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Physico-Chemical Characterization of Medical Solid Waste Leachate: Case of the Hospital de l'Amitié of Nouakchott, Mauritania

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ABSTRACT

At the Hospital de l'Amitié, hospital waste corresponds to a mixture of waste assimilated to household waste and the waste from healthcare activities with infectious risks. In the context of hospital hygiene, the conducted study focuses on the impact of this hospital waste on the people of the Hospital de l'Amitié and the environment, and their handling of hospital waste (collection and transport). From an environmental point of view, the physico-chemical characterization of the leachate leaving submerged waste in three media (drinking water, distilled water and alcoholic distilled water) show high concentrations for most of the parameters studied. Physico-chemical characterization of solid waste from Hospital de l'Amitié in Nouakchott (Mauritania) was carried out from September to December 2020. The objective was to determine the value of 14 parameters (pH, temperature, turbidity, electrical conductivity, COD, BOD_5, COD/BOD_5, BOD_5/COD, SS/BOD_5, SS, nitrite, nitrate, sulfate and phosphorus), and improve the treatment method for this solid waste by immersing it in three different mediums (drinking water, distilled water and alcoholic distilled water). Among the 14 parameters, seven exceeded the Moroccan and WHO standards for medium 1, 2 and 3 respectively, conductivity (5340.00 µs/cm, 5820.00 µs/cm and 3550.00 µs/cm), BOD_5 (122.00 mg/L, 106.00 mg/L and 142.00 mg/L), BOD_5/COD (2.30, 1.93 and 2.88), SS (1000.00 mg/L, 600.00 mg/L and 600.00 mg/L), nitrite (0.91 mg/L, 25.00 mg/L and 45.00 mg/L), nitrate (210.00 mg/L, 200.00 mg/L and 110.00 mg/L) and sulfate (1000.00 mg/L, 2000.00 mg/L and 1000.00 mg/L). These results indicate the existence of toxic substances in these leachates that may impact the environment. In addition, the study proposes solid waste treatment from the Hospital de l'Amitié in Nouakchott (Mauritania) before its discharge into the natural environment. This observation is consolidated by the analyses carried out on the leachate of the waste immersed in three aqueous media (drinking water, distilled water and alcoholic distilled water).

Keywords: hospital waste, impact, environment.

INTRODUCTION

Industrial development and medical technology lead to an increase in the production of different types of waste that pose a serious threat to humans and the environment (Benhaddou et al., 2019). All hospitals produce waste, which is generally classified into two categories, namely waste from health care activities with infectious risks and medical waste (Kasuku et al., 2016). According to the World Health Organization (PNUE et al., 2004), a large proportion of waste from health facilities (typically 75-90%) is general waste and can be considered to pose no greater risk than ordinary household waste, provided it is strictly separated from the potentially hazardous fraction. The conducted field observations also show that the household waste type is often found mixed with hospital waste.

In 2002, the results of an assessment conducted by WHO in 22 developing countries showed that the proportion of health facilities not using appropriate waste disposal methods ranged from 60% to 64% (Tinga Rayanatou, 1999). In Mauritania, one of the major concerns in health facilities remains the management of solid waste and its by-products. In developing countries, particularly in Mauritania, the most adopted solid waste management model is landfilling. These are mainly uncontrolled open dumps, where all types of waste are dumped in a raw and mixed state: urban, industrial, hospital and agricultural. Despite the large quantities produced in these hospitals, there is poor waste management, mainly due to the lack of a structure specializing in the treatment of hospital waste.

The annual production in Mauritania is 2340 234 kg, of which 468 047 kg corresponds to medical waste. The region of Nouakchott alone would produce almost a third (32%) with a daily production of 2024 kg. Therefore, this approach concerns hospitals, health centers and clinics, and does not include health posts, doctors' surgeries, medical practices, laboratories and radiology practices (Department of Public Hygiene, 2020). The discharge of various wastes is carried out at Nouakchott; a significant part of this waste is deposited in an uncontrolled manner in internal "landfills" which generate gaseous emissions and leachates likely to induce environmental and health impacts. This discharge is located above the highest water table of Mauritania (Trarza aquifer).

