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Evaluation of Wastewater Discharge from Al-Sadr Teaching Hospital and its impact on the Al-Khorah channel and Shatt Al-Arab River in Basra City-Iraq

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Abstract

This study aims to evaluate the performance of the wastewater treatment plant in Al-Sadr teaching hospital in Basrah, and effects of hospital wastes discharged from Al-Sadr teaching hospital to the Khorah channel and Shatt Al-Arab river. This study started from September 2015 to April 2016. Samples were collected monthly from four stations. pH of all the studied stations was found to be above 7. The average values of BOD_5, COD, TSS, TDS, PO_4 , NO_3, CL, in station 1 were 173.1, 385.9, 324.3, 2823.8, 4.3, 18.6, 1522.1 mg/l in station 2 were 146.7, 347.9, 270.6, 2849.3, 4.5, 14.3, 1429.4 mg/l in station 3 were 14.7, 94.3, 163.1, 2133.8, 4.5, 45.9, 1140.9 mg/l, and in station 4 they were 7.4, 66.3, 127.1, 2388.8, 3.2, 40.1, 1157.4 mg/l respectively. The results showed elevation in a number of the total bacterial count and total coliforms in stations one and two compared to the stations three and four.

According to the results, the concentration of BOD_5, COD, TSS, TDS, PO_4 , NO_3, CL, in station 1 of the hospital was more than the Iraqi reuse standard which indicates inefficient removal of pollutants in the mentioned hospital wastewater treatment plant.
Keywords: Hospital Wastewater, Physico-Chemical Characteristics, Environmental Threat.

Introduction

Wastewater in hospitals is similar in the texture to the wastewater in the city public and differen in containing very different and diverse types of liquid waste with low quantities that they contain many infectious and dangerous compounds resulting from patient care, which makes processing it separately from wastewater an urgent necessity. Multiple practices that happen in hospitals (surgery, drug, radiology, laundry, operation room, chemical and biological laboratories, etc.) are a principal source of pollutant discharge into the environment (Boillot, 2008 ; Verlicchi *et al*., 2010). Also, disinfectants, in particular, are often complex products or mixtures of active substances. Thus, hospital effluents considered an important source for the release of antibiotics and antibiotic resistant - bacteria into the environment (Lien *et al*., 2016).

Polluted wastewater discharged from hospitals causes many environmental hazards. Hospital wastewater may contain various potential hazardous materials including, microbiological pathogens, radioactive isotopes, disinfectants, drugs, chemical compounds and pharmaceuticals (Verlicchi *et al*., 2010 ; Jafrudeen and Naved, 2012). Hospitals discharge plenty of undesired potential pathogens like antibiotic-resistant bacteria and viruses (Brown, 2011). These problems are different in terms of the activity and nature of hospitals (Jolibois and Guerbet, 2006). And also chemicals used in hospitals are potential sources of water pollution, mainly through the sewerage system (Pratibha *et al*., 2014). Hospitals represent an incontestable release source of many chemicals compounds in the aquatic environment due to laboratory effectiveness or medicine secretion into wastewater (Kummerer and Helmers, 2001).

These pollutants can directly reach the water resources in the environment that can cause environmental aquatic pollution and human health problems (Ekhaise and Omavwoya, 2008; Akin, 2016) . Therefore, continuous assessment and observation of hospital wastewater and the method of treatment, disposal and sludge produced in such health-care centers is necessary for provision, maintenance and promotion of community and environmental health (Carballa *et al*., 2004; Jolibois and Guerbet, 2006 ; Escher *et al*., 2011) .

Studies suggested that hospital wastewater was generally of similar nature with domestic sewage (Verlicchi *et al*., 2010). Generally pollutant concentrations of BOD_5, COD, TSS, etc. are (2 – 3) times higher in hospital sewage compared to domestic sewage, where micro-pollutant, heavy metal, and pathogen concentrations are at higher amounts (Yaşar *et al*., 2013).

So, they have been set up treatment units to a number of hospitals to limit the negative effects on Iraqi water resources, but these plants are still based on old concepts, and many of the qualities of treatment processes not were fully understood either because of poor staff or weakness of processes of training and rehabilitation (Al-Rawi, 2009). According to the results of this research, the concentration of the parameters in the effluent of the studied Al-Sadr Teaching Hospital was more than the Iraq reuse standard which indicates inefficient removal of pollutants in the mentioned hospital wastewater treatment plant .

Material and Methods

Study Area

Al-Sadr Teaching Hospital is located on the western side of the Shatt Al-Arab in the north-eastern corner of the Al-bradaah area, and is one of the main hospitals in Basrah city, has about 504 beds, consists of eight floors, and reach the number of reviewers to the advisory division about 250 patients per day. The wastewater treatment system in the studied hospital was activated sludge with extended aeration. In this process the wastewater treated includes the steps of settling, aeration, and chlorination, in open tank which is called aeration tank, the air is supplied by the air blower to provide oxygen for the aerobic microbes**.** There is no primary sedimentation basin in any of these wastewater treatment systems. Hospital wastewater is disposed directly into Al-Khorah channel, which is 10 km long and has is a number of branches stretching towards the right and left; the mouth of this channel open in the Shatt Al-Arab river.

