Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2021.27414

230 (2021) 252–258
August

The effect of hospital wastewater discharge of Medical City, Baghdad on heavy metals concentration of the Tigris River

Nawras Hadi Abd Al Satar*, Dawood Eisa Sachit

Environmental Engineering Department, Al-Mustansiriyah University, Baghdad, Iraq, emails: nawrashadi1994@gmail.com (N.H. Abd Al Satar), dawood.sachit@uomustansiriyah.edu.iq (D.E. Sachit)

Received 17 January 2021; Accepted 11 May 2021

ABSTRACT

Tigris River is one of the main sources of water in Iraq; therefore, it is important to assess the quality of its water and determine the pollutants that may affect its quality. Several sources of contamination that impact the water quality of the Tigris River are located in Baghdad. The hospital of Baghdad Medical City is considered an important source of pollution to the Tigris River. This study examined the change of the heavy metals concentrations of Tigris River water as a result of the discharge of the hospital wastewater of Baghdad Medical City to the river. The water quality index was used to assess and evaluate the type of water quality. The period of the study started in January 2020 and ended in October 2020. In this study, three points to collect the water samples from the river were selected. The first point was 700 m before the Medical City complex. The second one was at the discharge point of the wastewater of the Medical City into the river. The third point was located at 400 m after the discharge point. Water samples were collected from these sites at a depth of approximately 10–30 cm below the water surface. Several variables such as Pb, Cd, Fe, Cu, Zn, Mn, Cr, Ni, Ag were used to determine the quality of the water. Results indicated that the concentration of the selected heavy metals of site 3 was much higher than that of site 1. For example, the concentration of Pb in January at site 1 was 0.0125 mg/L compared to that of site 2 which was 0.3213 mg/L. In addition, the concentrations of the constituents of site 3 were lower than that of site 2. For instance, the concentration of Pb of site 3 (0.0781 mg/L) was lower than that of site 2 (0.3213 mg/L) but still higher than that of site 1 (0.0125 mg/L). The lower concentration of site 3 indicates the presence of dilution by the river water body; however, it is not a solution since there are multiple sources of pollutants to the river. Moreover, the results showed that the concentration of most of the selected heavy metals of site 1 was either not deducted or very low compared to sites 2 and 3 which indicated the significant amount of pollution discharged to the river by the hospital wastewater. Overall, most of the findings highlighted that the concentration of the heavy metals exceeded the river maintenance system permissible of the Iraqi standard and the World Health Organization (WHO).

Keywords: Tigris River; Medical City; Wastewater; Heavy metals; Water quality index

1. Introduction

Rivers are considered as great natural streams of water which discharge into water bodies such as lake, sea, and ocean [1]. The availability and sustainability of safe drinking water are essential for life and important factors for disease prevention. Although the earth has diverse sources of water supplies, the difference between the total water available for human consumption and the great demand is rapidly growing and will most likely continue to rise due to the increase in population and water uses in commercial

* Corresponding author.

