

Analysis of Physico-Chemical and Bacteriological Parameters of Liquid Effluents from the Provincial Hospital Center in Sidi Kacem Morocco

Elouakfaoui Aziz¹, Mahjoub Aouane², Rouani Abdeljabbar³, Berrid naby⁴

¹PhD Student, ²University Professor, ⁴PhD Student, Laboratory of Natural Resources and Sustainable Development Ibn Tofail University, Department of Biology Faculty of Science Kenitra, Morocco,

³PhD Student, Laboratory of Materials and Subatomic Physics Ibn Tofail University, Department of Physics Faculty of Science Kenitra, Morocco

Abstract

Background: The effluents generated by the hospital activities and which are rejected into the municipal sewerage system without any prior treatment, present a chemical, biological and physical risk for public and environmental health. They cause a degradation of the aquatic ecosystem, and favor the propagation of antibiotic resistant germs. **Objective:** The aim of this study is to carry out physico-chemical and bacteriological analysis of the effluents of the provincial hospital of Sidi Kacem in Rabat-Salé-Kénitra region, Morocco, in order to evaluate the degree of wastewater pollution and to reduce its environmental impact.

Methods: 24 samples of wastewater were collected from the Hospital's main sewer according to Moroccan Norm NM 03.7.059 and transported to the Provincial Laboratory of Epidemiology and Environmental Health (LPEHM) for analysis. These analyses were conducted according to the requirements and methods recommended by Rodier 1996 and 2009.

Results: The results of the bacteriological analysis showed a very high bacterial load of fecal coliforms ($36,7.10^4$ CFU/100 ml), total coliforms (40.10^4 CFU/100 ml), and fecal streptococci (21.10^4 CFU/100 ml). The physicochemical parameters revealed a significant load of organic and mineral matter expressed in terms of nitrates (41,59 mg/l), nitrites (0,53 mg/l), sulphates (222,75 mg/l), ammonia (1,95 mg/l), electrical conductivity (3202 μ s/cm), hydrogen potential PH (7.82), all of which are well above the upper limit stipulated by the regulations. The COD/BOD5 ratio (7.66) higher than 3 means that these effluents are hardly biodegradable.

Conclusion: These results show that hospital effluent is loaded with mineral, organic and bacteriological pollutants and requires a monitoring system and pre-treatment before they are discharged into the municipal sewers.

Key words: Hospital effluent, bacteriological analysis, physicochemical, environmental impact.

Corresponding author:

Elouakfaoui Aziz:

PhD Student Laboratory of Natural Resources and Sustainable Development Ibn Tofail University,

Faculty of Science Kenitra, Morocco

Email : elouakfaouiaziz@gmail.com

Mobile No:+212614389623

Introduction

Water is much more than a simple human need. It is an essential and irreplaceable element for the continuity of life. Since the end of the last century, problems related to water scarcity and pollution have

arisen worldwide⁽¹⁾.

In Morocco, as in most African and Mediterranean countries, the scarcity and/or high cost of water and fertilizers make the use of raw wastewater for irrigation an alternative of choice for farmers. This is a very old practice throughout the world⁽²⁾. Every year, more than 7000 ha are irrigated directly with raw wastewater discharged from cities, or about 70 million m³/year of wastewater reused in agriculture without any prior treatment⁽³⁾.

This practice has a negative impact on the environment and human health. These impacts are further exacerbated when domestic wastewater receives special effluents such as hospital effluents. These have the reputation of being very dangerous because of the micro-organisms they could disseminate; the danger is rather linked to the antibiotic resistance of some bacteria. On the other hand, in quantitative terms, a 1000-bed hospital would be polluting as a city of 10000 habitants⁽⁴⁾.

The hospitals have an important demand for drinking water, whereas in a domestic environment the consumption is 150 to 200 L per habitant per day, in hospitals the average value is 400 to 1200 L. This important consumption of water gives rise to large volumes of waste water loaded with pathogenic microorganisms^{(4),(5)}.

The hospital effluents are polluted waters produced by different medical units. They are represented by domestic, chemical, pharmaceutical and radioactive discharges, and also discharge from laboratory and care rooms. These different sources give rise to hybrid liquid discharges, both domestic and industrial, which are very specific to medical care and research activities⁽⁶⁾.

Many biological and chemical contaminants in significant quantities are transported by hospital wastewater such as viruses, bacteria, endocrine disrupting compounds, radioelements, residual pharmaceuticals, and active residues of hygiene

products and other molecules^{(7),(8)}. Some of these substances persist even after advanced treatment of wastewater by sewage treatment plants, and can contribute largely to the spread of antimicrobial resistant bacteria and genes⁽⁶⁾.

The municipal wastewater treatment stations are not designed to treat medicinal and biological waste. In this context, the problem of hospital effluent discharge is becoming increasingly important⁽⁹⁾.

The liquid hospital discharges threaten the environment much more than urban effluents⁽¹⁰⁾. These discharges are nowadays in the center of the preoccupations of all the health actors and those of the environmental protection, because they constitute a potential source of the transmission of infections and epidemic diseases⁽¹¹⁾.

