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TITLE PAGE

Hospital effluents management: chemical, physical, microbiological risks and legislation in different countries

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ABSTRACT

Hospital wastewater (HWW) can contain hazardous substances, such as pharmaceutical residues, chemical hazardous substances, pathogens and radioisotopes. Due to these substances, hospital wastewater can represent a chemical, biological and physical risk for public and environmental health. In particular, several studies demonstrate that the main effects of these substances can't be neutralised by wastewater treatment plants (WWTPs). These substances can be found in a wide range of concentrations due to the size of a hospital, the bed density, number of inpatients and outpatients, the number and the type of wards, the number and types of services, the country and the season. Some hazardous substances produced in hospital facilities have a regulatory status and are treated like waste and are disposed of accordingly (i.e., dental amalgam and medications). Legislation is quite homogeneous for these substances in all industrial countries. Problems that have emerged in the last decade concern substances and microorganisms that don't have a regulatory status, such as antibiotic residues, drugs and specific pathogens. At a global level, guidelines exist for treatment methods for these effluents, but legislation in all major industrial countries don't contain limitations on these parameters. Therefore, a monitoring system is necessary for these effluents as well as for substances and pathogens, as these elements can represent a risk to the environment and public health.

Keywords: Hospital wastewater, legislation, guidelines, water pollution, emerging pollutant

1. Introduction

In recent years, many researchers have realised that hospital wastewater (HWW) could be hazardous to both humans and the environment due to the presence of pathogens, pharmaceuticals substances, and products of laboratories and research activities. Many of these substances are contained in the faeces and urine of patients and are excreted as non-metabolised drugs in the sewer system (Orias and Perrodin, 2013; Verlicchi et al., 2010a, 2012).

Several studies on HWW confined themselves to the investigation of a limited number of pharmaceutical compounds (in particular, antibiotics and anti-inflammatory drugs), their fate in the water management cycle and in the environment (Al Aukidy et al., 2014; Brechet et al., 2014; Boillot et al., 2008; Hartemann et al., 2005; Schuster et al., 2008; Verlicchi et al., 2010a).

Only a few countries have reference standards and specific treatment methods to manage these effluents. For industrial effluents, however, there are specific reference standards and treatment methods imposed at regional or municipal levels by competent authorities, with regard to direct discharge (in surface waters), the reuse after suitable treatment, and discharge in a municipal wastewater treatment plant (WWTP) (indirect discharge).

Some countries, in fact, consider hospital wastewater to be domestic and therefore discharged, directly in the municipal sewer network without any pretreatment or imposed quality limits. Reference standards and quality control are usually imposed only after the treatment of the WWTP effluents. In only few countries, hospital effluents are considered to be industrial and are pretreated before discharge in the municipal sewer network.

Parameters typically set by legislation for assessing the quality of a generic wastewater sample are the basic physico-chemical indicators: pH, temperature (usually <40 °C), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C (BOD_5)) and Total Suspended Solid (TSS). If the wastewater sample is considered to be industrial or a specific effluent (such as from hospitals, in some cases), measurements of other specific macropollutants are required, such as Adsorbable Organic Halogens (AOX), total and free chlorine, detergents, disinfectants, tensioactives, oil and

grease, sulphates, cyanides, organophosphorates, total nitrogen, heavy metals and rarely microbiological indicators (total coliform, faecal coliform or *Escherichia coli*) and toxicity.

An emergent concern about hospital effluents are the chemicals without regulatory status whose impact on the environment and human health are poorly understood. These are referred to as "emerging pollutants", such as pharmaceutical compounds (antibiotics, APIs), chemical residues, radioelements, antibiotic resistance strains, and pathogens that don't have a regulatory status but can represent a risk. In fact, the fate of these compounds in the environment and the possibility of reduction by the WWTPs are unknown. The introduction of these hazardous substances (particularly disinfectants, non-metabolised pharmaceuticals and radionuclides) into the aquatic ecosystem could have a heavy impact on aquatic organisms as well as for the human population, as the final recipient of this type of pollution (Emmanuel et al., 2005; Le Corre et al., 2012; Suarez et al., 2009; Varela et al., 2014).

