Journal of Materials Science and Engineering B 3 (4) (2013) 214-225

Global Approach and Targeted Approach in the Management of Hospital Effluents

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Received: December 21, 2012 / Accepted: January 08, 2012 / Published: April 25, 2013.

Abstract: Recent studies show a certain danger associated with drug residues, chemicals, radionuclides, biofilms, resistant bacteria and viruses, downstream of wastewater treatment plants (WTP). These results confirm the existence of hazardous substances in the hospital effluents. The University Hospital Frantz Fanon in Blida is located in a sensitive place of Mitidja. The effluents can contaminate surface water (valley Sidi El Kebir, valley Mazafran) and groundwater via infiltration and the porous nature of the soil. It is feared that the underground current (groundwater) contaminate a large portion of the basement of the Mitidja in the long run. Faced with the urgency and the risk they represent, we have developed a method called the targeted approach for more effective management of hospital waste. Indeed, in the global approach, the hospital effluents are collected by a sewer system treated in a wastewater treatment plant before being rendered in the environment. The targeted approach avoids the effluents in the sewer system of the hospital and the WTP, it neutralizes chemical and biological pollution out of each hospital unit. Furthermore, the realization of a washer-disinfector endoscope adapted to the specific protocols (exploration digestive, bronchial, etc.) represents an application of the targeted approach. Indeed, management of the disinfectant solution by electrical control in a closed circuit allows the mastery of biological pollution (ΣBi) and chemical (ΣCi). It seems that the evolution of medical science brings new concerns, in addition to biological pollution, bacterial and viral. Today we speak of pathogen proteins resistant to conventional disinfection processes. The targeted approach remains appropriate and focuses on the development and adaptation of new technology in the disinfection procedure.

Key words: Mitidja, sensitive hydrogeological system, special waste, chemical pollution, biological pollution.

Nomenclature

WTP:	Wastewater treatment plants
E_k :	Hospital unit
Abs:	Absence
Pres:	Presence
CFU:	Colony Forming Unit

1. Introduction

Contaminated fluids from hospitals are a multi factorial problem [1-2]. They generate serious chemical and biological pollution [3-6]. The diffusion of pollutant particles: direct and indirect [7] generates significant economic social prejudice in health facilities (contamination of the structure, equipment and personnel). Furthermore the management of these discharges according to the method of the global approach [8] (Hospital, Wastewater Treatment Plant, Environment) is limited. The consequences are already burdensome for the environment, water resources and health. The danger is all the more threatening because the point source (the hospital unit) [9] is situated in a highly sensitive area: Mitidja (Algeria).

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2. Materials and Methods

2.1 Point Source (Hospital of Blida)

The University Hospital Frantz Fanon of Blida,

built in 1933, is spread over an area of 35 hectares, with a total capacity of 1,613 beds (Fig. 3). The frame of the hospital consists of a variety of important disciplines (Table 1) [10]. It produces standard care (surgery, etc.) and specific (radio and chemotherapy, etc.). However it generates noxious and low biodegradable effluents in large quantities [2-3].

2.2 Hydrogeological Configuration of the Source

Our attention is reinforced especially since the hydrogeologic setting of the source (hospital) is sensitive. The plain of Mitidja which is a subsidence basin was filled by marine or continental deposits, during the Tertiary and Quaternary. Oriented in the direction of SW-NE (South West-North East), it is spread over four states (Wilayas: Tipaza, Blida, Algiers and Boumerdes), from valley Djer to Reghaia. It is bordered to the south by Atlas Blidéen, and to the north by the hills of the Sahel (Fig. 1, 2) [11].

Indeed, the Mitidja Basin represents a separate hydrogeological unit [12]. This plain extends over an area of 1,450 km^2. Furthermore, the lithology of the aquifer (alluvium, highly permeable in the majority of the floodplain) (Fig. 1), the communicating nature of the structure of surface water and groundwater [9], the bowl -like shape that characterizes the soil and subsoil on which our source of pollution sits (Table 2) [12], justify our study.

The production of large amounts of harmful solutions (estimated at 100 liters per bed, per day) by the hospital of Blida [10], can contaminate surface water (valley Sidi El Kebir, valley Mazafran) and groundwater via infiltration and the nature of

Table 1 Different services of the hospital of Blida [3-10].

Hospital	Unit	Chemicals and biological products
Hospital	Surgery, neurosurgery, orthopedic, cardiology, ophthalmology, radiology, biology, anapathologie, gynecology.	Anticoagulants, Anti-diabetics, Antifungals, anti-hypertensives, anti-Inflammatory, Antiparasitic, antiseptics, anti-ulcer, β-blockers, bronchodilators, diuretics; Steroids, hormones, antibiotics ...
Anti-cancer center	Surgery, radiology, radiotherapy, chemotherapy.	Anticancer drugs, antiseptics, Diagnostic products, Radionuclides .
Psychiatry	Psychiatry.	Anticonvulsants, Antidepressants Anxiolytics, antipsychotics, antiseptics ...