Leachates, which are waste juices coming out of hospitals, are vectors of pollution, the study of which is justified in the risk assessment. Thus, samples of solid hospital waste were collected that were immersed in three basins containing drinking water, distilled water and alcoholic distilled water for 72 hours, for the physico-chemical composition (pH, temperature, turbidity, electrical conductivity, COD, BOD_5, COD/BOD_5, BOD_5/COD, SS/BOD_5, SS, nitrite, nitrate, sulfate and phosphorus) of the leachates from the targeted establishments of this study.

The main objective of this study was to examine the physico-chemical characteristics of the solid waste leachate from the Hospital de l'Amitié for a possible study of the impact on water resources (underground) and on the health of the population living nearby, as well as optimizing the treatment of solid waste before it is discharged into the natural environment. The present work is the first study carried out on the evaluation of contaminants in medical waste. The secondary objective of this study is to estimate the potential impact of the management of hospital waste on the workers of health establishments on the one hand, and on the environment on the other. The leachates from uncontrolled dumps in hospitals were analyzed to assess their possible impacts. The authors first observed the behavior of workers at the Hospital de l'Amitié in Nouakchott.

The interior and exterior environment of the Hospital de l'Amitié was studied, and the absence of certain workers due to the causes related to headaches, colds, diarrhea, coughs, breathing difficulties and others were noted. Therefore, it was noticed that these symptoms are only related to the workers who deal with waste collection, and at the same time, the methods of waste collection and treatment in this hospital were studied.

MATERIAL AND METHOD

Study site

The Nouakchott Hospital de l'Amitié was created by Decree No. 2010-229 of 31/10/2010 and erected into a Public Administrative Institution, endowed with legal personality and financial autonomy, placed under the supervision of the Ministry of Health (Ministry of Health, 2010). The Hospital de l'Amitié was chosen as the study site. The Hospital has nine departments (surgery, internal medicine, paediatrics, gynaecology/obstetrics, emergency, ENT, ophthalmology, anesthesia, resuscitation/hemodialysis/ambulatory and medical laboratory) with 91 beds. The Hospital de l'Amitié has a unit in charge of public hygiene, which only deals with cleaning the premises and not with the treatment of waste from the various departments.

Sampling

The sampling was carried out during the col dry period (September to December) of 2020. The solid waste mediums were collected at the landfills of the Hospital de l'Amitié and then transported to the water, pollution and environment laboratories at the University of Nouakchott Al-Aasrya. The mediums were sorted into two classes (medical and domestic waste). The medical waste which is the object of study was immersed in three basins

containing drinking water, distilled water and alcoholic distilled water for 72 hours. Immediately after collecting the leachate, the temperature and pH were measured by a HANNA (HI 9126) instrument; and then conserved at 4 °C. Electrical conductivity (EC) was measured by a HANNA Instruments HI8733 and turbidity was measured by a Wagtech Turbidity meter. The chemical oxygen demand (COD) was determined by using the volumetric method. Suspended solids (SS) were determined by filtering a volume of waste leachate on 0.45µm cellulose paper, and calculating the difference in weight before and after two hours in the oven. Biochemical Oxygen Demand (BOD_5). Nitrate, nitrite, sulfate and phosphorus were analyzed by the colorimetric method using a Wagtech 7100 spectrophotometer.

RESULTS AND DISCUSSION

The results of the contents of the different parameters in the leachate obtained in the present study with the three mediums (drinking water, distilled water and alcoholic distilled water) were compared with other studies on liquid waste.

In the conducted study, 14 parameters were evaluated in the leachate mediums collected from three different media, drinking water (medium 1), distilled water (medium 2) and alcoholic distilled water (medium 3). Table 1 represents the results obtained in different mediums for all the physicochemical parameters and values for the Moroccan and WHO standards.

The analysis of the physico-chemical parameters varied in the different samples tested. For example, certain chemical elements were detected at varying levels (nitrate, nitrite, sulfate, and phosphorus).

In Mauritania, there are no regulations on standards for hospital waste; thus in the conducted study, we the obtained results were compared with the reglementation set by World Health Organization standards and Morocco (Table 1). The pH variation did not exceed one limit in the different samples (from 6.7 to 6.88) (Figure 1). However, the pH values measured in different samples are within the Moroccan regulations and the WHO standard. These pH values are lower than those found by (Kasuku, et al., 2016) and by (Souhaila, 2011).

