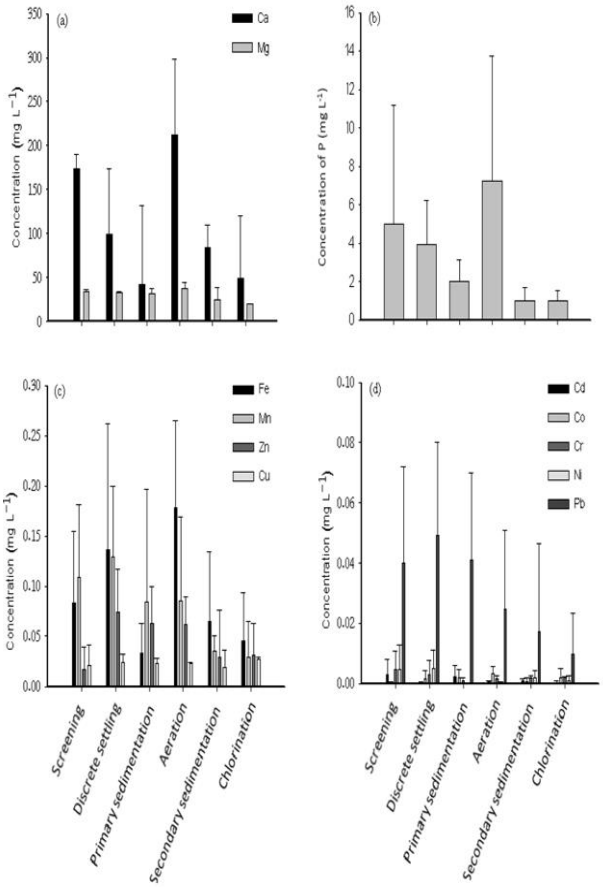

Fig. 5. Efficacy of different processes used at wastewater treatment plants for the removal of Ca & Mg (a), P (b), micro elements (c) and heavy metals (d).

Occurrence and removal of microbial pollutants

Important guideline of biological criteria consider that total coliform, fecal coliform bacteria, *Salmonella* and *Shigella* spp are arguing (Gerba and Rose, 2003). Human intestinal considered the main source of FC. Therefore, coexist FC in water considered an indicator for water pollution with human wastes; meanwhile *salmonella* and *shigella* spp. are pathogenic bacteria.

An evaluation for occurrence of total coliform, fecal coliform, *salmonella* and *shigella* in influent and effluents via five wastewater treatment plants in great Cairo are shown in Table (2). Total coliform bacteria in influent were ranged from 135 x 10^5 and 1x 10^7 cfu/100 ml, and from 4x 10^3 to 40 x 10^3 cfu/100 ml in effluents. Generally all units recorded high removal efficiency for total coliform bacteria more than 97%. In addition to, P1 and P2 recorded the highest removal efficiency for total coliform bacteria reached to 99.9%. This was attributed to chlorination process that used in these two units which have the ability for microbial inhibition. Although all units were achieved high removal efficiency for total coliform bacteria, but only units that have secondary treatment attain the guidelines of WHO (1989), and Egyptian code 501 (2005) as shown in Table (2). This led us to recommend extend other units to inflict secondary treatment in their processes.

Table 2. Numbers of total, fecal coliform bacteria, *Salmonella* and *Shigella* in some wastewater treatment plants in Cairo

Plants	Treatment	Total coliform CFU/100 ml	Fecal coliform CFU/100 ml	*Salmonella* and *Shigella* CFU/100 ml
P1	Influent	$113x\ 10^5$	$12\ x10^5$	$8\ x\ 10^3$
	Effluent	$4x\ 10^3$	$2\ x10^3$	1 0
	Removal %	99.9	99.8	99.8
P2	Influent	$2\ x\ 10^7$	$15\ x\ 10^5$	$7\ x\ 10^3$
	Effluent	$12\ x\ 10^3$	$16\ x\ 10^3$	30
	Removal %	99.9	98.9	99.5
P3	Influent	$9\ x\ 10^6$	$30\ x\ 10^5$	$30\ x\ 10^3$
	Effluent	$22\ x\ 10^3$	$25\ x\ 10^3$	40
	Removal %	99.7	99.1	99.8
P4	Influent	$135\ x\ 10^5$	$70\ x\ 10^5$	$35\ x\ 10^3$
	Effluent	$28\ x\ 10^4$	$41\ x\ 10^3$	60
	Removal %	97.9	99.4	99.8
P5	Influent	$13\ x\ 10^6$	$28\ x\ 10^5$	$11\ x10^3$
	Effluent	$40x\ 10^3$	$66\ x10^3$	50
	Removal %	99.6	97.6	99.5
WHO Guideline (2006)	CFU/100 ml	10^3-10^5	Less than 1000	Nil
Egyptian code 501 (2005)	CFU/100 ml	1000-5000	1000-5000	Nil

