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Identification of the Components of Wastewater from Al-Sadr Teaching Hospital in Basrah, Iraq

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ABSTRACT

The discharge of raw contaminated and inadequately treated pharmaceutical wastewater into water supplies and river canals contributes to short-, medium-, and long-term environmental and human health impacts. The deterioration and depletion of natural resources exemplified in recipient surface water systems, entirely account for the poor quality of pharmaceutical wastewater effluent. The experimental part involved three main wastewater sites for Al-Sadr Teaching Hospital in Basrah Governorate, Iraq. The first site was chosen from which the hospital's liquid waste is discharged after undergoing mechanical treatment. The second site is 500 meters to the right of the first site, and the third site is 500 meters to the left of the first site. Water samples were collected twice, the first collection was during the hot months (August and September), while the second collection was during the cold months (December and January). A wide range of pharmaceutical wastewater was obtained in the wastewater of Al-Sadr Teaching Hospital using the GC-Mass technique. The percentage of pharmaceutical waste during the cold months was much higher than in the hot months. In conclusion, this study reported a successful screening of the presence of antibiotics, analgesics, disinfectants, and antivirals in Al-Khorah water canals. The presence of pharmaceuticals detected in canal water indicated pollution by these substances. High concentrations during the colder months suggested that human activity is the main cause of pollution in those canals. As a result, continuous monitoring of pharmaceutical pollutant concentrations is required to protect public health, aquatic biodiversity, and water channel quality.

INTRODUCTION

Pollution is a significant threat to environmental safety. The environment is considered polluted when its physical-chemical, and biological characteristics deteriorate due to human or natural activity. Therefore, this will affect all aspects of natural life of the existing living organisms **(Vardhan *et al*., 2019; Al-Enazi *et al*., 2022)**. The aquatic environment is considered one of the environments that receive the most types of pollution from untreated liquid and solid waste. This pollution, comprising a wide range of pollutants and originates from numerous human activities, rendering aquatic environments, which makes this environment less suitable for familiar life forms.

Furthermore, the pollutants can be transmitted to humans through the consumption of contaminated organisms **(UNEP, 2016)**. Wastewater disposed from hospitals is considered a cause of many environmental risks. It contains a variety of potentially dangerous materials, including microscopic pathogens, radioactive isotopes, disinfectants, medicines, and chemical and pharmaceutical compounds **(Verlicchia *et al*., 2010)**. Hospital waste has increased in conjunction with COVID-19 over the past two years since hospitals release biomedical waste from wastewater, which hosts a wide range of pollutants that can negatively impact the environment **(Parida *et al*., 2022)**. Pharmaceutical waste includes the remains of liquid chemicals used in health centers, such as disinfectants and sterilization materials used to clean patients' wounds. The disposed antiseptic materials used to clean surgical devices or to clean surfaces, solvents and dyes used in pathology laboratories, expired chemicals and solutions, and pharmaceutical materials in sewage network pose environmental risks. This waste includes antibiotics and genotoxic drugs, contributing to the contamination of water resourses and potentially harming ecosystems **(Mark, 2015)**. Hospital wastewater contains dangerous medications and can cause severe environmental pollution. Therefore, hospital wastewater, containing pharmaceutical preparations is discharged to sewage without treatment, contributing to the presence of pharmaceutical residues in natural water bodies **(Amouei *et al*., 2011)**. Hence, the environmental risks associated with pharmaceutical preparations found in hospital liquid waste must be evaluated at a time when these pharmaceutical preparations are beginning to rise in their concentration levels inside the water **(Beyene *et al*., 2009)**. The city of Basrah, similar to other cities in developing countries worldwide, faces a serious challenge with regard to water quality, as the Shatt al-Arab represents the main artery of life for this city. It has been subjected to a severe deterioration in the quality of its water for several reasons. The most important issue is the deterioration of the quality of the flowing water in the internal canals, turning them into sewage drain and waste dumps **(Al-Hassan, 2011)**. The stated that wastewater dumped in the Shatt al-Arab is one of the main causes of river water pollution with quantities of harmful chemicals, organic materials, and microbial organisms. Increasing the release of these pollutants may lead to an increase in the concentration of salts and nutrients and the growth of aquatic algae, and thus an increase in consumption. The dissolved oxygen in the Shatt al-Arab river affects the quality of the water and the aquatic organisms present in it **(Lateef *et al*., 2020)**. The aim of this study was to quantify the liquid waste generated by Al-Sadr Teaching Hospital in Basrah Governorate and its direct discharge into the Shatt al-Arab river, resulting in highly pollutant water.