A sampling of physical, chemical and biological variables was performed from Four stations: **Station 1**: The main sedimentation tank from the treatment plant (untreated). **Station 2**: main discharge point, just before the hospital wastewaters are discharged into the Al-Khorah channel (After treatment). **Station 3**: 500 Meters from station 2 in Al-Khorah channel. **Station 4**: 500 Meters from station 2 in Shatt Al-Arab Fig.1.

Samples Collection

Samples were taken monthly from September 2015 to April 2016. Water samples were collected from surface water (30-40 cm depth) using autoclaved Winkler bottles for BOD_5 and autoclaved bottles for other physical, chemical and biological test all of them washed by water sample twice before filling. Duplicate samples were collected and stored in a refrigerator. After collection, all the samples were processed.

Figure 1: Map of the sampling stations. (Map from Google Earth Pro.)

Physio-Chemical and Microbiological Analyses

The samples for water temperature and pH were measured in the field then they were quickly sent to a laboratory for other chemical and microbial analysis including BOD_5, COD, TSS, TDS, PO_4, NO_3, CI, total bacterial count TBC and total coliform count TC. All parameters were measured according to the standard methods (APHA,1998). and filtration method for enumeration of microorganisms (Prescott, 2004). All of the analyses were conducted in the laboratory of analysis chemical in the department to protect and improve the environment in Basrah city.

Statistical Analysis

Statistical analysis of the data was done by analysis of variance which was adopted to analysis the data and $LSD_{0.05}$ was applied to determine significant differences between periods and hospital using a software program (SPSS version 19). All data were expressed as mean ± SE.

Results and Discussion

Table (1) shows the results obtained with physicochemical analysis of pre-treatment and after treatment from Al-Sadr teaching hospital and compared with Iraqi and WHO legislations.

Table 1. Comparison between of the pre-treatment and after treatment wastewater with of Iraqi and international validity

parameters	The measured value In the current study, pre-treatment	The measured Value In the present study after treatment	Iraqi environmental legislation(mg/L) (1967)	WHO environmental legislation(mg/L) (2011)
pH	7.50	7.84	6.5-8.5	6.5-9.5
BOD	173	147	5	Low5
COD	386	348	100	Low3
TSS	324	271	30	10-20
TDS	2824	2849	1500	1000
PO_4	4.3	4.5	3	0.5
NO_3	18.6	14.3	50	50
Cl^-	1522	1429	250-350	45-250

Water temperature is one important factor that affects the rate of many biological and chemical processes in the waterway and the amount of oxygen gas that can dissolve in the water. The water temperature average were (20.83)ºC, (20.83)ºC, (20.82)ºC and (20.81)ºC for station 1, station 2, station 3 and station 4, respectively Fig. (2). There was a high significant difference with respect to seasons and months, whereas no significant difference was recorded with respect to stations temperature.

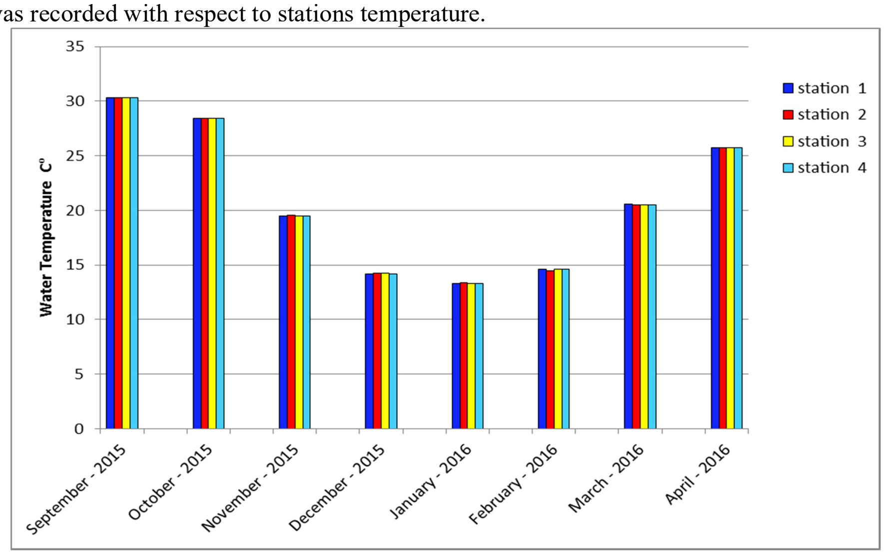

Fig. 2: Monthly changes in temperature for the four stations

One of the important parameters for evaluation of the quality of wastewater is a pH value or acidic or alkaline status. Increase or decrease of this parameter in a wastewater will cause the corrosion and damage of wastewater treatment plant. This index also plays a significant role in biologic processes of wastewater treatment (Chitnisa, 2004). In this research the a pH averages were (7.5), (7.48), (7.38) and (7.45) for station 1, station 2, station 3 and station 4, respectively Fig. (3).

