Physico-chemical and Biological Variables of Hospitals Wastewater in Erbil City

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Abstract
Three hospitals were chosen(Maternity hospital, Raperin hospital and Rhizgari hospital) for the present survey within Erbil city. Water samples were collected at regular monthly interval periods beginning in January 2012 to December 2012. pH of all the studied sites were found to be up 7. Electrical conductivity ranged from (1318-1790 µs.cm^{-1} in Maternity Hospital, 1770-2232 µs.cm^{-1} in Raperin Hospital, 1010-1615 µs.cm^{-1} in Rhizgari Hospital). BOD_5 and COD values ranged from 22-80 mg.L^{1} and 280- 1410 mg.L^{-1} respectively, this indicated a high pollution situation in the studied sites in respect to organic matter content. The quantitative analysis of counted microorganisms was more than that describe by WHO guidelines standard.
Keywords: hospital wastewater, BOD, COD.

المتغيرات الفيزيوكيميائية والبايولوجية لمياه الصرف الصحي لمستشفيات في مدينة اربيل

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الخلاصة
في هذه الدراسة اختيرت عينات المياه العادمة من ثلاث مستشفيات في مدينة اربيل هي مستشفى رزكاري ومستشفى رابرين ومستشفى الولادة، حيث جمعت العينات في فترات فاصلة منتظمة شهريا ابتداء من كانون الثاني 2012 إلى كانون الاول 2012. بينت نتائج الدراسة ان المياه كانت تميل الى القاعدية وكان الاس الهيدروجيني عموما اعلى من 7، تراوحت قيم التوصيل الكهربائي بين1318–1790 مايكروسيمنز.سنتيمتر$^{-1}$ في مستشفى الولادة، وبين 1770–2232 مايكروسيمنز.سنتيمتر$^{-1}$ في مستشفى رابرين، وبين 1010–1615 مايكروسيمنز.سنتيمتر$^{-1}$ في مستشفى رزكاري. تراوحت قيم كل من المتطلب الحيوي للاوكسجين والمتطلب الكيمياوي للاوكسجين 22 –80 ملغم/لتر$^{-1}$ و280–1410 ملغم/لتر$^{-1}$ على التتالي نستدل مما سبق على وجود تراكيز عالية من المواد العضوية في مياه الفضلة لتلك المستشفيات. وقد تجاوزت نتائج التحليل الكمي للكائنات الدقيقة الحدود العليا المسموح بها من قبل منظمة الصحة العالمية.

Introduction

Water is essential for maintaining an adequate food supply and a productive environment for the human population, animals, plants and microbes worldwide [1, 2]. Population and economics grow, accompanied by increased water use, will not only severely reduce water availability per person but also create stress biodiversity in the entire global ecosystem [2, 3].Approximately, 20% of the world's population lacks safe drinking water and nearly half the world population lacks adequate sanitation. This problem is acute in many developing countries, which discharge an estimated 95% of their untreated urban sewage directly to surface waters. Iraq is one of the nine middle eastern countries have insufficient freshwater [4].

Surface water bodies are affected because they received water from wastewater (point source), irrigated drainage and runoff (non-point source). Impacts depend on the extent that wastewater has

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been in contact with soil, on that type of water body, and their use, as well as the hydraulic retention time and the part played within the ecosystems [5].

The Erbil wastewater channel represents the outflow of sewage effluent and storm water of Erbil city. Shekha (1994) during his seasonal ecological work on Erbil wastewater channel revealed that dissolved oxygen was undetectable from April to September, which was coincided by increasing densities of microorganisms in the same period [6].

Aziz *et al.* (2001) described wastewater of Erbil channel according to physico-chemical and biological variables which include total bacterial count, coliforms, streptococci, staphyloccoci and fungi. They concluded that faecal pollution at the first four sites is originated from anthropogenic sources based on FC/FS ratio in contrast to second three sites which may return to cattle sources [7].
One of the main environmental problems putting by the hospital effluents is their discharge, in the same way as the urban classic effluents, towards the urban sewer network without preliminary treatment.

