BIOLOGICAL EVALUATION OF THE REUSE OF SOME DOMESTIC WASTEWATER FROM GREAT CAIRO

A. M. Fares[1], E. A. Abdel-Rahim[2], Y. M. Hafez[3] and M. E. Kobasy[2]

[1] Wastewater Treatment Dept., Chimi Art Co., Cairo, Egypt
[2] Biochemistry Dept., Faculty of Agriculture, Cairo University, Giza, Egypt
[3] Animal Prod. Dept., Faculty of Agriculture, Cairo University, Giza, Egypt

ABSTRACT

The present study was conducted to evaluate the treatment of domestic wastewater of great Cairo using different doses of coagulant and flocculent. The study was followed by biological evaluation of the best treatment from different sources of domestic wastewater using White New Zealand male Rabbits. A total of 18 domestic wastewater samples were collected from three different domestic wastewater treatment plants (Helwan, Zenin, and Gabal Al Asfar) which treated using Coagulant ($FeCl_3$) and Flocculent (polymer). Contaminants in domestic wastewater [Suspended Solids (SS), Organic Matters (COD or BOD_5), Nutrients (TN+TP) and Heavy Metals] were classified into dissolved and suspended. Each domestic wastewater sample was treated using six different chemical treatments. Upon the chemicals analysis of the resultant water the best treatment was chosen as drinking water for rabbits in this study relative to tap water. All these contaminants were removed by coagulation/sedimentation.

Results of analysis of domestic wastewater showed a great reduction after the chemicals treatment. In addition, the microbiological test against total Coliform and E.coli showed a great reduction after treatment expressed as number of colonies per cubic centimeter.

A total number of 64 white New Zealand male rabbits were used to biologically examine the drinkability of the treated wastewater without any adverse effects. Hematological and biochemical relevant parameters of White New Zealand male rabbits as affected by drinking wastewater treated with coagulant ($FeCl_3$) and flocculent (polymer) were in the normal physiological range without no obvious change. No significant changes in liver and kidney functions of the rabbits except a slight elevation in blood plasma creatinine in the fourth group (Gabal Al Asfar treated wastewater). Weight gain, Feed conversion, and feed efficiency did not significantly change among experimental groups. Slight increase in feed consumption in the rabbits drinking Gabal Al Asfar treated wastewater and slight decrease in feed consumption in the rabbits drinking Helwan treated wastewater.

The study showed the drinkability of domestic wastewater treated with the recommended doses (10-20 ppm $FeCl_3$, 5-15 ppm cationic polymer, 5 ppm Cl_2) of coagulant and flocculent in this research without any adverse effects on rabbits.

Keywords: domestic wastewater, heavy metals, dissolved matter, suspended solids, biological evaluation, rabbits.

INTRODUCTION

To overcome the traceability of water, the recycling of domestic wastewater is a must taking care of the cost of chemical treatment to make this water drinkable (Wang *et al.,* 2007). Domestic wastewater is included those from homes and commercial establishments. The impurities of the domestic wastewater can be removed by conventional and advanced treatments for the purposes of discharge or treated water reuse. The treatment processes consisted of primary treatment (physical process) and secondary treatment (biological process). Recently, enhanced primary treatment that utilized a chemical coagulant to assess the removal of suspended and dissolved impurities, has drawn wide attention for wastewater that are not amenable to conventional biological treatment (Semerjian and Ayoub, 2003 and Wang *et al.,* 2007), especially in developing countries (Harleman and Murcott, 1999 and 2001 and Gehr *et al.,* 2003). Primary and secondary treatments reduce the majority of contaminations found in wastewater (Sonune and Ghate, 2004). Several studies have been done on the optimization of particle separation (Ødegaard, 1992 and 1998, and Wang *et al.,* 2007), utilization of inorganic coagulants and polymers (Poon and Chu, 1999), post filtration (Van Bauren *et al.,* 1999) and post disinfection (Gehr *et al.,* 2003) in enhanced primary treatment process.

The synthetic polymer used in wastewater treatment is of long chain type with high molecular-weight organic compounds that have a strong tendency to be adsorbed on the particle surfaces in aqueous suspensions. The cationic polymers are after referred to as primary coagulants because they enhance the coagulation of negatively charged particles by a process of adsorption surface charge neutralization (Reali *et al.,* 2001). Chemical primary treatment is also recommended as the first step of wastewater (Levine *et al.*, 1985; Aiyuk *et al.,* 2004 and Eugenio *et al.*, 2006).

Rabbit's production plays a considerable role in solving the problem of meat shortage in Egypt, particularly on the level of the small-scale farmers and new reclaimed areas. However, the most obvious limitation to rabbit production in hot climate area is the susceptibility of this species to heat stress and availability of clean healthy and good quality drinking water, which lead to the impairment of production and feed efficiency (Marai *et al.,* 2004, Ahmed *et al.,* 2005 and 2006). In addition, the cost of buying clean drinking water in rabbit farms can affect the feasibility of rabbit production.

Thus, the objective of this work was to investigate the efficiency of different treatment regimes of domestic wastewater represent Great Cairo. Furthermore, examine the drinkability of the best treatment wastewater to the experimental rabbits without any adverse effects on it.

MATERIALS AND METHODS

Location of under-study wastewater treatment plants

Figure (1) shows the locations of the studied wastewater treatment plants in great Cairo.

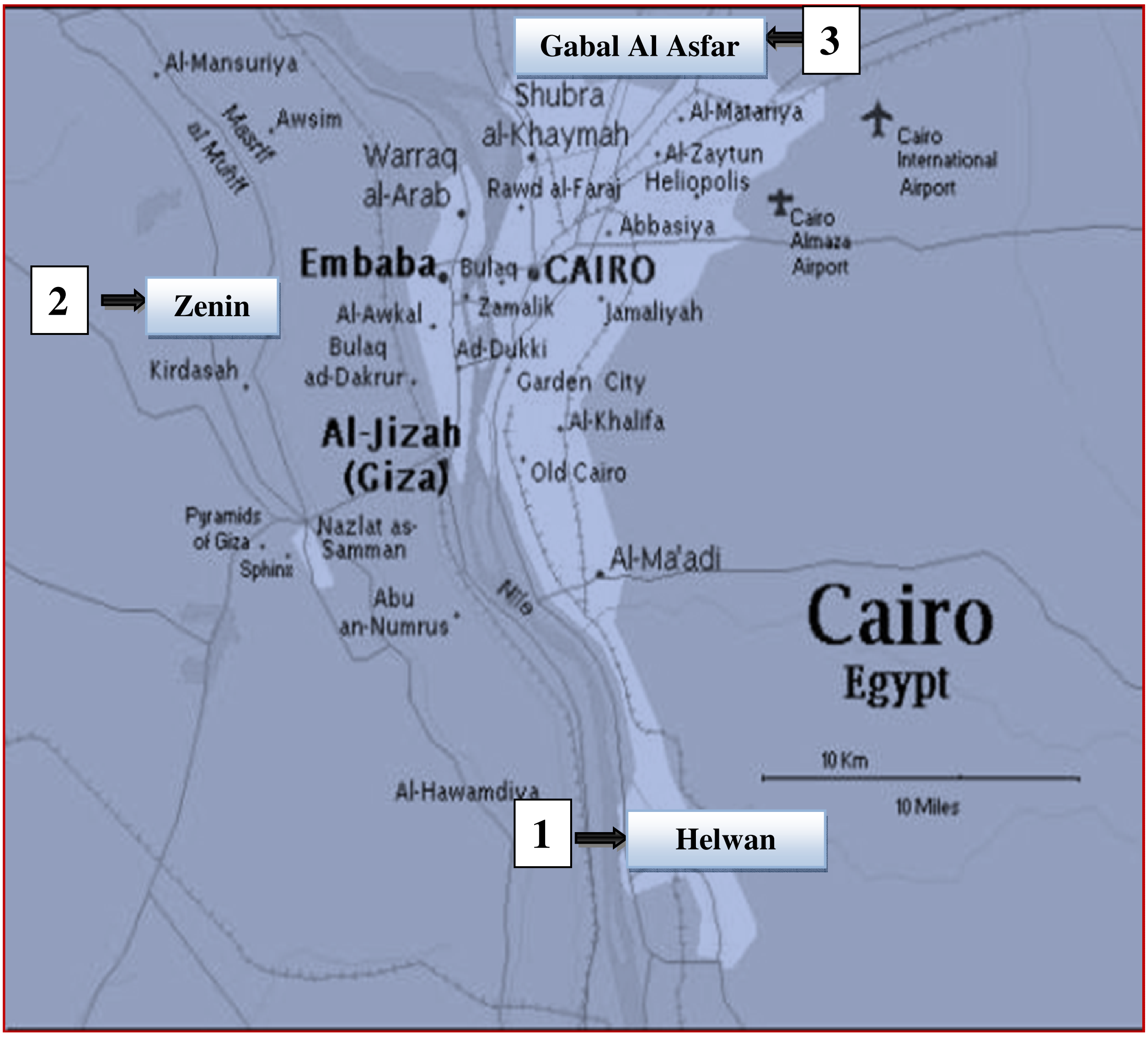

Fig. 1. Wastewater treatment plants in Great Cairo.
1. Helwan Wastewater Treatment plant
2. Zenin Wastewater Treatment plant
3. Gabal Al Asfar Wastewater Treatment plant

Sources of domestic wastewater in Great Cairo

The raw domestic wastewater samples used in the present study was collected from Helwan (South Cairo), Zenin (Middle Giza) and Gabal Al Asfar (North Cairo) domestic wastewater plants, Great Cairo, Egypt. During the experimental period, the samples before and after treatment quality items included suspended solids (SS), organic matters (COD or BOD_5), nutrients (total nitrogen + total phosphate), metals and heavy metals were determined according to the standard methods for the examination of water and wastewater. Metals and heavy metals content was determined by atomic absorption model 2380 according to (Page *et al.,* 1982).