and industrial sectors [2]. The increase of using the water in commercial and industrial applications worldwide resulted in increasing the contamination of the public water supplies [3,4]. Surface water is the most exposed source of water to contamination due to the discharge of the waste resulted from human activities into it [5]. Pollution of rivers and other types of the water surface is continuously becoming a dangerous problem mainly caused by the disposal of untreated wastewater, chemical fertilizers, and industrial waste directly to the river [6–8]. Wastewater is any water whose quality has been adversely being perversion by anthropogenic influence. This includes liquid waste discharged from sanitary drainage, commercial sectors, industries, agricultural and domestic homes [9]. Polluted water has a direct effect on human health. Industrial effluents and sewage have an indirect effect through consuming foodstuffs being irrigated with contaminated water. Recently, emerging numerous new pollutants such as pharmaceuticals and heavy metals in surface water and other sources of water is a global concern that could jeopardize human health [10]. According to the World Health Organization (WHO) [11], more than 80% of human diseases are related to water pollution [12]. The prompt growth of the population accompanies significant agricultural and industrial development that impacts the environment with all its components, and thus it impacts the surface water. About 90% of the contaminated water discharged into rivers and streams, especially in developing countries [13]. In Iraq, the Tigris River is considered one of the main important surface water resources which flow from north to south [3]. The water of the Tigris River is polluted as a result of the transmission of toxic anthropogenic activities. The various pollutants discharged directly into the river without any real treatments through crossing Bagdad city threatens the ecosystem for living organisms and plants [14]. Knowledge of the physical, chemical and biological parameters of water is very important before using it for various purposes, which inverts or describes water quality [3,15]. Many researchers have studied the effect of hospital wastewater on rivers. In a study carried out by Adewoye [16], the effect of sewage drainage on the quality of the Asa River along its course in Ilorin, Kwara State in Nigeria, was evaluated. The results showed that the level of pollution varies according to the season with a high level of pollutants. In addition, a study carried out by Razzak and Sulaymon [17] included the distribution of pollutants in the Tigris River for about 9 km in length in Baghdad city. The study included four sewage pumping stations that discharge into the river without treatment. It was then deduced that the concentrations of contaminants were increased at the discharge points in the river and override the acceptable limits according to the Iraqi standards specification of surface water. Another study done by Al-Obaidy et al. [18] assessed the water quality index (WQI) based on the weighted arithmetic index to find out the water quality (WQ) of the Tigris River for drinking purposes from three stations in Baghdad city during 2013. The WQI was calculated based on the concentration of 11 parameters. The calculation of the WQI showed that the WQ of the Tigris River can be classified as very poor and unsuitable conditions. Therefore, it was recommended that a need for orderly monitoring of water quality to reveal the changes in physio-chemical parameters concentrations. A different study done by Al-Salim and Shehab [19] analyzed some physicochemical water quality parameters of the Tigris River near Mosul city. They showed the complex water quality data of the river in an easy form that could be easily understood by the technical and non-technical staff. The results of the WQI showed that river water for all of the stations analyzed can be classified as a medium that is necessary to treat the water for public supply. In the last decades, treating and discharging hospital wastewater into the rivers has been widely studied. For example, Dolatabadi et al. [20] studied removing mefenamic acid (MFA) from hospital wastewater by refining the electro-Fenton (E-Fenton) method. The effects of key variables on the removal process were analyzed, and the optimal experimental state with sufficient desirability was found using response surface methodology. The removal performance of MFA from synthetic wastewater was found to be in good alignment with real-world hospital wastewater treatment.

The purpose of this study was to determine the change in the level of the heavy metal contaminants which were Pb, Cd, Fe, Cu, Zn, Mn, Cr, Ni, and Ag. These contaminants were caused by the discharge of the hospital wastewater from Medical City into the Tigris River in Bab-Al Muadham, Baghdad.

2. Methodology

2.1. Hospital waste

Hospitals generate comparatively large quantities of wastewater that may include various potentially hazardous materials; therefore, the appropriate management of hospital wastewater is considered one of the main basics in treating such waste [21]. Hospital wastewaters are composed of the effluents of three different services: (1) wards (general medicine, specialties, surgery, hemodialysis, etc.), (2) general services (kitchen, heating, internal laundry, and cooling systems), and (3) diagnostic services (laboratories, outpatient departments, radiology departments, transfusion centers) [22]. In addition, hospitals are the main sources of pharmaceutical compounds in a concentrated area and, together with industries and domestic, can be considered as significant urban area hotspots for discharging these contaminants into the surface waters and sewer network, with a potential effect on human health [23,24]. The Tigris River is vulnerable to significant levels of physical, chemical, and biological contamination caused by such water contaminants. These inflows have significantly altered the color, odor, taste, and other characteristics of the river's water [17].

2.2. Study area

In this study, the quality, and management of wastewater in the governmental hospitals in Medical City, Baghdad have been investigated. Medical City is located in Bab Al-Muadham between Al-Sarafia Bridge to the west and Bab Al-Muadham Bridge to the east. All hospitals and buildings of the complex overlook the side south to ensure that the facades of hospitals and buildings are exposed to sunlight

from sunrise to sunset [25]. Hospitals located within medical centers and a city dispose of wastewater directly to Tigris River without treatment, twice daily from 7 a.m. to 9 a.m. and from 6 p.m. to 8 p.m.