The temperature of sample 3 (24.5 °C), which corresponds to the leachate treated with the medium containing alcoholic distilled water, had a lower temperature than the two other leachate samples treated with drinking water and distilled water. These results are below the Moroccan and WHO regulatory limits. These temperature values are similar to those found by (Kasuku et al., 2016). The conductivity and turbidity values are shown in (Figure 2). The conductivity is high for three media compared to the Moroccan standard, and arranged in the following order: Medium 2>Medium 1>Medium 3. This parameter also allows the number of salts dissolved in the

Table 1. Overview of physico-chemical parameters in different mediums

Elements	Medium 1	Medium 2	Medium 3	Standard	
				Morocco	WHO
pH	6.74	6.88	6.70	5.5–9.5	6.5–8.5
Temperature (°C)	27.60	27.20	24.50	<30 °C	<30 °C
Turbidity (NTU)	416.00	234.00	534.00	-	-
Conductivity (µm/cm)	5340.00	5820.00	3550.00	<2700	-
COD (mg/L)	53.12	55.04	49.28	<500 mg/L	<90 mg/L
BOD_5 (mg/L)	122.00	106.00	142.00	<100 mg/L	<30 mg/L
COD/BOD_5	0.44	0.52	0.35	<100 mg/L	<20 mg/L
BOD_5/COD	2.30	1.93	2.88	-	<1 mg/L
SS (mg/L)	1000.00	600.00	600.00	<100 mg/L	<20 mg/L
SS / BOD5	8.20	5.66	4.23	-	-
Nitrite (mg/L)	0.91	25.00	45.00	-	<1 mg/L
Nitrate (mg/L)	210.00	200.00	110.00	-	<1 mg/L
Sulphate (mg/L)	1000.00	2000.00	1000.00	<600 mg/L	-
Phosphorus (mg/L)	9.90	8.25	14.85	<15 mg/L	-

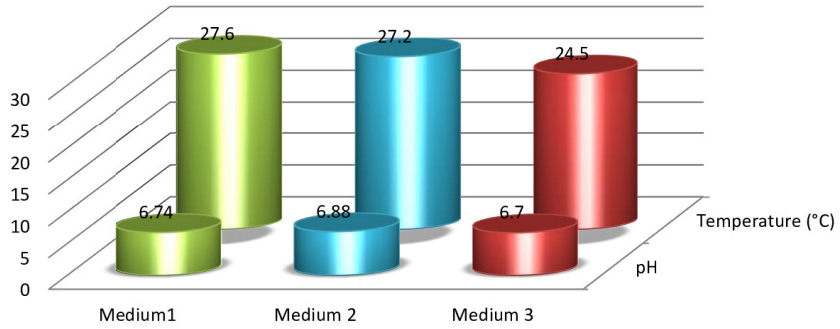

Figure 1. pH and temperature (°C) variation in mediums

groundwater (Rodier et al., 1996) The obtained results are above the value detected by (Kasuku et al., 2016). The turbidity values are higher in the first and third medium than in the second. Turbidity ranged from 243 to 534 NTU. COD, BOD5 and SS values are described in Figure 3. The COD and BOD_5 values are under the limits of the Moroccan regulation and WHO standards. The COD values are lower than those detected by (Kasuku et al., 2016) and by (Abdelaziz et al., 2014). The BOD_5 values are higher than reported values by (Kasuku et al., 2016).

The SS values obtained in the study are higher than the Moroccan regulation and WHO standards. The SS values varied between 600 mg/L and 1000 mg/L in this study. Medium 1 is the most loaded with SS (1000 mg/L). The result of Medium 1 is higher to the result found by (Shaker et al., 2011). For Medium 2 and 3, the obtained results were lower than those found by (Shaker, et al., 2011). The obtained results are above the WHO and the Moroccan regulations.