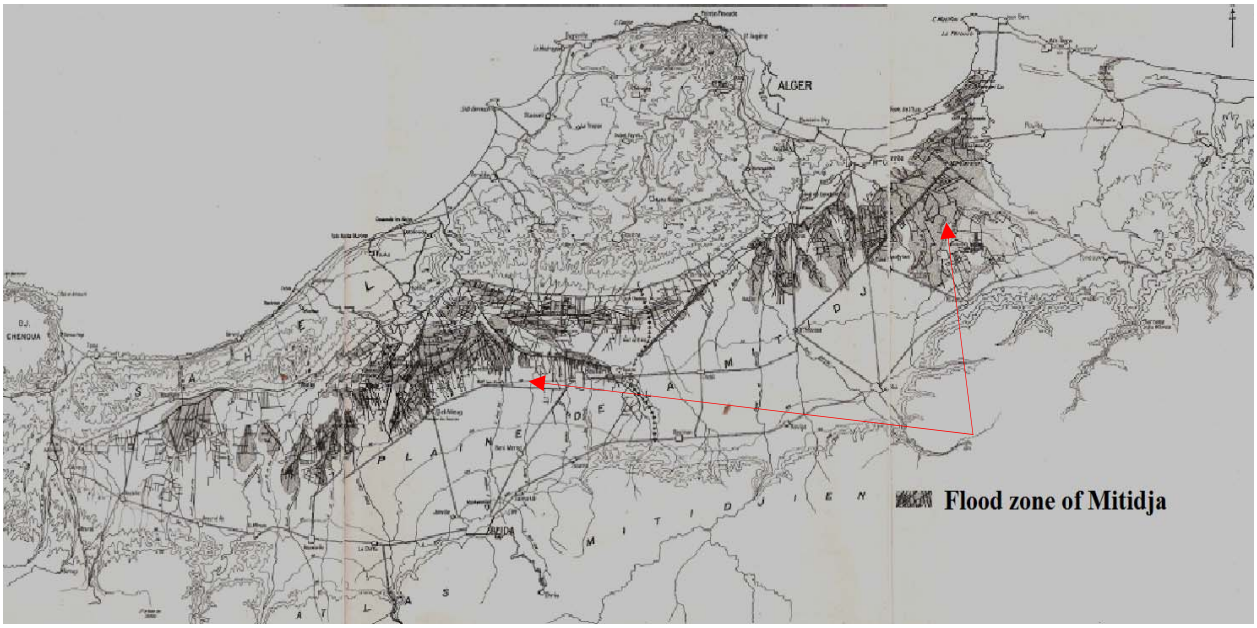

Fig. 1 Flood zone of mitidja [11].

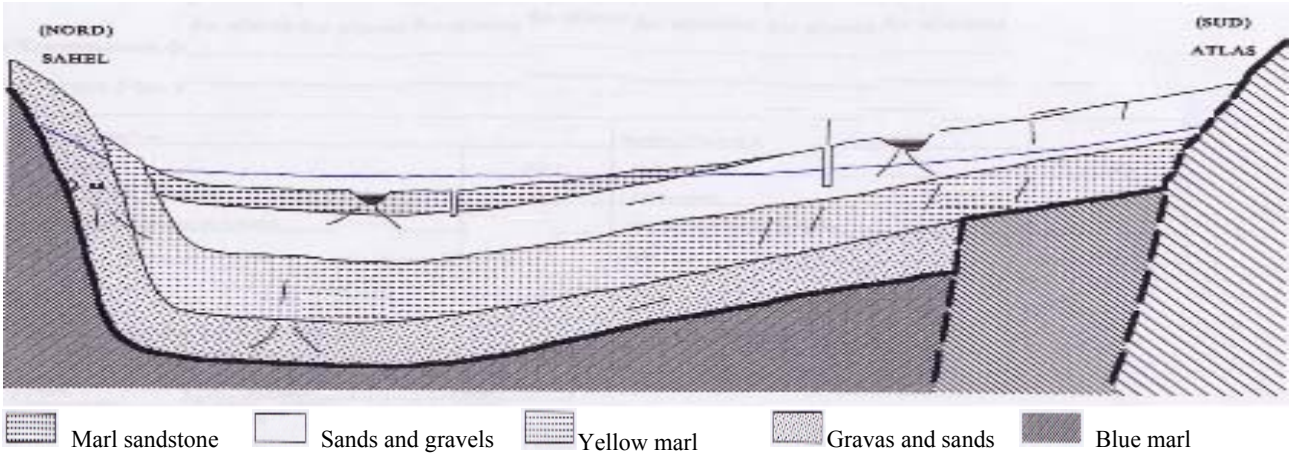

Fig. 2 Cutting interpretative Mitidja in Basin Mazafran [11].

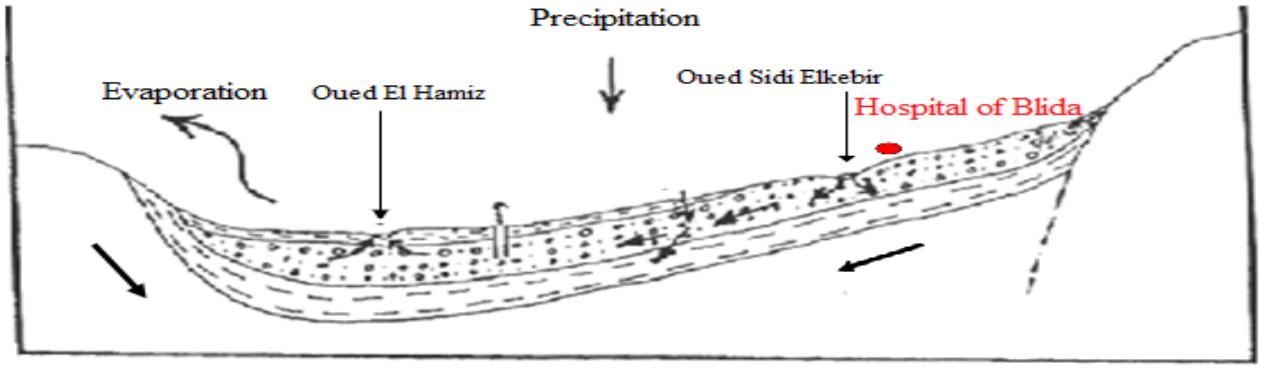

Fig. 3 Watershed cutting mazafran [11].