The increase in the relative values of pH in some periods is due to the effect of alkaline cleaning agents, because the detergents in the Iraqi markets container on the alkaline material, and lower values, may be due to the presence of CO_2, salts, sulphates, nitrates and chlorides (Mustafa, 2000). The pH value in Al-Sadr teaching hospital never fell below 7. Similarly, a study was conducted in Iranian hospitals found that the mean pH value of raw wastewater of all studied hospitals was 7.5 (Amouei, *et al*., 2012). The mean pH of raw wastewater in Turkey hospitals was 7.3 (Altin, *et al*., 2003).

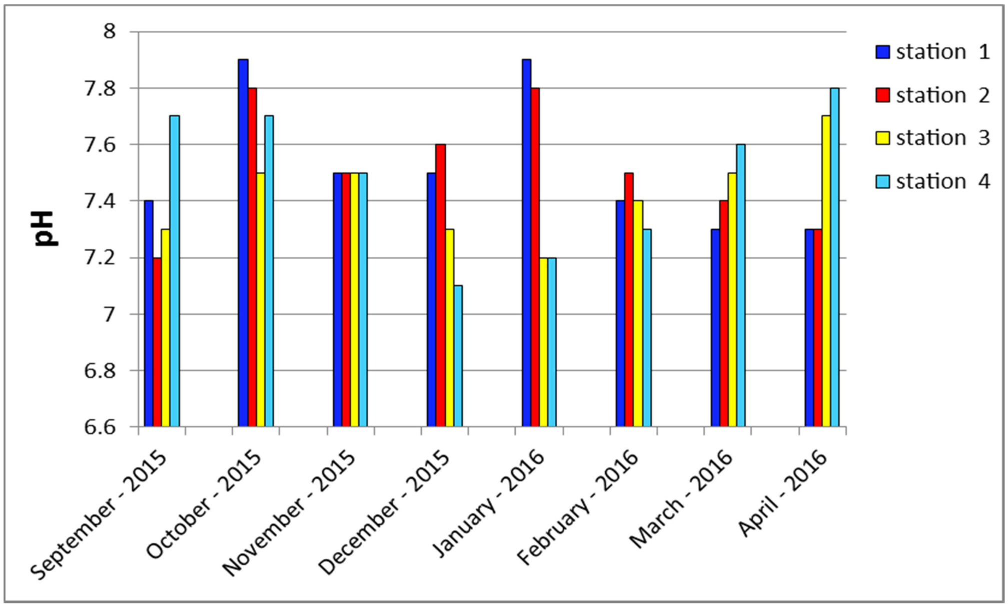

Fig. 3: Monthly changes in pH for the four stations

The relative decline of the values of pH in Al-Khorah channel during the study period may be due to alkaline detergent and the high content of organic matter as a result of wastewater discharge from Al-Sadr teaching hospital, when analyzed release of CO_2 into the aquatic environment, which works to reduce pH values in the water (Tietjen *et al*.,1999). The high pH value during autumn and spring in Shatt Al-Arab river, attributed to temperature elevation led to increasing the evaporation rate of water and increase in carbonate concentration (Odjadar and Okon, 2010). Also, a geological formation of the area, Iraqi inland water shifted to be on the alkaline side of neutrality by a dominated of HCO^{-3} ions (Al-Nimma, 1982). Morever, the process of continuous mixing in the water column could lead to a lifting of pH values toward the alkaline.

The parameters of BOD_5 and COD are widely used to describe the organic matter content of wastewater (Ekhaise and Omavwoya, 2008). The average of BOD_5 was (173), (147), (15), and (7) mg/l for station 1, station 2, station 3 and station 4, respectively Fig. (4). while the ranges of COD were (386), (348), (94), and (66) mg/l for station 1, station 2, station 3 and station 4, respectively Fig. (5).

