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Evaluation of the Physico-Chemical Parameters of Hospital Liquid Effluents and Study of Their Environmental Impact - case of Moroccan hospitals

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Abstract

Wastewater produced by hospitals and discharged directly into municipal sewers without any prior treatment presents a chemical, biological and physical risk to the environment and human health. It deteriorates aquatic ecosystems and encourages the spread of chemical toxins. Our study aims is to identify the physico-chemical parameters of hospital effluents from a provincial hospital in the Rabat-Salé-Kénitra region of Morocco, in order to assess the level of wastewater pollution and determine its environmental impact. 30 wastewater samples were taken in appropriate bottles from the Sidi Kacem provincial hospital in accordance with Moroccan Norm NM 03.7.059 and analyzed at the provincial laboratory of epidemiology and environmental hygiene (PLEEH). In compliance with the standards and requirements recommended by Rodier 2009. The results show that hospital effluent is highly charged with mineral and organic matter, represented in terms of ammonium (1.98 mg/l), sulphates (218.43 mg/l), electrical conductivity (3223 µs/cm), nitrites (0.53 mg/l), nitrates (33.92 mg/l), hydrogen potential PH (7.84), and suspended solids (SS) (188.79 mg/l). These numbers largely exceed the limit values set by international norms. The COD/BOD5 ratio (7.64) greater than 3 shows that these effluents are hardly biodegradable. It appears that this wastewater is very loaded with physical, chemical and biological pollutants and requires periodic monitoring and treatment before being discharged into the external environment.

Keywords: Physico-chemical parameters, Hospital liquid effluents, environmental impact.

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1. Introduction

Water is an essential element for all living species on our planet. It guarantees the continuity of life, its presence is essential to hospitals' activities, Hospitals consume large quantities of drinking water, sometimes more than 1,200 liters per patient per day. In addition, they need specific types of water, such as physiological or sterilized water and serums, this high consumption gives rise to large volumes of wastewater loaded with physical, chemical, and biological pollutants [1]. Hospital effluents are hybrid discharges containing both domestic and hospital-specific polluted water produced by the various medical departments, they present a potential risk for humans and their environment due to the nature and importance of the specific substances they contain such as: residual pharmaceutical products, drug residues, chemical reagents, antiseptics, active residues from hygiene products, detergents, endocrine disruptors, radiographic developers and fixers, etc. This effluent is discharged into the city's sewage system, where it mixes with urban wastewater without any prior treatment [2]. Irrigation using raw wastewater is a very common practice in most African countries, given the high cost of water and fertilizers, Morocco is no exception: every year more than 3000 hectares are irrigated with untreated wastewater. This practice has very serious consequences for health and the environment, these impacts increase when wastewater is mixed with hospital effluent, which is overloaded with chemical substances and microbiological pollutants such as multi-resistant antibiotic bacteria [3-4]. The problem of freshwater scarcity has been a global issue since the end of the last century. Among the technical options considered, wastewater treatment for possible reuse seems a pertinent solution [5]. In this context, hospital effluents are becoming an increasingly important problem, as they are difficult to treat by wastewater treatment plants due to the existence of a number of complex chemical substances and biological pollutants of hospital origin. These deficiencies in the mechanisms for purifying chemical compounds are exacerbated by the presence of pathogenic bacteria that are multi-resistant to antibiotics in hospital liquid effluent [6-7]. The various problems resulting from hospital liquid waste, encourages scientists to reflect on the fate of these pollutants in the environment and on the need to develop tools for the sustainable management of wastewater from these establishments. Ecotoxicity tests carried out by researchers show that hospital effluents are often highly toxic and genotoxic [8]. At present, hospitals are only partially involved in environmental management. Only solid hospital waste is subject to rigorous management, with control of every stage from collection to destruction. As with solid waste, however, healthcare establishments must manage their liquid waste, to reduce their impact on the environment and people's health [9].