Table 2 Hydrogeological parameters of the plain of Mitidja [11, 12].

Parameters	Value
Thickness of the groundwater (m)	100 to 150
Potential groundwater (m^3/year)	328 million
Drainage courses (m^3/s)	-0.06
Transmissivity	1.5×10^{-2} to 7×10^{-2}
Storage coefficient	0.1
Groundwater recharge (m^3/s)	1.04
Infiltration (m^3/s)	0.06 to 0.322
Outflow (m^3/s)	-0.012
Take Water (m^3/s)	1.4
Clearance (m^3/s)	-0.05

floodplain soils [11]. It is feared that the underground currents as shown in the section of the watershed of Mazafran (Fig. 3) contaminate in the long term much of the basement of the Mitidja [9]. Facing such a scenario, the least dangerous waste is not allowed in this system. The relationship "source-system" (Fig. 4) that is to say, hospital effluents-social and economic space in which the source evolves, and that requires a rigorous treatment of hospital wastewater. This relationship "source-system" requires a new approach in managing its waste.

2.3 Materials and Methods in the Analysis of Microbiological Pollution in the Hospital

We conducted analysis of the internal environment of the hospital (air, wall, floor and bench), we used the technique of swabbing is an indirect method of sampling surface. This technique which is easy to use [13], it can be used for large areas, non-absorbent, irregular or with corners. The project of European Standards CEN/TC 243 will standardize the swabbing [14]. After the dry swabbing with cotton swabs, the sample is incubated in different growth mediums according to the nature of the organism to search [15].

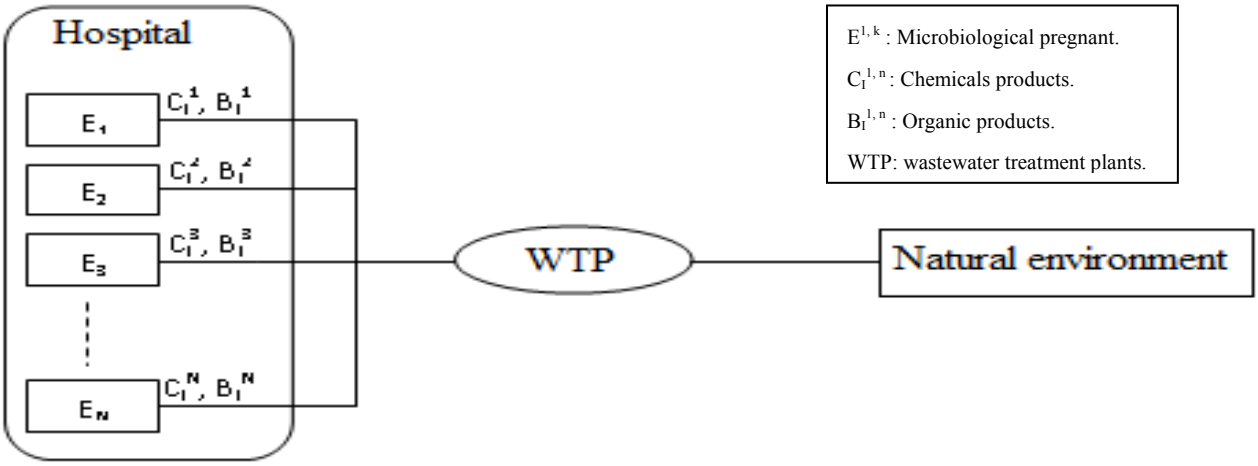

Fig. 4 Hospital Sketch.

2.3.1 Ambient Air

The technique used for the determination of airborne bio-contamination is to lay open Petri dishes in different places with the growth medium according to the category of the germ to determine. The particles suspended in the air are generated by sedimentation on the surface of the growth medium. After an exposure to the air of 15 to 20 min, the Petri dishes are incubated at 30 °C for 3 days [15].

2.3.2 Wall, Floor and Bench

Coliform: culture medium: Brilliant green lactose bile broth. Incubation at 37 °C for 48 h. Confirmatory test: culture medium: Bromocresol purple lactose broth + peptone water for indole. Incubation at 44 °C for 24 h [15].

Staphylococcus aureus: culture medium: Giolliti Cantoni broth. Incubation at 37 °C for 48 h. Isolation on selective solid medium: culture medium: Chapman agar. Incubation at 37 °C for 24 h [15].

Total mesophilic flora: culture medium: Plate Count Agar. Incubation at 30 °C for 72 h [15].

Streptococci: culture medium: Roth broth. Incubation at 37 °C for 48 h. confirmatory test: culture medium: Litsky broth. Incubation at 37 °C for 24 h [15].

Yeasts and molds: culture Medium: oxytetracycline glucose agar. Incubation of 20-25 °C for 3 days [15].