MATERIALS AND METHODS

The study demographic

Al-Sadr Teaching Hospital is located on the western side of Shatt Al-Arab River in Al-baradiya district **(Al-Mayahi, 2020)**. It has about 504 beds, consisting of eight floors, with approximately 250 patients reviewed in the advisory division on each day. The wastewater treatment system in the studied hospital, which utilizes extended aeration, involves the following steps: settling, aeration, and treatment in an open tank known as the aeration tank. There is no primary sedimentation basin in any of these wastewater treatment systems. Hospital wastewater is disposed directly into Al-Khorah canal, which is long and has a number of branches stretching towards it. Additionally, this canal eventually opens into the Shatt Al-Arab River **(Al-Enazi, 2016)**. The wastewater was collected and analyzed with a device at different three sites. The first site is the main discharge point, just before the hospital wastewaters are discharged into the water canals (After treatment). The second site is located 500 meters from the second site in Al-Khorah canal. The third site is also 500 meters from the second site but in Shatt Al-Arab (Fig. 1).

Sample collection

Samples were taken during hot months from August 2022 to October 2022 and during the cold months from November 2022 to January 2023. Water samples were collected using sterilized scotch bottles which were autoclaved at 121°C for 30min. Before sample collection, the bottles were rinsed with canal water twice, and approximately 1L of the water sample was collected from each site at a depth of approximately 0.5m from the water surface opposite to direction of the water current. Samples were properly labelled, stored in ice and transported into the laboratory for the analysis process. Prior to sample analysis, water samples were filtered through 0.45µm pore-sized membrane and stored at −4°C. Analysis of the samples was conducted within 48h, and the samples were collected twice in each river to ensure of pharmaceuticals were properly represented.

Fig. 1. Map of the sampling sites (Map from Google Earth pro)

Concentration of samples by lyophilization and extraction

Prior to chromatographic analysis, water samples were pre-concentrated using the freeze-drying method. Approximately 500mL of water from the canals was subjected to this process. The samples were frozen until they reached a temperature of approximately −40°C, and dried on a freeze-dry machine VirTis Bench Top K, model #2KBTES-55 (SP Scientific, Warminster, PA, Japan). The freeze-dryer condenser temperature was set at −50°C. The samples were left on a freeze-dryer machine until a powder sample was obtained. The product yield was weighed and transferred into a sterile 10mL vial and labeled properly. The lyophilised samples were sent to the Nahran Omer laboratories at Basrah oil company for ultra-performance Gas Chromatography-Mass Spectrometer (GC-MS) with an equipment from Shimadzu, Japan.

RESULTS

The results are obtained from the wastewater of Al-Sadr Hospital in a variety pharmaceutical wastes, such as antibiotics, therapeutic medications and disinfectants. The numbers of pharmaceutical compounds varied and were detected in the wastewater to the Al-Sadr Hospital. There was also no similarity in the types of antibiotics and other pharmaceutical preparations between hot and cold months. After evaluating the samples, the types of the antibiotics collected were higher in cold months and rainy season than in hot months. Tables (1- 6) show the chemical compounds found in the wastewater of Al-Sadr Teaching Hospital, and Al-Khorah channel. While, Fig (2- 7) show the GC-MS devices analysis of the components extracted from the water during hot and cold months for all sites. The results of the current study show the appearance of many pharmaceutical substances and disinfectants in the wastewater of the above-mentioned hospital and Al-Khorah canal. The highest percentage of pharmaceutical materials detected in the wastewater from Al-Sadr Hospital included biological, anti-cancer drugs, and some agricultural pesticides and antibiotics.