The aims of this overview are the following: I) to describe the qualitative characteristics of hospital effluent, II) to analyse their possible impact on the basis of their quantity, and III) to provide information about the major international legislation and guidelines of this effluent.

2. Characteristics of hospital wastewaters

There is a wide variability of the characteristics of the hospital effluents in relationship to the size of hospitals, the bed density, the number of inpatients and outpatients, the number and the type of wards, the number and types of services, the country and the seasonality (Al Aukidy et al., 2014; Verlicchi et al., 2012).

These effluents are generated from all activities of the hospital, including medical (operations, emergency and first aid, laboratories, diagnosis, radiology etc.) and non-medical activities (toilets, kitchens and laundry activities etc.), and these can be classified into two main categories:

- **domestic discharges** from kitchens, laundries and toilets of normal wards;
- **specific discharges** generated by care, analysis and research activities. These discharges can contain disinfectants, detergents, contagious faeces/excreta, biological

liquids, drug residues, metal radioelements, and many other chemicals (acids, alkalis, solvents, benzene, hydrocarbons, colorants, etc.). These effluents can potentially contain some hazardous substances with a genotoxic or cytotoxic activity, toxic or hazardous chemicals or pharmaceutical residues, and radioactive and/or infectious agents (WHO, 2013).

Table 1 and **Table 2** represent HWW data of physico-chemical indicators that concern facilities of different sizes, flow rate and countries, compared with those of urban wastewaters (UWW) plants with different population equivalents. These data confirm the evidence of the wide variability of characteristics of these effluents due to the many variables that come into play. The COD indicator that measures the total oxygen-depletion due to the presence of water contaminant (biodegradable and non-biodegradable oxidisable pollutants) shows high values for the hospital effluents.

Concerning the macropollutants it has been shown that only ammonium ions are more concentrated in HWW than in the UWW, despite data being limited.

Data of microbiological indicators indicate that total *E.coli* load is generally higher in urban than in hospital wastewater, due to the higher dilution of wastewater in hospital, in which water consumption per bed is high (~700 L per day) (Brechet et al., 2014). The content of faecal and total coliform are greater in UWW than in HWW.

2.1. Chemical riskss

The main chemical substances that can be found in HWWs are antibiotics, analgesics and anti-inflammatories, psychiatric drugs, β-blockers, anaesthetics, disinfectants, chemicals from laboratory activities, developer and fixer solutions from photographic film processing and X-ray contrast media (WHO, 2013).

These substances are excreted mainly in the urine (55-80%), less so in faeces (4-30%), as unmetabolised substances, metabolites, or conjugated with inactivating substances (Alcock et al., 1999; Al Aukidy et al., 2014; Jjemba, 2006; Verlicchi et al., 2012). These substances may have different behaviours in the WWTP due to their different solubility, volatility, molecular weight,

adsorbility and biodegradability, polarity, stability, half-life and persistency, and if they are not neutralised in the wastewater treatment, they are released in surface waters with treated effluents (Verlicchi et al., 2010a).

Most researchers concentrated their studies on pharmaceuticals, due to the worldwide increase of consumption (especially antibiotics), as well as their detection in wastewaters and surface waters, and for their potential impact on the environment and human health, such as endocrine disruption and sexual disturbance in aquatic organisms (Al Aukidy et al., 2014; Diwan et al., 2013; Fick et al., 2009; Jean et al., 2012; Kovalova et al., 2013; Le Corre et al., 2012; Orias et al., 2013; Passerat et al., 2010; Santos et al., 2013; Verlicchi et al., 2010a).

Some of these substance, (diclofenac, 17β-estradiol, 17α-ethinylestradiol), have been included in the European priority list (European Community Directive 2013/39, about water policy) and in the US contaminant candidate list (erythromycin, 17α-ethinylestradiol, 17α-estradiol, 17β-estradiol, equilenin, equilin, estriol, estrone, mestranol and norethindrone) that concern new substances for priority action (EPA, 2009).