The presence of fecal coliform contamination indicates that pathogens may be present. Densities of fecal coliform bacteria (pathogenic bacterial indicators) in raw wastewater (influent) were varied from plant to other. It was ranged from $12x\ 10^5$ to $70\ x\ 10^5$ cfu/100 ml. The occurrence and concentration of enteric pathogens in raw wastewater is dependent on a number of factors including the incidence of infection in the population, per capita water use, season, and social-economic status (Buras, 1974; Martins et al, 1983; NRC, 1998; Jimenez et al, 2002). Although, all units showed high removal efficiency for FC (> 97%), effluents of all units doesn't reached to the permissible limits of WHO (1989) or Egyptian code 501 (2005) with the exception of P1 which recorded $2\ x\ 10^3$ (99.8%) in their effluents. This was due to the presence of secondary treatment (chlorination) as mentioned before.

Salmonella and *shig*ella are pathogenic bacteria, influents of all WWTPs recorded high densities of *Salmonella* and *shig*ella that were ranged from $7x\ 10^3$ to $35\ x\ 10^3$ cfu/100 ml. While all plants showed high ability for efficient removal of *salmonella* and *shigella* (> 99%), but none of these plants were achieved the regulation of WHO (1989) or Egyptian code 501 (2005) for irrigation use. Since both regulations inhibit the existence of any colony of *Salmonella* and *Shigella* in irrigation water because it is considered a pathogenic bacteria for human WHO (1989).

The Chemical Oxygen Demand (COD) values defined as the amount of oxygen which is needed for the oxidation of all organic substances in water in mg/l or g/m^3. COD test procedure is based on the chemical decomposition of organic and inorganic contaminants, dissolved or suspended in water. High COD levels indicates high amount of pollution in the test sample. COD and BOD of influent and effluents of tested plants are summarized in Table 3.

Table 3. Chemical and biochemical oxygen demand in some wastewater treatment plants in Cairo.

Plants	Treatment	COD (mg/L)	BOD (mg/L)
P1	Influent	536	239
	Effluent	112	60
	Removal %	79.0	75
P2	Influent	350	129
	Effluent	70	45
	Removal %	80.0	65.0
P3	Influent	310	180
	Effluent	166	69
	Removal %	46.5	62
P4	Influent	402	150
	Effluent	250	90
	Removal %	38	40
P5	Influent	200	90
	Effluent	103	35
	Removal %	49	61.0
WHO (2006)	Effluent	10-30 mg/l	10-30 mg/l
Egyptian code 501 (2005)	Effluent		20-50 mg/l

Data in table 3 indicates that the values of COD were greater than BOD in all tested samples. COD ranged between 200 to 536 mg/L in influents, while it was ranged between 70 to 250 mg/L in effluent. On the other hand, BOD ranged between 90 to 239 mg/l in raw water (influent), while it was ranged between 35 to 90 mg/L in effluents. P1 and P2 plants recorded high removal efficiency for COD and BOD since they have secondary treatment, even though all plants recorded high concentration values of COD and BOD in effluents which can prevent using this water in irrigation.