2.4 Materials and Methods in Analysis of Chemical Pollution in the Hospital

The principle of control is based on the sucking of air into microbiological units, passing through the wet filters which retains molecules of glutaraldehyde in the air, this principle allows detecting the amount of glutaraldehyde by the method of UV-Visible spectrophotometry (Spectrophotometer instrument, mark ZUZI model 4201/50) [16].

3. Results and Discussion

3.1 Targeted Approach

In our targeted approach, we consider the hospital as a set of units; each unit is a service or a specialized laboratory (Fig. 4).

$$H = \sum_{k=1}^{n} E_k \quad (1)$$

k is from 1 to n where n is the number of units in the hospital).

$$E_k = \sum_{i=1}^{m} Ci + \sum_{j=1}^{m} Bj + y_{ij} \quad (2)$$

$$H = \sum_{k=1}^{n} (\sum_{i=1}^{m} Ci + \sum_{j=1}^{m} Bj + y_{ij}) \quad (3)$$

$$H = \sum_{k=1}^{n} \sum_{i=1}^{m} Ci + \sum_{k=1}^{n} \sum_{j=1}^{m} Bj + \sum_{k=1}^{n} yij \quad (4)$$

$\sum\sum C_i$: Chemicals including solvents, drugs and metabolites in the sewer system of the hospital in their intrinsic aspects.

$\sum\sum B_i$: Organic products composed of physiological substances, germs from different hospital departments in their intrinsic aspects.

Table 3 the average of microbiological analysis (air, wall, floor and bench) in the Laboratory of Infectious Diseases in El Kettar Hospital.

Germs (CFU/m^3)	Air	Wall	Floor	Bench	Norms
Yeasts	525	7.38×10^4	7.30×10^4	6.56×10^2	< 0.2
Molds	675	2.10×10^3	3.62×10^3	1.90×10^3	< 0.2
Mesophilic aerobic flora	530	2.50×10^4	1.26×10^4	1.80×10^4	< 0.2
Total coliforms	Abs	Abs	Abs	Abs	Abs
Staphylococcus aureus	Abs	Abs	Pres	Abs	Abs
Salmonella	Abs	Abs	Abs	Abs	Abs
Shigella	Abs	Abs	Abs	Abs	Abs

Abs: absence, Pres: presence

$\sum y_{ij}$: The combination of different chemical and biological factors depending on the physical condition given.

The outline of this hospital is represented in general in the form of Fig. 4.

3.2 Characterization of Biological Pollution of Hospital Units ($\sum_{j=1}^{m} Bj$)

Central Laboratory of Microbiology of the Hadi Flici Hospital in Algiers.

Separation laboratory, blood transfusion center in Blida.

Serology laboratory, blood transfusion center in Blida.

3.3 Characterization of Chemical Pollution of Hospital Units ($\sum_{i=1}^{m} Ci$)

The passage of the air through the cotton filters of 3 cm diameter, gluteraldehyde fixes molecules. The spinning of cotton parts after settling and filtration, UV-Visible spectrum of the crude solution shows traces of gluteraldehyde contained in the air of the endoscopic unit. This detection method is applied during the disinfection operation, it can reasonably estimate the pollution of the air from the hospital unit by glutaraldehyde vapors [17-20] (Fig. 14). For glutaraldehyde, Regulation on the quality of the workplace (RQMT) limits the standard average exposure to the concentration of 0.2 ppm in the air. The American Conference of Governmental Industrial hygienists (ACGIH) limits the average and standard exposure ceiling of glutaraldéhude at 0.05 ppm [21]. Recent studies show that exposure of persons engaged in disinfection with glutaraldehyde varies depending on the type of process used (dip tanks or automatic

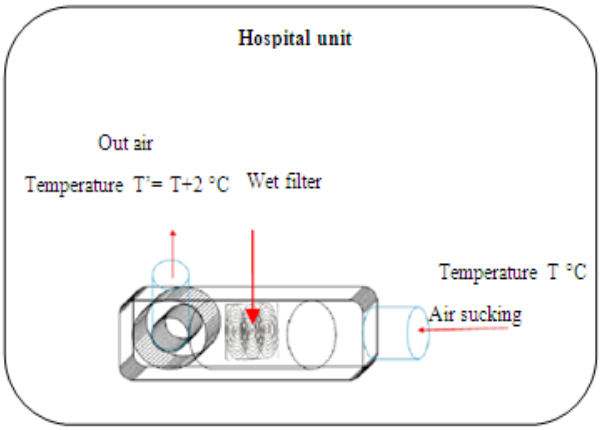

Fig. 5 Detection of glutaraldehyde.

Table 4 The average of microbiological analysis (air, wall, floor and bench) of the blood transfusion center of Blida, Separation laboratory.

Germs (CFU/m^3)	Air	Wall	Floor	Bench	Norms
Yeasts	533	1.56×10^4	1.18×10^4	6.56×10^2	< 0.2
Molds	750	1.71×10^3	3.62×10^3	1.07×10^3	< 0.2
Mesophilic aerobic flora	570	3.45×10^4	1.26×10^4	1.38×10^4	< 0.2

Table 5 The average of microbiological analysis (air, wall, floor and bench) from the center of blood transfusion of Blida, serology laboratory.