2.3. Samples collection

Three sites were chosen to collect samples from the Tigris River near the Medical City. The first point was located 700 m before the Medical City Complex. The second one was in the discharge point of the wastewater of the Medical City into the River. The third point was located 400 m after the discharge point as shown in Fig. 1. The samples were taken at a depth of 10 cm to 30 cm below the water surface. Samples were collected between 7 am and 8 am during the pump operation. The time of the study proceeded for the period from January to October 2020 and then was suspended for five months due to coronavirus conditions (COVID-19) for the difficulty in reaching the sites.

2.4. Samples analysis

The collected samples were analyzed for the heavy metals' concentrations of Pb, Cd, Fe, Cu, Zn, Mn, Cr, Ni, and Ag in the u-science scientific laboratory in Diwaniyah, Iraq by atomic absorption spectrophotometer. They were conducted according to the standard methods for the examination of Water and Wastewater. American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF), 2017 [26].

2.5. Water quality index

The water quality index (WQI) is a method used to analyze and monitor data of the water quality and hence allowing the scientists to put the results of discrete monitoring in a wider context. This allows the water chemistry results to be meaningfully interpreted. WQI performs best on regional or local scales because of confounding environmental conditions [27]. WQI has been chosen and applied according to the available data of this study. Table 1 displays the estimation and evaluation of the chosen index. Nine water quality parameters were selected. These parameters were Pb, Cd, Fe, Cu, Zn, Mn, Cr, Ni, and Ag. The WQI was calculated by using the weighted arithmetic index method for the concentrations of heavy metal. The standard values for the present analysis, shown in. Table 2, are taken from the Iraqi stream standard by the criteria of the Iraqi legislation of water sources preservation system number 25 dated 1967.

3. Results and discussion

The water quality index (WQI) was used to determine the quality of water by applying the equations listed in Table 1 using Microsoft Excel. Statistical analysis of calculated parameters are shown in Table 3, and Fig. 2. The analysis displayed that the disparity among the sites and the percentage of contamination during the study period. The results showed that the first site was between, excellent, good, while the second and third sites were unsuitable during the study period.

Fig. 1. Sampling site from the Tigris River: Adapted from Google Earth Pro.

Table 1
Calculation and evaluation of the selected indices

Index	Parameters	Evaluation	Ref.
$WQI = \frac{\sum Q_i W_i}{\sum W_i}$	WQI: water quality index Q_i: quality rating W_i: relative weight	WQI < 50: Excellent.0 < WQI < 100: Good	[28]
$W_i = \frac{K}{V_{si}}$	K: proportionality constant	100 < WQI < 200: Poor	
$K = 1/\Sigma\ (1/V_{si})$	V_{si}: standard value	200 < WQI < 300: Very poor	
$Q_i = \left(\frac{C_i}{S_i}\right) \times 100$	C_i: measured value	WQI > 300: Unsuitable	

Table 2
Iraqi standard for heavy metals properties [29]

Element	Iraqi standard (mg/L)
Pb	0.05
Cd	0.005
Fe	0.3
Cu	0.05
Zn	0.5
Mn	0.1
Cr	0.05
Ni	0.1
Ag	0.01

Table 3
WQI throughout for the present study

Months	Site 1	Site 2	Site 3
Jan.	110.2889	764.3281	236.927
July	3.261246	769.53	254.675
Aug.	8.646125	802.3888	301.8302
Sep.	95.1955	2,814.649	308.9634
Oct.	20.31706	3,010.298	351.2917

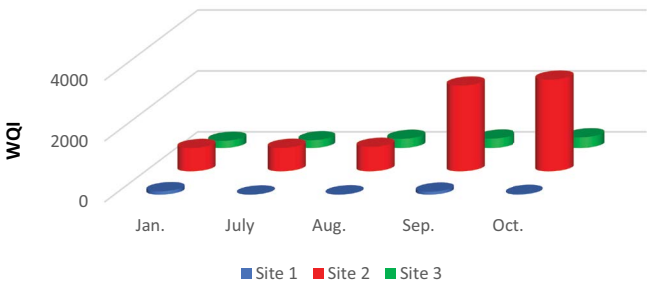

Fig. 2. WQI throughout for the present study

The measured concentration of the heavy metals of site 1 which are shown in Table 4 indicated that water is appropriate at site 1 according to the indices listed in Table 1. Fig. 3 illustrates the concentrations of lead, cadmium, iron, copper, zinc, manganese, chromium, nickel, and silver, for site 1 that precedes the Medical City. The values of the parameters were within the allowed limits during the period of the study.