In this context, and to resolve the problem of managing hospital liquid waste, we carried out this study with the aim of determining the physico-chemical parameters of liquid effluents from the Sidi Kacem regional hospital center in order to raise awareness of the importance of treating these effluents before they are discharged, in order to protect the environment and human health.

2. Materials and methods

2.1 Study design

A prospective study was carried out at the Sidi Kacem provincial hospital centre over a period of 6 months, from 1 February 2023 to 31 July 2023, with the aim of determining the physical and chemical parameters of hospital effluents and assessing their environmental and health impacts.

2.2 Study setting

Sidi Kacem is an important city in the Rabat-Salé-Kénitra region of Morocco. Its province covers an area of approximately 8063 km². The population of the province estimated at 830000 inhabitants according to the population census in 2018. Located on the Meknès (46 km) - Tangier (220 km) and Fès (87 km) - Rabat (123 km) axes, the city is crossed by the Rdoom river, which flows from Meknès into the vast and fertile Gharb plain. The Sidi Kacem regional hospital is a multidisciplinary center covering the health needs of the province's population, organized into 9 departments and several care units with a bed capacity of 322 beds. Its average consumption of drinking water is estimated at 395 m3 / day with a flow rate of 1.22 m3 / day / bed. The hospital sewage system is connected directly to the urban sewage system, with no hospital wastewater treatment. Our study is being carried out to determine the physico-chemical parameters of hospital effluent in order to reduce its impact on the environment and human health.

2.3 Methods and frequency of sampling

Our study was carried out over a period of 6 months. A total of 30 samples of hospital liquid effluent were taken from the global sewerage network and the internal sewers of the Sidi Kacem provincial hospital, with a frequency of 5 samplings per month, distributed as follows: one sampling per week every Tuesday at 13 o'clock, and the fifth sampling was carried out on the last Thursday of each month at 13 o'clock. The wastewater collected was placed in autoclaved 500 ml glass bottles, the samples were taken in accordance with Moroccan standard NM 03.7.059[10] and transported in an icebox at a temperature of 5°C to the provincial laboratory of epidemiology and environmental health for possible determination of physico-chemical parameters.

2.4 Physico-chemical analysis of samples

The wastewater samples were stored in accordance with the general guide for the storage and handling of samples based on ISO 5667/3 [11]. Hydrogen potential (PH), temperature and electrical conductivity are determined using a multi-parameter analyzer Type CONSORT - Model 835. BOD5 (biochemical oxygen demand) is determined by the respiratory method using a WTW BOD meter, 1020T model, in accordance with the technique described by (Deutsche Industrie Normes) DIN [12]. COD (chemical oxygen demand) is determined by oxidation in an acid medium by excess potassium dichromate at a temperature of 148°C, in the presence of oxidisable matters such as silver sulphate as a catalyst and mercury sulphate. Suspended solids (SS) are determined by filtering a volume of wastewater through a cellulose filter (0.45 µm) in accordance with Rodier's guidelines [13]. The sulfates (SO4 2-) are determined by the colorimetric method according to DIN [14]. Nitrates were determined using the photometric method with 2,6 - dimethylphenol in accordance with DIN [15], nitrites and ammonium (NH4+) were determined using the photometric method in accordance with DIN [16]. A range of calibrations of all the parameters analyzed at the provincial laboratory of epidemiology and environmental health (PLEEH), as well as a control of all the factors affecting the quality of the results, were carried out in accordance with the requirements and procedures described by the NM ISO 17025 adopted by the (PLEEH).

2.5 Statistical analysis

All the data collected on the physico-chemical parameters of hospital effluents were analyzed using SPSS version 20 software, and descriptive statistics were produced in percentage form for the qualitative variables.

2.6 Ethical considerations

Our study has been authorized by the regional ethics committee, as well as by the director of the Sidi Kacem provincial hospital center. An investigation team has been created and trained in ethical methods, sampling procedures and sample analysis methods.