Germs (CFU/m^3)	Air	Wall	Floor	Bench	Norms
Yeasts	7.5 C	Abs	13.5×10^3	Abs	< 0.2
Molds	19.5	Abs	11^3	11^3	< 0.2
Mesophilic aerobic flora	40.5	Abs	36×10^3	< 30	< 0.2
Staphylococci	Abs	1.5	5	Abs	Abs
Streptococcus	Abs	Pres	Pres	Pres	Abs

Abs: absence, Pres: presence.

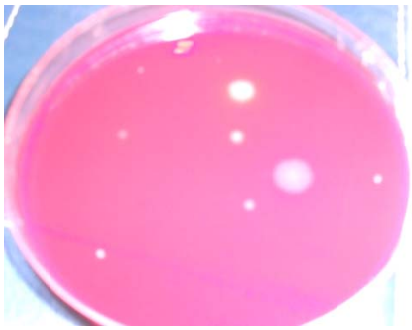

Fig. 6 Identification of *Staphylococcus* aureus (wall, floor and bench) of the Central Laboratory of Infectious Diseases in El Kettar Hospital.

Fig. 7 Identification of *Mesophilic* aerobic flora (air, wall, floor and bench) of the Central Laboratory of Infectious Diseases in El Kettar Hospital.

Fig. 8 Identification of *yeasts* and *molds* (air, wall, floor and bench) of the Central Laboratory of Infectious Diseases in El Kettar Hospital.

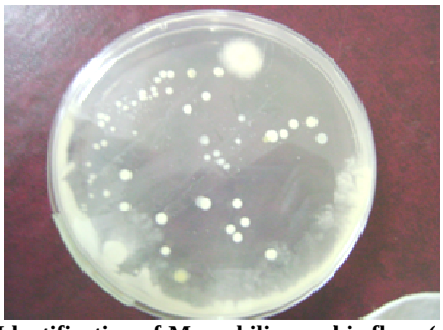

Fig. 9 Identification of Mesophilic aerobic flora (air, wall, floor and bench) of the blood transfusion center of Blida, Separation laboratory.

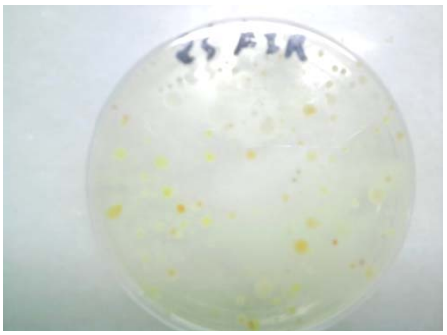

Fig. 10 Identification of Mesophilic aerobic flora (air, wall, floor and bench) of the blood transfusion center of Blida, Serology laboratory.

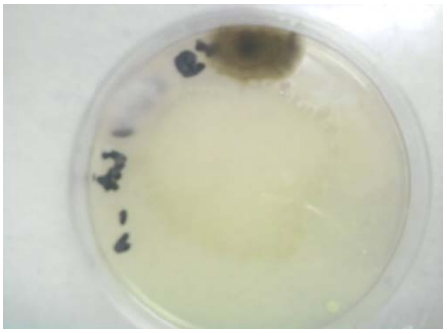

Fig. 11 Identification of *yeasts* and *molds* (air, wall, floor and bench) of the blood transfusion center of Blida, Separation laboratory.

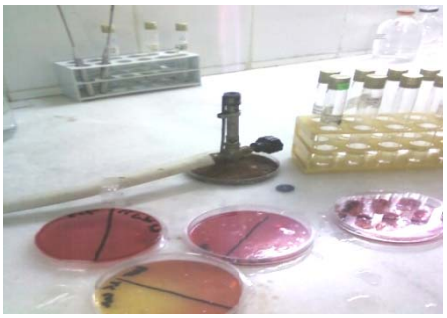

Fig. 12 Identification of *staphylococci* (air, wall, floor and bench) of the blood transfusion center of Blida, Separation laboratory.

Fig. 13 Identification of *streptococcus* (air, wall, floor and bench) of the blood transfusion center of Blida, Separation laboratory.

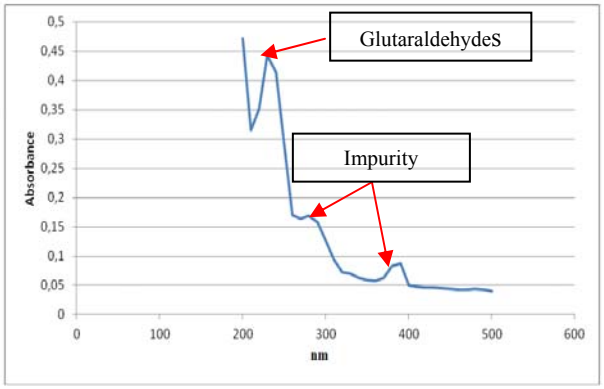

Fig. 14 UV spectrum of gluteraldehyde derivative.

Table 6 Physical and chemical properties of gluteraldehyde [1-25].

Characteristics	Value
Formula	$C_5H_80_2$ (CHO-$(CH_2)_3$-CHO)
N° CAS	111-30-8
Molar mass (g/mol)	100.12
Density (kg/m^3)	0.72
Melting point (°C)	-14
Boiling point (°C)	188 (at 1 002 hPa)
Vapor pressure (hPa)	22 à 23 (at 20 °C)
Water solubility	100 g/100 g H_2O (at 25 °C)
Solubility	Soluble in water, alcohol and benzene
Henry's constant (atm/m^3 mol)	1.1×10^{-7}
Olfactory detection limit	0.04 (ppm)

washers) and the presence or absence of ventilation at the source [22-23]. Exposure levels are, on average, around the threshold suggested by the ACGIH 0.05 ppm [21].

