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Physicochemical and bacteriological characterization of hospital effluents and their impact on the environment

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ABSTRACT

Liquid effluents discharged by hospitals may contain chemical and biological contaminants whose main source is the different substances used for the treatment of patients. This type of rejection can present a sanitary potentially dangerous risk for human health and can provoke a strong degradation of diverse environmental compartments mainly water and soils. The present study focuses on the quality of the liquid effluents of Hassani Abdelkader's hospital of Sidi Bel-Abbes (West of Algeria). The results reveal a significant chemical pollution (COD: 879 mgO_2/L, BOD_5: 850 mgO_2/L, NH_4^+: 47.9 mg/l, NO_2^-: 4.2 mg/l, NO_3^-: 56.8 mg/l with respect to WHO standard of 90 mgO_2/L, 30 mgO_2/L, 0.5 mg/l, 1 mg/l and 1 mg/l respectively). However, these effluents are biodegradable since the ratio COD/BOD_5 do not exceeded the value of 2 in almost all samples. The presence of pathogen germs is put into evidence such as pseudomonas, the clostridium, the *staphylococcus*, the fecal coliforms and fecal *streptococcus*. These results show that the direct discharge of these effluents constitutes a major threat to human health and the environment.

Capsule Summary: This study reveals a chemical and biological pollution of hospital liquid effluents. This waste requires effective treatments before being rejected in the natural environment to don't provoke a strong degradation of diverse environmental compartments.

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INTRODUCTION

Hospital can be at the origin of a pollution that must be taken into consideration in a general strategy of sanitary and environmental risk evaluation. The generated effluents by hospital activities can present a threat for Human and environment due to the nature and quantity of specific substances that they contain. On the other hand, in many developing countries (PED), the hospitals liquid effluents are generated by the communities are often dumped directly in the environment (in the natural water flows or in the soils without prior pretreatment.

Different problems that result from the liquid rejection by Health services require, for scientists, a questioning on the future of hospital pollutant in the environment and on the necessity of developing durable management tools of waste water for these institutions and health services. The

Fig. 1: Geographic location of HASSANI Abdelkader's hospital of Sidi Bel Abbes

implementation of eco-toxicity tests shows that the hospitals effluents have often high toxicity levels (Leprat, 1998, Jehannin ,1999, Emmanuel et al., 2001).

The socio-economic development and the demographic growth in Algeria during these last decades have generated an increase in the quality of wastes emanating essentially from households, industries and health institutions.

Several studies carried out for treating different types of wastewater in order to reduce the impact on the environment (Benouis et al., 2016, Ramdani et al., 2016). Research results have shown that the management of waste is inefficient especially when the elimination of waste does not respect the environment (Dremont and Hadj, 1997). In fact, this evolution has not been followed by adequate measures to improving the management of these wastes leading to a multitude and intensity of negative effects on Human health and on the environment.

In this context, it seems important to carry out a study on the hospitals liquid effluents in order to know their degree of pollution both on the physicochemical and bacteriologic aspects. These effluents are evacuated into the urban network without prior treatment in the same way as for the classical domestic waste water which constitutes a risk for the environment.

It is this perspective that the present study is made and aims to characterize the effluents of HASSANI Abdelkader's hospital of the city of Sidi Bel Abbes (West of Algeria). This investigation is carried out to characterizing physiochemical and bacteriological aspects of waste water located at the internal network collectors and at the main embouchure before their rejection into the urban network.

MATERIAL AND METHODS

Location of the investigation

HASSANI Abdelkader hospital is university hospital center of the wilaya of Sidi Bel-Abbes located at the west of Algeria (figure 1). The hospital is a Civil Hospital constructed in 1936 since then its area has not been change and was founded as a sanitary center just after the independence. The hospital university center has 639 beds dispatched between 23 services as well as exploration services such as: a Central Laboratory, Nuclear Medicine, Radiology, and Physiology.

Sampling

Samples were drawn from three different locations points.