Studies that focus on comparisons between hospital and urban effluents have shown that the concentration of pharmaceuticals in hospital effluents is greater than in UWWs for almost all compounds, in particular antibiotics (Al Aukidy et al., 2014; Santos et al., 2013; Stalder et al., 2013; Verlicchi et al., 2012) (**Table 3**). Environmental drug contamination, however, can be derived from other sources, such as livestock, slaughterhouses, aquacultures, and agriculture, and in some case with a greater total concentration of pharmaceutical compounds (Harris et al., 2013; Lupo et al., 2012; Sim et al., 2013; Rizzo et al., 2013). The report on surveillance of antimicrobial consumption in Europe of European Centre for Disease Prevention and Control (ECDC) revealed that in Latvia and Finland, 20% of total consumption of systemic antibacterials is derived from the hospital sector. In other countries, this proportion does not reach 10%, and greater consumption is derived from the community (domestic and commercial facilities).

Many studies utilised the Risk Quotient (RQ) for evaluating the ecotoxicological potential of HWW in the environment. The risk quotient is a common method utilised for any other chemical hazard substances. This value is derived from the ratio of the Predicted Effect Concentration (or

measured) (PEC) of the substance and its Predicted No Effect Concentration (PNEC): the concentration that has no adverse effects on the Environment.

In the case of HWW, the PEC value is derived from the amount of each active ingredient consumed in the hospital, M (g), the fraction of excreted unchanged active ingredients in urine and faeces, $f_{excreted}$, and the volume of the HWW in the main wing where pharmaceuticals are consumed, V (L) (Escher et al., 2011; Orias et al., 2013).

$$PEC = \frac{M * F\ escreted}{V}$$

Several studies show that in hospital effluent, the RQs were above 1 for the majority of analysed substances, in particular for certain compounds (Ofloxacin, 17α-ethinylestradiol, erythromycin and sulfamethoxazole) (Al Aukidy et al., 2014; Kümmerer and Henninger, 2003; Le Corre et al., 2012; Brackers de Hugo et al., 2013).

For other potentially hazardous substances, the WHO stated that health care facilities contribute up to 5% of the release of mercury to bodies of water through untreated wastewater, and in the United Kingdom, more than 50% of total mercury emissions come from mercury contained in dental amalgam and laboratory and medical devices (WHO, 2013). In Europe and in other countries, the discharge of the dental amalgam in WWTPs is prohibited because it contains a mixture of mercury (approximately 50%) and a number of other metals, including silver, tin, copper and zinc. In fact, mercury is on List I of dangerous substances in the European Dangerous Substances Directive n. 2006/11/EC.

Other hazardous substances that can be present in HWW are disinfectants, such as chlorine, quaternary ammonium, and metal ions, i.e., for the deactivation of *Legionella* bacteria in the warm water system or as an alternative for chlorine disinfection using copper-silver ionisation. Other disinfectants that are used in large quantities in health-care facilities are formaldehyde-based disinfectants (formalin) for dialysers and disinfection of dialysis equipment and the associated reverse osmosis units, as well as in pathology (WHO, 2013). X-ray contrast media is the source of AOX compounds (in particular iodine-molecules). These compounds are toxic to fish and other aquatic organisms at low concentrations. Many are persistent and have a tendency to bioaccumulate. Little is known about the fate and long-term effects of these substances (WHO, 2013).

2.2. Physical risks

The main physical hazard derived from HWW is associated with the radioactive substances in the effluents, which are utilised in nuclear medicine therapies. The main isotope utilised is the ^{131}I radioisotope, while other radionuclides used are typically simple beta emitters (e.g., phosphorus-32, strontium-89, and yttrium-90) that pose much less risk. The contamination by this radioisotope, derived from the excreta of treated patients, can reach levels of up to 90% of the radioactive dose administered, depending on the type of therapy the patient underwent. Given its radioactive half-life of 8 days, there is a significant risk of ^{131}I radioisotope accumulation after its discharge into the sewer network (through sanitary wastewater) and into the environment (Rodríguez, 2012; Tavakoli, 2005). The method normally utilised for abating radioactivity is the natural decomposition of the isotope, decay and delay, in holding tanks (8 days for ^{131}I), before the discharge in the foul sewer.