To evaluate organic pollution, the calculation of COD/BOD_5, BOD_5/BOD_5, SS/BOD_5 is

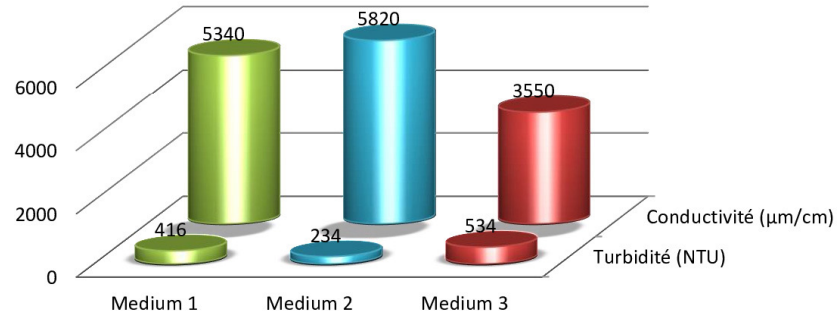

Figure 2. Turbidity and conductivity variation in mediums

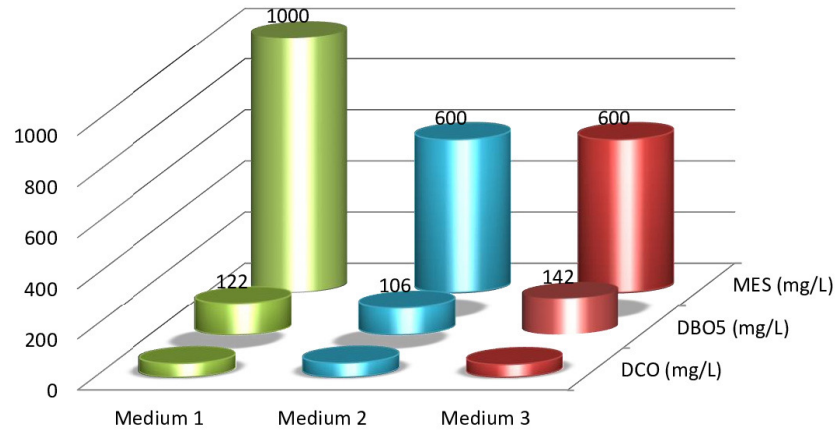

Figure 3. COD, BOD_5 and SS variation in mediums

essential to better picture the degree of pollution of the solid waste leachates in a different medium. Using these characterization parameters is also an efficient way to optimize the physico-chemical parameters of these mediums to propose a suitable treatment method. COD/BOD_5 in different mediums is within the limits of the standards set. The obtained results are lower than the value detected by (Abdelaziz et al., 2014). The BOD_5/COD ratio gives very interesting indications of the origin of the pollution of a wastewater and the possibilities of its treatment. In this study, the BOD_5/COD is above the WHO standard and is higher than the value detected by (Kasuku et al., 2016). The SS/BOD_5 ratio has values ranging from 4.23 to 8.2. This ratio also gives an idea of the discharge load of biodegradable organic matter in the total suspended solids. Nitrite and nitrate values are described in Figure 4. Nitrite value in Medium 1 is under the limits of the WHO standard; however, for Medium 2 and 3, they are above the limits of the WHO standard. The nitrate values are above the limit set by the WHO standard for the entire three mediums. For example, an increase in nitrate was observed in the three mediums, unlike with nitrate a decreasing order was observed. The nitrate values in the three mediums are higher than those detected with (Kasuku et al., 2016).

The values for sulfate and phosphorus are exposed in Figure 5. In the three mediums, sulfate was above the limits of the Moroccan regulation, with a higher value obtained in Medium 2 (2000 mg/L) that is the double of those obtained in Medium 1 and 3 (1000 mg/L). The results of sulfate amounts in Medium 2 are higher than those obtained by (Kasuku et al., 2016); however, regarding Medium 1 and 3, the obtained results are lower than those obtained by (Kasuku et al., 2016). For phosphorus, the values varied from 8.25 to 14.85 mg/L but remain in the regulation limits; however for Medium 3 (14.85 mg/L), the value was close to the Moroccan limit. The obtained results for phosphorus content are higher than those reported by (Driss , et al., 2009) and by (Aguemon et al., 2014).