Due to the lack of literature regarding hospital waste management on Erbil`s hospitals, this study was initiated. The aim of this study was to present both data on the biological as well as physico-chemical hospital wastewater in Erbil city before their discharge to the municipal sewage system and to the environment.

Materials and Methods

Sampling of physical, chemical and biological variables were performed from three sites, effluents of hospitals in Erbil city; Rhizgari (general hospital), Raperin pediatrics hospital and maternity hospital at monthly intervals during January 2011 to December 2012.
In order to determine the quality of wastewater samples were taken in usually started at 9 am and was completed at 12pm. Water samples were collected from surface water (30-40 cm depth) using autoclaved Winkler bottles for BOD and autoclaved amber bottles for other physical, chemical and biological test all of them pre-washed by water sample twice before filling.

The samples for EC, pH and water temperature were measured in the field then samples were quickly sent to laboratory for other chemical and microbial analysis including BOD_5, COD, Total bacterial count and total coliform count. All parameters were measured according to the standard methods [8] and filtration method for enumeration of microorganisms [9]. Statistical analysis of the data was done by one way analysis of variance which was adopted to analyse the data and $LSD_{0.05}$ was applied to determine significant differences between periods and hospitals using software program (SPSS version 19). All data were expressed as mean ± SE.

Results and discussion

Water temperature

The water temperature ranges were 16.4-32.3ºC, 15.3-32.8ºC and13.8-30.7ºC for effluents of Maternity hospital, Raperin hospital, and Rhizgari hospital effluents, respectively. The minimum water temperature was recorded during January 2012 in Rhizgari hospital effluent, while the maximum temperature was during August 2012 in Raperin hospital effluent (figure 1).

Spatial variation of water temperature was observed during sample collection with no significant differences ($p<0.05$) between Maternity hospital and Raperin hospital. Nevertheless, significant differences ($p<0.05$) were found between both of these hospitals and Rhizgari hospital, table 1.

Table 1- water quality characteristics for studied hospitals, data represented as min., max., mean± Standard error.

Sites	Parameters*						
	Temperature (°C)	pH	Electrical conductivity (μs.cm^{-1})	BOD_5 mg.l^{-1}	COD mg.l^{-1}	Total bacterial count *10^6 (CFU.100ml^{-1})	Total coliform *10^6 (CFU.100ml^{-1})
Maternity Hospital	16.4-32.3^a 23.7±1.71	7.34- 7.84^a 7.65± 0.04	1318-1790^a 1528±42.2	25- 77^a 44.4± 4.55	280- 1043^a 619.2± 79	65- 390^a 148.5± 32.9	14- 59^a 41.9± 3.68
Raperin Hospital	15.3- 32.8^a 23.14± 1.85	7.36-7.82^a 7.53± 0.039	1770-2720^b 2232±95.4	26- 67^a 43.4± 3.54	433- 1300^b 720.7± 83	5- 95^b 50.1± 7.59	0.565- 52^b 24± 5.13
Rhizgari Hospital	13.8- 30.7^b 22.0± 1.78	7.28-7.99^a 7.62± 0.066	1010-1615^c 1205±43.1	22- 80^a 46.4± 4.80	338- 1410^a 580.4± 86	40- 225^b 73.6± 15	0.38- 43^b 15.2± 4.52

***Values in each column with different letters are significantly different at LSD5%. Values in columns with same letters are not significantly different.**