The present study was carried out at Chimi Art Co. Lab., 6 October City, Giza, Egypt and Animal Physiology Lab., Faculty of Agriculture, Cairo University, Giza, Egypt.

A total of 18 domestic wastewater samples were taken from 3 different treatment plants in Great Cairo, (Helwan domestic wastewater treatment plant-South Cairo., Zenin domestic wastewater plant-middle Giza and Gabal Al Asfar domestic wastewater treatment plant- North Cairo).

Treatment of domestic wastewater

Domestic wastewater samples used in the present work were primary treated with coagulant ($FeCl_3$ obtained from Chimi Art Co., Cairo, Egypt) and flocculent (Artfloc 242) (Polymer obtained from SNF, Saint Etienne, France), then followed by secondary treatment with chlorine solution (Cl_2 sodium hypochlorite-obtained from Misr for chemical industries, Alexandria, Egypt), which differed according to the wastewater sources. Each domestic wastewater sample from each plant was treated with coagulant ($FeCl_3$) and flocculent (polymer) and upon the chemical analysis of the resultant water, the best treatment was chosen as drinking water in this study.

a. Preparation of chemicals used in wastewater treatment

- Ferric chloride ($FeCl_3$, 40% w/w solution)
  An amount of 2.5 cm^3 of $FeCl_3$, 40% w/w was dissolved in 1liter water (each 1 cm^3 of the resultant solution represents 1 ppm).
- Polyelectrolyte (polymer, 100% powder)
  An amount of 1 g. of polymer 100%, powder was dissolved in 1 liter water (each 1cm^3 of the resultant solution represent 1 ppm).
- Sodium hypochlorite (Cl_2, 12% solution)
  An amount of 7.5 cm^3 of sodium hypochlorite 12%, solution was dissolved in 1liter water (each 1 cm^3 of the resultant solution represents 1 ppm).

b. Primary Treatment

A total of 18 wastewater samples were collected (6 samples from each wastewater plant, Helwan, Zenin and Gabal Al Asfar from the same inlet and the same time, each sample is 200 liter in a plastic drum). A total of six different chemical treatments were conducted similarly for each wastewater treatment plant (T1 = 30 ppm $FeCl_3$, T2 = 40 ppm $FeCl_3$, T3 = 50 ppm $FeCl_3$, T4 = 10 ppm $FeCl_3$ + 15 ppm cationic polymer, T5 = 10 ppm $FeCl_3$ + 5 ppm cationic polymer, T6 = 20 ppm $FeCl_3$ + 5 ppm cationic polymer).

The chemical treatment was executed in the laboratory first in jar tester, which is consisted of 6 cylinders, the capacity of each cylinder is 5 liters having a stirrer operated by a motor The operational condition was set as: rapid mixing (120 rpm/min) for 1 min, slow mixing (45 rpm/min) for 15 min, and settling for 2 min. (Wang *et al.,* 2007). Figures 2 and 3 show the photos of jar testing apparatus.

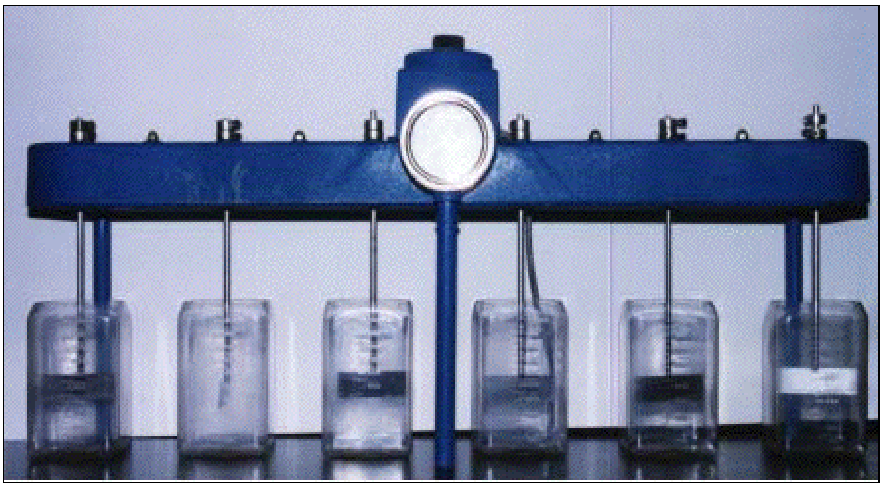

Fig. 2. Photo of jar testing apparatus

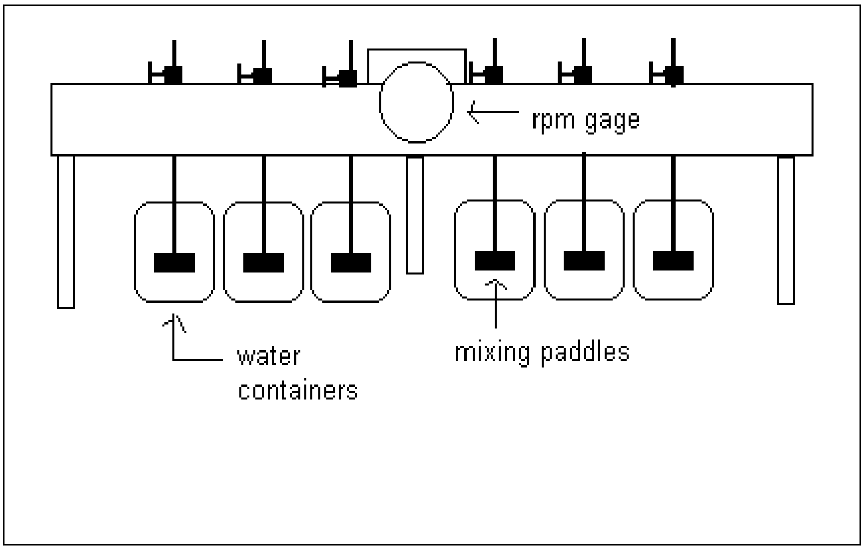

Fig. 3. Diagram of jar testing device

The chemical treatment of wastewater was done in three stages for each step as follow:

1. A total of 5-liter wastewater in each cylinder was stirred.
2. Six different chemicals were added in three stages (Ferric chloride then cationic polymer and then sodium hypochlorite) followed by stirring for 2 minutes after each adding. (T1 = 30 ppm $FeCl_3$, T2 = 40 ppm $FeCl_3$, T3 = 50 ppm $FeCl_3$, T4 = 10 ppm $FeCl_3$ + 15 ppm Cationic polymer, T5 = 10 ppm $FeCl_3$ + 5ppm

cationic polymer, T6 = 20 ppm $FeCl_3$ + 5 ppm cationic polymer) and followed by stirring for 2 minutes.

3. Chlorine (sodium hypochlorite) was added as a polishing 5ppm for each cylinder and as a germicidal and germ static agent.

Chemical and biological analysis was done for domestic wastewater pre and post treatment.

Measuring treated wastewater quality

To measure the treated wastewater quality and drinkability different chemical, bacteriological and biological, the application of the biological assessment of treated wastewater could be done after the validity of the previous chemical and bacteriological assays.

a. Treated domestic wastewater samples

The three sources of domestic wastewater were Helwan, Zenin, and Gabal Al Asfar wastewater plants a 200 litter of the pretreated domestic wastewater from each treatment plant were transferred to Chimi Art labs (6^{th} October City, industrial zone no.2, block no.232). A laboratory sub-samples were taken after a complete steering for analysis of suspended solids (SS), organic matters (COD or BOD_5), nutrients (TN+TP), metals and heavy metals a total of 3 litres from each domestic wastewater source were divided into 6 cylindrical jar test to conduct different treatment plants.

The best treatment (as shown by analysis in the Results and Discussions) for each sources (Helwan 20 ppm $FeCl_3$ + 5 ppm Cationic polymer, Zenin 10 ppm $FeCl_3$ + 5 ppm cationic polymer, Gabal Al Asfar 10 ppm $FeCl_3$ + 15 ppm cationic polymer) using coagulant and flocculent was started immediately after the transfer of the domestic wastewater from its sources using plastic tanks.