Physico-chemical analyses of leachate from three environments reveal variable pollution. However, the global parameters followed here, in particular organic, do not provide the information on the nature of the molecules present. Some of them might have high toxicity. Ecotoxicity analyses using biological tests would therefore be necessary to verify this. Physico-chemical analyses of the aqueous medium such as drinking water, distilled water and alcoholic distilled water show that no anomaly is reflected, Table 2 represents the results obtained in different aqueous solutions.

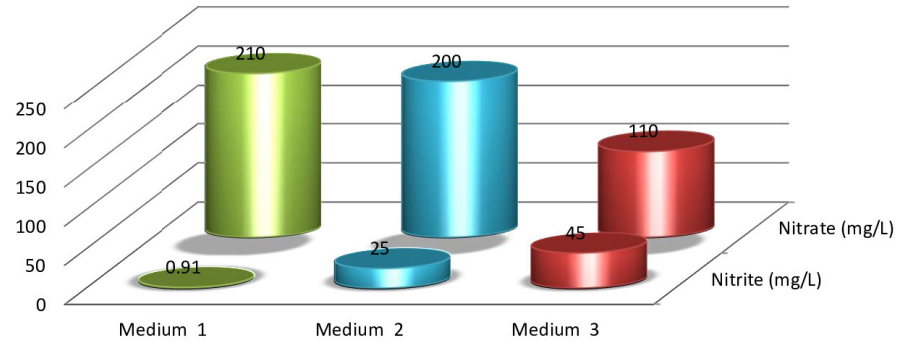

Figure 4. Nitrite and Nitrate variation in mediums

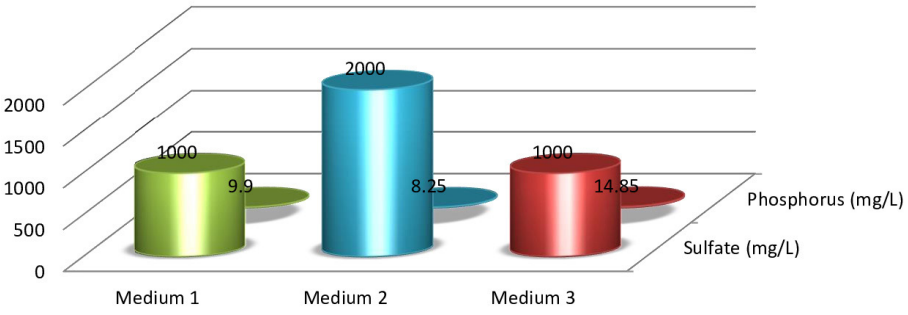

Figure 5. Sulfate and phosphorus variation in mediums

Table 2. Overview of physico-chemical parameters in different aqueous solutions

Elements	Potable water	Distilled water	Alcoholic distilled water
pH	7.32	8.14	5,48
Temperature (°C)	25.00	23.50	23.80
Turbidity (NTU)	0.86	1.28	1,39
Conductivity (µm/cm)	129.00	0.53	0.53
COD (mg/L)	0.32	0.41	0.46
BOD5 (mg/L)	0.40	0.24	0.17
COD/BOD_5	0.80	1.70	2.70
BOD_5/COD	1.25	0.58	0.37
SS (mg/L)	0.00	0.00	0.00
SS/BOD_5	0.00	0.00	0.00
Nitrite (mg/L)	0.00	0.00	0.00
Nitrate (mg/L)	0.42	0,33	0,29
Sulphate (mg/L)	20.00	0.00	0.00
Phosphorus (mg/L)	–	0.02	0.10

CONCLUSIONS

The values of physic-chemical parameters in solid waste leachates from the Hospital de l'Amitié provide valuable information; the toxicity of these leachates should be taken into account when comparing the potential impact of these elements on the environment and on aquatic animals. This preliminary study highlights the presence of toxicity in solid waste from the Hospital de l'Amitié. The results of this study highlighted the pollution generated by the leachate of hospital solid waste and the nuisance that this waste represents for the environment. The results thus obtained show a COD value for which the polluting matter is difficult to decant and biodegradable. In addition, the nitrate, sulfate and phosphorus values exceeded the standards. Therefore, treatment of these solid wastes is necessary to reduce the risk of these toxic elements in hospital wastes before disposal into the aquatic environment.

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