To confront the problem of hospital wastewater, the objective of this study is to analyse the physicochemical and bacteriological parameters of the liquid effluents in the provincial hospital of Sidi Kacem in order to make more conscious of the importance to treating them before they are discharged into the public sewage system, in the aim of reducing their environmental impact.

Materials and Methods

Presentation of the study site

Sidi Kacem is a medium-sized city in the northwest of Morocco in the Rabat-Salé-Kénitra region, its population numbers are 90000 (according to 2015 census). far from Meknes with (45 km), Tanger (210 km), Fez (85 km) and Rabat (120 km), located next to the Rdoom river coming from Meknes and crossing the great fertile plain of Gharb, the province of Sidi Kacem covers an area of 4060 km² (5,7% of the national area)⁽¹²⁾.

The provincial hospital of Sidi Kacem is a multidisciplinary health establishment. It was built in 1986, on a total area of 7 hectares, with a capacity of 210 beds, organised in 7 departments and several

services, its water consumption is estimated at 260 m³ / day with a rate of 1.90 m³ / day / bed. The hospital's sewage network contains several collectors, draining the discharges of various departments.

Type of study

This is a prospective study carried out in the provincial hospital of Sidi Kacem with the objective of carrying out physicochemical and bacteriological analyses of the liquid effluents of the different hospital services

Sampling methods and frequency

This study was carried out in a period of 6 months from March the first to August thirty-one with a frequency of 4 samples per month, one sample per week every Monday at 12 o'clock, with a total of 24 samples. the samples were collected from the principal sewer, in appropriate bottles of 500 ml according to the Moroccan Norm NM 03.7.059⁽¹³⁾ and transported in an icebox maintained in a temperature of 4°C to the provincial laboratory of epidemiology and environmental hygiene (LPEHM) for analysis.

Sample analysis:

Physicochemical analysis

The temperature measurement was carried out at the time of sampling, while the other analyses were carried out at the provincial laboratory of epidemiology and environmental hygiene (LPEHM) according to the recommendations of Rodier 1996⁽¹⁴⁾ and 2009⁽¹⁵⁾. The physicochemical analyses concerned the measurement of hydrogen potential (pH), temperature, electrical conductivity at 20°C,

nitrate (NO₃⁻), nitrite (NO₂⁻), sulphate (SO₄²⁻), ammonia (NH₄⁺), suspended solids (SS), chemical oxygen demand (COD), biochemical oxygen demand (BOD5). A calibration for all parameters and a control of all factors affecting the quality of the analyses, were carried out according to the requirements and procedures described by the NM ISO 17025 adopted by the LPEHM.

Bacteriological Analysis

These analyses were carried out according to the requirements and methods recommended by Rodier 1996⁽¹⁴⁾ and 2009⁽¹⁵⁾, and conjoint decree no. 2942-13 of 07 October 2013⁽¹⁶⁾. The culture media used were prepared according to the norm and respecting rigorous procedures of quality. Before using the culture media, a control plate with a suitable temperature for each type of media was checked for 24 hours. a Regular and daily quality control of reagents, distilled water, materials and equipment, autoclaving operation as well as the ambient conditions of the environment (temperature and humidity measurement) was performed.⁽¹⁷⁾

Statistique Tools

All the information was entered and processed using the Excel program.

Results and discussion

Physicochemical parameters:

The results of the physicochemical analysis for each parameter are presented in the figures: 1, 2, 3, and 4. The values shown represent the average of four samples taken during the same month.

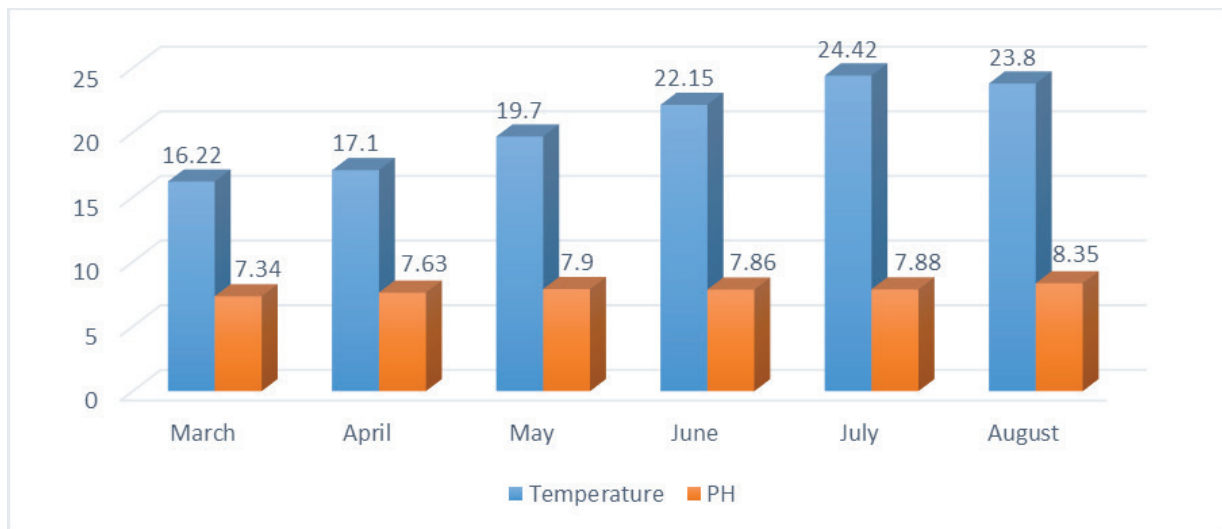


Figure 1: Variation the average of temperature and pH values of hospital effluents.