The resultant treated domestic wastewater was transferred in plastic drum to the experiment farm of Animal Physiology Lab, Cairo University, Giza, Egypt. Then the drum was divided into 10 portions in other smaller plastic drums. To keep the treated wastewater fresh, the sub-samples in the small drums were frozen then offered after thawing on a weekly basis.

b. Chemical analysis

Chemical assays of the treated wastewater to determine its drinkability are suspended solids (SS), organic matter (COD and BOD_5), nutrients (total phosphate (TP) and total nitrogen (TN)), metals and heavy metals. Chemical analysis in this study was conducted regarding SS, COD, BOD_5, TN (NH_3^+ –N, NO_3^- –N, NO_2^- –N), TP (Wang *et al.,* 2007) and metals (Ca, Cu, Fe, Ni, Mg, Pb, Zn, K, Na, Cd, Cr, Hg, and As). All metals were quantified using Atomic Absorption model 2380 according to Page *et al.*, (1982). The samples were prepared before assaying using the standards of AOAC (AOAC, 1995). Methods utilized are shown in Table (1).

c. Bacteriological analysis

Bacteriological assays of the treated wastewater to determine its drinkability are the count of total Coliform and E. coli in colonies per cubic centimeter. Verocytotoxin producing Escherichia coli O157 (VTEC) was first recognized as being a virulent human pathogen and serious threat to public health in 1982 (Riley *et al.,* 1983). Clinical symptoms of the disease range from mild diarrhea and hemorrhagic colitis through to complications arising from infection such as hemolytic uremic syndrome (HUS) and thrombocytopenic purpura (Su and Brandt, 1995). Escherichia coli became the primary indicator of water pollution. As methods for the specific detection and identification of E. coli were not well developed, an E. coli surrogate.

The total Coliform group was developed. Its detection was based on the physiological observation that the fermentation of lactose in a growth medium, which allowed the manifestation of only enteric bacteria, would elucidate E.coli and its relatives, the total Coliforms. Shortly afterwards, Coliform monitoring became codified throughout the world. Coliform monitoring, being rapid, inexpensive, and easy to perform, proved effective. The rates of water-borne bacterial disease outbreaks in developed countries today are low (Leclerc *et al.,* 2000).

d. Biological analysis

Biological assays of the treated wastewater to determine its drinkability are numerous in case of using it in the irrigation of forage, vegetables and horticulture plants, (Costa and Heuvelink, 2004). However, the attempts of using the treated wastewater in the drinking of laboratory animals or farm animals are rare. Biological examinations of the drinkability of treated wastewater are based on the use of animals drinking the treated wastewater and clinically examine the blood constituents and the performance of these animals. The examinations on the experimental animals include hematological (Hb, PCV), biochemical (total protein (TP), albumin, globulin, glucose and some vital organs function; liver function tests (alanine amino transferase (ALT), aspirate amino transferase (AST) and bilirubin), kidney function tests (urea, uric acid and creatinine).

Table 1. Methods and kits used to quantify the relevant blood biochemical parameters

Parameter	Method	Company	Reference
Heavy metals, ppm	Atomic absorpyion	Atomic Absorption model 2380	Page *et al.* (1982).
SS (Suspended Solids)	Gravimetric	(GB 11901-89)	Wang, *et al.*(2007)
COD (Chemical oxygen demand)	Dichromate	(GB 11904-89)	Wang, *et al.* (2007)
BOD_5 (Biological oxygen demand)	5-days BOD test		Wang, *et al.* (2007)
TN, ppm (Total nitrogen)	Alkaline potassium per – sulfate digestion UV spectrophotometric	(GB 11894-89)	Wang, *et al.* (2007)
TP, ppm (Total Phosphorus)	Ammonium molybdate spectrophotometric	(GB11893-89)	Wang, *et al.* (2007)
Hemoglobin, g/dl	Colorimetric	Stanbio Laboratory (Antonio , Texas , 78202 USA)	Henry (1964)
Total Protein, g/dl	Colorimetric	Stanbio Laboratory(Boerne, Texas, 78202 USA)	Cannon (1974)
Albumin, g/dl	Colorimetric	Stanbio Laboratory(Boerne, Texas, 78202 USA)	Dumas and Biggs (1972)
Glucose, mg/dl	Enzymatic Colorimetric	Diamond diagnostics	Trindder (1969)
Bilirubin , mg/dl	Colorimetric	Bio Adowic	Chapman *et al.* (1959)
AST&ALT (RFU/l)	Colorimetric	Quimica Clinica Aplicada S.A. (Ampposta, Spain)	Reitman and Frankei (1975)
Urea, mg/dl	Colorimetric	Bio Adowic	Tabacco (1979)
Uric Acid, mg/dl	Colorimetric	Bio Adowic	Fabiny and Ertinghausen (1971)
Creatinine, mg/dl	Colorimetric	Bio Adowic	Fabiny and Ertinghausen (1971)

Biological evaluation of treated wastewater

A total number of 64 White New Zealand male (NZW) rabbits aging 6 weeks old were used. The animals were housed during the experimental period (70 days) in metal batteries with automatic drinkers. All experimental rabbits were kept under normal healthy conditions and feed commercial pellets diets prepared by Atmeda, Dakahlia, Egypt.

Feed allowances of rabbits were calculated according to NRC requirements (NRC, 2005). Water was provided ad libitum.

After feeding on the diet and tap water for one week, (adaptation period) rabbits were divided randomly into four groups (16 rabbits each) according to the following scheme to evaluate the effect of drinking chemically treated wastewater as following:

First group : Control group, which provided tap water.
Second group : Rabbits provided treated the best wastewater from Helwan (treated by 20 ppm $FeCl_3$ + 5 ppm cationic polymer+5 ppm Cl_2).
Third group : Rabbits provided treated the best wastewater from Zenin (treated by 10ppm $FeCl_3$ + 5 ppm cationic polymer + 5 ppm Cl_2).
Forth group : Rabbits provided treated the best wastewater from Gabal Al Asfar (treated by 10 ppm $FeCl_3$ + 15 ppm cationic polymer + 5 ppm Cl_2).

During the experimental period (10 weeks), the consumed diet and body weights were recorded every week and at the same time, blood was collected using a heparenized vaccutainer tubes from the ear marginal vein. Whole blood hemoglobin (Hb,g/dl) and packed call volume (PCV%) were quantified immediately then blood was centrifuged at 3000 rpm to obtain the plasma and keep it at – 20°C till further analysis.

Body weight gain, food intake and feed efficiency were recorded and calculated. Blood plasma AST (aspartate trensaminase) and ALT (alanine transaminase) activities were determined also. Total protein, albumin, glucose, urea, creatinine and billirubin of plasma were determined. Globulin was calculated by subtracting albumin from total protein.

Statistical analysis

Data set was analyzed using the general linear model of SAS (SAS, 1999). Differences among means were tested using Duncan (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical studies

Ferric Chloride and Polymer (coagulant/flotation) dosages are necessary for water and wastewater flocculation. $FeCl_3$ with polymer use was investigated aiming to the best reduce of the sludge production, applying smaller dosages of chemicals. The results obtained in tables 2 to 4 indicated. Tables (2 to 4) indicated the efficiencies observed with T1 (30 ppm $FeCl_3$), T2 (40 ppm $FeCl_3$), T3 (50 ppm $FeCl_3$), T4 (10 ppm + 15 ppm cationic polymer), T5 (10 ppm $Fecl_3$ + 5 ppm cationic polymer) and T6

(20 ppm $Fecl_3$ + 5 ppm cationic polymer) and 5 ppm Cl_2 was added to each cylinder. The best efficiencies observed with 20 ppm $FeCl_3$ + 5 ppm cationic polymer + 5 ppm Cl_2, for Helwan wastewater, 10 ppm $FeCl_3$ + 5 ppm cationic polymer + 5 ppm Cl2, for Zenin wastewater, 10 ppm $FeCl_3$ + 15 ppm cationic polymer + 5 ppm Cl_2, for Gabal Al Asfar wastewater. Domestic wastewater samples were treated to remove the total suspended solids (SS), and dissolved fractions included heavy metals. The average removal of (SS) was 95.6 %, regarding chemical oxygen demand (COD) and biological oxygen demand (BOD_5) the overall removals were 94.6 % and 94.2 %, respectively.

Tables (2, 3 and 4) represent the complete analysis of different samples of wastewater from different sources pre and post treatment using (six) different treatments for each sample. The samples of the wastewater taken from Helwam, Zenin and Gabal Al Asfar were analyzed for their initial concentration of the studied metals and heavy metals i.e., Ca, Cu, Fe, Ni, Mg, Pb, Zn, K, Cd, Cr, Hg and As before treatment and the obtained results are shown in Tables (2, 3 and 4) which were detected except Hg and As. Tables (2, 3 and 4) show that the initial concentration of the studied metals and heavy metals in the wastewater of the three station were higher than the permissible levels reported by Egyptian Environmental Affairs Agency (Low#4, 1995) where for example the permissible limits of Zn, Cu, Pb and Cd were 1.00, 0.10, 0.05 and 0.05 ppm respectively, which the values of the initial concentration of the above mentioned metals in Helwan wastewater were 2.30, 0.32, 0.33 and 0.40 ppm respectively whereas, the corresponding values were 0.80, 0.20, 0.09 and 0.06 in Zenin wastewater and 0.10, 0.04, 0.10 and 0.006 in Gabel Al Asfar wastewater respectively. Tables (2, 3 and 4) show also the pH values, Suspended Solid, (SS), Organic Matters (COD and BOD_5) and Nutrients (TP and TN) of the three plants wastewater samples before treatment these values they were 7, 617 ppm, 394 ppm, 940 ppm, 3.40 ppm and 25.00 ppm in Helwan wastewater, while in Zenin wastewater were 7 of pH and 215, 292, 276, 2.60 and 23.00ppm, but in Gabal Al Asfar wastewater the values were 7.3 for pH and 342, 321, 760, 2.80 and 21.00 ppm respectively. The concentration values were decreased relative to those of Gabal Al Asfar raw wastewater by the studied six treatments, which produced concentration values, ranged from 4.09 to 4.39 % from 4.98 to 6.23 %, from 5.39 to 7.24 %, from 55.36 to 71.43 % and from 61.90 to 77.67 % respectively for SS, COD, BOD_5, TP and TN.