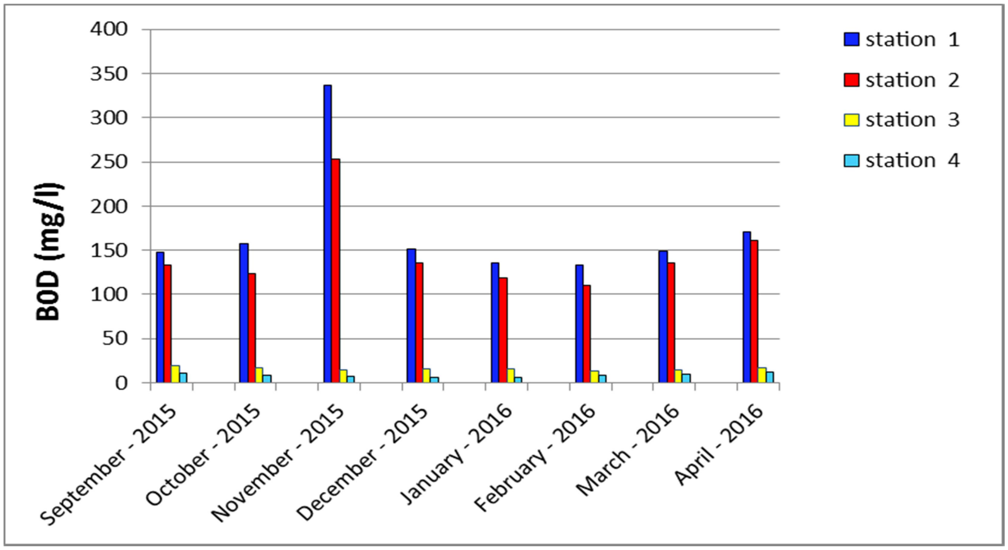

Fig. 4: Monthly changes in BOD for the four stations

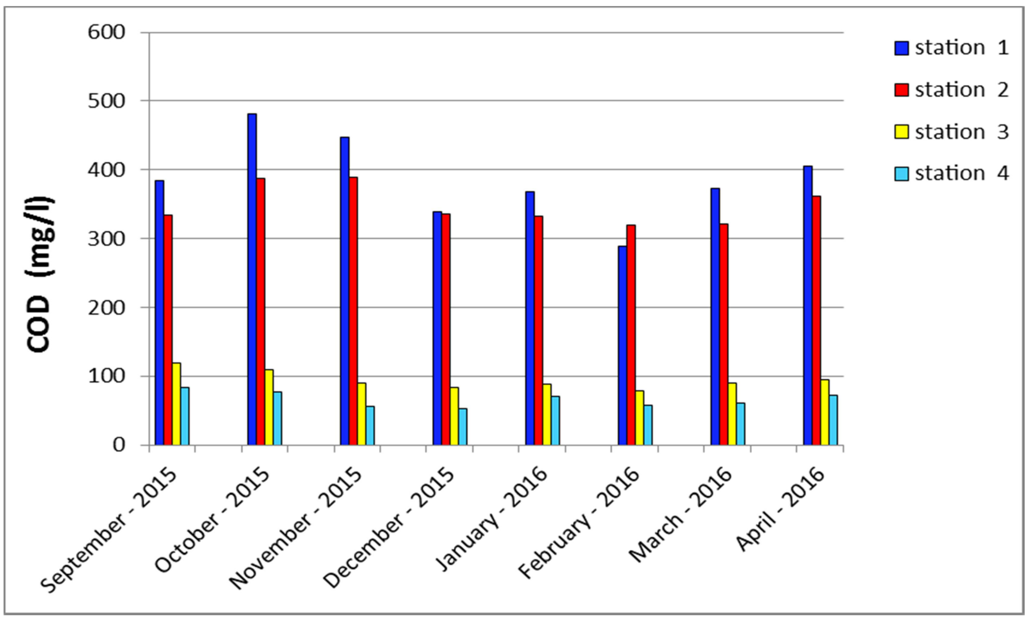

Fig. 5: Monthly changes in COD for the four stations

The values for BOD_5 recorded higher than standards to be discharged into surface waters Table 1. BOD_5 and COD also have a high significant difference with respect to months, and stations. These values of BOD_5 and COD could constitute potential pollution problems to the water bodies since it contains organic compounds that require large amounts of oxygen for degradation. The BOD_5 and COD concentrations of wastewater are almost equal to domestic wastewater values. The mean concentration of BOD_5 and COD in domestic wastewater, in terms of wastewater strength, are reported in the range of 110 to 350 and 250 to 800 mg/l (Tchobanoglous *et al*., 2004). This may indicate problems in the treatment process which affect the performance and removal efficiency of different pollutants from the sewage being treated in this plant. Also, all the untreated and treated samples were found unacceptable for their direct discharge. The high biodegradability of organic matters is very necessary for wastewater treatment and promotes the efficiency of wastewater treatment plants (Tchobanoglous *et al*., 2004).

The results showed that the BOD_5 in station 3 and station 4, is increased as the temperature increases. This may be due to the effect of temperature on the activity of the microorganisms, these results are identical to the results obtained by (Dalrymple *et al*., 2007 ; Mohammed and Ali, 2013). Generally, a high value of COD was observed during the warm months which coincided with a high water temperature (Anber, 1984).