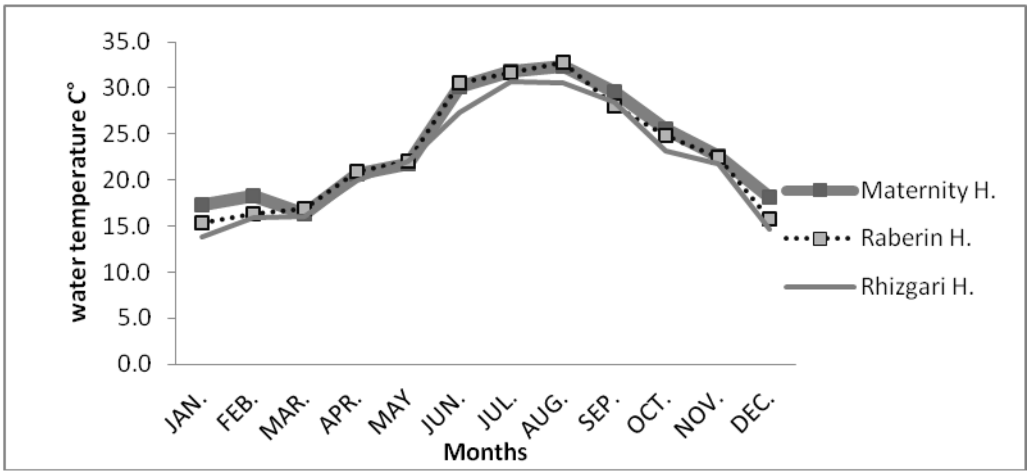

Figure 1- Monthly variation of water temperature (ºC) in Erbil`s hospitals wastewater**.**

Water temperature is an important factor that affects the rate of many biological and chemical processes in the water way and the amount of oxygen gas that can dissolve in the water. The well being of aquatic life, from bacteria to fish, is influenced by temperature [10, 11].

The variation in water temperature was affected by air temperature, and this was obvious throughout the present study (for both studied aquatic ecosystem). Such phenomenon was observed by many authors in different parts of the world [12].

Generally, annual water temperature variation in the three hospitals was 13.8-32.8^{o}C, which was similar to the previous studies done by Shekha [2,6] and Ali [13] in Erbil channel.

The factors that led to such a phenomenon were shallowness of effluent, as well as, large surface area of water body in comparison with volume size [14]. The results shown that the BOD is increased as the temperature increases this may be due to the effect of temperature on the activity of the microorganisms, these results identical to the results which obtained by [15, 16].

Hydrogen ion concentration

The pH values of wastewater were 7.34 -7.84, 7.36-7.82, and 7.28-7.99 for the effluents of Maternity hospital, Raperin hospital, and Rhizgari hospital, respectively. The highest value was recorded during November 2012 for Rhizgari hospital effluents and the lowest value during May 2012 belonged to Rhizgari hospital effluents (Figure 2 and table 1). Statistically, no significant differences ($p<0.05$) were observed between the studied sites.

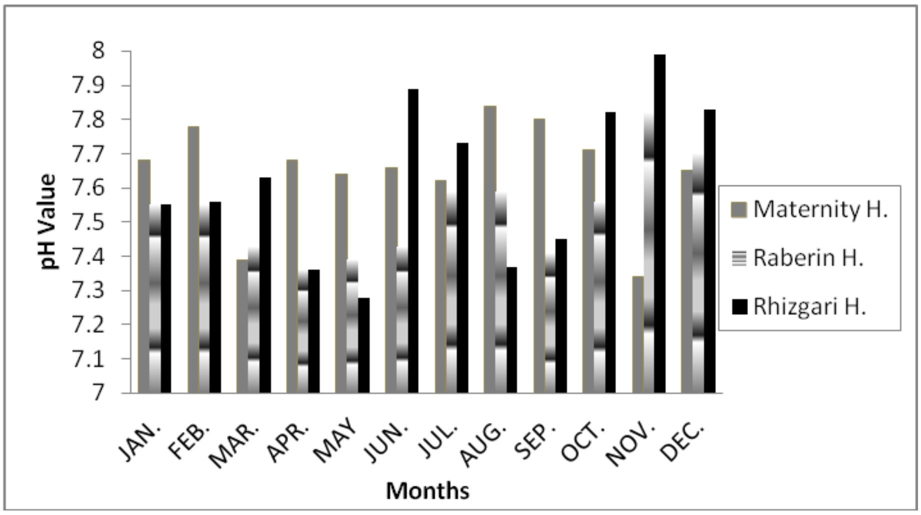

Figure 2- Monthly variation of pH value of Erbil`s hospitals effluents.