Table 4
Monthly variations of parameters of water samples for site 1

Parameter*	Jan.	July	Aug.	Sep.	Oct.
Pb	0.0125	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Fe	ND	0.105	0.153	ND	ND
Cu	ND	0.027	0.0124	0.0646	ND
Zn	ND	ND	0.0141	ND	0.0021
Mn	0.0082	0.006	0.114	0.0282	0.0328
Cr	0.0429	ND	0.038	0.0429	ND
Ni	ND	ND	ND	ND	ND
Ag	0.0402	ND	ND	0.0321	0.0075

*All values are measured in mg/L

Table 5
Monthly variations of parameters of water samples for site 2

Parameter*	Jan.	July	Aug.	Sep.	Oct.
Pb	0.3213	0.5	0.4211	0.3943	0.3521
Cd	0.0388	0.04	0.0398	0.0435	0.0453
Fe	4.2167	3.110	3.272	3.5167	4.1321
Cu	0.6275	0.730	0.721	0.7575	0.8210
Zn	4.1022	3.5	3.394	4.2315	4.3201
Mn	0.8713	0.614	0.694	0.7713	0.8335
Cr	0.3857	0.3	0.423	0.4857	0.5210
Ni	0.3102	0.333	0.345	0.3965	0.4250
Ag	0.0678	0.061	0.072	0.8278	0.8921

*All values are measured in mg/L

The results of the measured heavy metals of site 2, however, are shown in Table 5 and Fig. 4. The results indicated that the amount of contamination resulted from the discharge of the hospital wastewater to the river for all the parameters exceeded the permissible standards during

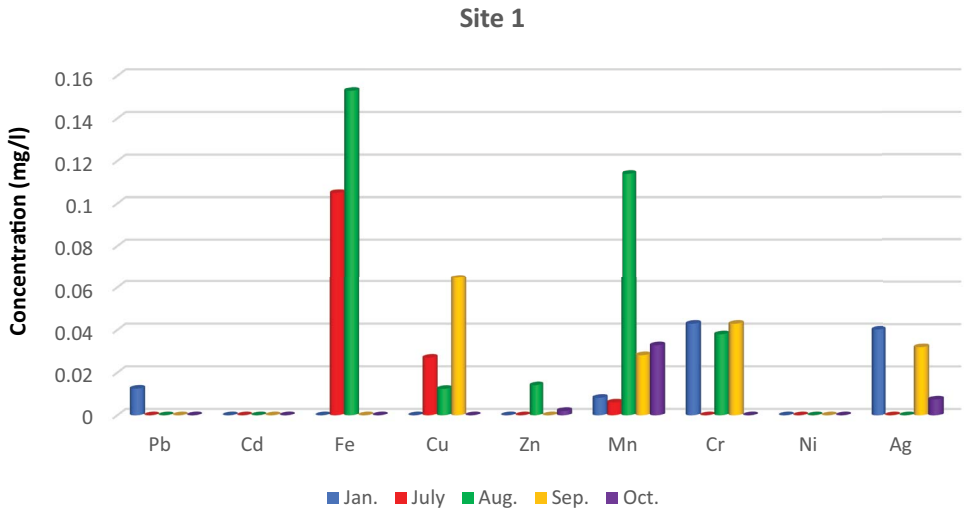

Fig. 3. Monthly concentrations of the parameters measured for site 1.