Temperature: In our study, the average temperature values of the wastewater from the different samples taken show a variation ranging from 16,22°C to 23,8°C, with a total average value of 20,56°C. This observed temperature variation is closely linked to the climatic change and the seasonal periods, and is suitable for the development of micro-organisms and the phenomenon of self-purification of wastewater. These results is conform to the WHO standards (1989) which fix the maximum temperature at 30°C. However, these results are comparable to those reported by : Touzani and al with a temperature of 20.79 °c⁽¹⁸⁾ and Tahiri and al at El Ghassani

Hospital in Fez with a value of 17.11 °C ⁽¹⁹⁾.

Hydrogen Potential (pH): The analysis of the wastewater samples shows an average of pH values between 7.50 and 8.35. This interval is slightly alkaline, and can have harmful consequences for the environment, the suitable interval of pH for the aquatic environment is between 6 and 7.2. These results are in conformity with the Moroccan norms ranging between 6.5 and 8.5. However, the pH values reported are higher than those found by Touzani and al in Taza hospital⁽¹⁸⁾ and similar to those found by Berrada and al ⁽¹⁷⁾

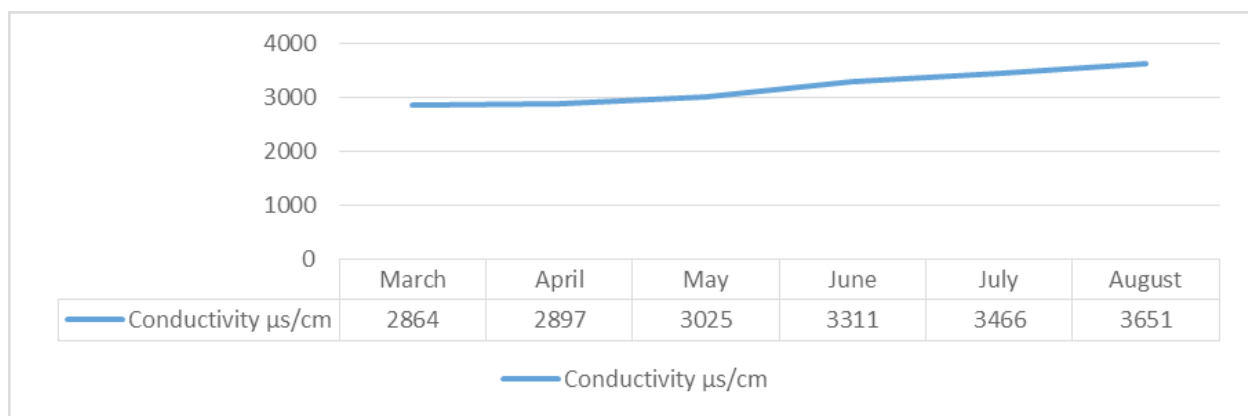


Figure 2: variation in the conductivity during the study period.

Electrical conductivity (EC): The average values of electrical conductivity recorded in the wastewater during the six month study period showed values between 2864 $\mu\text{s}/\text{cm}$ and 3651 $\mu\text{s}/\text{cm}$, these results exceed the upper limit stipulated by the regulation which is 2700 $\mu\text{s}/\text{cm}$ ⁽²⁰⁾, and similar to those found

by Berrada and al with the values ranging from 3340 $\mu\text{s}/\text{cm}$ to 3560 $\mu\text{s}/\text{cm}$ ⁽¹⁷⁾, and El Mountassir and al with the values ranging from 5202 to 8940 $\mu\text{s}/\text{cm}$ ⁽²¹⁾. While Bouchaib and al⁽²²⁾ and El ogri and al⁽²³⁾ found a result below the norm, with 1500 $\mu\text{s}/\text{cm}$ and 1195.60 $\mu\text{s}/\text{cm}$ respectively.