One of the important parameters for evaluation the quality of wastewater is pH value (acidic or alkaline status). Increase or decrease of this parameter in a wastewater will cause the corrosion and damage of WTP (Water Treatment plant) and sewers. This index also plays a significant role in biologic processes of wastewater treatment [17].

In natural water the pH value is usually between 6.5- 9.5 [32]. Because of geological formation of area, Iraqi inland water shifted to be in alkaline side of neutrality by a dominated of HCO_3- ions [18; 19]. The pH value in all the three hospitals never fell below 7. Similarly, a study was conducted on Iranian hospitals found that the mean pH value of raw wastewater of all studied hospitals was 7.5 (20). Likewise, in Turkey hospitals, the mean pH of raw wastewater hospitals was 7.3 [21].
During investigation of Mustafa and Sabir (2001); Amin and Aziz (2005); and Lak (2007), they attributed the reason to sewage discharge enriched with detergent of an alkaline in nature[22, 23, 24]. It is clear most results high pH value during summer attributed to temperature elevation led to increase the evaporation rate of water and increase in carbonate concentration[2].

Electrical Conductivity (EC)

The minimum EC value of Maternity hospital was 1318µs.cm^{-1} during Septemper 2012, and the maximum value was 1790 µs.cm^{-1} during December 2012 (Figure 3and table 1). The minimum EC value of Raberin hospital was 1770 µs.cm^{-1} during May 2012, and the maximum value was 2720 µs.cm^{-1} during June 2012. The minimum EC value of Rhizgari hospital was 1038µs.cm^{-1} during June 2012, and the maximum value was 1615 µs.cm^{-1} during November 2012. Raperin hospital was characterized by a higher EC value than those other sites. The statistical analysis showed that the EC value was significantly different ($p<0.05$) between the three hospitals.

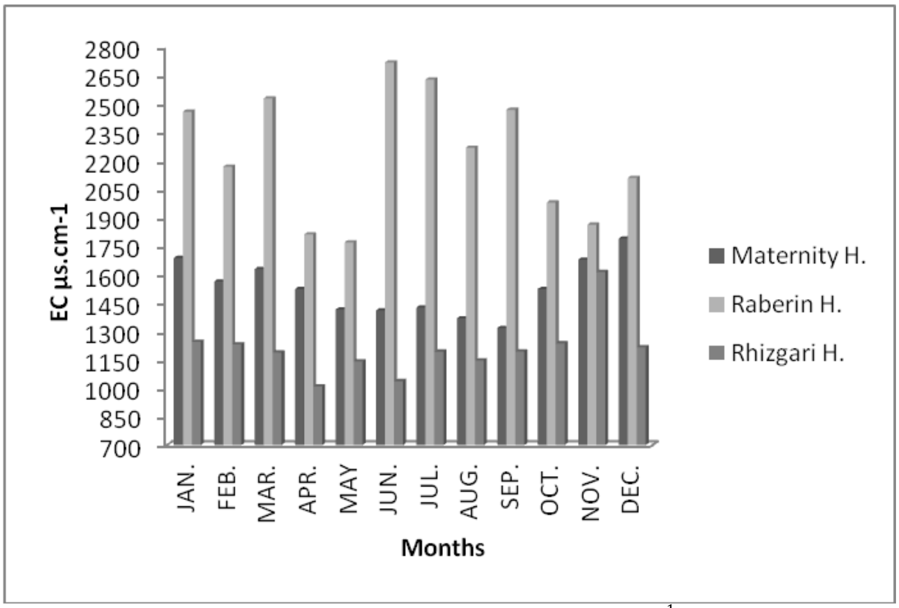

Figure 3- Monthly variation of electrical conductivity (µs.cm^{-1}) in Erbil`s hospitals effluent

A study by Mamta *et al.* (2011) showed a high EC 2.12 and 2.76 dS/m sewage channel in India [25]. Schwartz and Gruendling (1985) noticed a high EC value in Steven Brook wetland which indicated higher dissolved ions originating from sewage [26]. Salih (1982) attributed the reason to accumulation of salt ions due to increasing distance from their sources [27]. Mustafa (2006) showed that sewage wastewater in Sulaymania were characterized by high electrical conductance resulting from high ions and dissolved salt concentration[28] and that results were higher than of sewage samples that of Erbil city sewages that studed by Shekha (1994) and arranges between 430-946 µs.cm^{1}[6]. Ntengwe (2006) pointed to a high mineral salt concentration which comes from the dissolution of minerals discharges into the sewage [29]. Goldman and Horne (1983) suggested that the EC value more than 500 µs.cm^{1} in a water system was regarded to be hard [30]. Neves *et al.* (2003) had commented that the probably rise in EC value linked to a greater concentration of organic residue originating from domestic sewage [31].