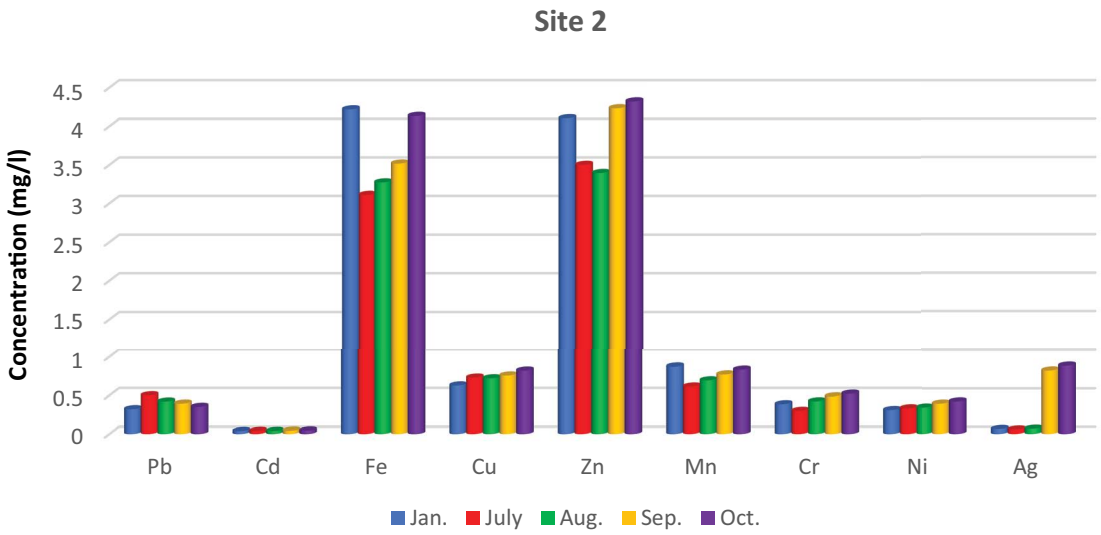

Fig. 4. Monthly concentrations of the parameters measured for site 2.

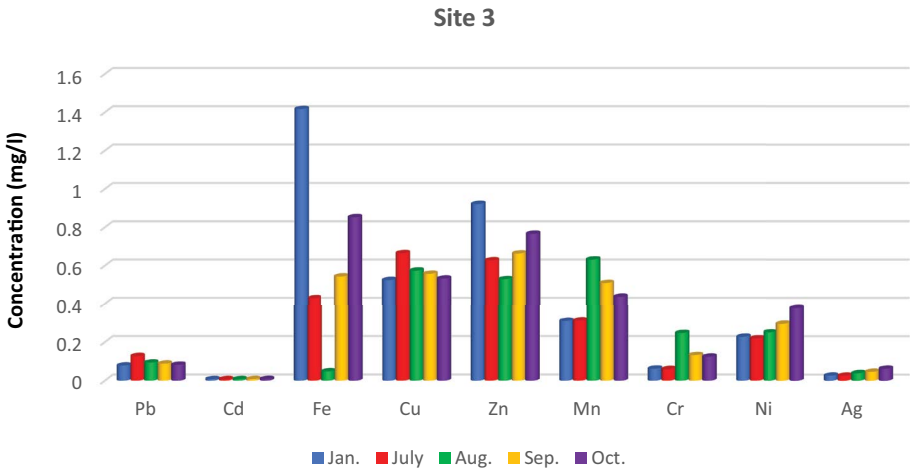

Fig. 5. Monthly concentrations of the parameters measured for site 3.

Table 6
Monthly variations of parameters of water samples for site 3

Parameter*	Jan.	July	Aug.	Sep.	Oct.
Pb	0.0781	0.1275	0.094	0.0881	0.0821
Cd	0.0078	0.008	0.0079	0.0082	0.0085
Fe	1.4169	0.430	0.0482	0.5432	0.8523
Cu	0.5245	0.665	0.574	0.5575	0.5321
Zn	0.9213	0.6275	0.5292	0.6634	0.7660
Mn	0.3093	0.3114	0.632	0.5093	0.4370
Cr	0.0621	0.06	0.247	0.1324	0.1245
Ni	0.2272	0.2192	0.252	0.2972	0.3793
Ag	0.0262	0.026	0.039	0.0462	0.0624

the study period and the water quality was unacceptable and very poor according to the indices mentioned in Table 1.