- The first point: the sample was drawn from the pavilion collector of the general chirurgical surgery services, gastro logy, ophthalmology, infections and radiology;
- The second point: The sample was drawn from the collector receiving the wastes from the laboratory including hematology, microbiology and biochemistry laboratories;
- The third sample drawing point was from the collector of the pavilion containing cardiology, endocrinology,

Table 1: Incubation conditions, culture medium and Analytical methods of germs sought

Micro-organisms	Incubation	Culture medium	Volume	Analytical methods
Total Coliforms	37°C for 24 h	VRBL	100 mL	Membrane filter technique - filter at 0.45µm
Fecal Coliforms	44°C /18-24 h			
Fecal streptococci	37°C /48 h	Rothe (presomptive) Litsky (confirmative)		
Staphylococcus	37°C /24-48 h	Chapman		Incorporation agar
Pseudomonas	42°C/24 h	Gélose infusion cœur-cervelle		
Clostridium aeruginosa	37°C/24-48 h	SPS	20 mL	

Table 2*:* Variation of the Physicochemical Properties of effluent from Hassani abdelkader's hospital

	*Limit Value**	*March*				*April*			
week		1st	2nd	3rd	4th	5th	6th	7th	8th
Temperature (°C)	30°C	18.8	18.4	16.9	19.2	16.6	18.9	17.11	18.8
Conductivity µs/cm	2700 (µs/cm)	152	270	350	289	256	281	169	245
pH	5.5-8.5	7.69	8.85	8.2	8.1	7.8	7.93	7.8	7.45
BOD_5 (mgO_2/L)	30 (mgO_2/L)	850	520	480	280	285	255	290	280
COD (mgO_2/L)	90 (mgO_2/L)	879	690	688	545	680	455	488	545
COD/BOD_5	-	1.03	1.32	1.43	1.94	2.34	1.78	1.68	1.94
TSS (mg/L)	20 mg/l	640	520	586	630	560	420	480	510
NH_4^+	<0,5mg/l	26.5	7	18.6	21	11	23.5	36.6	47.9
NO_2^-	<1 mg/l	3.6	2.1	2.8	3.9	2.6	3.5	4.2	3.9
NO_3^-	<1 mg/l	32.3	54.2	46.8	56.7	56.8	23.9	31.2	35.9

Limit value * International standards for wastewater discharge recommended by WHO **(**WHO, 1989)

pH: potential of hydrogen, BOD_5 :5-day Biochemical Oxygen Demand, COD: Chemical Oxygen Demand, TSS : Total Suspended Solids, NH_4^+: Ammonium, NO_2^- : Nitrogen dioxide, NO_3^- : Nitrate

dermatology, ana-pathology, hemodialys and oncology services.

The waste water of each pavilion is rejected in its own collector before joining the main hospital collector. The different physicochemical analyses were made from averaged samples of effluents which were drawn twice a day with a volume of 1 liter each during five days.

The following schedule has been adopted:

a- First sample draw between 08H: 30 and 11H:30;

b- Second sample draw between 13H:00 and 16H:30;

c- Third sample draw between 18H:00 and 21H:00.

The time of drawing samples corresponds to the period of maximum activity and is in the range of 08H00 and 21H00. The composite and periodic samples have been fractioned, put into isothermal boxes and transported to the laboratories selected for the analyses in order to quickly make the analyses and avoid aging of the samples. The transport was made using enclosure maintained at a temperature equal to 5°C. In order to guarantee the integrity of the samples all the analytical procedures were carried out at the same day of the sample drawing. The sampling of water for bacteriological analyses has been made in aseptic manner using sterilized flacons of 500mL.

Parameters and methods of wastewater analysis

Physicochemical analysis

Several physicochemical parameters have to be followed up at regular intervals in order to verify the performance of the system of wastes treatment. The temperature, the pH , the conductivity, the turbidity, the Total suspended solids , Biological Oxygen Demand at 5 days BOD_5, the Chemical Oxygen Demand COD, NH_4^+, NO_2^-, NO_3^-, and heavy metals are examples of chemical parameters to be followed up for verification.

The standard methods of wastewater analysis are described by (Rodier, 1996) and also in catalogs of the

Table 3: Water consumption in HASSANI Abdelkader's hospital and comparison with other international health institutions

Country	Average water demand (liters/bed/day)
Thaïlande (children's hospitals-Bangkok)	1,589 (Wangsa atmaja., 1997)
Iran	800-1000 Mesdaghinia, 2009
USA (health facilities)	968 (EPA, 1989)
France	750 (Paris-Nord Wink, 1999)
Developing Countries	Around 500 (Laber, 1999)
Meknès (average the 2006,2007 and 2008)	401.63 (Ameziane, 2014)