The ranges of TSS were (324), (271), (163), and (127) mg/l for station 1, station 2, station 3 and station 4, respectively Fig. (6). Based on the study findings, the mean removal of TSS by the wastewater treatment plant in Al-Sadr teaching hospital, were (213 - 320) mg/l, more than the results obtained by Moersidik (1993) during studing the wastewater quality of a hospital in Indonesia, the TSS concentration was determined to be in the range of 36-269 mg/l. Also, the TSS concentration of a hospital wastewater in Thailand was 103 mg/l (CTC, 1994). (Wangsaatmaja, 1997) obtained the TSS concentration of a hospital wastewater in Bangkok to be 90 mg/l. Another study in Iraq shows that mean a removal of TSS by treatment system of five hospitals, located in each district in Bagdad province, was 495, 302.5, 662.5, 307.5 and 758.7 (Abd-Sharif and Rasheed, 2008).

Results of TSS showed that the highest value in station 3 and station 4. These results may be due to the weather effect the months that showed an increase in TSS concentration in winter months that included rains that carry many suspended materials such as dusts and others beside the increase in winds velocity during these months as a result of that increase velocity of water in its turbidity (Lane, *et al*., 1999).

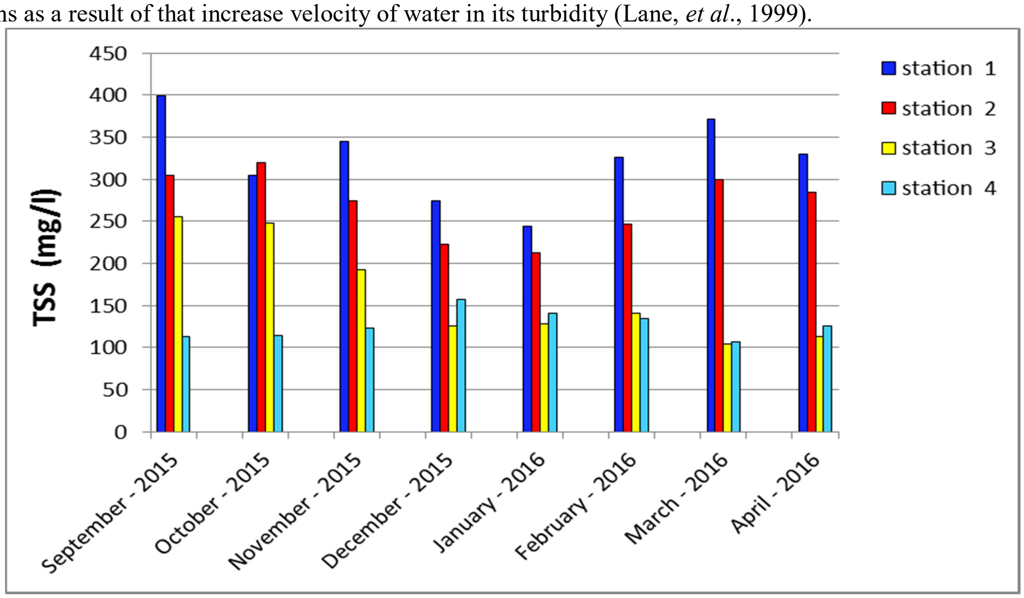

Fig. 6: Monthly changes in TSS for the four stations

Total dissolved solids is the used to describe the inorganic salts and small amounts of organic matter present in solution in water. The ranges of TDS were (2824), (284), (2134), and (2389) mg/l for station 1, station 2, station 3 and station 4, respectively Fig. (7). The increase of TDS in all stations was more than the value of 1000 mg/l or 1ppt as prescribed by WHO (Jayalakshmi *et al*., 2011)