Table 2. Treatments and Analysis of Helwan domestic wastewater treatment plant pre and after chemical Treatments

Chemicals Analysis		Helwan						
		Before	*After (Value - %)					
			T1	T2	T3	T4	T5	T6
pH		7.0	6.90 -98.57	6.90 -98.57	6.83-97.57	6.95-99.29	6.95-99.29	**6.93-99.00**
METALS And HEAVY METALS,ppm	**Ca,** ppm	7.90	4.30-54.44	4.00-50.63	3.80-48.10	4.60-58.13	4.60-58.23	**4.30-54.44**
	Cu, ppm	0.32	0.15-46.88	0.11-34.38	0.10-31.25	0.18-56.25	0.17-53.13	**0.14-43.75**
	Fe, ppm	8.80	5.10-57.95	5.30-60.23	5.60-63.23	4.60-52.27	4.50-51.14	**5.00-56.82**
	Ni, ppm	0.42	0.19-45.34	0.14-33.33	0.11-26.19	0.20-31.18	0.20-31.18	**0.18-42.86**
	Mg, ppm	6.10	3.40-55.74	2.90-47.54	2.40-39.34	3.90-63.93	3.80-62.30	**3.50-57.38**
	Na, ppm	18.60	12.30-66.13	12.10-65.05	12.10-65.05	13.20-70.97	13.00-69.89	**13.30-71.51**
	Zn, ppm	2.30	0.98-42.61	0.99-43.04	0.99-43.04	1.10-47.83	0.97-42.17	**0.96-41.74**
	K, ppm	19.30	14.90-77.20	13.80-71.50	13.00-67.46	16.20-83.94	15.20-78.86	**14.90-77.20**
	Pb, ppm	0.33	0.10-33.30	0.07-21.20	0.04-12.12	0.11-33.33	0.11-33.33	**0.10-30.30**
	Cd, ppm	0.40	0.07-17.50	0.06-15.00	0.03-7.50	0.09-22.50	0.08-20.00	**0.06-15.00**
	Cr, ppm	0.10	0.04-40.00	0.01-10.00	0.01-10.00	0.05-50.00	0.05-50.00	**0.03-30.00**
	Hg, ppm	Nil	Nil	Nil	Nil	Nil	Nil	**Nil**
	As, ppm	Nil	Nil	Nil	Nil	Nil	Nil	**Nil**
Suspended Solids (SS), mg**.l**		617	17.00-2.67	16.00-2.59	18.00-2.92	19.00-3.08	16.00-2.59	**15.00-2.43**
Organic Matters	**COD,** ppm	394	22.00-5.58	24.00-6.09	25.00-6.35	22.00-5.58	24.00-6.09	**24.00-6.09**
	BOD_5, ppm	940	53.00-5.46	63.00-6.70	59.00-6.28	54.00-5.74	58.00-6.17	**55.00-5.85**
Nutrients	**TP,** ppm	3.40	3.00-88.24	2.85-83.82	2.35-69.12	2.30-67.65	2.55-75.00	**2.20-74.71**
	TN, ppm	25.00	15.00-60.00	14.00-56.00	16.00-64.00	20.00-80.00	15.00-60.00	**14.00-56.00**

*Value – percentage (percentage related to value before treatment; T1=30ppm $FeCl_3$,T2=40ppm $FeCl_3$, T3=50ppm $FeCl_3$, T4=10ppm $FeCl_3$ + 15ppm Cationic polymer, T5=10ppm $FeCl_3$ + 5ppm Cationic polymer**, T6=20ppm $FeCl_3$+5ppm Cationic polymer+5ppmCl_2**

Table 3. Treatments and Analysis of Zenin domestic wastewater treatment plant pre and after chemicals treatments

Chemicals Analysis		**Zenin**						
		Before	***After (Value - %)**					
			T1	**T2**	**T3**	**T4**	**T5**	**T6**
pH		7.2	7.19-99.86	7.20-100.00	7.01-97.36	6.99-97.08	**6.95-96.53**	6.99-97.08
METALS And HEAVY METALS,ppm	**Ca,** ppm	4.60	3.60-78.16	3.10-67.39	3.80-82.61	3.80-82.61	**3.30-71.74**	3.70-80.43
	Cu, ppm	0.20	0.01-5.00	0.01-5.00	0.03-15.00	0.03-15.00	**0.01-5.00**	0.02-10.00
	Fe, ppm	2.80	2.40-85.71	1.80-64.29	2.60-92.86	2.40-85.17	**2.40-85.17**	2.39-85.36
	Ni, ppm	0.18	0.03-16.77	0.01-5.56	0.04-22.22	0.04-22.22	**0.03-16.67**	0.03-16.67
	Mg, ppm	2.20	1.70-77.27	1.10-50.00	1.90-86.36	1.80-81.82	**1.60-72.73**	1.75-79.55
	Na, ppm	11.20	9.80-87.50	9.10-81.25	10.60-94.64	10.50-93.75	**9.50-84.82**	9.50-84.82
	Zn, ppm	0.80	0.20-25.00	0.30-37.50	0.60-75.00	0.60-75.00	**0.10-12.50**	0.40-50.00
	K, ppm	13.2	10.30-78.03	9.20-69.70	11.30-85.61	11.20-84.85	**9.80-74.24**	9.50-71.97
	Pb, ppm	0.09	0.02-22.22	0.01-11.11	0.07-77.78	0.07-77.78	**0.02-22.22**	0.03-33.33
	Cd, ppm	0.06	0.01-16.67	0.01-16.67	0.03-50.00	0.03-50.00	**0.01-16.67**	0.01-16.77
	Cr, ppm	0.02	0.003-15.00	Nil-00.00	0.01-50.00	0.01-50.00	**0.006-30.00**	0.005-25.00
	Hg, ppm	Nil	Nil	Nil	Nil	Nil	**Nil**	Nil
	As, ppm	Nil	Nil	Nil	Nil	Nil	**Nil**	Nil
Suspended Solids (SS), mg.**l**		215	13.00-6.05	13.00-6.51	14.00-6.98	15.00-4.65	**10.00-6.51**	14.00-6.98
Organic Matters	**COD,** ppm	292	15.00-5.14	17.00-5.82	16.00-5.46	12.00-4.11	**14.00-4.79**	14.00-4.79
	BOD_5, ppm	676	41.00-6.07	43.00-6.36	45.00-6.66	44.00-6.51	**40.00-5.92**	45.00-6.66
Nutrients	**TP,** ppm	2.60	1.60-61.54	1.20-46.15	1.35-51.92	1.25-48.08	**1.30-50.00**	1.30-50.00
	TN, ppm	23.00	15.00-65.22	15.50-67.39	16.40-71.30	15.00-65.22	**14.00-60.87**	14.00-60.87

*Value – percentage (percentage related to value before treatment; T1=30ppm $FeCl_3$,T2=40ppm $FeCl_3$, T3=50ppm $FeCl_3$, T4=10ppm $FeCl_3$ + 15ppm Cationic polymer, **T5=10ppm $FeCl_3$ + 5ppm Cationic polymer**, T6=20ppm $FeCl_3$+5ppm Cationic polymer+5ppm Cl_2.