Table 4: Weekly Enumeration of micro-organisms in the hospital effluents (log UFC/100 ml)

Week	1st	2nd	3rd	4th	5th	6th	7th	8th
Total Coliforms	8.51	8.45	8.50	8.51	8.51	8.62	8.47	8.52
Fecal Coliforms	6.97	6.92	6.91	6.96	6.94	6.96	6.97	6.92
Fecal streptococci	5.19	5.26	5.21	5.09	6.21	5.06	5.28	5.18
Staphylococcus	7.49	7.92	7.81	7.79	7.73	7.73	7.79	7.73
Pseudomonas	6.48	6.45	6.33	6.51	6.36	6.33	6.47	6.52
Clostridium	2.88	2.92	2.96	3.08	2.97	2.91	3.00	2.52

equipment. The pH and conductivity are measured by a pH meter (HANNA type HI 991001) and a conductimeter (HANNA type HI 8033) of laboratory respectively. The procedure uses the standardized method (NFT 90-101) to measure COD. An OxiTop (VELP SCIENTIFICA) is used to analyze the BOD_5.

A spectrophotometer DR2000 type has been used for the determination of the nitrates (NO_3^-) and the nitrites (NO_2^-). The dosage of heavy metals contents (Cd, Cr, Pb, Ni, Cu, Fe, Mn and Zn) was made at the laboratory. The analysis has been achieved on filtered samples to 0.45 µm by simple system of filtration by means of an atomic absorption spectrophotometer M6 AA.

Microbiological analysis

The microbiological parameters are measured by bacteriological counting of the effluents of the hospital. A certain number of analytical techniques have been used for microbiological characterization of the effluents. The cellular culture is the most used technique for bacteriological examination. The sowing can be made on different existing cultivation environments to select the pathogen bacteria. The count is made directly by counting the colonies formed on the solid environment (it is then expressed in Colony Formation Unit CFU). The instrument used for filtration is a stainless steel reservoir such as used in reference (Rodier, 1996).The filtration membrane is made of cellulosis with pore diameter of 0.45 µm. The analysis methods used are given in Table 1.

RESULTS AND DISCUSSION

The results of the physicochemical analysis are shown in Table 2.

Temperature

The temperature plays an important role in the solubility of salts especially of gases and the determination of the pH. The recorded temperature varies between 16.9 and 19.2 °C. This is in agreement with the international standard established by WHO which fixes the maximum temperature at 30°C (WHO, 2012). These values are in good agreement with of Elghassani's hospital of Fes whose average is 17.11°C (Tahiri and al., 2012).

pH

The obtained results have shown a pH fluctuating between 7.69 and 8.85. Concerning the measure of the pH, it is observed that the fluctuation appear during the morning with a peak of 8.8 pH unit. For values greater than 8.5 they affect the growth and survival of aqueous micro-organisms according to the WHO (WHO, 1989).

Electrical conductivity

Results have shown that the measure of the electrical conductivity has concentrations ranging from 152 up to 350 µs/cm with an average value of 250 µs/cm. The values were less than the WHO standard.

TSS

For the samples under study, high values of TSS had been observed; they ranged from 420 to 640 mg/L. The obtained

values were higher than the WHO standard which is less than 20 mg/L. Also they were greater than the values proposed by Emmanuel ad al for hospital wastewater samples whose concentrations ranged from 46 to 298 mg/L. (Emmanuel and al, 2005).

The hospital waste water contain organic and ammonia nitrogen. The first is an element of living cellules. The second NH_4^+ came from the decomposition of organic nitrogen by the bacteria and direct rejections of human wastes. The ammonia and the nitrogen dioxide are a problem for public health.