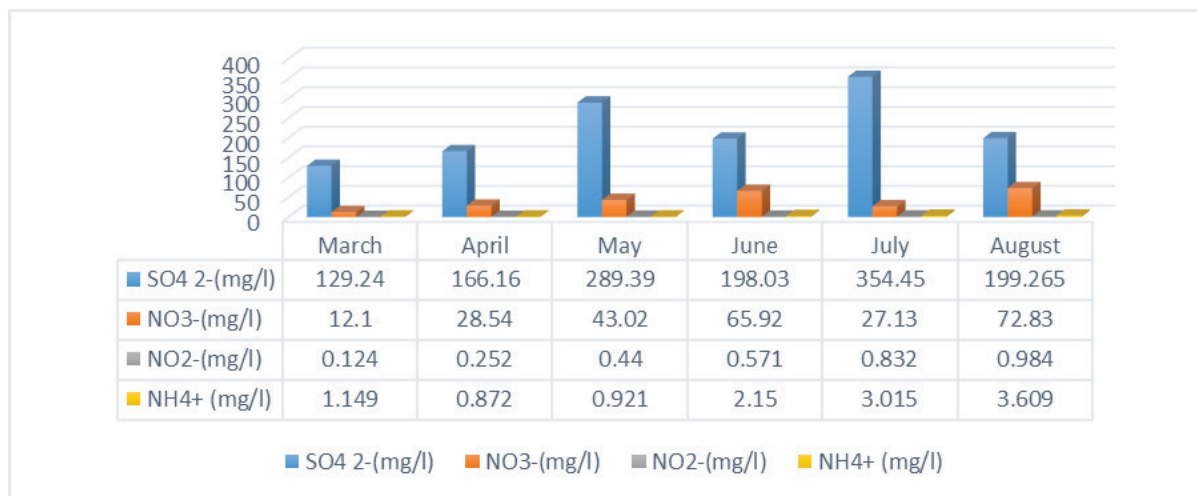


Figure 3: Concentration of nitrogen compounds and sulphate in wastewater.

Sulphates (SO₄²⁻): The average concentration of sulphates in the samples analyzed in our study ranged from 129.24 mg/l to 354.45 mg/l, with a total average value for six months of around 222.75 mg/l, these results do not exceed the limit value set by the regulations (500 mg/l)⁽¹⁶⁾.

Nitrates (NO₃⁻): In our study, the nitrate concentration in the samples analyzed showed values ranging from 12.1 to 72.83 mg/l with a total average value of 41.59 mg/l. These results exceed the limit value set by Moroccan norms (30 mg/l)⁽¹⁶⁾. **Nitrites (NO₂⁻):** The concentration of nitrites in the analyzed samples showed values ranging from 0.124 to 0.984 mg/l, exceeding the maximum value set by the national

regulation which is 0.5 mg/l⁽¹⁶⁾. Similar results were found by El Mountassir and al⁽²⁴⁾ on the other hand Touzani and al found a result in conformity with the regulation⁽¹⁸⁾.

Ammonia (NH₄⁺): The presence of a large quantity of ammonia NH₄⁺ in water indicates an incomplete degradation process of organic matter, which is a contamination indicator of the water by human discharges, probably due to the transformation rate of urea into ammonia⁽²⁵⁾. The results of the analyzed samples are between 0.872 and 3.609 mg/l, these concentrations are very high compared to the WHO standard of 0.5 mg/l, and are similar to that of Berrada and al with concentrations ranging from 0.935 to 4.03 mg/l⁽¹⁷⁾

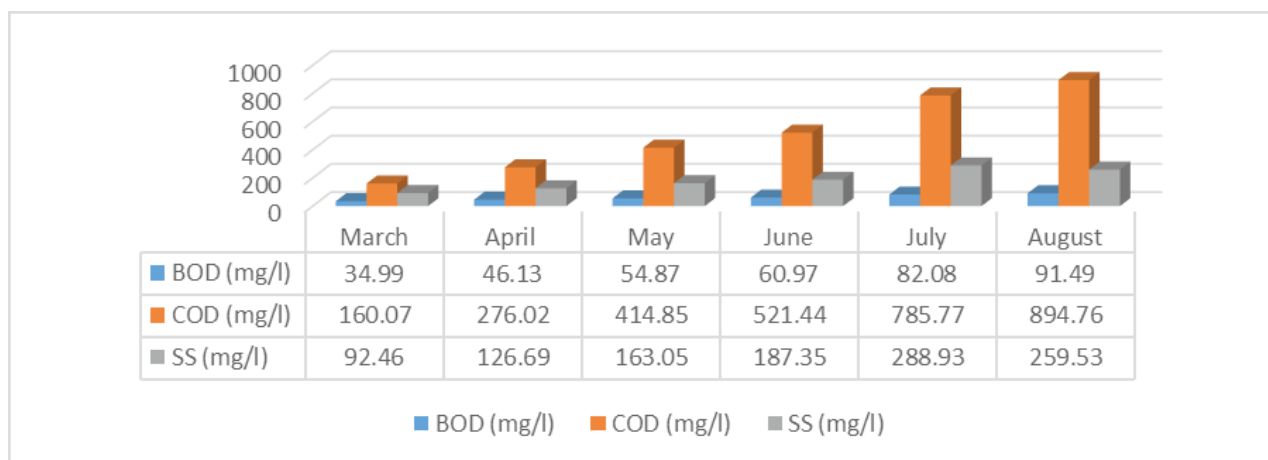


Figure 4: Variation in BOD5, COD and SS concentrations of hospital effluent.