3. Results and Discussions

3.1 Physico-chemical parameters

During this study, we carried out several laboratory analyses to determine the physico-chemical parameters of hospital effluents from the Sidi Kacem provincial hospital center, in order to determine the degree of pollution of this wastewater and its environmental impact. We carried out 30 samples of hospital wastewater over a period of 6 months, divided into 5 samples per month. The identified parameters included the measurement of hydrogen potential (pH), temperature, electrical conductivity at 20°C, nitrate (NO3-), nitrite (NO2-), sulphate (SO4 2-), ammonium (NH4+), suspended solids (SS), chemical oxygen demand (COD) and biochemical oxygen demand for 5 days (BOD5). The results of the physico-chemical parameters identified in our study are shown in Tables 1, 2 and 3.

Temperature: Identifying the temperature of wastewater is an essential factor because it has a significant impact on environmental parameters. It is important to measure this temperature because it influences the chemical, biological and physical properties of liquid effluents, such as the influence of chemical and biological reactions, determines the concentration of dissolved oxygen in the water, the photosynthesis of aquatic plants, as well as its eventual effects on health. The degree of temperature also influences the natural biodegradability and treatment of wastewater in treatment plants [18]. In the context of our study, the results of the analysis of the wastewater samples reveal that the temperature of these liquid effluents varies between 14.5°C and 25.9°C during the study period. The average temperature identified over the six months is around 20.8°C, and this temperature change is influenced by several factors: the nature of the activities in the hospital establishments, domestic and industrial activities, seasonal changes, global warming and other factors. This temperature range is favourable for the survival and multiplication of germs and for the natural degradation of these liquid effluents. These values are in accord with WHO standards, which set the temperature limit for waste water at 30°C. Several studies have found comparable results to ours, such as the study by Tahiri and al [19] at a hospital in the city of Fez, which found an average temperature of 17.11°C, and the study by Touzani and al [20] with a temperature value of 20.79°C.

Hydrogen potential (pH): Hydrogen potential (pH) is the concentration of hydrogen ions in water, manifested by the presence of hydrated H^+ ions, or $H3O^+$. The concentration of these ions in the solution determines either the acidity or alkalinity of the solution. A PH value below 7 means that the solution is acidic, a value above 7 means that the solution is alkaline and a value of 7 means that the solution is neutral. The PH value of wastewater, which determines acidity or alkalinity, is an essential determinant because it has a powerful impact on biodegradability, wastewater treatment and the aquatic environment. Several studies have shown that the average PH value of domestic wastewater is between 6.5 and 8.0, which is not a suitable range for the development of the micro-organisms needed in the natural degradation process of liquid effluents [21]. In our study, we measured the PH of 30 samples of hospital liquid effluent. The results showed a variation in PH between 7.13 as a minimum value and 8.64 as a maximum, with a total average value of 7.84 over six months. This interval is relatively alkaline, which can have a very harmful impact on aquatic life and the external environment. Whereas the most suitable interval for aquatic microorganisms is between 6 and 7,2. Our results are in line with Moroccan standards, which set limit values between 6,5 and 8,5. Several studies have found similar results, such as that of Berrada and al [22], with an average value of 7.68, and the study by Touzani and al [20] in the city of Fez, with a PH value of around 7,25.