3.4 Application of the Targeted Approach to the Endoscopic Unit in the Hospital of Blida

We applied the concept of a targeted approach to the endoscopic unit in the hospital of Blida. Exploring upper gastrointestinal endoscopy and duodenal colonoscopy is practiced by thermolabile endoscopes disinfected cold manually using glutaraldehyde as a disinfectant.

3.4.1 Characterization of Chemical Pollution ($\sum_{i=1}^{m} Ci$)

In the case of endoscopic unit, chemical pollution is based on the properties of glutaraldehyde (Table 6) used for disinfection of endoscopes in Algeria.

$$\sum_{i=1}^{m} Ci = \text{gluteraldehyde} \quad (5)$$

The GA is an aldehyde whose chemical function CHO unite with amino groups of lysines of the enzyme [1].

The gluteraldehyde is found to be generally toxic or very toxic to aquatic organisms. Only the Hyalella azteca amphipod appears insensitive to gluteraldehyde [1-25].

3.4.2 Characterization of Biological Pollution ($\sum_{j=1}^{m} Bj$)

In this unit where the pathogenic risk is always high, we studied the nature of biological pollution in the disinfectant solution, where chemical, biological and biochemical risks unfold.

3.4.3 Characterization of Biological Pollution in Disinfectant Solution before Installing the Endoscope Disinfector Washer of Health Technology of Algeria

The periodic takings of samples of the disinfecting solution in the endoscopic unit during endoscopic exercises before installing the disinfector washer of the endoscope are presented in Table 7.

$$\sum_{j=1}^{m} Bj = Molds + Yeasts + \text{Mesophilic aerobic flora} + Total\ Coliform + Total\ germs + Salmonella + E.\ coli + S.\ aureus + P.\ auruginosa. \quad (6)$$

$\sum_{i=1}^{m} Ci = 0$ (Closed circuit)

In the case of the endoscopic unit the findings and the results of sampling and analysis reveal the equation:

$$E_k = gluteraldehyde + Molds + Yeasts + \text{Mesophilic aerobic flora} + Total\ Coliform + Total\ germs + Salmonella + E.\ coli + S.\ aureus + P.\ auruginosa + y_{ij} \quad \text{Eq. (7)}$$

These results show the existence of two groups of germs: standing germs (*Total coliforms* (Figs. 17 and 25) Mesophilic aerobic flora (Fig. 24), *Yeast* (Figs. 21 and 23), *Mold* (Figs. 20 and 22), *Germs total* (Figs. 17 and 25)) consequence of the nature of construction materials and pathogens (*E. coli* (Fig. 16) *S. aureus* (Fig. 18), *Salmonella* (Fig. 15), *P. auruginosa* (Fig. 19)) consequence of a high frequency of consultations [26].

Table 7 Average microbiological analysis of the disinfectant solution before installing the disinfector washer of the endoscope (endoscopic unit of hospital of Blida).

Germs (CFU/ml)	Specimens			Norms AFNOR
	10 Days	20 Days	30 Days	
Molds	> 100	> 100	> 100	25-100
Yeasts	> 100	> 100	> 100	25-100
Mesophilic aerobic flora	> 100	> 100	> 100	25-100
Total Coliform	> 100	> 100	> 100	25-100
Total germs	> 100	> 100	> 100	25-100
Salmonella	Pres	Pres	Pres	Abs
E. coli	Pres	Pres	Pres	Abs
S. aureus	Pres	Pres	Pres	Abs
P. auruginosa	Pres	Pres	Pres	Abs

Abs: absence, Pres: presence

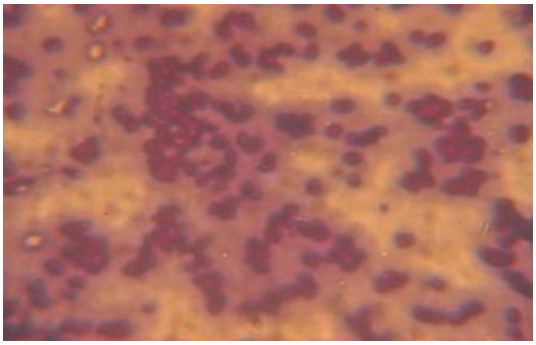

Fig. 15 Microscopic observation G × 40 of *Salmonella*.

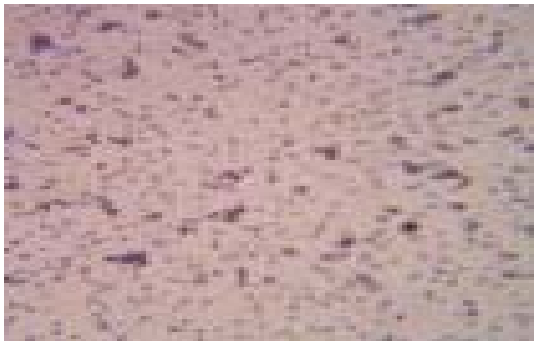

Fig. 18 Microscopic observation G × 40 of *S. Aureus*.