2.3. Biological risks

The biological risk of HWWs is derived from the plausible presence of infectious agents. In general, wastewater can contain a large variety of pathogen microorganisms (bacteria, protozoa, helminths and viruses) that are principally derived from the faeces of infected humans and primarily transmitted by the faecal-oral route (enteric microorganism) and secondly by bodily fluid discharge, usually in small quantities.

In **Table 4** are EPA data (EPA, 2012) of the concentration of infectious agents potentially present in raw domestic wastewater compared with the pathogen concentration from the reviewed literature, in both UWWs and HWWs. The bibliography about detection of pathogenic bacteria and protozoa in the HWW is practically non-existent, probably because a legislation is not present and because the interest is focalised on other important problems, such as bacterial resistance and the detection of pathogens in effluents of WWTPs or in surface water. On the contrary, the enteropathogenic virus (Norovirus, Adenovirus, Rotavirus and Hepatitis A Virus) concentrations in hospital effluents are 2-3-fold greater than in UWWs (**Table 4**).

A problem over the last decade concerns bacterial resistance to antibiotics. Bacterial resistance to antibiotics has become an issue of growing concern worldwide frequently attributed to the excessive use of antibiotics, in particular .

wastewater treatment plants can serve as potential reservoirs of antibiotic resistant-bacteria (ARB). The fate of ARB in wastewater is primarily linked to release of ARB from patients (e.g. *E. coli*) or from both patients and hospital equipment (e.g. *P. aeruginosa*) (Tumeo et al., 2008). Antimicrobials also rejected in wastewater exert a continuous selective pressure on ARB. In acute-care hospitals, the antimicrobial selective pressure is particularly high, for instance, 20 to 30% of European inpatients receive an antibiotic treatment (ECDC, 2013). In the community, only 1-3% of individuals received an antibiotic treatment. The selective pressure is consequently much more important in HWW than in UWW. Antimicrobial residues may also induce bacteria to transfer horizontally antibiotic resistance genes for other community members (Varela et al., 2014). Antimicrobial residues would be implicated in the rearrangement of the bacterial communities in surface and wastewater, supported by the demonstration of the significant correlation among the concentrations of antimicrobial residues, antibiotic resistant bacteria or their genes and rearrangements of the communities (Brechet et al., 2014; Gros et al., 2013; Stalder et al., 2013; Huerta et al., 2013; Novo et al., 2013; Varela et al., 2014). Regarding antibiotic classes, β-lactams are the most widely used group of antibiotics in inpatients, followed by fluoroquinolones. However, β -lactams are rarely detected in wastewater because the β -lactam ring is readily cleaved by hydrolysis (Brechet et al., 2014). By contrast, high concentrations of fluoroquinolones are found in HWW, WWTPs and downstream from the WWTP, in rivers (Rodriguez-Mozaz et al., 2015). This is also the case for macrolides or sulphonamides.The ARB represent a risk to humans and animals because they can reduce the therapeutic potential against pathogens.

3. Production of hospital wastewater

Regarding water consumption and the consequential production of wastewaters, the peak coefficients for hospital flow rates are fairly analogous to those generally assumed for the influent to a small WWTP (<10,000 inhabitants or population equivalent, p.e.) (Verlicchi et al., 2010a). The total production, however, depends on the same factors mentioned above for several characteristics (number of inpatients and outpatients, number of beds, number and type of wards and units, facility size, number and types of services), as well as on the facility age and maintenance requirements, cultural and geographical factors, hour of the day and the season. Other contributors include steam

sterilisers, autoclaves, medical processes, heating ventilation and air conditioning, sanitary, x-ray equipment and other services that the hospital provides (e.g., kitchen, laundry) (Diwan et al., 2013; Galletti et al., 2011; Wissenschaftszentrum Umwelt, 2000).