Electrical conductivity (EC): Conductivity can be defined as the ability of a substance to transmit electricity. In the case of hospital effluent, conductivity refers to its ability to conduct electric current. Conductivity values are closely related to the degree of current flow in wastewater. Measuring conductivity gives us an idea of the wastewater quality and dissolved components, such as the concentration of ions, organic and mineral matter, in order to identify the environmental impact and the means required for effective treatment of this effluent. There are several factors that influence conductivity, but the main ones are the presence of dissolved solids in the wastewater, high temperature favours the passage of electric current, so high pH values give high conductivity, and some chemical products increase conductivity, while others disrupt the passage of electric current [23]. The results of our study concerning the conductivity of hospital effluents show that there is a variation in conductivity values between 2441 µs/cm as a minimum and 3972 µs/cm as a maximum, with a total average value over six months of around 3223 µs/cm. These values are higher than the limit set by the regulations, which is around 2,700 µs/cm. These results show that the wastewater is highly charged with organic and mineral matter dissolved in the water, with an optimum temperature for conducting electric current. These results are similar to those of El Mountassir and al [24], with values ranging from 5202 to 8940 µs/cm, and Berrada and al [22], with values ranging from 3340 µs/cm to 3560 µs/cm. On the other hand, the studies by El ogri and al [25], and Bouchaib and al [26], found results compatible with the standard with values of 1195.60 µs/cm and 1195.60 µs/cm respectively.

Sulphates (SO4 2-): Sulphate is a chemical compound present in almost all-natural waters and wastewater. It is formed by oxidation reactions of mineral compounds such as sodium sulphate, magnesium sulphate and calcium sulphate, as well as from shale rock or liquid industrial waste. Sulphate is always present in rainwater, drinking water and, consequently, waste water. High sulphate levels in water have a very harmful impact on human health and the environment, manifesting themselves in laxative effects that cause diarrhea leading to serious dehydration. Digestive problems, nausea and abdominal pain may also occur in some people. Measuring the concentration of sulphate in wastewater is very important, because it provides an idea of the toxicity of this effluent and its environmental impact [27]. In the context of our study, the results found for sulphate concentrations in hospital effluents show a variation in concentration between 27.1 6mg/l and 498.72 mg/l, with the average concentration of 30 wastewater samples being around 218.43 mg/l. This concentration range is in line with current regulations, because it does not exceed the limit value. Several studies have found similar results, such as Boillot et al [28] and Emmanuel et al [29].

Nitrates (NO_3^-) and Nitrites (NO_2^-): Nitrate is a chemical component that naturally occurs everywhere in the environment. It is formed by the oxidation of nitrogen by microorganisms of various origins. In chemistry, nitrate is formed by combining NO3- and other anions to form several molecules such as ammonium nitrate, silver nitrate or potassium nitrate. Nitrates represent the majority of nitrogen sources in nature. They are the most stable form and can be transformed into nitrite, which is less stable and more toxic under the effect of germs. In the aquatic environment, sources of nitrates can include the precipitation of animal and plant matter, fertiliser residues and geological compounds containing soluble nitrogenous substances. High nitrate levels in wastewater have a very harmful impact on human health and the environment. It can disrupt the growth of aquatic organisms, especially in the early stages of life, leading to stunted growth. While nitrites are more toxic than nitrates, their blood presence disrupts oxygen transport, causing methaemoglobinemia with cyanosis and breathing difficulties, and an acid-base imbalance that can lead to death [30]. Analysis of the hospital effluent samples in our survey showed that nitrate concentrations ranged from a minimum of 7.35 mg/l to a maximum of 64.62 mg/l, with a total average value of 33.92 mg/l over six months. These results largely exceed the maximum acceptable value set by Moroccan regulations, which is 30 mg/l. concerning the determination of nitrite (NO_2^-), our study revealed that the concentration of nitrite varied between 0.008 mg/l and 1.248 mg/l, with a total average value of 0.538 mg/l. These values exceed the limit stipulated by the regulations, which is 0.5 mg/l. Several studies have found similar results, such as Boumchita et al [31] and El Mountassir et al [24], who found results higher than the standard, while Touzani et al found a result in line with the standard.