Table 4. Treatments and Analysis of Gabal Al Asfar domestic wastewater treatment plant pre and after chemicals treatments

Chemicals Analysis		**Gabal Al Asfar**						
		Before	***After (Value - %)**					
			T1	**T2**	**T3**	**T4**	**T5**	**T6**
pH		7.30	7.20-98.63	7.10-97.26	7.15-97.95	**7.2-98.63**	7.30-100.00	7.20-98.63
METALS And HEAVY METALS,ppm	**Ca,** ppm	6.25	3.81-60.96	3.50-56.00	3.41-54.56	**3.11-46.76**	3.82-61.13	3.01-48.16
	Cu, ppm	0.04	0.0002-0.50	0.0020-5.00	Nil-0.00	**0.0001-0.25**	0.0001-0.25	Nil-0.00
	Fe, ppm	3.20	3.10-96.88	3.10-96.88	2.30-71.88	**2.10-65.63**	2.00-62.50	2.50-78.13
	Ni, ppm	0.001	Nil-0.00	Nil-0.00	Nil-0.00	**Nil-0.00**	Nil-0.00	Nil-0.00
	Mg, ppm	16.00	13.00-81.25	13.00-81.25	12.00-75.00	**12.00-75.00**	10.00-65.50	13.00-81.25
	Na, ppm	17.00	16.00-80.95	13.00-76.19	14.00-61.90	**14.00-61.90**	11.00-90.41	24.00-66.67
	Zn, ppm	0.10	0.0020-2.00	0.0500-50.00	0.0001-0.10	**0.0001-0.10**	Nil-100.00	0.0030-3.00
	K, ppm	14.00	11.40-81.43	11.40-81.43	11.00-78.57	**11.10-79.29**	11.00-78.57	11.10-79.29
	Pb, ppm	0.10	0.0001-0.10	Nil-0.00	Nil-0.00	**0.0001-0.00**	0.0001-0.00	0.0001-0.00
	Cd, ppm	0.006	0.0001-1.67	Nil-0.00	Nil-0.00	**Nil-0.00**	Nil-0.00	Nil-0.00
	Cr, ppm	0.02	Nil-0.00	0.0001-0.50	Nil-0.00	**Nil-0.00**	Nil-0.00	Nil-0.00
	Hg, ppm	Nil	Nil	Nil	Nil	**Nil**	Nil	Nil
	As, ppm	Nil	Nil	Nil	Nil	**Nil**	Nil	Nil
Suspended Solids (SS), mg.**l**		342	15.00-4.39	16.50-4.93	15.00-4.93	**14.00-4.09**	14.50-4.24	16.00-4.68
Organic Matters	**COD,** ppm	321	16.00-4.98	16.00-4.98	18.00-5.61	**17.00-5.3**	19.00-5.92	20.00-6.23
	BOD_5, ppm	760	55.00-7.24	49.00-7.45	54.00-7.11	**42.00-5.53**	43.00-5.66	41.00-5.39
Nutrients	**TP,** ppm	2.80	2.00-71.43	1.95-69.64	1.55-55.36	**1.90-67.86**	2.00-71.43	1.93-68.93
	TN, ppm	21.00	15.00-71.33	13.00-61.90	16.31-77.67	**15.00-71.43**	14.70-70.00	15.30-72.86

*Value – percentage (percentage related to value before treatment; T1=30ppm $FeCl_3$,T2=40ppm $FeCl_3$, T3=50ppm $FeCl_3$, **T4=10ppm $FeCl_3$ + 15ppm Cationic polymer,** T5=10ppm $FeCl_3$+ 5ppm Cationic polymer, T6=20ppm $FeCl_3$+5ppm Cationic polymer+5ppm Cl_2.

From the present results of Tables (2, 3 and 4), it can be concluded that the 6th treatment (T6 = 20 ppm $FeCl_3$ + 5 ppm cationic polymer + 5 ppm Cl_2), the 5th treatment (T5= 10 ppm $FeCl_3$ + 5 ppm cationic polymer + 5 ppm Cl_2) and the 4th (T4 = 10 ppm $FeCl_3$ = 15 ppm cationic polymer + 5 ppm Cl_2)seemed to be the most suitable and efficient treatment for removal or reduction of the concentration in domestic sewage respectively of Helwan, Zenin and Gabal Al Asfar raw wastewaters respectively.

Table (5) represents the chemical analysis of tap water and domestic wastewater before and after treatment using the best resultant treatment.

The contaminants in domestic sewage can be divided into four categories: suspended solids (SS), organic matter (Chemical oxygen demand or biochemical oxygen demand), nutrients (nitrogen and phosphorus), and heavy metals, which are the substances to be removed by conventional and / or advanced treatment for the purposes of discharge or treated water reuse. The three best treatments resulted in the highest total removal percentage of the heavy metals, in which the treatments removed about the all amount of Cu, Ni, Pb, Zn, Cd, and Cr but removed the other metals Ca, Fe, and Mg of about half their amounts of the wastewater. In case of Na and K the treatment removed about ¼ their amount in the studied samples. The wastewater before and after treatments were free from Hg and Ar. It means that, the treatments with $FeCl_3$ + polymer + Cl_2 seemed to be the most suitable and efficient for removed or reduction the contaminants or impurities of domestic wastewater.

The present results are in agreement with those obtained by Huge *et al.,* (2005), Zeng (2006), Jiange *et al.,* (2004), Reali *et al.,* (2001) and Nandy *et al.,* (2003). They reported that the both inorganic and organic cautions were intercalated into $FeCl_3$ and cationic polymer in which the coagulation-flocculation significantly reduced/removed the contaminants in domestic sewage, which induced heavy metals, suspended solids, organic matter and nutrients.

In connection, the odor of the all raw wastewater samples of the three plants was very bad and differed from one plant to another. That was before treatment, but after all six treatment either suitable of in suitable treatment the all treatment samples has normal odor without any abnormal status.

As $FeCl_3$ and cationic polymer process a capacity for adsorption by coagulation-flocculation process, they could adsorb metals ions or organic molecules, this could be one of the mechanisms of the studied treatment which may be act as stock for ion exchange of toxic ions in solution (Reali *et al.,* 2001) or will be effective reinforcement for capturing ions or organic matter in water (Mavrov *et al.,* 2004). The present studies suggested that there could be strong interactions between the pollutants and FeCl*3* with polymer and resulting pollutant complexes will be retained by coagulant-flocculation process to in hence coagulation performance (Nandy *et al.,* 2003; Abdel-Lateef, 2006 and Wang *et al.,* 2007).

Table 5. Analysis of best resultant water from sources (Helwan, Zenin, and Gabal Al Asfar domestic wastewater plants) before and after treatment

Chemical analysis		Tap Water	Helwan (T6)			Zenin (T4)			Gabal Al Asfar (T5)		
			Before	After	Reduction %	Before	After	Reduction %	Before	After	Reduction %
pH		7.90	7.0	6.93	1.00	7.2	6.95	3.40	7.30	7.2	1.36
METALS And HEAVY METALS,ppm	**Ca**	0.40	7.90	4.30	45.60	4.60	3.30	28.26	6.25	3.11	53.24
	Cu	Nil	0.32	0.14	56.25	0.20	0.01	95.00	0.04	0.0001	99.75
	Fe	0.20	8.80	5.00	43.00	2.80	2.40	14.29	3.20	2.10	34.78
	Ni	Nil	0.42	0.18	57.14	0.18	0.03	83.33	0.001	Nil	100.00
	Mg	0.10	6.10	3.50	42.62	2.20	1.60	27.27	16.00	12.00	25.00
	Na	7.40	18.60	13.30	28.50	11.20	9.50	15.18	27.00	24.00	11.11
	Zn	Nil	2.30	0.96	58.26	0.80	0.10	87.50	0.10	0.0010	99.00
	K	4.20	19.30	14.90	27.80	13.2	9.80	25.75	4.00	3.10	22.50
	Pb	Nil	0.33	0.10	69.70	0.09	0.02	77.78	0.10	0.0001	99.99
	Cd	Nil	0.40	0.06	85.00	0.06	0.01	83.33	0.006	Nil	100.00
	Cr	Nil	0.10	0.03	70.00	0.02	0.006	70.00	0.02	Nil	100.00
	Hg	Nil	Nil	Nil	------	Nil	Nil	------	Nil	Nil	-----
	As	Nil	Nil	Nil	------	Nil	Nil	------	Nil	Nil	-----
Suspended Solids (SS) mg.l		Nil	617	15.00	97.60	215	14.00	93.49	342	14.00	95.90
Organic matters ppm	**BOD5**	Nil	394	24.00	93.90	292	14.00	95.20	321	17.00	94.70
	COD	Nil	940	55.00	94.15	676	40.00	94.00	760	42.00	94.47
Nutrients ppm	**TP**	Nil	3.40	2.20	35.29	2.60	1.30	50.00	2.80	1.90	32.14
	TN	Nil	25.00	14.00	44.00	23.00	14.00	39.13	21.00	15.00	28.57

The 6th treatment (T6= 20ppm $FeCl_3$ + 5ppm cationic polymer + 5ppm Cl_2),
the 5th treatment (T5= 10ppm $FeCl_3$ + 5ppm cationic polymer + 5ppm Cl_2)
and the 4th (T4= 10ppm $FeCl_3$ = 15ppm cationic polymer + 5ppm Cl_2)

Zeng *et al.,* (2006) reported that $FeCl_3$ is widely used as a flocculent agent in municipal wastewater treatment, its potential role as a source of electron acceptors for anaerobic respiration has not been recognized as a means to promote odor abatement. $FeCl_3$ is also used extensively to remove phosphorus during secondary municipal wastewater treatment. Those $FeCl_3$ treatments of wastes would generate two fractions a clarified liquid that could be applied to load as a nitrogen source and phosphorus-enriched flocculated solids that could be composted or readied as inoculants. The enhancement of iron respiring by limestone gravel may also have applications for chemical oxygen demand removal by other tricking filter systems.