Suspended solids (SS): Represent all mineral and organic particles contained in the wastewater. The knowledge of the concentration of colloidal elements in wastewater is necessary to evaluate the impact of pollution on the aquatic environment⁽²⁶⁾. The average values found in our study are between 92.46 and 259.53 mg/l, these values largely exceed the WHO standard which is 20 mg/l, and the Moroccan norm of 30 mg/l, these high concentrations can have a very harmful impact on the environment through the soil clogging and the reduction of the light penetration in the water⁽¹⁵⁾. These results can be explained by the increased hospital activity during the study period. Our results are similar to those found by Touzani and al with an average of 165.99 mg/l⁽¹⁸⁾, Nourdine and al at Mohamed V hospital in Meknes with 424.25 mg/l⁽²⁷⁾.

Chemical Oxygen Demand (COD): COD measures the quantity of oxygen necessary to oxidize the organic and inorganic oxidizable matter contained

in an effluent⁽¹⁵⁾. The average values of COD recorded during the six months of the study show an evolution between 160.07 and 894.76 mg/l with a total average value of 508.81 mg/l, which largely exceeds the Moroccan norm fixed at 120 mg/l⁽¹⁶⁾, and the WHO norm which is 90 mg/l, These recorded values are similar with those found by : El Mountassir and al with an average of 1593.5 mg/l⁽²¹⁾, and El ogri and al with an average of 3901 mg/l⁽²³⁾.

Biochemical oxygen demand (BOD5): BOD5 measures the quantity of biodegradable organic matter in the water. This biodegradable organic matter is evaluated by the consumption of oxygen by the microorganisms involved in natural purification mechanisms⁽¹⁾. The results found show an evolution of the average values between 34.99 and 91.49 mg/l with a total average value of 61.75 mg/l in the six months of study, which is higher than the WHO standard of 30 mg/l, and comparable to other results found by : Touzani and al with an average of 488.11 mg/l⁽²⁶⁾, and Nourdine and al with a value of 737.5 mg/l⁽²⁷⁾.

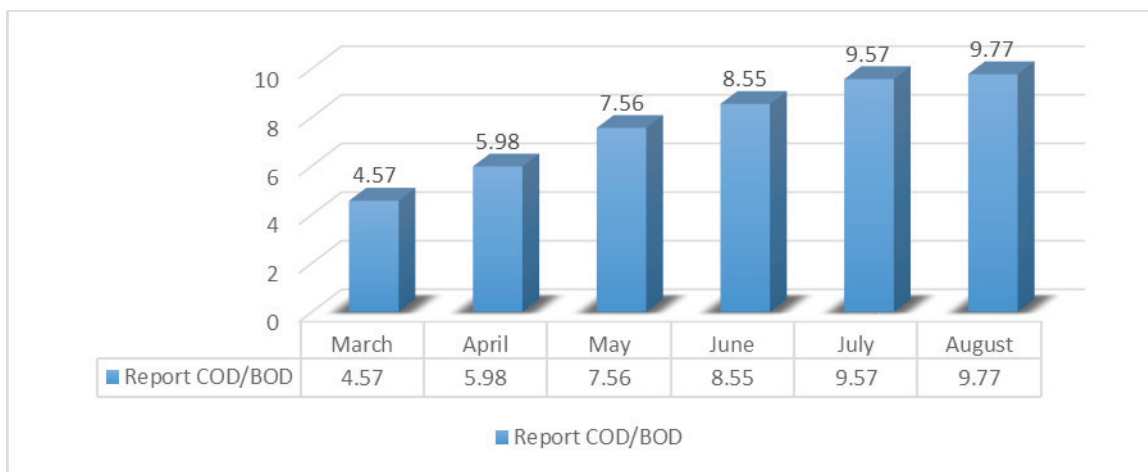


Figure 5: Variation of the biodegradability report during the study period.

COD/BOD5: The COD/BOD5 report makes it possible to estimate the biodegradability of the organic matter, to determine the degree of pollution and to optimize the physicochemical parameters of effluent, in order to propose an adapted treatment (28). In our study the result of the average values of this report is between 4.57 and 9.77, with a total average value of six months at about 7.66, this value higher than 3 means that these effluents are hardly biodegradable. Other studies have similar results: Sarhane and al with

an interval between 6.5 and 8.21(29), and El Mountassir and al with values ranging from 5.7 to 10.85 (21), on the other hand Tahiri and al(19) and Touzani and al (18) found results lower than 3: 2.83 and 2.10 respectively.

Bacteriological parameters:

The germs sought, identified and counted in the effluents are firstly fecal coliforms, total coliforms, fecal streptococci, staphylococci and clostridium. The results obtained are presented in figures 6 and 7.