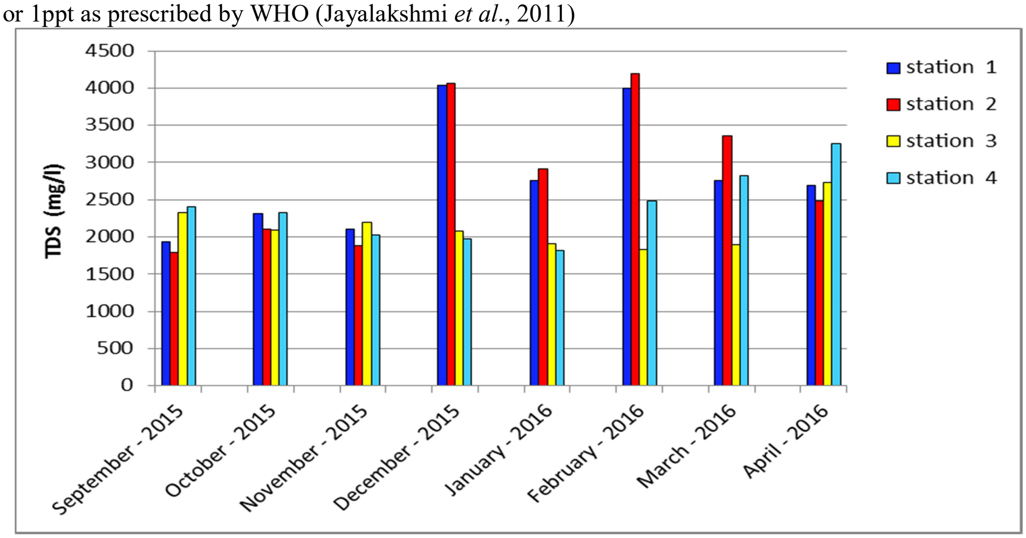

Fig. 7: Monthly changes in TDS for the four stations

The increasing of the dissolved salts in Al-Khorah channel and Shatt Al-Arab river due to the increase in water temperature affects the level of dissolved solids in water body, fertilizer run-off, wastewater and septic

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effluent, soil erosion , decaying plant and animals ,and geological features in the area (Al-Haidary, 2003 ; Al-Fatlawey, 2007).

Phosphorus is a nutrient, which is an important constituent of living organisms. It occurs in wastewater bound to oxygen to form phosphates. The ranges of Phosphorus were (4.3), (4.5), (4.5), and (3.2) mg/l for station 1, station 2, station 3 and station 4, respectively Fig. (8).

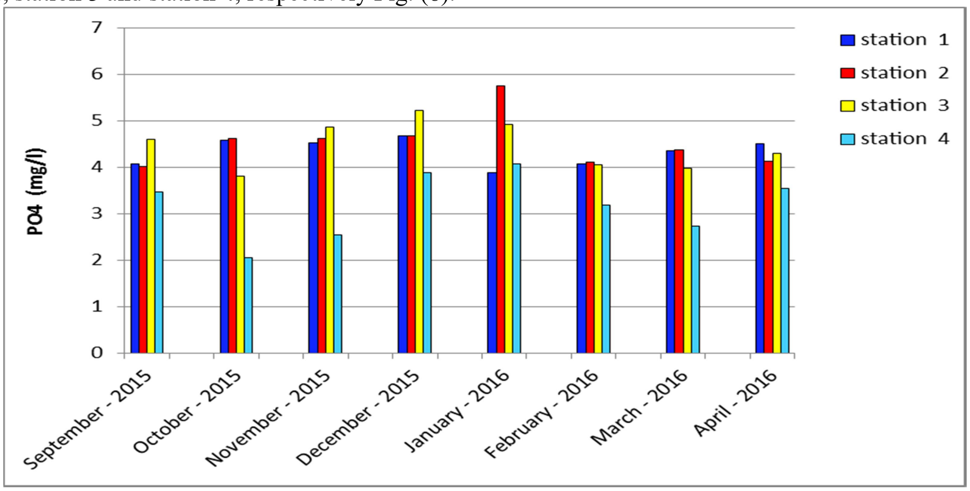

Fig. 8 : Monthly changes in PO_4 for the four stations

The removal phosphate rate in the plant depends on the level phosphate in the inlet to the plant. Also, some detergents used for cleaning contained polyphosphate compounds. More complex appears to be the problem of phosphorus incoming from detergents because the structure of their use has a tendency to vary in different countries. The excess content of phosphorus in receiving waters leads to extensive algae growth (eutrophication). In aquatic environment concentration of phosphorus that supports algal bloom is only 0.005 to 0.05 mg/l (Yang *et al*., 2008), and the results of all sampling stations were high enough to produce eutrophication phenomenon. The ranges of nitrates were (18.6), (14.3), (45.9), and (40.0) mg/l for station 1, station 2, station 3 and station 4, respectively Fig. (9).