Inagaki and Kiuchi (2001) observed that the low viscosity of treatments chemical have the week electrostatic bridging between inorganic particles and sulfate of polymer and although high viscosity of treatment chemicals has a strong electrostatic bonding force, the hydrophobic area generated by the sulfone bridges in the polymer makes adsorption of the polymer onto the hydrophilic surface of inorganic particles difficult.

According to Goyal *et al.,* (1979), Kopecka *et al.,* (1993) and Puig *et al.,* (1994), there are a large number of potentially pathogenic animal enteric viruses and bacteria in wastewater. The aim of wastewater treatment is to reduce or remove the wastewater chemicals and biological pollutants, including viruses. Thus, information on the effectiveness of virus removal by conventional sewage treatment processes is of major concern. Inefficient sewage treatment may result in waterborne diseases caused by polluted recreational, potable or shellfish-growing waters wastewater treatment processes are mainly designed to satisfy physicochemical or bacterial standards (Nsabimana *et al.,* 1996). Extent of enteric virus reduction varies according to the sewage treatment used and the virus type (Leong, 1983 and Lewis and Metcalf 1988).

The optimum concentrations of different coagulating agents with respect to contaminants removal were determined by conducting series of jar tests, and analyzing the untreated and treated samples for various parameters, viz. SS, BOD and COD. The conventional jar test involved setting up a series of samples wastewater on a special multiple paddle stirrers, and dosing the samples with range of various coagulants in different concentrations. This was performed by mixing one liter of wastewater sample for a short period of rapid mixing (at an impeller rotational speed (n) of 100 rpm and mixing time (t) of 60 sec) followed slow mixing (at an impeller rotational speed of 30 rpm and mixing time of min). After slow mixing operation, the suspensions with flocks were allowed to settle for 30 min, and the supernatant was analyzed for various physicochemical parameters. (Nandy *et al.,* 2003).

The present study used ferric chloride and cationic polymer as coagulant and flocculent, the pH range over which effective flocculation can be achieved varies for different coagulant agents, viz. ferrous sulphate between 1.0 and 3.0 (Eckenfelder, 1989), ferric salts greater than 4.5 (Tebbutt, 1998), aluminum sulphate between 0.7 and 8.0 (WPCF and ASCE, 1977), while polyaluminium chloride is effective over wide pH range above neutral (Masschelein, 1992). However, other optimum values have also been reported in the literature for specific cases (Black, 1960; Black and Willems, 1961; Packham, 1962 and Black and Christman, 1963). Research carried out so far has indicated that hydrolysis of aluminium and iron salts in the water results in decrease in the alkalinity due consumption of hydroxyl ions. Therefore, raw printing ink wastewater being alkaline (pH: 12.5–13.6) was adjusted to pH between 7.4 and 7.6 using sulphuric acid to achieve pH of the pre-treated effluent after flocculation and settling in the range of 7.0–7.2. This would enable further biological treatment to bring down the concentration of organic substances (BOD and COD) within the statutory standards.

This would need no further pH adjustment after pre-treatment (coagulation - flocculation), thereby reducing the cost of treatment, and further addition of TDS the pre-treated effluent.

The prime necessity of the study was to find the most efficient coagulant for this type of domestic wastewater. Preliminary studies with aluminum and iron salts indicated that their addition even in small concentration caused formation of visible flocks, which may be caused due to destabilization, and further neutralization of particle charges.

Studies were conducted with pH-adjusted wastewater using varying concentrations of ferrous sulphate, ferric chloride, aluminum sulphate, and polyaluminium chloride separately. The effect of various coagulant agents on removal of SS, BOD and COD at varying concentrations increased with increase in coagulant concentrations.

The ability of an agent to coagulate is related to its charge. There is more than an order of magnitude increase in the effectiveness of an ion as its charge increases by one based on Schultze-Hardy rule. Black and Willems (1961) reported improved effectiveness of trivalent ions as compared to bivalent ions. The present study also revealed that less coagulant concentration of trivalent ions was required with better removal efficiencies than with coagulant of bivalent ions. Therefore, the trivalent ions formed very large complex, which removed many of the contaminants in domestic sewage of the studied wastewater.

Our results related to domestic wastewater treatment were in agreement with Reali *et al.,* (2001), Abd El Lateef *et al.,* (2006) and Wang *et al.,* (2007).

Wang *et al.* (2007) treated raw domestic sewage obtained from a domestic wastewater plant in China. They classify the contaminants in the raw sewage to SS, COD, BOD_5, TN, NH_3^+ –N, NO_3^- –N, and TP. The authors used inorganic coagulant (poly aluminum chloride) and cationic polymer for the treatment of the domestic wastewater. They concluded that the inorganic coagulant and polymer are efficient in treating wastewater significantly reduced contaminants.

Furthermore, Reali *et al.,* (2001) used inorganic coagulant (ferric chloride) and/ or cationic polymer in the treatment of dissolved air flotation (DAF Units). They used the same range of coagulant and flocculent as used in the present study. They concluded that the use of ferric chloride and polymer with the dose of 15- 30 ppm ferric chloride and average 1 ppm cationic polymer were efficient in the removal of contaminants in wastewater from DAF units.

The doses used by Reali *et al.,* (2001) were slightly higher than that used in the present study in ferric chloride but lower in cationic polymer. This might be attributed to the difference in the treated water and the load of contaminants in that water.

1. The criteria of choosing the best resultant treatments

    The lowest total heavy metal content after chemical treatment

    The lowest organic matter (COD + BOD) content after chemical treatment

    The lowest nutrients (Total phosphates + Total Nitrogen)

    The lowest content of bacteria (Total Coliform and E. coli)

    The more closer analysis to the control (tap water)

2. General Considerations in wastewater treatment

    The success of wastewater treatment depends on the following considerations:

    - Source and quality of wastewater
    - Added materials to domestic wastewater (industrial wastewater, Domestic wastewater or mixed)
    - Pretreatment analysis of wastewater (which give an indication to the materials and doses needed for chemical treatment) especially heavy metals, organic matters and nutrients.

Bacteriological studies

Bacteriological tests of the drinking treated wastewater were done against Total Coliform and E. coli. The results in Table (6) of the bacteriological test showed that total Coliform and total E. coli were 20 and 2 colony/cm^3 in tap water, respectively. Meanwhile, the number of colonies of total Coliform in the treated wastewater from Helwan, Zenin and Gabal Al Asfar were 40, 49 and 35, respectively. While, the number of colonies of E. coli in the treated wastewater from Helwan, Zenin and Gabal Al Asfar were 4, 6 and 3, respectively. Table (6) represents the great reduction in the number of colonies of total Coliform and E. coli after each treatment 99.93 and 99.99 %, respectively.

The great reduction in the content of Total Coliform and E.coli in the treated water after treatment was previously reported by several investigators (Lucena, *et al.,* 1996; Hilton and Stotzky, 1973 and IAWPRC, 1991).

In accordance to our results, (Lucena *et al.,* 1996), the numbers of several bacterial indicators [faecal Coliforms (FC), Enterococci (ENT) and sulphite-reducing clostridia (SRC)] and bacteriophages (somatic Coliphages, F-specific RNA phages and bacteriophages infecting bacteroides fragilis strain RYC2056) were determined in incoming raw sewage and effluents from various primary and secondary wastewater treatment processes in several geographical areas. Reductions in the numbers of indicators were calculated as log10 reductions. Processes based on removal and mild disinfection, showed no significant differences in the elimination of any of the indicators tested or between geographical areas. (Leclerc *et al.,* 2000).

Table 6. Bacteriological analysis of experimental water

Total Bacteria Tap Water		Helwan			Zenin			Gabal Al Asfar		
	Tap Water	Before	After	Reduction %	Before	After	Reduction %	Before	After	Reduction %
Total Coliform, Colony/cm3	20	60000	40	99.93	75000	49	99.93	55000	35	99.9
E. coli, Colony/cm^3	2	40000	4	99.99	68000	6	99.99	38000	3	100

In contrast, treatment processes that include strong microbial inactivation, such as lime aided flocculation and lagooning, showed significant differences between the log10 reductions of the various microorganisms studied, FC showing the highest reduction and spores of SRC and phages infecting B. fragilis the lowest (Leclerc *et al.,* 2000).

Hematological tests

Tables 7, 8 and 9 represent the relevant blood biochemical parameters of rabbits drinking wastewater treated with:

- (Tap Water) as control group,
- (Helwan treated wastewater) 20 ppm $FeCl_3$ + 5 ppm cationic polymer + 5 ppm Cl_2,
- (Zenin treated wastewater) 10 ppm $FeCl_3$ + 5 ppm cationic polymer + 5 ppm Cl_2, and
- (Gabal Al Asfar treated wastewater) 10 ppm $FeCl_3$ + 15 ppm cationic polymer + 5 ppm Cl_2.

Blood biochemistry profile was used for the diagnosis of certain problems and defects that may be encountered with drinking the treated wastewater. Values of hematological parameters of experimental rabbits were in the normal physiological range being the highest in rabbits drinking tap water and the lowest in the fourth treatment. Blood metabolites values such as plasma proteins, albumin, globulin, A/G ratio and glucose concentration were also in the normal physiological range reported by (Kaneko *et al*. 1997). These findings reflect that the three treatments of the three sources of domestic wastewater are efficient to make this water drinkable.