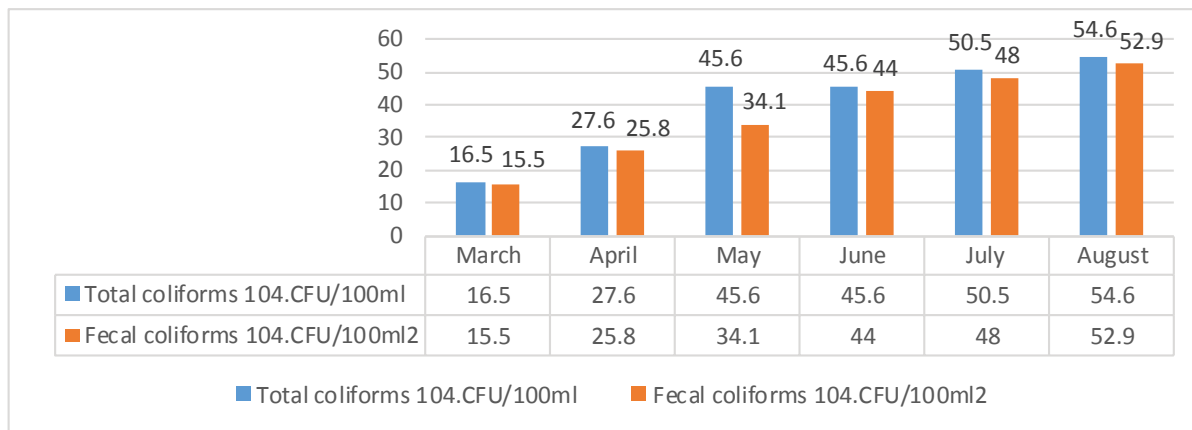


Figure 6: Concentration of total and fecal coliforms in hospital effluent.

Fecal coliforms: The fecal coliforms could provide information on the ecotoxicity rate of the studied effluent. The concentration of fecal coliforms can be an indicator of the degree of water pollution

and also an indirect indicator of the presence or absence of antibiotics or disinfectants.(21) In our study the average concentration of fecal coliforms found in the provincial hospital of Sidi Kacem is 36,7.

10^4 CFU/100 ml, largely exceeds the limit values recommended by the WHO of 1000 CFU/100 ml, is also comparable with different studies, for example: El Mountassir and al with values between $39,1.10^4$ and 45.10^4 CFU/100 ml ⁽²¹⁾, Nourdine and al with an average of $7,44.10^7$ CFU/100 ml ⁽²⁷⁾, on the other hand Evens Emmanuel found a value of 2.10^3 CFU/100 ml ⁽⁵⁾.

Total coliforms: The total coliforms are enterobacteria that include bacterial species that live in the intestine, but also in the environment (soil,

vegetation and water). This bacterial group is used as an indicator of the microbial quality of water because it contains bacteria of fecal origin, such as Escherichia coli. ⁽¹⁾ In our study, the samples analyzed showed the presence of total coliforms with a proportion ranging from $16,5.10^4$ to $54,6.10^4$ CFU/100 ml, with a total average value of 40.10^4 CFU/100 ml, this value largely exceeds the limit values recommended by the WHO of 1000 CFU/100 ml, and similar with other results: El Ogri and al with a value of $3,9.10^7$ CFU/100 ml ⁽²³⁾, Touzani and al with an average of $2,95.10^4$ CFU/100 ml ⁽¹⁸⁾, and Tahiri and al with 2.10^4 CFU/100 ml ⁽¹⁹⁾.

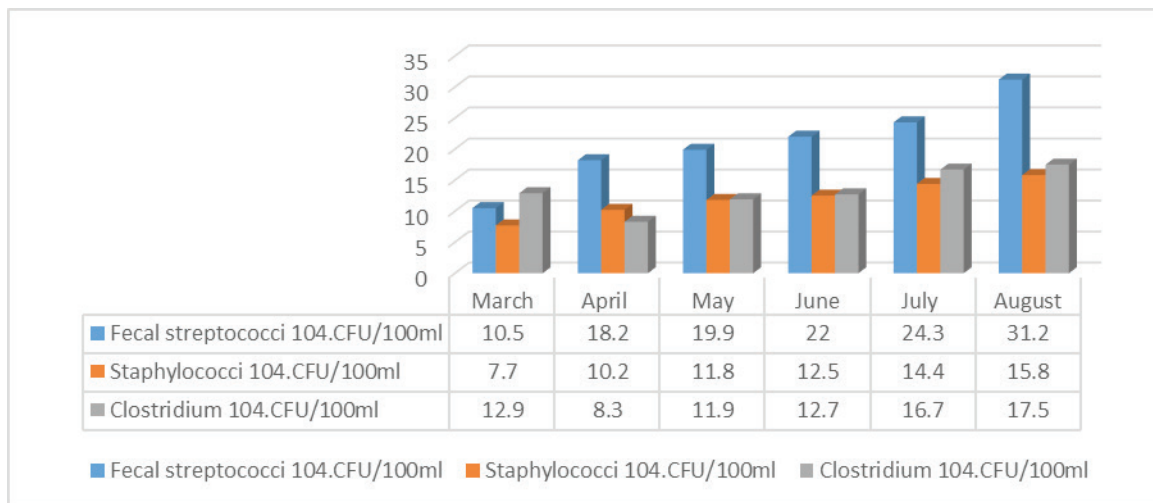


Figure 7: Concentration of Fecal streptococci, staphylococci and clostridium in the effluent.