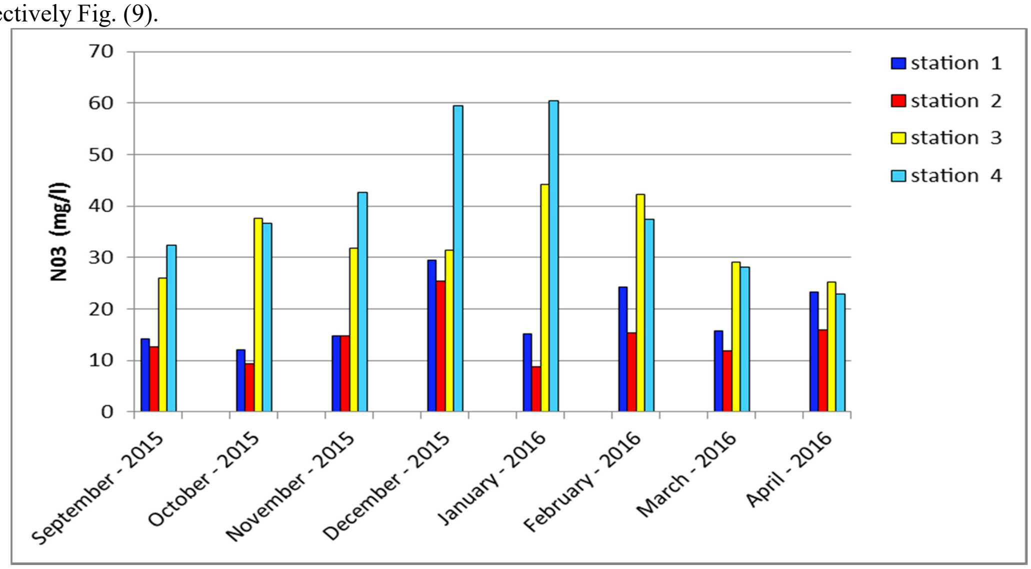

Fig. 9: Monthly changes in NO_3 for the four stations

The highest value of nitrate due to an increased level of nitrates in wastewater which includes (urine and other secretions), consists of urea, protein, and hydrocarbons. Higher values which were recorded at stations 3 and 4, may be due to the sewage discharge, or the agriculture runoff (Al-Saad *et al*., 1996). Antoine and Shihab (1977) have recorded high concentrations of nitrate in Al-Khorah channel occurred between 3.08 – 65.5 µm/l . High concentration of nutrient in the forms of PO_4 and NO_3 the existing activated sludge system is not designed for nutrient removal.

The ranges of chlorine were (1522), (1429), (1141), and (1157) mg/l for station 1, station 2, station 3 and station 4, respectively Fig. (10). Chlorine is commonly added to wastewater treatment plant to reduce potential pathogens. Chlorine is used to disinfect wastewater in either gaseous form (Cl_2), or as hypochlorite salts.

All forms of chlorine react with water to produce HOCl, which rapidly dissociates to form the hypochlorite ion according to the following reaction: $HOCl \leftrightarrow OCl^- + H^+$ (EPA, 2002). Due to the toxicity of chlorine, and risk of environmental damage and noncompliance, the accuracy, and reliability of the analyzer equipment is critical. Also, residual chlorine can be toxic to aquatic life.

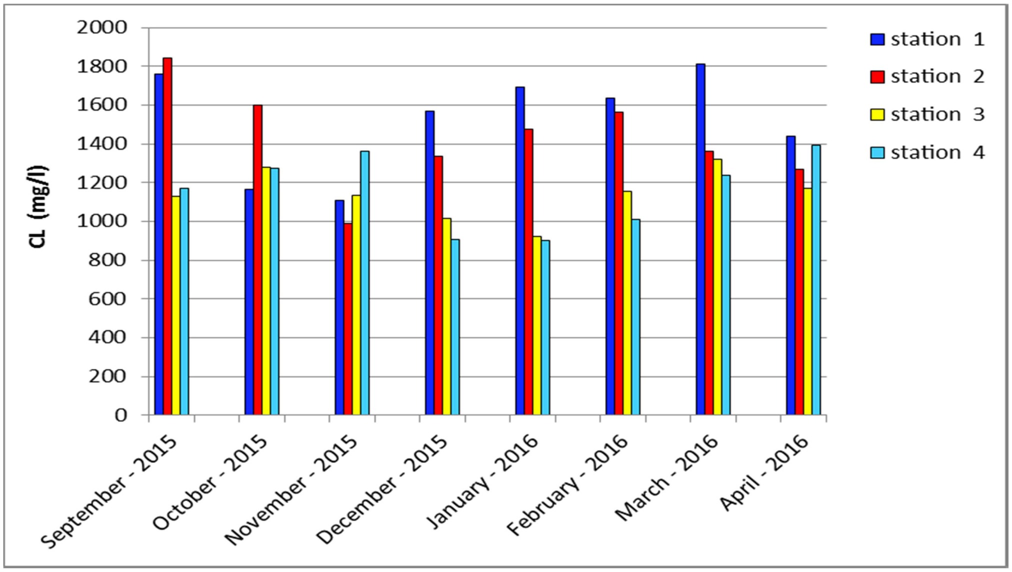

Fig. 10: Monthly changes in CL for the four stations

When chlorine is added to wastewater, a portion of it is consumed by reactions with materials of chemicals in the water, making it unavailable for disinfection . Free chlorine, which is by far the better detergent is produced when sodium hypochlorite or chlorine gas is added to water. Studies on hospital wastewater reported that Cl value might reach to higher concentrations, especially due to the disinfectants (Emmanuel *et al*., 2004).

The total bacterial count is an important test in the microbial water tests which gives an estimate of the total number of bacteria in the water sample, but it does not provide evidence of health risk or fecal pollution (WHO, 2006). Wastewater of hospitals treating patients with enteric diseases is a particular problem during outbreaks of diarrhoeal disease, Therefore the microbial quality of hospital wastewater is very critical (Tsai *et al*., 1998 ; Verlicchi *et al*., 2010).