Table 7. Some blood hematological and biochemical parameters (M±SD) of White New Zealand male rabbits as affected by drinking domestic wastewater treated white coagulant and flocculent

Blood Parameters	Tap Water*	Helwan**	Zenin***	Gabal Al Asfar****
Hb, g/dl	9.51a ±1.71 (5.37-14.39)	8.86b ±1.97 (5.00-14.00)	8.81c ±1.68 (4.17-13.19)	7.77d ±2.02 (4.17-13.19)
PCV, %	41.39a ±5.55 (30.00-59.00)	41.31a ±6.11 (21.00-59.00)	39.99b ±5.26 (28.80-57.80)	39.35b ±5.85 (19.80-57.80)
Total Protein, g/dl	6.9b ±0.15 (6.61–7.40)	7.02ab ±0.12 (6.78-7.32)	7.07a ±0.11 (6.89-7.32)	7.06 a ±0.10 (6.87-7.32)
Albumin, g/dl	3.86b ±0.0.36 (2.96-4.66)	4.15a ±0.32 (3.87-5.06)	4.16a ±0.51 (3.11-5.08)	4.06a ±0.14 (3.79-4.44)
Globulin, g/dl	3.10a ±0.38 (2.22-3.96)	2.86b ±0.49 (1.98-4.13)	2.91b ±0.49 (1.98-4.13)	2.98ab ±0.17 (2.06-3.33)
A/G, ratio	1.28b ±0.27 (0.76-2.10)	1.50a ±0.38 (1.19-2.92)	1.50a ±0.47 (0.75-2.53)	1.37ab ± 0.12 (1.17-1.66)
Glucose, mg/dl	100.18a ±1.99 (96.00-104.00)	100.50a ±1.55 (97.00-103.00)	100.76a ±1.64 (98.00-103.00)	100.13a ±1.87 (96.00-104.00)

Means having different superscript letters differ significantly ($P<0.05$). Between parentheses is the range. Tap water, **Helwan wastewater treated with 20ppm $FeCl_3$ + 5ppm Polymer + 5ppm Cl_2, ***Zenin wastewater treated with 10ppm $FeCl_3$ + 5ppm Polymer + 5ppm Cl_2, ****Gabal Al Asfar wastewater treated with 10ppm $FeCl_3$ + 15ppm polymer + 5ppm Cl_2.

Values of liver and kidneys function are presented in Table 8. Activities of Alanine amino transferase (ALT), aspartate amino tranferase (AST) and ALT/AST ratio showed that there were no significant differences among experimental groups.

In addition, Activities of liver enzymes were in the normal physiological range reported by (Kaneko *et al.* 1997) and (Harkness and Wagner 1995). Other kidneys function tests were in the normal physiological range reported by (Kaneko *et al.* 1997).

Table 8. Some liver and kidneys function parameters (M±SD) of white New Zealand male rabbits as affected by drinking wastewater treated with coagulant and flocculent

Liver and Kidneys Function	Tap Water*	Helwan**	Zenin***	Gabal Al Asfar****
AST, RFU/l	12.37a ±0.18 (11.99-12.72)	11.99a ±1.57 (2.32-12.42)	12.23a ±0.17 (11.87-12.12.62)	12.20a ±0.15 (11.89-12.61)
ALT, RFU/l	13.93a ±0.12 (13.57-14.12)	13.89a ±0.15 (13.54-14.11)	13.94a ±0.22 (13.56-14.88)	13.95a ±0.55 (13.08-17.02)
AST/ALT, ratio	0.89a±0.10 (0.79-0.99)	0.86a±0.12 (0.79-0.98)	0.88a±0.20 (0.76-0.99)	0.87a±0.31 (0.75-0.98)
Bilirubin, mg/dl	0.70b ±0.06 (0.56-0.82)	0.69b ±0.12 (0.10-0.81)	0.73b ±0.62 (0.59-0.82)	0.80a ±0.58 (0.58-4.00)
Urea, mg/dl	13.81a ±0.47 (12.79-14.56)	13.11b ±0.95 (10.99-14.12)	13.01b ±0.83 (10.79-14.00)	12.92b ±0.76 (11.79-14.20)
Uric Acid, mg/dl	4.06a ±0.20 (3.61-4.77)	4.04a ±0.10 (3.80-4.21)	4.04a ±0.12 (3.69-4.23)	4.06a ±0.10 (3.79-4.22)
Creatinine, mg/dl	0.83b ±0.04 (0.74-0.91)	0.84b ±0.04 (0.77-0.91)	0.85b ±0.04 (0.78-0.91)	1.11a ±1.61 (0.73-10.00)

Means having different superscript letters differ significantly ($P<0.05$). Between parentheses is the range.
Tap water, **Helwan wastewater treated with 20ppm FeCl3 + 5ppm Polymer + 5ppm Cl2, ***Zenin wastewater treated with 10ppm FeCl3 + 5ppm Polymer + 5ppm Cl2, ****Gabal Al Asfar wastewater treated with 10ppm FeCl3 + 15ppm polymer + 5ppm Cl2.

These functions showed that there were no harmful effects on rabbit liver and kidneys due to drinking domestic wastewater treated with coagulant and flocculent.

Feed consumption throughout the experimental period (offered feeds - residual feeds) is presented in Table 7. Rabbits consumed feeds throughout experimental period ranged between 15.35 and 17.75 Kg. Slight increase in feed consumption was noticed in rabbits drinking water treated with 10 ppm $FeCl_3$ + 15 ppm cationic polymer (T4) and slight decrease in feed consumption was noticed with group drinking treated wastewater with 20 ppm $FeCl_3$ + 5 ppm cationic polymer (T2). Total feed consumptions are within the normal requirements and allowances (NRC, 2005).

Feed conversion (daily feed intake/daily weight gain) and feed efficiency (daily weight gain/daily feed intake) is a good indicator of any stresses that the animal weight suffers due to the quality of drinking water. Values of both feed conversion and feed efficiency indicate that there are no significant differences among experimental groups. There was almost no change among the experimental groups in rabbits weight gain except slight decrease in (T2) 20 ppm $FeCl_3$ + 5 ppm cationic polymer. Weight gain of control rabbits were within the range reported in growing rabbit (Abdel-Shafy, 2007).

Feed efficiency and Feed conversion values were in the normal range reported by (Marai, *et al*, 2004) and (Abdel-Shafy, 2007) and did not also affected by drinking the treated wastewater.

Table 9. Some feed parameters (M±SD) of white New Zealand male rabbits as affected by drinking wastewater treated with coagulant and flocculent

Total feed parameters	Tap Water*	Helwan**	Zenin***	Gabal Al Asfar****
Feed consumption, kg	16.85b±2.32 (12.75-20.25)	15.35c±3.52 (11.70-24.00)	16.41b±2.43 (10.95-19.50)	17.75a±3.57 (12.75-30.00)
Weight gain, kg	3.17a ±1.58 (0.43-7.07)	2.67a ±2.24 (-7.29- +6.43)	3.24a ±2.37 (-5.36- +12.64)	3.07a ±1.92 (-2.14- +7.71)
Feed conversion	5.32	5.75	5.06	5.78
Feed efficiency	0.19	0.17	0.20	0.17

Means having different superscript letters differ significantly (P<0.05). Between parentheses is the range.
*Tap water, **Helwan wastewater treated with 20ppm FeCl3 + 5ppm Polymer + 5ppm Cl2, ***Zenin wastewater treated with 10ppm FeCl3 + 5ppm Polymer + 5ppm Cl2, ****Gabel Al Asfar wastewater treated with 10ppm FeCl3 + 15ppm polymer + 5ppm Cl2.

CONCLUSIONS

It can be concluded that the drinkability of domestic wastewater treated with the recommended doses (10-20 ppm $Fecl_{3}$ + 5-15 ppm cationic polymer + 5 ppm Cl_2) of coagulant and flocculent in these studies without any adverse effects on rabbits.

REFERENCES

Abd El Lateef, M. E.; Hall, J. E.; Lawrence, C. P. and Mohamed, S. N. (2006). Cairo-East Bank effluent reuse study 3, Effect of field irrigation with secondary treated wastewater on biological and chemical properties of soil and groundwater, Biologia, Bratislava, 61(19): S240–S245.

Abdel-Shafy, H. (2007). Effect of Early Heat Exposure and rbST on Some Physiological Parameters and Productive Performance of Male Rabbits. M.Sc. Thesis, Faculty of Agriculture, Cairo University, Egypt, 136 pp.

Ahmed, N. A.; Azamel A. A.; Barkawi, A. H and Morsy, A. S. (2006). Thermo-respiratory responses and hormonal profiles of male rabbits injected with vitamin C under high and low ambient temperatures in Egypt. Egyptian Journal of Rabbit Science, 16: 61–75.

Ahmed, N. A.; Ismail, A. M. and Abdel-Kafy, E. M. (2005). Effect of heat exposure and feed restriction on performance of pregnant rabbit-does with emphasis on heat shock protein detection. Second International Conference of Veterinary

Research Division, National Research Center, 27-29 June, Cairo, Egypt. p. 27–37.