Concerning the total effluent contribution of hospital facilities in a city, the volume unloaded in the municipal WWTP depend also on other factors, such as number of hospitals, industrialisation level, population density and the number of beds used per day. For the calculation of this percentage in Europe, considering that there are approximately 2.6 hospitals for every 100,000 inhabitants (ranging from 1 in the Netherlands to almost 6 in Finland) (EHHF, 2011), with on average 530 hospital beds (ranging from approximately 320 in Spain and little more than 800 in Germany) and that HWW discharge is approximately 0.3 to 0.7 m^3 per bed a day (Boillot et al., 2008; Esher et al., 2011; Kovalova et al., 2013; Lienert et al., 2011; Suarez et al., 2009), the total effluents produced from these facilities are approximately 265 m^3/d (from an average of 0.5 m^3/d for hospital bed) in a city with 100.000 inhabitants.

In a city like Turin with 1,500,000 inhabitants with a total wastewater production of about 7.2 x 10^5 m^3/d (SMAT, Turin Metropolitan Water Society informative guide), the percentage of hospital effluents is approximately 0.6% of the total discharge treated in a municipal WWTP. In other studies, the percentage may be 0.2% (in a city with a 50 bed per 100,000 inhabitants hospital and a WWTP capacity of 55,300 m^3 per day) (Le Corre et al., 2012) to 2% (Galletti et al., 2011; Korzeniewska, 2012).

4. Guidelines for the management of hospital wastewater

The only existing guidelines concerning hospital effluents were published by the World Health Organization (WHO) in 1999: “Safe Management of Wastes from Health-care Activities” (WHO, 1999) and updating in 2013 (WHO, 2013). This publication describes the methods for the treatment and disposal of health-care wastes, in which there is a section that concerns the collection and the disposal of wastewater from health-care activities.

The WHO states that, *“A large part of the wastewater from health-care facilities is of a similar quality to domestic wastewater and poses the same risks. Just as domestic wastewater is considered to*

be potentially infectious, wastewater from health-care facilities must also be considered in a similar manner and precautions taken" but "*A proportion of the generated wastewater from health-care facilities will pose a higher risk than domestic wastewater. Depending on the service level and tasks of the health-care facility, the wastewater might contain chemicals, pharmaceuticals and contagious biological agents, and might even contain radioisotopes*" (WHO, 2013).

In the first part, the guideline describes the hazardous characteristics of these wastewaters that agree with majority of studies reviewed. The second part suggests the methods of treatment of particular hazardous effluents. These methods are summarised in **Table 5**. In general, pretreatment is recommended for wastewater streams from departments such as medical laboratories (could include acid–base neutralisation, filtering to remove sediments, or autoclaving samples from highly infectious patients) and from the dental department, by installing an amalgam separator in sinks. Moreover, the minimum requirements for the discharge of HWW into a municipal sewerage system are the following:

- an efficient sewage-treatment plant with primary, secondary and tertiary treatment of a municipal sewers that is connected to the hospital sewer;
- the municipal sewers should be connected to a central treatment plant that ensures at least 95% removal of bacteria;
- the sludge resulting from sewage treatment is subjected to anaerobic digestion, leaving no more than one helminth egg per litre in the digested sludge**;**
- the waste management system of the health-care establishment maintains high standards, ensuring only low quantities of toxic chemicals, pharmaceuticals, radionuclides, cytotoxic drugs, and antibiotics in the discharged sewage.

For countries operating only with basic sewage systems or those experiencing epidemics of enteric disease or with endemic intestinal helminthiasis, the onsite treatment, or at least pretreatment, of the wastewater before discharge into the municipal sewerage system should be considered. If the treatment plant doesn't meet the requirements above or the hospital is not connected with a public wastewater treatment, the facility should have an efficient on-site wastewater treatment that includes primary treatment, secondary biological purification, and tertiary treatment (such as lagooning).

The disinfection of wastewater is often required, particularly if the wastewater is discharged into any body of water used for recreational activities or as a source of drinking water (including aquifers). Disinfection of the wastewater is particularly important if it is discharged into coastal waters close to shellfish habitats, especially if the dietary habits of local people include eating raw shellfish. Chlorine disinfection can be utilised only with the requirements described in **Table 5**.