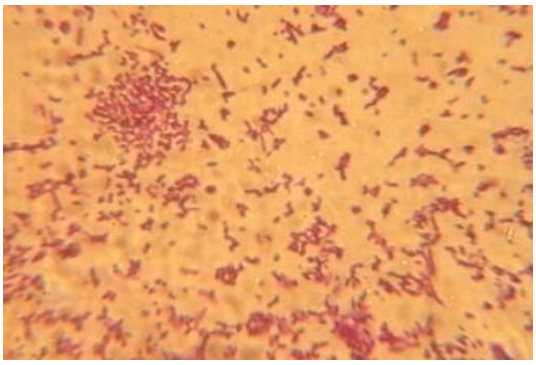

Fig. 16 Microscopic observation G × 40 of *E. Coli*.

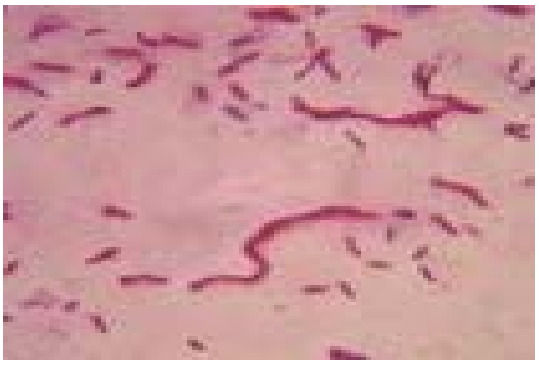

Fig. 19 Microscopic observation G × 40 of *P. aeruginosa*.

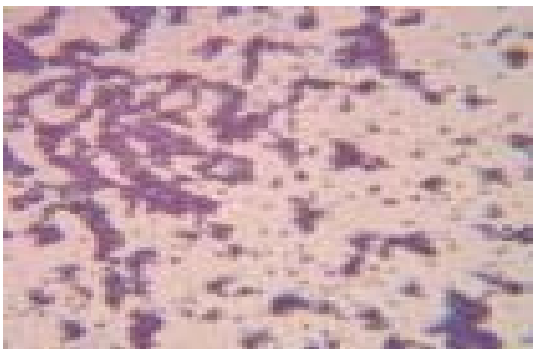

Fig. 17 Microscopic observation G × 40 of total *coliform*.

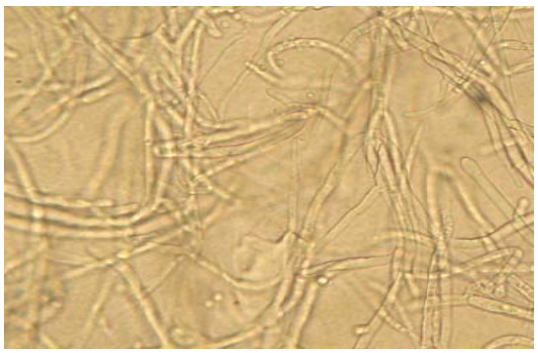

Fig. 20 Microscopic observation G × 40 of *molds*.

Table 8 Average microbiological analysis of the disinfectant solution after installing the endoscope disinfector washer (endoscopic unit of hospital of Blida).

Germs (CFU/ml)	Specimens			Norms AFNOR
	10 Days	20 Days	30 Days	
Molds	< 30	< 30	< 30	25-100
Yeasts	4×10^3	32×10^2	15×10^2	25-100
Mesophilic aerobic flora	< 30	< 30	< 30	25-100
Total Coliform	< 30	< 30	< 30	25-100
Total germs	< 30	< 30	< 30	25-100
Salmonella	Abs	Abs	Abs	Abs
E. coli	Abs	Abs	Abs	Abs
S. aureus	Abs	Abs	Abs	Abs
P. auruginosa	Abs	Abs	Abs	Abs

Abs: absence, Pres: presence

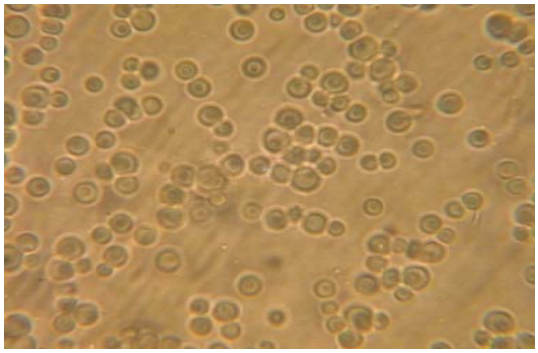

Fig. 21 Microscopic observation G × 40 of *yeast*.

Fig. 22 Microscopic observation G × 40 of *molds*.

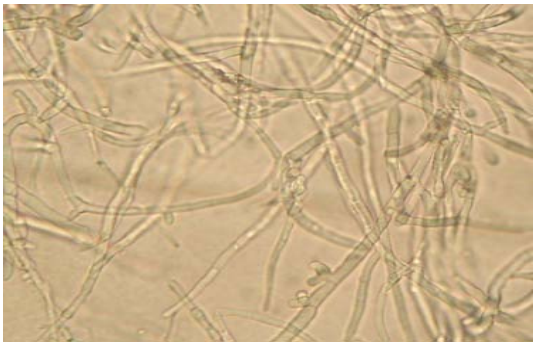

Fig. 23 Microscopic observation G × 40 of *yeast*.

The complex technology of endoscopes (capillary and optical canalization paired) [27] on one side and the phenomenon of encapsulation of germs [28] leave the disinfectant highly contaminated and contaminating. Eliminating the factor y_{ij} in the concept of a targeted approach can only be achieved if the disinfection takes place in a closed circuit [29]. This condition prevents the vapors of the gluteraldehyde and biological contamination via the phenomena of microbial encapsulation [30]. The technology of endoscope disinfector washer meeting this requirement will be the subject of another publication.