Table 1. The chemical compounds in wastewater of the first site in hot months

Name	Molecular formula	Retention time	Area
Succinic acid, cyclohexylmethyl 2,4-dimethylpent-3-yl ester	$C_{18}H_{32}O_4$	23.955	10401
1H-Pyrimido[1,2-a]quinoline-2-acetic acid, 1-oxo-, ethyl ester	$C_{16}H_{14}N_2O_3$	31.6	13714
5-Bromo-2-chloropyridine	C_5H_3BrClN	35.098	15657
Octamethylcyclotetrasiloxane	$C_8H_{24}O_4Si_4$	38.73	33843

Table 2. The chemical compounds in wastewater of the second site during hot months

Name	Molecular formula	Retention time	Area
Para – Isopropyl benzoic acid trim ethyl silylester	$C_{13}H_{20}O_3Si$	19.201	231432
Ethyl [5-hydroxy-1-(6-methoxy-4-methyl-3-quinolinyl)-3-methyl-1H-pyrazol-4-yl]acetate	$C_{19}H_{21}N_3O_4$	19.611	83376
pyrrolo[2,1-b]benzothiazole, 2-phenyl-	$C_{16}H_{11}NS$	19.734	82600
(2R,4aS,5R,8aS)-2,5-Diallyl-1-methyldecahydroquinoline	$C_{16}H_{27}N$	21.106	329800

Table 3. The chemical compounds in wastewater of the third site in hot months

Name	Molecular formula	Retention time	Area
Succinic acid, dec-2-yl 2,2,3,4,4,4-hexafluorobutyl ester	$C_{18}H_{28}F_6O_4$	19.497	54891
Pyridine, 2-hydroxy-5-iodo-	$C_5H_{4I}NO$	20.934	21898
1H-1,2,3-Triazole-4-carboxaldehyde	$C_3H_3N_3O$	25.078	6397
pyrrolo[2,1-b]benzothiazole, 2-phenyl-	$C_{16}H_{11}NS$	28.893	6909
Morpholine, 4-(4-nitrophenyl)-	$C_{10}H_{12}N_2O_3$	30.263	5733
Pyrazole, 5-methyl-3-(5-nitro-2-furyl)-	$C_8H_7N_3O_3$	32.57	6086
pyrrolo[2,1-b]benzothiazole, 2-phenyl-	$C_{16}H_{11}NS$	33.684	7142

Table 4. The chemical compounds in wastewater of the first site in cold month

Name	Molecular formula	Retention time	Area
3(2H)-Thiophenone, dihydro-2-methyl-	C_5H_8OS	4.9054	14.3484
4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	6.764	0.9824
2,5-Dihydroxybenzaldehyde, 2TMS derivative	$C_7H_6O_3$	11.0933	2.3136
Thiazole, 4-butyl-2,5-dimethyl-	$C_9H_{15}NS$	18.8374	1.4847
9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{36}O$	27.4591	1.1248
4-(4-Hydroxyphenyl)-4-methyl-2-pentanone, TMS derivative	$C_{12}H_{16}O_2$	38.1091	6.628

Table 5. The chemical compounds in wastewater of the second site in cold months

Name	Molecular formula	Retention time	Area
Propanamide, 2-hydroxy-	$C_5H_{11}NO_2$	4.286	5.3324
Cyclotetrasiloxane, octamethyl-	$C_{10}H_{30}O_5Si$	8.9915	1.4172
Octadecane	$C_{18}H_{38}$	19.7373	1.7308
E-8-Methyl-9-tetradecen-1-ol acetate	$C_{17}H_{32}O_2$	20.7919	0.8839
n-Hexadecanoic acid	$C_{16}H_{32}O_2$	21.4262	4.0198
9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{32}O$	22.6726	25.3833
4-(4-Hydroxyphenyl)-4-methyl-2-pentanone, TMS derivative	$C_{12}H_{16}O_2$	35.1812	4.681