Fecal streptococci: In our study, the analysis of the samples showed an evolution of the values of fecal streptococci ranging from $10,5.10^4$ to $31,2.10^4$ CFU / 100 ml, this progressive increase in the concentrations of streptococci is justified by the nature of the care provided, the infectious diseases received and the increase in the flow of patients during the period of the study. The average total value was $21,10^4$ CFU/100 ml. These results are similar to those found by: Nourdine and al with an average of $2,28. 10^6$ CFU/100 ml ⁽²⁷⁾. On the other hand, Tahiri and al found results between $1,1.10^3$ CFU/100 ml and $2,1.10^4$ CFU/100 ml ⁽¹⁹⁾.

Staphylococci: The analysis of the samples revealed a concentration of staphylococci between

$7,7.10^4$ and $15,8.10^4$ CFU / 100 ml, these results showed a progressive increase, with a total average value of 12.10^4 CFU / 100 ml, and comparable with those found by : Nourdine and al with an average of $3,6.10^7$ CFU/100ml ⁽²⁷⁾, and Boillots and al which is in the order of $6,08.10^2$ CFU/100 ml ⁽³⁰⁾. This could be explained by the low consumption of water, cleaning products, disinfectants and detergents by the hospital ⁽²⁷⁾.

Clostridium: The analysis of the samples showed the presence of clostridium with proportions ranging from $8,3.10^4$ to $17,5.10^4$ CFU / 100 ml. These values show an evolution of the concentration during the study period. The total average value of clostridium

is in the order of 13,33. 10⁴ CFU / 100 ml. Similar results were found by Nouridine and al with a variation ranging from 10. 10⁴ to 60. 10⁴ CFU / 100 ml⁽²⁷⁾. The clostridium is known for its high resistance to disinfection and they can survive in water much longer than coliforms. This resistance could explain their concentration in hospital effluents⁽²¹⁾.

Conclusion

In this study, it was found that hospital effluents are heavily loaded with physical, chemical and biological pollutants. We therefore hope, in the light of the results obtained by this study, to have generated a real awareness in the competent and responsible authorities to create a system for treating hospital effluents such as in developed countries. because the impact of these effluents on human and environmental health is very harmful and can lead to serious consequences.

Conflicts of Interest: All authors have no conflict interest to declare.

Source of Funding: The source of the research cost from self.

Ethical Clearance: Nil

References

1. El ouali Alami Adil. Caractérisation physico-chimique des effluents d'hémodialyse avant traitement. Université sidi mohamed ben abdellah faculté des sciences et techniques département de chimie; 2014.
2. Drapeau AJ, Jankovic S. Manuel de microbiologie de l'environnement. École polytechnique (Montréal Québec), Organisation mondiale de la santé; 1992.
3. Mokhtar Bzioui. Rapport national sur les ressources en eau au Maroc. UN Water Africa. 2004;94.
4. Darsy C, Lescure I, Payot V, Rouland G. Effluents des établissements hospitaliers : teneur en microorganismes pathogènes, risques sanitaires, procédures particulières d'épuration et de gestion des boues. 2002;
5. Evens E, Perrodin Y, Blanchard J-M, Keck G, Vermande P. Approche méthodologique de l'évaluation des risques écotoxicologiques des effluents hospitaliers vis-à-vis de la Step locale et de l'écosystème aquatique récepteur. Revue francophone d'écologie industrielle. 2004;
6. Bessila Chaima, Meghraoui Rayene. Evaluation Bactériologique des eaux usées hospitalières du CHU de Constantine prélevées à partir de la station de relevage Sidi M'cid. Université des Frères Mentouri Constantine Faculté des Sciences de la Nature et de la Vie Département : Microbiologie; 2018.
7. Kümmerer K. Drugs in the environment: emission of drugs, diagnostic aids and disinfectants into wastewater by hospitals in relation to other sources – a review. Chemosphere. nov 2001;45(6-7):957-69.
8. Drechsel P, Christopher A, Scott, Liqa, Raschid-Sally, Mark Redwood, Akiça Bahri, éditeurs. L'irrigation avec des eaux usées et la santé: évaluer et atténuer les risques dans les pays à faible revenu. Presses de l'Université du Québec; 2011.
9. Clotilde Boillot. Evaluation des risques écotoxicologiques liés aux rejets d'effluents hospitaliers dans les milieux aquatiques. Contribution à l'amélioration de la phase « caractérisation des effets ». 2008;298.
10. Verlicchi P, Al Aukidy M, Galletti A, Petrovic M, Barceló D. Hospital effluent: Investigation of the concentrations and distribution of pharmaceuticals and environmental risk assessment. Science of The Total Environment. juill 2012;430:109-18.
11. Loi n°28-00 relative à la gestion des déchets et à leur élimination promulguée par le dahir n° 1-06-153 du 30 chaoual 1427 (22 Novembre 2006). (B.O. n° 5480 du 7 décembre 2006).