3.4.4 Characterization of Biological Pollution in Disinfectant Solution after Installing the Endoscope Disinfector Washer of Health Technology of Algeria

$$\sum_{j=1}^{m} \text{Bj} = \textit{Molds} + \textit{Yeasts} + \text{Mesophilic aerobic flora} + \textit{Total Coliform} + \textit{Total germs} \quad (8)$$

After the installation of chemical and biological antipollution system suitable for endoscopic unit in the university hospital of Blida. We performed periodic analysis of the sanitizing solution taken in the closed circuit [29]. The results presented in Table 8 shows that equation (8) results in:

$$E_k = \textit{Molds} + \textit{Yeasts} + \text{Mesophilic aerobic flora} + \textit{Total Coliform} + \textit{Total germs} \quad (9)$$

3.5 Discussion

We conducted sampling in the air, on the walls, floors and laboratory benches at the hospital of Blida

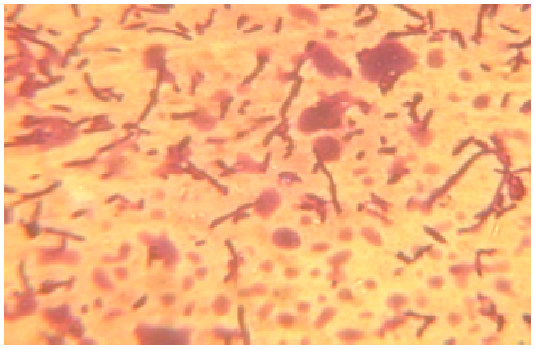

Fig. 24 Microscopic observation G × 40 Mesophilic aerobic flora.

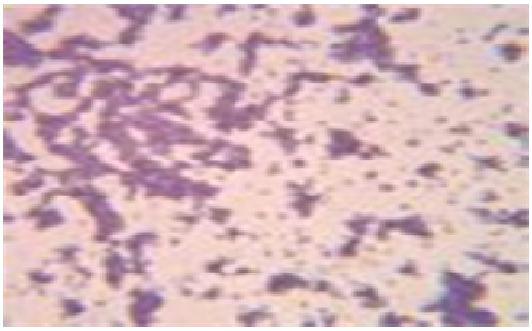

Fig. 25 Microscopic observation G × 40 of *total coliform*.

separation laboratory (Figs. 9 and 11-13) and serology laboratory (Fig. 10)) and the central laboratory of Infectious Diseases in El Kettar Hospital (Figs. 6-8). Microbiological analysis in the concept of global approach shows a significant contamination by yeasts, molds (Figs. 8 and 11) and total mesophilic aerobic flora (Figs. 7, 9 and 10) (Table 3-5). This common denominator in microbiological units is the result of non-specific coatings and materials that characterize our hospitals. In addition, the porous and brittle materials are all infected homes that are beyond disinfection which implies the continuity of nosocomial infections. The dreaded biological pollution staphylococci 1.5 and 5 colonies (Fig. 12) (Table 5) in walls and floors is recognized at the serology laboratory (Blida) is explained by the high frequency of blood tests taken, it can also be explained by the rising of air currents via the sewer system.

In the framework of the application of the concept of the targeted approach which is based on the control of biological an chemical pollution in the endoscopic unit, the microbiological analysis of the disinfectant before the installation of disinfector washer show a significant contamination by yeasts, molds, mesophilic aerobic flora total coliforms and total bacteria (Table 7). This is probably true due to a permanent contamination of walls, floors and ceilings. Biological engineering studies show that porous and brittle materials are infected homes where the disinfection of such germs is impossible [26]. The dreaded pathogen biological pollution (*E. coli*, *S. aureus*, *Salmonella* and *P. auruginosa*) remains the main concern. Its detection in the disinfectant solution is a consequence of the phenomenon of encapsulation of germs. This often results in cross contamination endoscope-patient. More over the presence of gluteraldehyde detectable by the smell 0.04 ppm is revealed by the analysis of disinfectant via UV-Visible. This results show important and random concentration of gluteraldehyde because of exchanges with outside environment.

Sampling results of the disinfectant solution samples after installing the washer disinfector of endoscope indicate the absence of pathogens in the closed system (Table 8) [29]. The lack of pathogenicity is due to the presence of adapted filters (anti-glare filter, capsule filter) [29]. On the other hand, the gluteraldehyde vapors are undetectable by the smell and the UV-Visible due to the application of the pollution control system.

4. Conclusions

The system "structure-network (sewer system)-WTP" does not control the behavior of the polluting entity. It does not allow the traceability in case of leaking. Point source (hospital) presents itself as a community of secondary sources (hospital unit). Each unit produces a specific chemical and biological pollution. The targeted approach confines the factor y (zero effluent) based on the adaptation of antipollution system specific to each secondary source E_k in the process of managing of pollution. As

result chemical and biological components ($\sum_{k=1}^{n}\sum_{i=1}^{m} Ci + \sum_{k=1}^{n}\sum_{j=1}^{m} Bj$) would be significantly simplified:

$H = \sum_{k=1}^{n}\sum_{i=1}^{m} Ci + \sum_{k=1}^{n}\sum_{j=1}^{m} Bj$ with y_{ij} = zero.

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