Table 6. The chemical compounds in wastewater of the third site in cold months

Name	Molecular formula	Retention time	Area
5-Hydroxymethylfurfural	$C_6H_6O_3$	13.7559	1.2956
Heptadecane	$C_{17}H_{36}$	18.6679	2.4109
9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	$C_{19}H_{36}O$	25.4679	1.219
Oleic Acid	$C_{18}H_{34}O_2$	25.8293	2.0526
2,3-Dihydroxypropyl elaidate	$C_{21}H_{40}O_4$	27.4592	3.0976

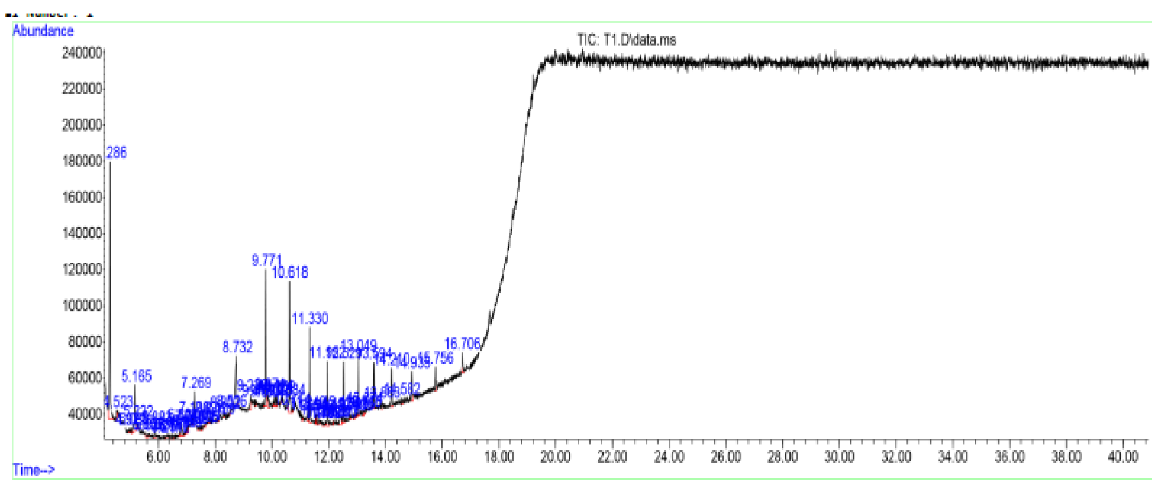

Fig. 2. Chromatogram of GC-MS analysis of an extracts from wastewater of the first site in hot months