Ammonium (NH_4^+): The presence of high levels of ammonium in wastewater reflects incomplete degradation of organic compounds. Several chemical reactions give rise to ammonium molecules, such as mineral oxidation in the presence of iron and nitrates. The high concentration of ammonium in wastewater is an indication of liquid effluent pollution by organic matter of various industrial, agricultural or domestic origin. Few studies have been carried out on the toxicity of the ammonium molecule, but some researchers consider this substance to be of low human toxicity; it is found in several natural forms, but the most commonly found is ammonium chloride. Inhalation of ammonium by humans can cause respiratory discomfort and coughing, frequent contact with the eyes causes redness, skin irritation, while ingestion causes vomiting, abdominal pain and sore throat. In terms of its environmental impact, ammonium encourages corrosion and germ development in waste water by inhibiting the chlorine used in water treatment. It causes an imbalance in the aquatic environment, which can lead to fragile plants and even the disappearance of flora and fauna [32]. In our study, the wastewater samples analyzed showed ammonium concentrations ranging from 0.289 mg/l to 4.564 mg/l, with an average value of 1.98 mg/l. These values are higher than the limit value set by the WHO standard, which is 0.5 mg/l. Other studies have found similar results, such as that of Berrada et al [22], with a range of 0.935 to 4.03 mg/l, while Tahiri et al [19] found results in line with WHO standards.

Suspended solids (SS): Suspended solids are considered to be all the organic and mineral substances found in natural water or liquid effluents. Determining the concentrations of solids with a diameter greater than 0.45 μm enables us to identify the impact of polluted wastewater on the aquatic environment [34]. In our study, the analysis of the samples showed that the concentration of suspended solids ranged from a minimum of 86.23 mg/l to a maximum of 320.78 mg/l, with a total average value of 188.79 mg/l over six months. This result is higher than the limit value set by the WHO standard, which is 20 mg/l, and the Moroccan standard of 30 mg/l. These high levels of SS can have serious consequences for the environment, in the form of soil clogging and reduced light penetration into the water. Several studies have found similar results, such as that by Ameziane et al [35] at Mohamed V Hospital in Meknes, with an average concentration of 424.25 mg/l, and the study by Touzani et al [20] with an average concentration of 165.99 mg/l.

Chemical oxygen demand (COD): COD calculates the oxygen percentage required to carry out the oxidation reactions of organic and inorganic substances in wastewater. COD is a key indicator in the wastewater treatment process. It allows good control of the performance and quality of liquid effluent treatment. COD values can be used by those responsible for authorizing treatment plants to discharge this water into the aquatic environment [36]. In our study, the COD results show a range between 141.23 mg/l and 916.74 mg/l as the maximum value, with a total average value for six months of 508.79 mg/l. These results are higher than the Moroccan standard, which is 120 mg/l, and also the WHO standard, which is 90 mg/l. Several studies have found similar results, such as that by El ogri et al [25], with a total mean value of 3906 mg/l, and the study by El Mountassir et al [24], with a mean value of 1595.5 mg/l.

Biochemical oxygen demand for five days (BOD_5): BOD, also known as biological oxygen demand, corresponds to the oxygen percentage required for wastewater germs to degrade the organic matter suspended or dissolved in the wastewater, so it's the quantity of oxygen biologically consumed. This parameter is a good index of the presence of biodegradable organic matter in liquid effluents, the impact of which is a reduction in the percentage of dissolved oxygen, leading to asphyxiation of living creatures in the aquatic environment [37]. Analysis of the samples in our study showed that BOD5 values ranged from a minimum of 34.99 mg/l to a maximum of 32.65 mg/l, with a total mean value of 61,75 mg/l for the 30 samples analyzed. Other studies have found similar results, such as that by Nourdine et al [35]. with an average value of 738.5 mg/l, and the study by Touzani et al [20]. with an average of 489.11 mg/l.