Biochemical Oxygen Demand (BOD_5)

The minimum and maximum of BOD5 values were 25 and 77mg.L^{-1} during January and June 2012, respectively recorded in Maternity hospital. The minimum and maximum values ranged from 28 to 67 mg.L^{-1} during March and August 2012 recorded in Raperin hospital respectively, The minimum and maximum values ranged from 22 to 80 mg.L^{-1} during January and August 2012 recorded in Rhizgari hospital respectively (Figure 5)(table 1). Non significant differences ($p<0.05$) between the three hospitals were recorded.

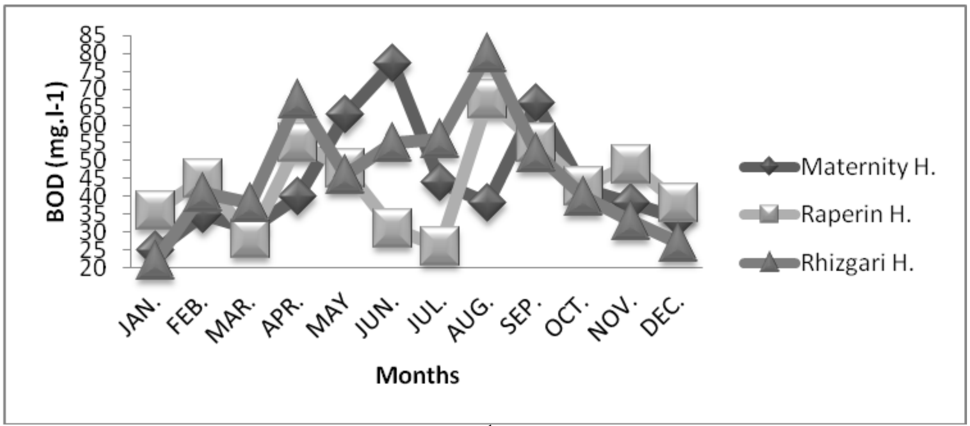

Figure 5- Monthly variation of BOD_5 ($mg.L^{-1}$) in Erbil hospitals effluents

The BOD_5 value has been measured in Erbil wastewater channel in several studies [35, 24], these studies showed that BOD_5 value was generally maintained above 13 $mg.L^{-1}$. In the present investigation, the BOD_5 value ranged from 22-80 $mg.L^{-1}$ comparing with other results of hospital in Malang City that showed range between 86.96-238.98 $mg.L^{-1}$[36]. A study in Thailand showed the mean concentration of BOD in hospitals raw wastewater 113 $mg.L^{-1}$ [37]. In hospitals wastewater study in Iran showed 110 $mg.L^{-1}$ [20].

According to Pandey *et al*. (2005) the BOD5 value for untreated city sewage water ranged from 100-400 $mg.L^{-1}$[38] and Bitton (2005) classified wastewater that ranged from 0-220 $mg.L^{-1}$ as a weak to medium wastewater [39]. Meanwhile, wastewater of studied hospitals can be regarded as a weak wastewater. However, the result of this study was close to that found by Aziz *et al*. (2001); Amin and Aziz (2005) and Bapeer (2010) in Erbil wastewater channel[23, 7, 40], Mohammed and F.L.S. (1980) on a polluted channel in Baghdad area[34].