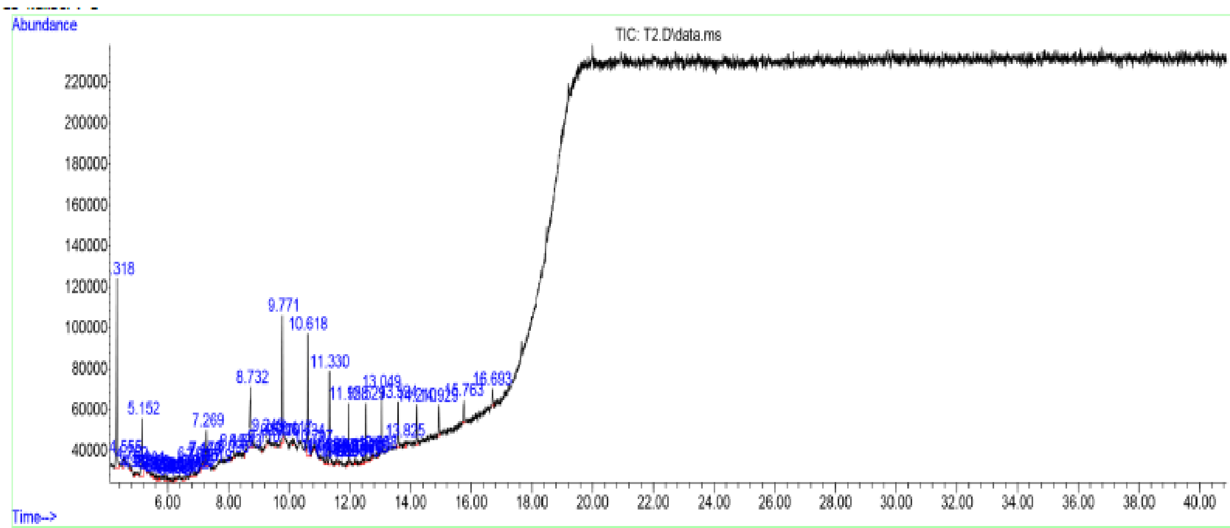

Fig. 3. Chromatogram of GC-MS analysis of an extracts from wastewater of the second site in hot months

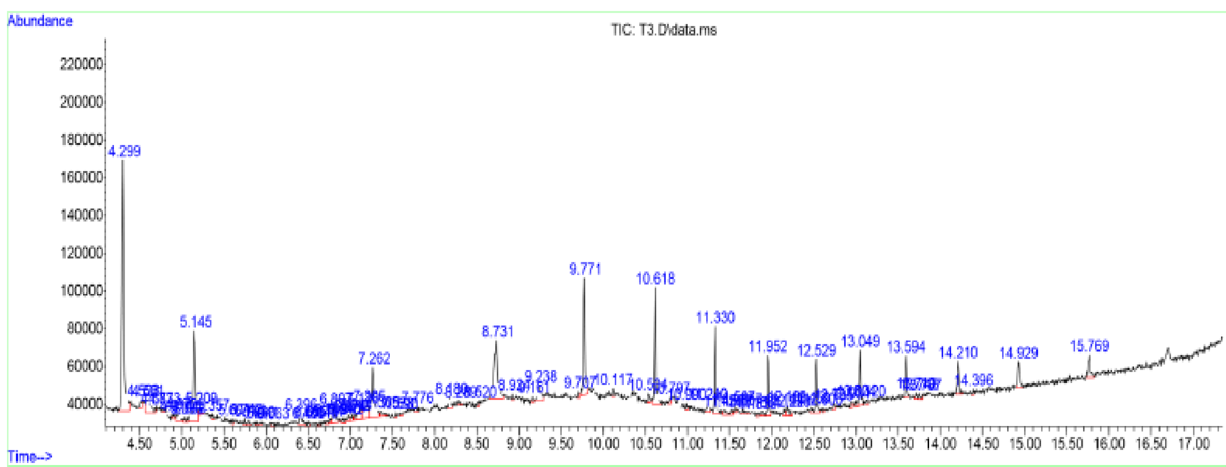

Fig. 4. Chromatogram of GC-MS analysis of an extracts from wastewater of the third site in hot months