For site 3, the measured heavy metals are shown in Table 6 and shown in Fig. 5. The results showed a slight decrease in the concentrations of the measured heavy metals compared to the second site concentrations, but they remain outside the permissible and unacceptable standards. This indicated that the amount of pollution resulting from the wastewater discharged to the river was higher than the acceptable ranges.

4. Conclusion

The results showed that the wastewater affects the quality of the Tigris River, as it was mostly above the natural limits of the water supplies by measuring heavy metals for the wastewater discharged to the river from the city of Medical City hospitals. The waste of Medical City contains a far great amount of antibiotics (which contains heavy metals) than the city's wastewater. These pollutants are an exporter of worry for water bodies as they are the major source of water for humans, animals, and plants. Increased amounts of heavy metals and chemical compounds may cause a set of diseases.

5. Recommendations

The following suggestions are recommended:

- Monitoring wastewater treatment plants effectively.
- Measuring pollutants are released to the river periodically to ensure that no violation of the standard has occurred.
- Treat the wastewater before discharging it to the river.
- Using disinfectants and chemicals in the treatment which should be less polluted wastewater.

References

[1] A. Kumar, A. Dua, Water quality index for assessment of water quality of river Ravi at Madhopur (India), Global J. Environ. Sci., 8 (2010) 49–57.
[2] N.O. Kariem, D.E. Sachit, Z.Q. Ismael, The performance of a spiral wound RO membrane to desalinate a brackish groundwater in the middle of Iraq, Desal. Water Treat., 136 (2018) 72–82.
[3] R.R. AL-Ani, A.M.J. AL Obaidy, H.F.M., Multivariate analysis for evaluation the water quality of Tigris River within Baghdad city in Iraq, Iraqi J. Agric. Sci., 50 (2018) 331–342.
[4] D.E. Sachit, J.N. Veenstra, Analysis of reverse osmosis membrane performance during desalination of simulated brackish surface waters, J. Membr. Sci., 453 (2014) 136–154.
[5] A.H.M.J. Al Obaidy, A.A.M. Al Mashhady, E.S. Awad, A.J. Kadhem, Heavy metals pollution in surface water of Mahrut River, Diyala, Iraq, Int. J. Adv. Res., 2 (2014 1039–1044.
[6] A.H.M.J. Alobaidy, B.K. Maulood, A.J. Kadhem, Evaluating raw and treated water quality of Tigris River within Baghdad by index analysis, J. Water Resour. Prot., 2 (2010) 629–635.
[7] A.H.M.J. Al Obaidy, M.A. Al-Khateeb, The challenges of water sustainability in Iraq, Eng. Technol., 31 (2013) 828–840.
[8] R.R. Al-Ani, A. Hameed, M. Jawad, A. Obaidy, R.M. Badri, Assessment of water quality in the selected sites on the Tigris River, Baghdad-Iraq, Int. J. Adv. Res., 2 (2014) 1125–1131.
[9] F.O. Ekhaise, B.P. Omavwoya, Influence of hospital wastewater discharged from University of Benin Teaching Hospital (UBTH), Benin City on its receiving environment, American-Eurasian J. Agric. Environ. Sci., 4 (2008) 484–488.
[10] M. Dolatabadi, S. Ahmadzadeh, A rapid and efficient removal approach for degradation of metformin in pharmaceutical wastewater using electro-Fenton process; optimization by response surface methodology, Water Sci. Technol., 80 (2019) 685–694.
[11] World Health Organization (WHO), Water Quality for Drinking, WHO Guidelines, Encyclopedia of Earth Sciences Series, 2012, pp. 876–883.
[12] N. Nambatingar, Y. Clement, A. Merle, T.N. Mahamat, P. Lanteri, Heavy metal pollution of Chari River water during the crossing of N'Djamena (Chad), Toxics, 5 (2017) 26, doi: 10.3390/toxics5040026.
[13] Z.Q. Lateef, A.S.T. Al-Madhhachi, D.E. Sachit, Evaluation of water quality parameters in Shatt Al-Arab, Southern Iraq, using spatial analysis, Hydrology, 7 (2020) 1–33.
[14] R. Gadzała-Kopciuch, B. Berecka, J. Bartoszewicz, B. Buszewski, Some considerations about bioindicators in environmental monitoring, Pol. J. Environ. Stud., 13 (2004) 453–462.
[15] A. Sargaonkar, V. Deshpande, Development of an overall index of pollution for surface water based on a general classification scheme in Indian context, Environ. Monit. Assess., 89 (2003) 43–67.
[16] S.O. Adewoye, Effects of detergent effluent discharges on the aspect of water quality of ASA River, Ilorin, Nigeria, Agric. Biol. J. North America,1 (2010) 731–736.
[17] I. Razzak, A. Sulaymon, Effects of discharging sewage of Baghdad to Tigris River on the water quality, Eng. Tech. J., 27 (2009) 2903–2917.
[18] A. Hameed, M.J. Al-Obaidy, Impact of Medical City and Al-Rasheed Power Plant Effluents on the Water Quality Index Value of Tigris River at Baghdad City, Eng. Tech. J.,34 (2019) 28–29.
[19] T.H. Al-Salim, Z. Nafea, M. Shehab, Assessments of Water Quality Index (WQI) for Tigris River in Mosul City/North of Iraq, Int. J. Latest Res. Eng. Technol., 2 (2016) 82–93.
[20] M. Dolatabadi, S. Ahmadzadeh, M.T. Ghaneian, Mineralization of mefenamic acid from hospital wastewater using electro-Fenton degradation: optimization and identification of removal mechanism issues, Environ. Progress Sustainable Energy, 39 (2019) e13380.
[21] A.R. Mesdaghinia, K. Naddafi, R. Nabizadeh, R. Saeedi, M. Zamanzadeh, Wastewater characteristics and appropriate method for wastewater management in the hospitals, Iran. J. Public Health, 38 (2009) 34–40.
[22] P. Verlicchi, A. Galletti, L. Masotti, Management of hospital wastewaters: the case of the effluent of a large hospital situated in a small town, Water Sci. Technol., 61 (2010) 2507–2519.
[23] K. Kümmerer, Drugs in the environment: emission of drugs, diagnostic aids, and disinfectants into wastewater by hospitals in relation to other sources – a review, Chemosphere, 45 (2001) 957–969.