Chemical Oxygen Demand (COD)

A maximum concentration occurred (1410 $mg.L^{-1}$) during August 2012 in Rhizgari hospital and minimum (280 $mg.L^{-1}$) during December 2012 in Maternity hospital (Figure 6 and table 1). Generally, no significant differences ($p<0.05$) were observed between Maternity hospital and Rhizgari hospital. On the other hand, the statistical analysis indicated that significant differences ($p<0.05$) were found between those hospitals and Raperin hospital.

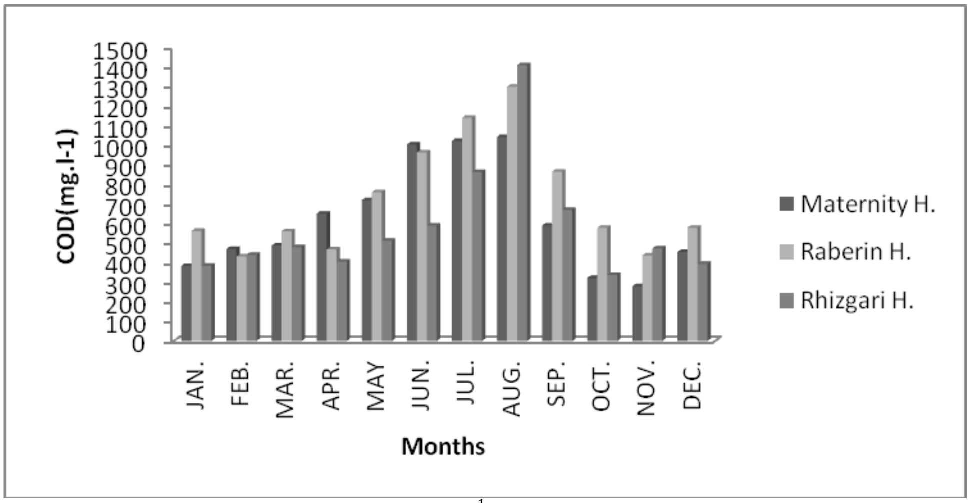

Figure 6- Monthly variation of COD ($mg.L^{-1}$) in Erbil hospitals effluents.

The chemical oxygen demand (COD) is an important and rapidly measured variable for characterizing water bodies, sewage, industrial waters and treatment plant effluent [44]. The COD values were related to the major factors such as allochthonous and autochthonous inputs [33].

In the present study, the COD values ranged from 280-1410 $mg.L^{-1}$, this result was higher than that recorded by Prayitno *et al*. (2013) in hospital in Indonesia[36] and also in results of study in sewage channel in Erbil city (Bapeer, 2010) and in study carried out by Amouei (2012) for Iranian hospitals wastewater[20,40].

Rhizgari hopital was characterized by the highest value of COD in comparison with the other two hospitals; this was probably related to the high organic matter in this site, which coincided with undetectable oxygen throughout several months during the studied period. Moreover, statistically no significant differences ($P<0.05$) were noticed between Rhizgari hospital and Maternity hospital. Nonetheless, significant differences ($P<0.05$) were found between these two hospitals and Raperin hospital. Generally, a high value of COD was observed during the warm months which coincided with a high water temperature [41].

Wetzel (1975) reported an increase in conductivity and salinity reduces the solubility of oxygen in freshwater which caused a high COD value [42], as well as, Welch (1980) stated that water temperature increased the metabolic rate of microorganisms for organic matter decomposition, in addition to the inverse relationships between water temperature and solubility of DO in water[43].

Enumeration of microorganisms

Figure 7 and table 1 show densities of different microorganisms analyzed in Erbil hospitals wastewater samples by using filtration method.