As shown in Tab.2, levels of total bacterial count resulting in wastewaters discharged from studied hospital effluents appear to so elevated, the highest number of TBC appears in winter, which might be the consequence of the high level of suspended solid and nutrients in the waste water which affected the survival of aquatic microflora (Hader *et al*., 1998). While a low number of bacteria during spring may be due to flood period which dilutes the organic matter which used as food for the bacteria, as well as high temperature that caused kill off a large number of the bacteria (Abdo *et al*., 2010).

Table 2. Mean Concentration ± SD of TBC and TC values during the study period

Months / Parameters	September 2015	October 2015	November 2015	December 2015	January 2016	February 2016	March 2016	April 2016
Station 1								
TBC cell/1ml	145 ± 7.1	140 ±14.1	150 ±4.1	205 ± 21.2	260 ±14.1	240 ± 28.3	150 ±14.1	90 ± 0.0
TC cell/100ml	75 ± 7.1	65 ± 21.2	80 ± 14.1	190 ± 14.1	140 ±28.3	105± 21.2	225 ±21.2	95±35.4
Station 2	125 ± 21.2	135 ± 7.1	170 ± 14.1	160 ± 14.1	220 ±14.1	130 ±28.3	120 ±14.1	95 ± 7.1
TBC cell/1ml								
TC cell/100ml	55 ± 7.1	55± 7.1	105 ± 7.1	145 ± 7.1	140 ±14.1	125 ±7.1	125 ±7.1	65 ±7.1
Station 3	65 ± 7.1	55 ± 7.1	80 ± 14.1	160 ± 14.1	190 ±14.1	115 ±7.1	105 ±7.1	80 ±14.1
TBC cell/1ml								
TC cell/100ml	25 ± 7.1	50 ± 14.1	35 ± 7.1	35 ± 7.1	15 ± 7.1	50 ±14.1	140 ±14.1	55 ±7.1
Station 4	35 ± 7.1	45 ± 7.1	60 ± 14.1	65 ± 7.1	60 ± 14.1	45 ±7.1	35 ±7.1	35 ±7.1
TBC cell/1ml								
TC cell/100ml	15 ± 7.1	20 ± 14.1	50 ± 14.1	50 ± 14.1	45 ±7.1	30 ± 14.1	35 ±7.1	30 ±14.1

SD: Standard deviation

Coliform bacteria are a group of bacteria present in great quantities in human feces (Alley, 2007). Total coliforms have long been utilized as a microbial measure of water quality and largely because they are easy to detect and enumerate in water (Al-Zubaidi, 2011). pH values tended to be neutral at sampling stations (Fig. 2). Studies by (Gerba and Pepper, 2006) mention that enteric bacteria are less stable at pH >9 and < 6. Generally, favorable pH for the growth and activity of bacteria is in the range of 6.5-8.5 and the activity of most of the effective bacteria in reefing the wastewater is interrupted or stopped at pH greater than 9.5 (Amouei *et al*., 2010).

In the present study, the overall mean number of total coliforms bacteria is observed in wastewater after treatment in hospital of Al-Sadr Teaching was 101.87 cell/100ml (Table. 2), and discharging the wastewater after treatment to the Khorah channel, increasing in total coliforms bacteria concentration in March 2016 this was because of rising in water temperature to about 20 C^{o} which helps bacteria to live especially river water and the concentrations of fecal coliform reached to 140000 /100ml . Depending on resulting in Shatt Al-Arab river, are unsuitable for swimming due to it involve on numbers of total coliforms, so that exceeds the recommended exposure level. Epidemiological studies have demonstrated a relationship between swimming-associated gastroenteritis and the densities of fecal coliforms and other microbes (Gerba and Pepper, 2006). The study by Al-Bayatti *et al*., 2012 on Tigris river water showed that the total coliform counts exceeded (1795–63000 CFU/100 mL) and in all seasons they were more than the international permissible levels recommended by WHO.

Conclusions

According to the results obtained, the following conclusions are found :

1- The study concludes that hospital wastewaters could not be regarded safe to be disposed off directly into the environmental water bodies, wastewater from hospitals either treated or partially treated can alter water quality and biological diversity in adjacent water, the quality of the effluent was found to be higher than the Iraqi standards for disposal to water bodies.
2- Effluent discharge after suitable treatment protects the environment and public health, the government has to adapt integrated wastewater management approach, generates new guidelines or policies or standards (if require) and monitor and enforce existing present standards.
3- The presence of chemical materials such as antibiotics, organic chlorinated compounds and other hazardous materials in the hospital wastewater and disability of wastewater treatment systems will result in many environmental disorders and consequently harmful effects on human health.
4- One disadvantage with chlorine disinfection is that of free and combined chlorine residues being toxic to aquatic organisms. There is also the potential for the formation of organochlorinated derivatives. These derivates are of particular concern, as they tend to be relatively toxic, persistent and bioaccumulative.

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