[24] B. Pauwels, W. Verstraete, The treatment of hospital wastewater: an appraisal, J. Water Health, 4 (2006) 241–254.
[25] M.H.T. Shenawa, M.J.A.H. Freih, M.Z.Q. Sadiq, R.M.K.S. Abdul, A study on the environmental reality of the Medical City Hospital Complex, (2009) Available at: http://www.moen.gov.iq/ Portals/0/Studies/%D8%AF%D8%B1%D8%A7%D8%B3%D8%A9%20%D8%B9%D9%86%20%D8%A7%D9%84%D9%88%D8%A7%D9%82%D8%B9%20%D8%A7%D9%84%D8%A8%D9%8A%D8%A6%D9%8A%20%D9%84%D9%85%D8%AC%D9%85%D8%B9%20%D9%85%D8%B3%D8%AA%D8%B4%%81%D9%8A%D8%A7%D8%AA%20%D9%85%D8%AF%D9D9%8A%D9%86%D8%A9%20%D8%A7%D9%84%D8%B7%D8%A8.pdf.
[26] E.W. Rice, R.B. Baird, A.D. Eaton, American Public Health Association, American Water Works Association, and Water Environment Federation, 2017.
[27] J.L. Berry, Development of a Water Quality Index (WQI) for the Susquehanna River Basin, 322 (2020) 1–41. Available at: https://www.srbc.net/our-work/reports-library/technical-reports/322-water-quality-index-2020/docs/water-quality-index-2019.PDF
[28] S.N.H. Al-Hussaini, A.H.M.J. Al-Obaidy, A.A.M. Al-Mashhady, Environmental assessment of heavy metal pollution of Diyala River within Baghdad City, Appl. Water Sci., 8 (2018) 1–6.
[29] Rivers Conservation Regulation, Profile on Environmental and Social Considerations in Iraq, 2011.