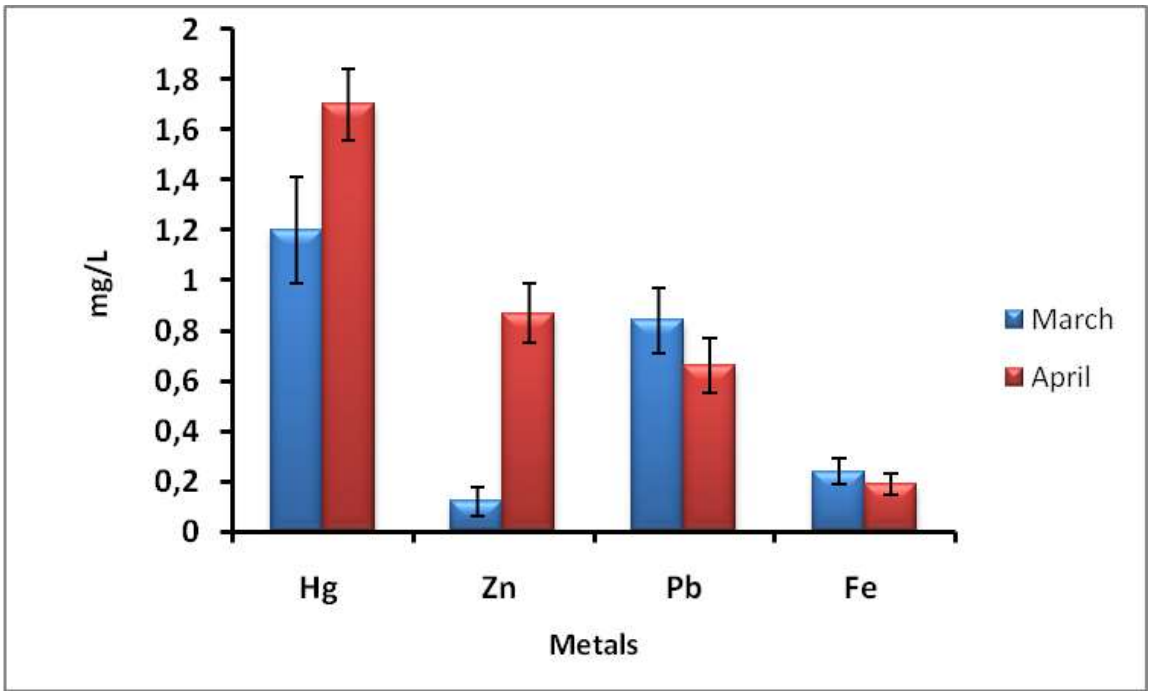

Fig. 2: Evolution of the heavy metals concentrations in the hospital effluent

Chemical oxygen demand (COD)

The results of this work show a variation of COD from 879 to 455 mgO_2/L with an average of 621.25 mgO_2/L. At Limoges university hospital the COD is in average equal to 539 mgO_2/L. Values far exceed the standard for effluent discharge (90 mgO_2/L).

Biochemical oxygen demand (BOD_5)

The BOD_5 varies between 850 to 255 mgO_2/L with an average of 405 mg O_2/L. The WHO sets a value lower than 30 mgO_2/L as a rejection standard, Darsy (Darsy, 2002) have recorded an average BOD of 177 mgO_2/L and which reaches 1095 mgO_2/L as a maximum value (Emmanuel et al., 2005). This significant increase of COD and BOD_5 values show a strong proliferation of organic pollution of these effluents. The COD/BOD_5 ratio is less than 2. This allows to concluding that the effluents of the hospital are biodegradable with selected stumps. This ratio determines the possibility and the efficiency of degradation that can be sought through biological oxidation treatment.

Nitrogen (NH_4^+, NO_3^- , NO_2^-)

They induce a bacterial proliferation in the water. On the other hand, nitrates NO_3^- are the main source of restlessness. These ions are transformed in acid environment weaker in nitrite ions which are toxic for human organism. According to the results illustrated in figure.8, it can be observed that the values exceed the standards established by the WHO.

Heavy metals

In this study, the micro-mineral "water pollution factors" considered are iron, cadmium, copper, lead, mercury, chromium and zinc (Fe, Cd, Cu, Pb, Hg, Cr, Ni, and Zn). The results obtained showed that, with the exception of mercury which is in high concentration 1.10 mg/L (Fig. 2) Moreover, it finds no trace of Cd, Cu, Cr, and Ni in effluent hospital studied. The metals Fe, Pb and Zn concentrations are slightly rises to meet accepted standards.