In this investigation, the mean value of total bacterial counts was found to be 148.54×10^6 CFU.100 mL^{-1} in Maternity wastewater sample, 50.12×10^6 CFU.100 mL^{-1} in Raperin wastewater sample, 73.58×10^6 CFU.100 mL^{-1} in Rhizgari wastewater sample. Generally, coliform mean numbers of Erbil wastewater samples were 41.87×10^6 CFU.100 mL^{-1} in Maternity hospital, 24.04×10^6 CFU.100 mL^{-1} in Raperin hospital, 15.18×10^6 CFU.100 mL^{-1} in Rhizgari hospital (Figure 8 and table 1).As shown in table 1, the total bacteria counts in wastewater samples were $5\text{-}390\times10^6$ $CFU.ml^{-1}$. These results exceeded local and international guidelines ranges. A study in Nigeria showed that total heterotrophic bacterial population from hospital wastewater is ranging between 1.9×10^7 to 8.3×10^{12} CFU/ ml and attributed the reason as reflected the level of pollution in the environment that is an indication of the amount of organic matter present [45]. Mutlak *et al*. (1985) recorded higher bacterial counts 45×10^9 $CFU.ml^{-1}$ in Baghdad sewage water [46]. Meanwhile, Nasser *et al*. (2004) reported 2.88×10^7 CFU.ml-1 in Alkiesh river/Syria, they attributed the reasons to the increased pollution discharge into river, elevation of water temperature and low water velocity leading to the increase of various microbial densities[47]. Generally, Erbil wastewater channel was regarded as a poor type according to WHO (2006), which classified water containing 10^6-10^8 total count as a poor water quality [32].

Coliform organisms refer to Gram- negative, rod shaped bacteria, non spore forming, able to ferment lactose at 35- 37ºC with the production of acid, gas and aldehyde within 24-48hours. Coliforms bacteria are one of the significant indicators for microbial quality assessment of wastewater and to show the hygienic condition of the water, they are not pathogens by themselves but their appearance is an indicator to the pathogens [1]. The coliform numbers of studied Erbil hospitals wastewater was $0.38\text{-}59 \times10^6$ $CFU.100ml^{-1}$. A study in New Delhi showed that an increase in numbers of *E. coli* from 1.7×10^3 to 6.9×10^7 CFU/ml by 24 hours, and to 7.9×10^9 CFU/ml by 48 hours [47]. Shekha (1994) reported that coliform density in Erbil wastewater channel was 45.4×10^2 CFU.100 ml^{-1}[6]. Another study in Nigeria showed that total coliform counts 1.2×10^5 $MPN/1000ml^{-1}$ to 1.6×105 $MPN/100ml^{-1}$ and that is indication of faecal pollution of the environment due to human activities [45].

A study by Al-Hashimi *et al*, 2013 was studied the biological pollution in Al-Wathba water treatment plant stages and to study water quality in water treatment plants and how Tigris River in Baghdad, affected by discharging the untreated sewage and wastes from industries and hospitals to the river, showed that there was an increasing in fecal coliform concentration in April this was because of raising in water temperature to about 22^{o}C which helps bacteria to live especially river water and sand filter media and the concentrations of fecal coliform reached to 180000 /100 mL of sample [48].

A study by Ibrahim *et al.* (2013) on the Tigris river in Baghdad city showed that The total Coliforms and fecal Coliforms were ranged from 300-1600ml and126-1600 /100 mL respectively and discussed how the main sources of pollution of Tigris river water in Baghdad city are due to the agricultural, industrial and housing sectors and it was found that domestic discharges are among the important sources of pollution of the Tigris within Mosul area , sanitary waters are often discharged untreated into the Tigris., there are more than forty pumps installed along both sides of the Tigris river disposing sewage water directly into the river without any treatment [49].

The study by Al-Bayatti *et al*, 2012 on Tigris River water showed the total coliform counts exceeded (1795–63000 CFU/100 mL) and in all seasons were more than the international permissible levels recommended by WHO [50].

Mustafa (2006) showed in his study higher pollution load with coliforms were recorded in sewage samples in Sulaimani City [28].

Nasser *et al*. (2004) suggested that nature and degree of pollution by coliform bacteria in water depend on many factors such as pollution strength, temperature [47]. From the above results Erbil wastewater is far from WHO guidelines standards. WHO (1989) recommended that irrigation water used for raw consumable crops is 1000/100 ml coliform bacteria [51].

The results were markedly evident to risks of using untreated wastewater for irrigation purposes. All of these could be controlled through primary; secondary treatment in addition to disinfectant processes for wastewater before being used. EPA (1992) recommended that the water used for irrigation of food crops to be eaten raw required secondary treatment, filtration and disinfection [52].