COD/BOD5: The COD/BOD5 ratio is a good indicator of biodegradability, reflecting the capacity of organic matter to biodegrade, whether or not it is readily biodegradable. It can identify the level of wastewater pollution and give an idea of the physico-chemical parameters with the aim of determining an effective treatment method for this liquid effluent. The results found in our study show that this ratio varies between 4.74 as the minimum and 9.78 as the maximum average value, with a total average value of around 7.69. These results show that hospital wastewater is difficult to biodegrade, since all the values identified are greater than 3. Several studies have found similar results such as that of El Mountassir et al [24]. with a range of this ratio between 5.8 and 10.9, the study of Sarhane et al [38] with a variation ranging from 6.8 to 8.7. While the study by Touzani et al (2.13) [20]. and Tahiri et al (2.91) [19] found that these effluents are easily biodegradable with ratio values of less than 3.

Table 1: Variation in temperature, pH and conductivity values for hospital effluents

Month	Samples	Temperature	PH	Conductivity (µs/cm)
February	S.1	14,5	7,13	2736
	S.2	15,6	7,25	2885
	S.3	16,7	7,45	2956
	S.4	17,8	8,14	2839
	S.5	16,3	7,32	2795
	Average	16,18	7,46	2842
March	S.6	15,7	7,58	2934
	S.7	17,8	7,63	2441
	S.8	18,6	7,72	3521
	S.9	18,4	7,16	2864
	S.10	17,5	8,21	2761
	Average	17,6	7,66	2904
April	S.11	18,6	7,49	2947
	S.12	19,4	8,31	2976
	S.13	20,5	8,46	3167
	S.14	19,8	7,81	3249
	S.15	18,6	7,55	2837
	Average	19,38	7,92	3035
May	S.16	20,7	7,94	3451
	S.17	22,4	7,37	2976
	S.18	21,9	7,84	3549
	S.19	23,6	8,61	3372
	S.20	22,7	7,72	3428
	Average	22,26	7,89	3355
June	S.21	23 ,6	7,92	3745
	S.22	24,7	7,77	3834
	S.23	25,8	8,12	3467
	S.24	23,4	7,65	2869
	S.25	24,6	7,87	3471
	Average	24,42	7,86	3477
July	S.26	24,8	7,76	3759
	S.27	23,9	8,54	3546
	S.28	24,6	8,47	3972
	S.29	25,7	8,64	3491
	S.30	25,9	7,92	3857
	Average	24,96	8,26	3725
Maximum values		25,9	8,64	2441
Minimum values		14,5	7,13	3972
Maximum Admissible Value*		30°C	5,5-8,5	2700(µs/cm)
PH= Potential for Hydrogen. S = Sample				

(Limit value* International standards for wastewater discharge recommended by WHO1989 [17]).

Table 2: Variation in concentration of nitrogen compounds and sulphate in hospital effluent

Month	Samples	SO42- (mg/l)	NO3- (mg/l)	NO2- (mg/l)	NH4+ (mg/l)
February	S.1	59,53	11,23	0,023	0,323
	S.2	27,16	18,28	0,138	1,029
	S.3	175,71	24,75	0,236	1,189
	S.4	249,85	27,17	0,135	2,035
	S.5	30,31	19,42	0,042	1,125
	Average	108,51	16,17	0,114	1,140
March	S.6	193,75	7,35	0,008	0,824
	S.7	135,83	48,53	0,378	0,545
	S.8	57,62	42,24	0,169	0,642
	S.9	277,48	47,21	0,475	1,436
	S.10	126,53	46,58	0,263	0,869
	Average	158,24	31,98	0,281	0,863
April	S.11	361,62	57,09	0,387	2,263
	S.12	215,42	58,32	0,495	0,764
	S.13	467,53	49,56	0,287	0,323
	S.14	117,82	52,12	0,394	0,289
	S.15	278,64	64,62	0,453	0,934
	Average	288,20	46,95	0,403	0,914
May	S.16	88,73	48,93	0,521	1,963
	S.17	144,41	62,56	0,638	2,134
	S.18	253,91	37,75	0,432	1,632
	S.19	301,61	42,45	0,745	3,203
	S.20	196,72	27,75	0,583	2,256
	Average	197,07	36,57	0,583	2,237
June	S.21	426 ,68	61,64	0,857	1,431
	S.22	498,72	29,14	0,723	4,421
	S.23	275,82	39,15	0,934	3,178
	S.24	196,43	41,75	0,826	3,279
	S.25	364,62	62,69	0,865	3,148
	Average	356,05	39,06	0,841	3,091
July	S.26	131,86	45,82	0,983	2,769
	S.27	207,92	61,51	1,248	4,564
	S.28	172,18	33,84	0,874	3,214
	S.29	297,71	29,78	0,978	4,063
	S.30	203,15	25,94	0,958	3,703
	Average	202,56	32,81	1,008	3,662
Maximum values		498,72	61,64	1,248	4,564
Minimum values		27,16	7,35	0,008	0,289
Maximum Admissible Value*		500 mg/l	30mg/l	0,5mg/l	0,5mg/l