Mercury is widely used in hospitals via thermometers. Today, given the toxic risk it represents, its use tends to decrease significantly (on average 6 thermometers/bed/year or 2g Hg). There is a risk when it breaks; it disperses in the form of small beads which are easily recovered. Eliminated by the hospital's sewerage system generates a significant danger to the environment. (Darsy et al., 2002) noticed that accidental releases of

mercury in the wastewater network contribute to diffuse contamination of the atmosphere and the aquatic environment. In the sediment of rivers where it is stored, metal mercury is converted into organic mercury by bacteria

Bacteriological parameters

Hospitals are typically large consumers of water and this leads to a dilution of the effluent along the path from different generating blocks bacteriological waste to the main. Therefore there is a reduction in concentration of various bacterial species studied above. As the water consumption at the hospital HASSANI Abdelkader, it is very small. In this perspective, Table 3 compares the amount of water consumed by the hospital with that used by other hospitals internationally.

Water consumption in the hospital HASSANI Abdelkader - Sidi Bel Abbes is low compared to that of Thailand, Iran, the United States, France and developing countries. This low water consumption of the hospital giving birth to low volumes of liquid waste and therefore less diluted and therefore effluent highly charged with pathogenic microorganisms.The number of micro-organisms expressed in colony formation units (UFC) is in the order of 10^2 to 10^7UFC/mL, The results of the microbiological testing are summarized in (Table 4).

The sought bacteria species, identified and counted from the effluents of the HASSANI Abdelkader hospital were the clostridium, the *pseudomonas*, the total and fecal coliforms and fecal *streptococcus*. These results are in good agreement with those of other research works which had shown the presence of many types of pathogen germs (Boillot, 2008).

Clostridium

The clostridium is present with an average of 2.9 log UFC/100mL at a temperature of 37°C. The average concentration of the total coliforms present with an average of 8.51 log UFC/100mL is important compared to the concentration of these germs reported by different studies. This concentration is over than those found by (Darsy et al., 2002).

Fecal coliforms

The concentration of the fecal coliforms of a hospital effluent can give an indication of its ecotoxicity. According to (Darsy et al., 2002) had considered that the concentration of fecal coliforms as an indicator of the degree of pollution of water by fecal germs. This is probably linked to the concentrations, a low presence of disinfectants or antibiotic in the hospital effluents. On the other hand, the presence of cleaning products mainly chloride products whose the mostly used is bleach and other toxic products such as disinfectants and antiseptics needed for healing activities found with high concentration in the hospital waste is at the origin of the bacterial flore concentration attenuation (Metcal and Eddy, 1991 ; Rapt , 1992).

Streptococcus

The average number of *streptococcus* is 5.31 log UFC/100 mL. This result is in light excess with respect to those by Tahiri et al who had put into evidence the *streptococcus* with a variation of 1.1 10^3 to 2.1 10^4 (Tahiri et al., 2012).

Staphylococcus

The hazard that characterizes the hospital effluents is the presence of bacteria responsible for nosocomial infections such as *Staphylococcus aureus*, *Pseudomonas aeruginosa* (and *Escherichia coli*) etc... as well as polyresistant bacteria to antibiotics such as salmonelles present in human wastes (Emmanuel et al., 2001), the *staphylococcus*, the *Pseudomonas aeruginosa* (Peyrat , 2008), or certain stocks typically pertaining to hospitals. In fact, a new type of *Staphylococcus* aureus resistant to methicilline has emerged in the urban community during the last decade but is different from those found in the hospitals environment. That is why these bacteria has been isolated in the USA, Canada and in Australia. This bacterial is characterized by its resistance mainly to antibiotics of ß- lactamines family but not to the hospitals stocks and too many other antibiotics (Chitnis et al., 2004).

Pseudomonas

The results concerning the *pseudomonas* found in the effluents of HASSANI hospital are of the order of 6.43 log UFC/100 mL. For the *staphylococcus*, their average concentration value is 5.6 10^7 UFC/100 mL which higher with respect to those reported by (Darsy et al., 2002; Chitnis et al., 2004). This can be explained by low consumption of water, cleaning products, disinfectants and detergent by the hospital.

CONCLUSIONS

The results of this study show that the values of indicator parameters of the chemical pollution in the hospital effluents are widely overrun the WHO standards. This pollution is mainly of organic origin, expressed by a very high COD and BOD_5. The ratio COD/BOD_5 is less than 2, one may say that the effluent is biodegradable and that a biological oxidation treatment might be able to eliminating the essential of this pollution. The fecal contamination of effluents is much higher to that reported in witnessing literature. Indeed, the important bacteria concentrations witnessing specific responsible of nosocomial infections and poly resistant to antibiotics such as *Pseudomonas* and the *staphylococcus* constitute a potential danger which must not neglected.

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