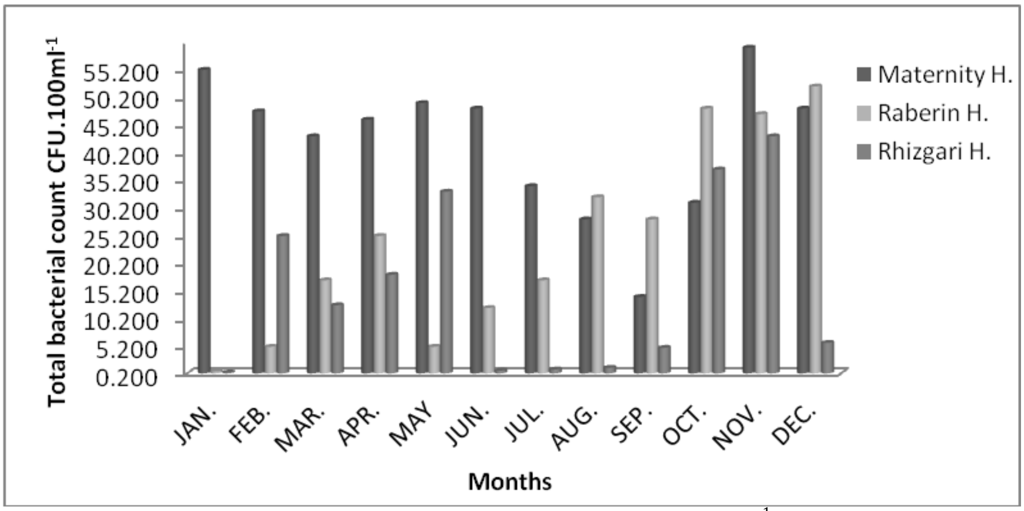

Figure 7- Monthly Enumeration of total bacterial counts CFU.100 mL^{-1} in Erbil hospitals channel

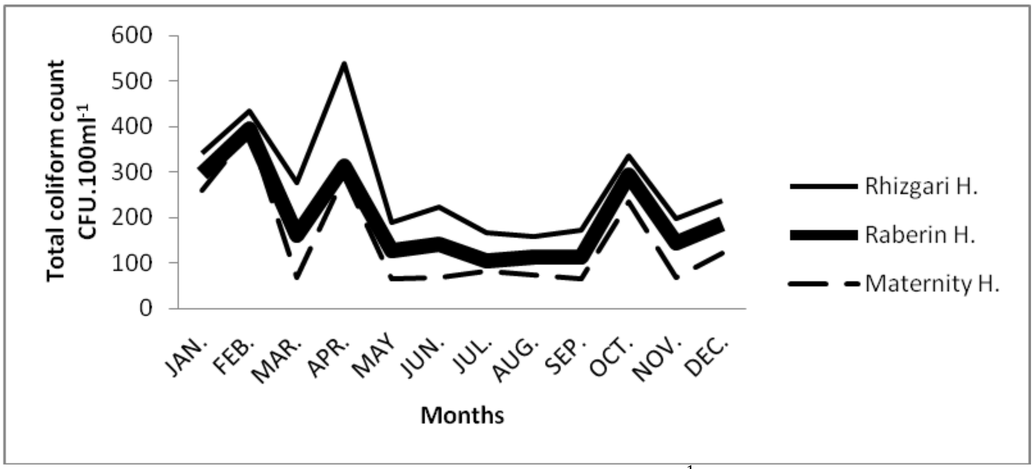

Figure 8- Monthly Enumeration of total coliform CFU.100 mL^{-1} in Erbil hospitals channel.

Conclusion

Erbil`s hospitals wastewater was considered as bad to medium type or poor type and the analysis revealed that wastewater from those hospitals polluted source of pollutant in wastewater channel, whereas, Greater Zab river was polluted by effluent of polluted channel. The high densities of microorganisms and detection of faecal contamination showed the risk of using Erbil wastewater for unrestricted irrigation.

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