12. Description de la ville de Sidi Kacem. In: Wikipédia [Internet]. 2021 [cité 3 juin 2021]. Disponible sur: https://fr.wikipedia.org/w/index.php?title=Sidi_Kacem&oldid=181230795
13. Norme Marocaine NM 03.7.059. Essais des eaux - Echantillonnage guide général pour la conservation et la manipulation des échantillons. 1997.
14. Rodier J, Bazin C, Broutin J.P, Chambon P, Champsaur H, Rodi L. L'analyse de l'eau : eaux naturelles, eaux résiduaires, eau de mer, 8ème édition. Dunod, Paris, France. 1996.
15. Rodier J, Bazin C, Broutin J.P, Chambon P, Champsaur H, Rodi L. L'Analyse de l'eau. 9ème Edition. Dinod. Paris, France. 2009.
16. Arrêté conjoint du ministère de l'intérieur, du ministère de l'énergie et des mines de l'eau et de l'environnement, du ministère de l'industrie et de commerce et des nouvelles technologies et du ministère de l'artisanat n° 2942-13 du 07 octobre 2013 fixant les valeurs limites générales de rejet dans les eaux superficielles et souterraines. Bulletin officiel; 2013.
17. Berrada S, Squalli FZ, Squalli HT, Hannin M, Oualti AE, Lalami AEO. Recyclage des effluents du service d'hémodialyse de l'hôpital Al Ghassani de la ville de Fès : caractérisation avant et après traitement. 2014;13.
18. Machkor M, Boudouch O, Machrafi IE, Flouchi R, Fikri-Benbrahim K. Evaluation of physicochemical and bacteriological parameters of effluents in Taza hospital Morocco application of principal component analysis (PCA). 2020;8.
19. El Mehdi Tahiri, Lahcen Benaabidate, Chakib Nejjari, Kawtar Fikri Benbrahim. Caractérisation des effluents liquides de l'hôpital Al Ghassani, CHU Hassan II de Fès, Maroc. 2008.
20. Health Guidelines For the Use of Wastewater in Agriculture and Aquaculture. World Health Organization Technical Report Series 778, Geneva. 1989.
21. Mountassir RE, Bennani B, Merzouki H, Touimi GB, Boumchita S, Benjelloun Y, et al. Characterization of the chemical and bacteriological risks of the effluents from some services of the Hassan II Hospital Center in Fez. 2017;8.
22. Bouchaib S, Messaad SA, Khallaf M, Rhaouat OE, Belghyti D. Caractérisation physicochimique et bactériologique des effluents liquides de deux grands hôpitaux de la région de Rabat Salé Zemmour Zaer. 2014;9(4):7.
23. Fouzia El-Ogri, Naaila Ouazzani, Fatima Boraâm, Laila Mandi. A survey of wastewaters generated by a hospital in Marrakech city and their characterization. Desalination and Water Treatment. 2016;16.
24. Mountassir RE, Bennani B, Merzouki H, Touimi GB, Boumchita S, Benjelloun Y, et al. Characterization of the chemical and bacteriological risks of the effluents from some services of the Hassan II Hospital Center in Fez. 2017;8.
25. Derwich E, Benaabidate L, Zian A, Sadki O, Belghyti D. Caractérisation physico-chimique des eaux de la nappe alluviale du haut sebou en aval de sa confluence avec oued fes. Larhyss journal, issn 1112-3680, n° 08, pp. 101-112; 2010.
26. Touzani I, Machkor M, Boudouch O, El Machrafi I, Flouchi R, Fikri-Benbrahim K. Environmental Impact Assessment of Taza City's Wastewater: Application through Principal Component Analysis. Scientifica. 30 nov 2020;1-7.
27. Nouredine A, Abdelaziz K, Lahcen B. Effet de l'épuration par électrocoagulation sur la pollution des effluents de l'hôpital Mohamed v de Meknès. 2013;18.
28. Carraro E, Bonetta Si, Bertino C, Lorenzi E, Bonetta Sa, Gilli G. Hospital effluents management: Chemical, physical, microbiological risks and legislation in

- different countries. *Journal of Environmental Management*. mars 2016;168:185-99.
29. Sarhane B, Tantane A, Rhaouat OE, Ouardi AE, Kharim KE, Belghiti D. Evaluation of biological and physicochemical risk of hospital liquid waste in Morocco. *IJOEAR*. 30 nov 2017;3(11):80-4.
30. Dagot C, Mezzanotte V, Perrodin Y, Gourdon R, Martel L, Tissot-Guerraz F, et al. Évaluation des risques écotoxicologiques liés aux rejets d'effluents hospitaliers dans les milieux aquatiques. Contribution à l'amélioration de la phase. 2008;299.