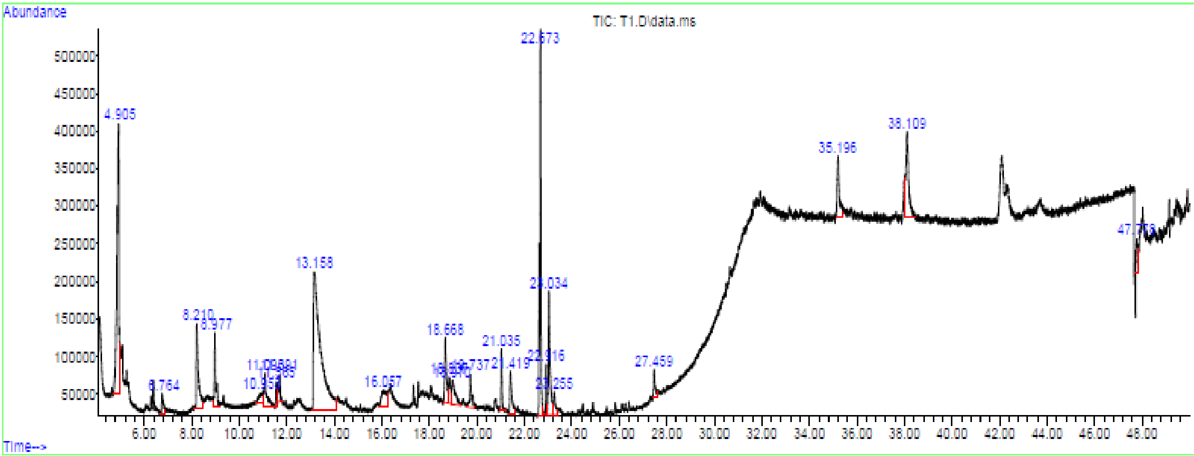

Fig. 5. Chromatogram of GC-MS analysis of an extracts from wastewater of the first site in cold months

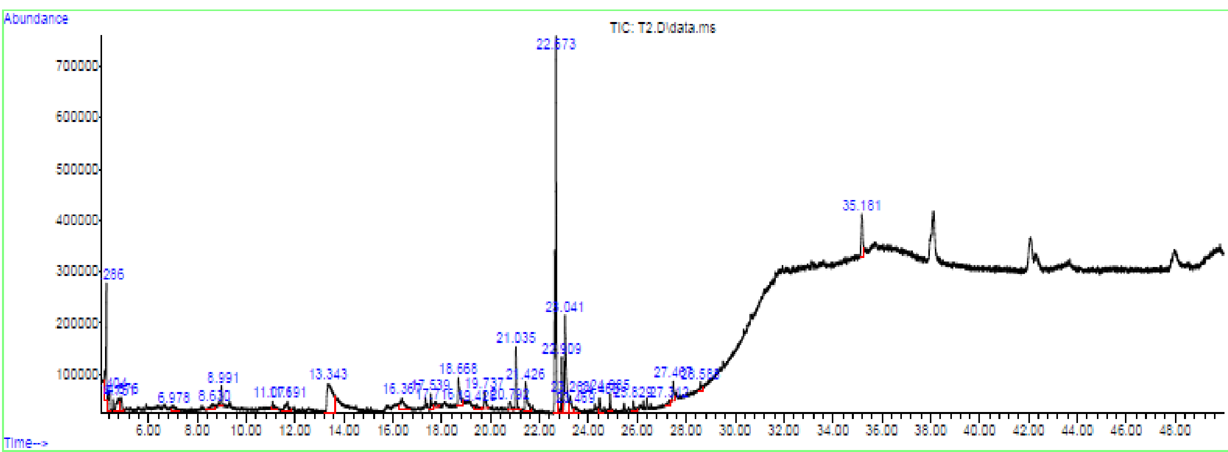

Fig. 6. Chromatogram of GC-MS analysis of an extracts from wastewater of the second site in cold months