(Limit value* International standards for wastewater discharge recommended by WHO1989 [17]).

Table 3: Variation in concentrations of BOD5, COD and SS in hospital effluent

Month	Samples	BOD (mg/l)	COD (mg/l)	SS mg/l
February	S.1	36,25	141,23	86,23
	S.2	34,22	174,38	92,29
	S.3	32,65	149,36	105,18
	S.4	38,14	177,35	88,35
	S.5	33,72	161,42	91,25
	Average	34,99	160,74	92,66
March	S.6	46,25	243,38	95,84
	S.7	43,55	277,38	125,54
	S.8	47,22	266,19	134,62
	S.9	48,39	316,45	150,46
	S.10	46,67	277,23	125,86
	Average	46,41	276,12	126,46
April	S.11	54,19	383,38	132,63
	S.12	55,35	446,45	168,74
	S.13	50,46	408,28	170,33
	S.14	59,52	421,34	181,29
	S.15	55,69	415,45	162,94
	Average	55,04	414,98	163,18
May	S.16	54,93	508,51	131,63
	S.17	49,16	432,38	169,13
	S.18	66,35	518,32	211,32
	S.19	73,75	625,45	237,23
	S.20	59,72	522,53	188,26
	Average	60,78	521,43	187,51
June	S.21	75,35	761,57	311,31
	S.22	85,17	815,23	290,21
	S.23	79,12	684,34	320,78
	S.24	88,25	876,26	228,79
	S.25	81,41	786,65	289,48
	Average	81,86	784,81	303,75
July	S.26	85,32	837,83	190,69
	S.27	96,54	913,48	257,64
	S.28	94,64	916,74	305,24
	S.29	89,78	911,78	283,63
	S.30	90,84	893,58	258,73
	Average	91,42	894,68	259,18
Maximum values		96,54	916,74	320,78
Minimum values		32,65	141,23	86,23
Maximum Admissible Value*		30 mg/l	120 mg/l	30mg/l

*Joint order no. 2942-13 of 07 October 2013 [33].