Parasites consider one of important indicators for efficient quality performance of WWTPs for microbial pollutants removal, especially *Guardia lembila* which causes gastrointestinal illness (e.g., diarrhea, vomiting and cramps). Table 4 showing the Existing parasites in different stages used in WWTPs under study. The results revealed that *Schistosoma girgarica* was discovered only in screening phase. On the other hand, *Entemobia coli*, *Balantidium coli* and *Guardia lembil* were detected in all stages except chlorination stage which destroyed all microorganisms and parasites. This was attributed to the toxicity effect of chlorination for all living parasites. Therefore, plants that hasn't chlorination process (P3, P4 and P5) were contained some kinds of parasites in their effluents. It's worthily to mention that, *Entemobia histolytic* exist in screening phase then disappeared and return to be detected in aeration stage. This was attributed to sludge fractions which used in aeration stage as activated sludge to minimize the microbial growth.

The use of untreated wastewater for irrigation, no doubt, poses a high risk to human health in all age groups. However, the degree of risk may vary among the various age groups. Untreated wastewater irrigation leads to relatively higher prevalence of hookworm, and Ascariasis infections among children (Cifuentes et al., 2000). So the authors recommend using secondary treatment (chlorination, UV …) in all wastewater treatment plants to gain the benefit of their effluents in irrigation purpose.

Table 4. Existing parasites in the different stages of WWTPs under study.

Parasites	Screening	Discrete settling	Primary sedimentation	Aeration	Secondary sedimentation	Chlorination
Schistosoma girgarica	*	Nil	Nil	Nil	Nil	Nil
Entemobia histolytica	***	Nil	Nil	*	*	Nil
Entemobia coli	*	**	**	*	**	Nil
Balantidium coli	***	**	**	**	**	Nil
Guardia lembila	**	**	**	**	*	Nil
paramecium	Nil	Nil	Nil	Nil	*	Nil
WHO(1989)	Not more than one egg or cyst of parasites					

*** Number of units exists.**

Water quality index

WQI was used to identify the quality of effluents of WWTP for irrigation purpose. Water quality index for the effluents of 5 WWTPs were shown in Table 5. The results revealed that the effluents of WWTPs rating as bad or very bad water for irrigation use, since the water quality index were ranged between 21 to 29. This was attributed to high values of BOD and Fecal coliform which exceed than the permissible limits of FAO (1985). P4 is using primary treatment which result high suspended solids in their effluents. Therefore, values of turbidity were contributed with a high degree in reducing the quality of water to very bad in P4. While high values of NO_3 were responsible for decreasing the quality of water to very bad in P1 and P5, since they doesn't have and processes for charged ions removal. Generally, effluents of WWTPs were not applicable for irrigation purpose, so we recommend to modernization these units with other processes can removal these pollutants found.

Risk assessment of toxic metal on aquatic organisms.

In Greater Cairo, Egypt, most wastewater treatment plant effluents are discharged into the nearest water stream whether it was fresh or drainage water stream. This might lead to negative impacts on the aquatic environment. Consequently, adverse health impacts on human health may be existed.

Environmental risks of heavy metals to aquatic organisms were assessed for the worst case scenario in the effluent of WWTPs based on the risk quotients (RQ) calculated using the of effluents of five WWTPs expressed as measured environmental concentration (MEC) and PNECs (Table 5). P1 effluents might cause hazard effects on the aquatic organisms, since the RQ of Cu and Zn were above 1. Also, P4 and P5 were assessed to cause health impacts for aquatic organisms due to high RQ of Cu, Pb and Zn.

This might led to accumulation of lead in the gill, liver, kidney, and bone of fish live in water streams receive these effluents. In juvenile fish, lead causes a blackening of the tail followed by damage to the spine. It also reduces larvae survival. Lead bio-concentrates in the skin, bones, kidneys, and liver of the fish rather than muscle and does not biomagnify up the food chain. This makes lead less problematic via this route of exposure. However, people who eat the whole fish and wildlife, who, of course, eat the whole fish, can potentially be exposed to high concentrations of lead (Wright and Welbourn, 2002).

Copper also exerts a wide range of physiological effects on fishes, including increased metallothionein synthesis in hepatocytes, altered blood chemistry, and histopathology of gills and skin (Igre et al., 1994).

Zinc toxicities affect freshwater fish by destruction of gill epithelium and consequent tissue hypoxia. Signs of acute zinc toxicities in freshwater fish include osmoregulatory failure, acidosis and low oxygen tensions in arterial blood, and disrupted gas exchange at the gill surface and at internal tissue sites (Spear, 1981).