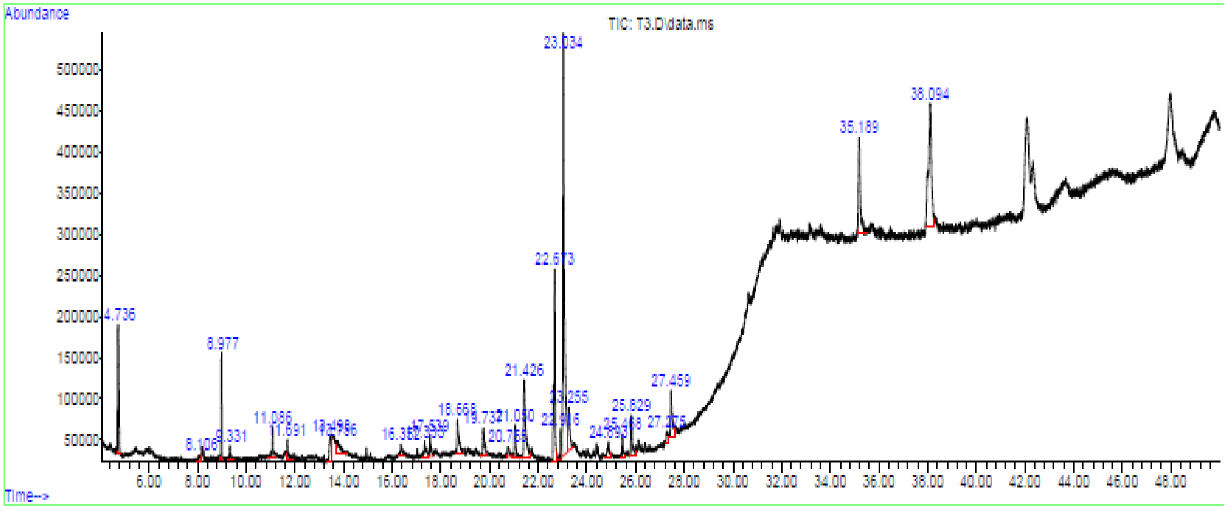

Fig. 7. Chromatogram of GC-MS analysis of an extracts from wastewater of the third site in cold months

DISCUSSION

The pattern of regulation is variable according to different factors in different countries, and the methods used to dispose wastewater from hospitals and houses are very narrow and ineffective. This water contains active pharmaceutical waste and chemicals resulting from the use of medical devices in hospitals and disinfectant materials for sterilization, as well as the direct disposal of medicines. Wastes are considered hazardous waste that reaches the water canals without treatment or inefficient treatment **(Verlicchi, 2018)**. These micro-pollutants are present in much higher concentrations in hospital wastewater compared to pollutants found in household sewage, with levels ranging from 4- 150 times higher. The presence of pharmaceuticals waste in the water is mainly attributed to undigested drugs that are excreted with human waste **(Maheshwari *et al.*, 2016)**. While considering the importance of wastewater in hospitals, there is not yet specific legislation regarding its discharge into the environment. However, hospitals liquid waste is considered a dangerous issue **(Khan & Ahmed, 2019)**. The results obtained from the wastewater of Al-Sadr Teaching Hospital, and aqueducts allow for a variety of pharmaceutical residues, such as antibiotics, therapeutic drugs and antiseptics **(Diwan *et al.*, 2013)**. It is always possible to detect the variation in antibiotic residues of wastewater in Al-Sadr Hospital due to the difference in the number of patients, the number of medical departments, the halls, and the quantitiy of medical equipment . This was the goal of our study, which examined wastewater samples from a hospital and water canals under investigation. It was found that antibiotics were the highest among the chemical compounds that appeared in the water samples. Various pharmaceutical treatments, which are substance used to diagnose or treat diseases that affect humans, have been identified in the studied wastewater samples. Adamantylamin, octadecenoic acid, pyrazole, pipyridine, morpholins, lodo-phenyl-pyrazol, and chloropropionic acid were among the antibiotics diagnosed in wastewater. The concentrations of antibiotics in the wastewater of Al-Sadr Teaching Hospital detected in winter were much higher than those detected in the hot months. This is due to the abundance of rain, low temperatures, and dilution to which the internal water canals are exposed, as well as due to the abundance of diseases in the cold months. Regarding the widespread use of pharmaceutical treatments by patients this season, particularly with the spread of the influenza virus, the environmental consequences on human health are a result of the presence and accumulation of these pollutants in water sources. These developing pollutants pose significant dangers, and the residues of these pharmaceuticals can permeate the water layers, posing a risk to plants, aquatic organisms, and even humans **(Vumazonke *et al*., 2020)**.

CONCLUSION

The discharge of wastewater from hospitals, such as Al-Sadr Hospital, contributes to continuous exposure of water in internal canals to various pollutants. The presence of biopharmaceutical wastes like antibiotics, antivirals, pain relievers, and disinfectants elevate pollution levels at the study sites. Implementing a monitoring program and establishing a local treatment facility for liquid waste treatment in accordance with environmental criteria are recommended actions. Moreover, large-scale investigations on disinfection byproducts, known carcinogens and genotoxinsm should be conducted to assess potential risks to public health.

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