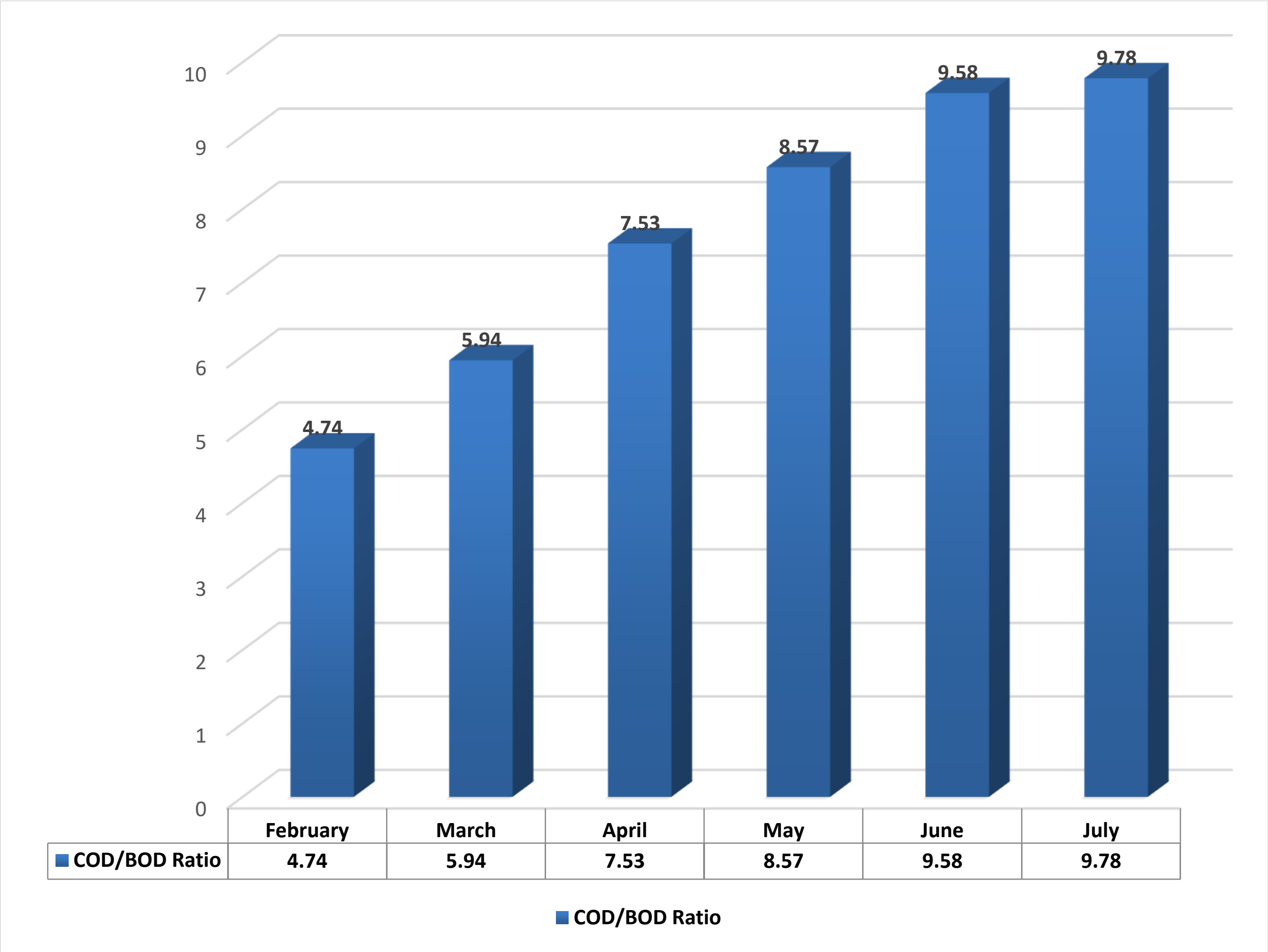

Figure 1: Evolution of the biodegradability rate over the study period.

4. Conclusions

The results of our study show that this hospital wastewater is loaded with chemical, physical and biological pollutants. The diagnosis reveals that this effluent is discharged directly into the public sewage system without any prior treatment, which can have a very harmful impact on the aquatic environment, as follows: pollution of surface water and groundwater, leading to serious health risks for animals and people, and destruction of ecosystems, as the chemical pollutants contained in hospital effluent can disrupt the natural biodegradation process. It was therefore necessary for those in charge to be aware of this problem and to set up facilities for the possible treatment of this hospital effluent before it is discharged into the public sewage system, in order to reduce its environmental impact.

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Conflicts of Interest

The authors declare that there is no conflict of interests.

Ethical approval

All ethical procedures have been respected and our study has been validated by a provincial ethics commission.

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