Aiyuk, S.; Amoako, J.; Raskin, L.; van Haandel, A. and Verstraete, W. (2004). Removal of carbon and nutrients from domestic wastewater using a low investment, integrated treatment concept. Water Res., 38(13): 3031–3042.

AOAC (1995). Official Methods of Analysis 14th ed., Association of Official Analytical Chemistics, Washington, DC, USA., 1250 PP.

Black, A. P. (1960) Basic mechanisms of coagulation. J. Am. Wat. Works Assoc., 52: 492–501.

Black, A. P. and Christman, R. F. (1963) Characteristics of colored surface waters. J. Am. Wat. Works Assoc., 55: 753–770.

Black, A. P. and Willems, D. G. (1961) Electrophoretic studies of coagulation for removal of organic color. J. Am. Wat. Works Assoc. 53: 589–604.

Costa, J. M. and Heuvelink, E. (2004). Horticultural Production Chains Group China's greenhouse horticulture: An overview. In: "Greenhouse Horticulture in China Situation and prospects" (Eds. Costa, J.M., Heuvelink, E. and Botden, N.) the Netherlands, p. 7–41.

Eckenfelder, W. W. (1989). Industrial Water Pollution Control, 2nd ed., McGraw-Hill Book Co., Singapore. 42 pp.

Eugenio, F.; Marcelo, Z. and Marcus (2006). Anaerobic processes as the core technology for sustainable domestic wastewater treatment: Consolidated applications, new trends, perspectives, and challenges. Reviews in Environmental Science and Bio/Technology, 5:3–19.

Gehr, R.; Wagne, M.; Veerasubramanian, P. and Payment, P. (2003). Disinfection efficiency of per acetic acid, UV and ozone after enhanced primary treatment of municipal wastewater. Res. 37(19): 4573-4586.

Goyal, S. M.; Gerba, C. P. and Melnick, A. J. (1979). Human enterovirus in oysters and their overlying waters. Applied and Environmental Microbiology, 37: 572–581.

Harkness, J. E. and Wagner, J. E. (1995). The Biology and Medicine of Rabbits and Rodents. 4th ed. Lea & Febiger, Philadelphia, USA., 220 pp.

Harleman, D. R. F. and Murcott, S. (1999). The role of physical-chemical wastewater treatment in the mega-cities of the developing world. Water Sci. Technol, 40(4-5):75-80.

Harleman, D. R. F. and Murcott, S. (2001). Aninnovatine approach to urban wastewater treatment in the developing world. Water, 21:44–88.

Hilton, M. C. and Stotzky, G. (1973). Use of coliphages as indicators of water pollution. Canadian Journal of Microbiology, 19: 747–751.

Huge, A.; Gonzalez, C. and Bruns, M. A. (2005). Dissimilatory iron reduction and odor indicator abatement by bioflim communities in Swine manure microcosms. App. Environ. Microbiol., 4: 4972–4978.

IAWPRC (Study Group on Health Related Water Microbiology) (1991). Bacteriophages as model viruses in water quality control. Water Research, 25: 529–545.

Inagaki, Y. and Kiuchi, S. (2001). Converting waste poly styrene into a polymer flocculent for wastewater treatment. J. Mater Cycles Waste Manag., 3:14–19.

Jiang, J. Q.; Zeng, Z. and Pearce, P. (2004). Preparation and use of modified clay coagulants for wastewater treatment. Water, Air and Soil Pollution, 158:53–65.

Kaneko, J. J.; Harvey, J. W. and Bruss, M. L. (1997). Clinical Biochemistry of Domestic Animals. 5th ed. Academic Press. New York, USA, 230 pp.

Kopecka, H.; Dubrou, S.; Prevot, J.; Marechal, J. and Lopez-Pila, J. M. (1993). Detection of naturally occurring enteroviruses in waters by reverse transcription, polymerase chain reaction, and hybridization. Applied and Environmental Microbiology, 59: 1213–1219.

Leclerc, H.; Edberg, S.; Pierzo V. and Delattre, J. M. (2000). Bacteriophages as indicators of enteric viruses and public health risk in groundwater. Journal of Applied Microbiology, 88: 5–21.

Leong, L. Y. C. (1983). Removal and inactivation of viruses by treatment processes for potable water and wastewater. A review. Water Science Technology, 15: 91–114.

Levine, A. D.; Tchobanoglous, G. and Asano, T. (1985) Characterization of the size distribution of contaminants in wastewater: Treatment and reuse implications. J. WPCF, 57(2): 805–812.

Lewis, D. and Metcalf, T. G. (1988). Removal of viruses in sewage treatment: assessment of feasibility. Microbiological Sciences, 5: 260–264.

Lucena, F.; Araujo, R. and Jofre, J. (1996). Usefulness of bacteriophages infecting *Bacteroides fragilis* as index microorganisms of remove fecal pollution. Water Science Technology, 30: 2812–2816.

Marai, I. F. M.; Habeeb, A. A. M. and Gad, A. E. (2004). Growth performance traits and the physiological background of young doe rabbits as affected by climatic conditioned and lighting regime, under sub-tropical conditions of Egypt. Eighth World Rabbit Congress, 7-10 September, Puebla, Mexico, p. 288-279.

Masschelein, W. J. (1992) Unit Processes in Drinking Water Treatment, Marcel Dekker Inc., New York, USA, 54 pp.

Mavrov, V.; Erwe, T. and Chmiel, H. (2004). Selective separation of heavy metals from industrial wastewater streams by means of heavy metal bonding agents, Water, Air and Soil Pollution. Focus, 4: 147–155.

Nandy, T.; Shastry, S.; Pathe, P. P. and Kaulpre, S. N. (2003). Treatment of Currency printing ink wastewater through coagulation-flocculation process. Water, Air, and Soil Pollution, 148:15–30.

NRC (2005). Nutrient Requirements of Rabbits. National Research Center Washington, DC., USA. Cited by Abdel Shafy, (2007).

Nsabimana, E.; Bohatier, J.; Bogaerts, P.; Twagilimana, L.; Bamdad, M.; Sauvant, M. P. and Pepin, D. (1996). Effects of the herbicide atrazine on the activated sludge process: microbiology and functional views. Chemosphere, 33: 479–494.

Ødegaard, H. (1992). Norwegian experiences with chemical treatment of raw wastewater. Water Sci. Technol., 25(12): 255–264.

Ødegaard, H. (1998). Optimised particle separation in the primary step of wastewater treatment. Water Sci. Technol., 37(10): 43–53.

Packam, R. F. (1962). The coagulation process. II. Effect of pH on the precipitation of aluminium hydroxide. J. Appl. Chem., 12: 564–568.

Page, A. L.; Miller, R. H. and Keeney, D. R. (1982). Methods of soil analysis. Part 2 Soil Sci. Am., Inc. Madison, Wisc. USA. Cited by Wang *et al.,* (2007).

Puig, M.; Jofre, J.; Lucena, F.; Allard, A.; Wadell, G. and Girones, R. (1994). Detection of adenoviruses and enteroviruses in polluted waters by nested PCR amplification. Applied and Environmental Microbiology, 60: 2963–2970.

Reali, A. P. M.; Penetra, R. G. and De Carvaiho, M. E. (2001). Flotation technique with coagulant and Polymer application applied to the post treatment of effluents from anaerobic reactor treating sewage. Water Sci. Technol., 44: 205–212.

Riley, L. W.; Remis, R. S.; Helgerson, S. D.; McGee, H. B.; Wells, J.G.; Davis, B. R.; Hebert, R. J. and Olcott, E. S. (1983). *Haemorrhagic colitis* associated with a rare *Escherichia coli* serotype. New England Journal of Medicine, 308: 681–685.

Semerjian, L. and Ayoub, G. M. (2003). High-pH-magnesium coagulant-flocculation in wastewater treatment. Advances in Environmental Research, 7 (2): 389-403.

Sonune, A. and Ghate, R. (2004). Developments in wastewater treatment methods. J. Desalination, 167: 55–63.

Su, C. and Brandt, L. J. (1995). *Escherichia coli* O157:H7 infection in humans. Annals of Internal Medicine, 123: 698–714

Tebbutt, T. H. Y. (1998). Principles of Water Quality Control, Butterworth Heinemann, Oxford, U.K. 74 pp.

Van Buuren, J. C. L.; Abusam, A.; Zeeman, G. and Lettingavan, G. (1999). Primary effluent filtration in small-scale installation. Water Sci-Technol., 39(5):195-202.

Wang, X.; Jin, P.; Zhao, H. and Meng, L. (2007). Classification of contamination and treatabilility evaluation of domestic wastewater. Event. Environ. Sci. Engin. China, 1(1):57-62.

WPCF and ASCE (Water Pollution Control Federation and American Society of Civil Engineers) (1977). Wastewater Treatment Plant Design, 2nd ed., Water Pollution Control Federation, Washington, DC and American Society of Civil Engineers, New York, NY, USA, 35 pp.

Zeng, X. (2006). Sorption of wastewater containing reactive red X-3B on inorgano-organo pillared bentonite. J. Zhejiang Univ. Sci. B., 7(4): 314–31.