These toxic metals were exist in the effluents of WWTPs due to the absence of processes that have the ability to remove these pollutants, such as adsorption on activated carbon, coagulation & flocculation….).

The authors recommend adding secondary treatment (Chlorination, UV and Ozonation) for the units use only primary treatments (i.e. P3, P4 and P5). Also all these units should be supported by tertiary treatment for different toxic metals removal.

Table 5. Water quality index and risk quotient of effluents of WWTPs under study.

Unit	WQI	WQI Degree	RQ					
			Cd	Cr	Cu	Ni	Pb	Zn
P1	21	Very bad	0.00	0.29	1.67	0.00	0.56	2.18
P2	25.74	Bad	0.00	0.59	0.38	1.00	0.14	0.00
P3	29.4	Bad	0.00	0.88	0.38	0.40	0.00	0.26
P4	19.5	Very bad	0.00	0.00	1.79	0.00	5.28	0.51
P5	21.61	Very bad	0.00	0.59	1.03	0.20	5.28	4.62

CONCLUSION

An evaluation process for the occurrence of chemical and microbial pollutants in WWTPs were done, the removal efficiency of processes used at these WWTPs for the elimination of different pollutants were also studied. The concentration of inorganic pollutants were exist in trace amounts as compared with permissible limits according to different legislations, Although wastewater treatment processes used were unspecific for the elimination of heavy metals, large amount of these metals were eliminated due to adsorption on the sludge fraction. WWTPs that used secondary treatment (Chlorination) were have the capability to scrape much amount of microbial pollutants (e.g. Total coliform; Fecal coliform; Salmonella & Shigella and different parasites), while units that have only primary treatments were unable to eliminate the microbial organisms. Effluents of these units studied weren't applicable for using in irrigation of crops and vegetables. Inorganic pollutants in the effluents of WWTPs studied showed high risk values on aquatic organisms, especially for Cu, Pb and Zn

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متابعة, رصد وتقييم المخاطر البيئيه للمواد السامه بمحطات معالجة الصرف الصحي: دراسة خاصه, القاهرة الكبري, مصر.

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تم عمل تقييم لمدي صلاحية المياه الخارجه من محطات الصرف الصحي لاستخدامها في الري. تم قياس الملوثات الكيماوية والبيولوجيه علي فترات متعاقبه بخمس محطات لمعالجة الصرف الصحي بالقاهرة الكبري, مصر. أظهرت النتائج أن محطات معالجة الصرف الصحي التي تستخدم المعالجه الثانويه (الكلورة) كانت لديها القدرة علي ازالة كميه كبيرة من الملوثات البيولوجيه, بينما لوحظ زيادة الملوثات البيولوجيه في المياه الخارجه من المحطات التي لديها معالجه ابتدائيه فقط. بالرغم من أن التكنولوجيات المستخدمه داخل محطات الصرف الصحي غير متخصصه في معالجة الملوثات المعدنيه, الا أنه وجد انخفاض تركيز الملوثات المعدنيه بالمياه الناتجه من المعالجه بنسبه تزيد عن 50% عن المياه الداخله. هذا الانخفاض يرجع الي ادمصاص العناصر المعدنية علي الحمأة النشطه التي تستخدم في مرحلة التهويه. وبالرغم من انخفاض تركيز الملوثات المعدنيه بالمياه الناتجه من محطات المعالجه, وجد أن هذه التركيزات قد تتسبب في احداث أضرار جسيمه للاحياء المائيه خاصه عناصر الكادميوم, النحاس, الرصاص والزنك وذلك اعتمادا علي معيار التركيز الذي لا يطهر عند أي أضرار للاحياء المائيه. تم حساب مؤشر جودة المياه للحكم علي مدي صلاحية استخدام المياه الخارجه من المجطات في مجال الري. أوضحت النتائج أن المياه الخارجه من جميع محطات المعالجه غير صالحه للاستحدام في مجال الري. هذه النتائج قد تؤثر علي التنوع الحيوي لذلك يقترح اجراء مزيد من الدراسات حول عمل احتياطات ومعايير لاستخدام هذه النوعيه من المياه.