Other factors necessary include a monitoring of wastewater losses between entry points (sinks, toilets, drains) and an onsite treatment plant or tank or discharge point into a municipal sewage system. The monitoring of the wastewater system should include two aspects: monitoring the sewage system and monitoring effluent quality. This includes the most common parameters for monitoring the effluent quality (temperature, pH, BOD5, COD, nitrate, total phosphorus, total suspended solids, presence and concentration of *Escherichia coli*). Furthermore, if an onsite treatment plant is operated, the inflow of wastewater and the outflowing treated effluent should be tested regularly to monitor how efficiently the treatment plant reduces the concentration of contaminants.

The International Commission on Radiological Protection (ICRP) has published a guideline for the release of patients after therapy with unsealed radionuclides. These patients who undergo radioactive therapy release radioactive isotopes with their excreta, Technetium-99m in particular, but its short half-life limits its importance, and the main concern is iodine-131, which can be detected in the environment but has no measurable environmental impact. The guidelines state that storing patients' urine after therapy appears to have minimal benefit and that the radionuclides released into modern sewage systems are likely to result in doses to sewer workers and the public that are well below public dose limits (ICRP, 2004).

In the USA, the Environmental Protection Agency (EPA) enacted the Clean Water Act (CWA) in 1972, which establishes effluent guidelines for facilities that discharge directly into its waters, as well as facilities that discharge into municipal WWTPs. In this guideline, HWW characteristics were described that should exist for discharge in surface waters, after the application of the Best Practicable control Technology (BPT) currently available (EPA, 2010). The BPT does not require the use of any specific technology, but the facility chooses its own approach to comply with its permit limitations. Concerning discharge in the municipal WWTPs, hospital facilities are considered to be a commercial

facility. For these categories, the authority of the WWTP may develop local limits, after the collection of site-specific data on pollutant loadings of facilities and on the WWTP's capacity of removal of those pollutants. The concentration of pollutant loading may not exceed the maximum allowable headworks loading of the WWTP. If the concentration exceeds this, little or no pollutant loading is available for the facilities. The maximum allowable headworks loading is the estimated maximum loading of a pollutant that can be received at a WWTP's headworks that should not cause a WWTP to violate a particular treatment plant limit or environmental criterion (EPA, 2004).

The EPA permits that member states and local city pretreatment programs implement guidelines through the publication of regulations and local limits that reflect the specific needs and capabilities at individual WWTPs, designed for its protection, its receiving waters, and its sludge disposal practices (**table 6**).

5. Normative about the hospital wastewaters

In Europe there is not a specific directive or guideline for the management of hospital effluents. However, the European Directive n. 91 of 21 May 1991 (91/271/CEE modified from Directive 27 of February 1998 n. 98/15/CE) on the treatment of UWW required a pre-authorisation if the wastewater is considered to be industrial before discharge into UWW collection systems (as in certain country is considered the hospital effluent). Moreover, the European Directive n. 98 of 19 November 2008 (2008/98/CEE) about the management of hazardous waste and the list of hazardous waste of the European Decision n. 532 of 3 May 2000 (2000/532/CEE) stated that some hospital liquid waste (pharmaceutical products, medicines, residues from substance for employed as solvents, soaps, no-halogenated organic substance etc.) must not be discharged into a foul sewer but treated as a waste and collected and disposed as such. For the effluents from the hospital foul sewer, there isn't a specific disposition, so member states of the European Union have their own legislation, evaluation and selection criteria for HWW quality and its management.

If a hospital facility is considered, by the legislation of the state, to be industrial or like a facility that discharges not only domestic wastewater (as in Spain and France), specific characteristics of the wastewater will be required for the permission to discharge it in the municipal WWTP (**Table 7**);

usually a pretreatment is required. Instead, in a country where the HWW is considered to be domestic or communal, neither authorisation nor specific characteristics are required (as in Germany).

In other cases, if the HWW complies with the specific characteristics established by the WWTP authority, the wastewater may be considered to be domestic effluent and discharged in WWTPs without any pretreatment. Even if the indicator parameters exceeded the limits imposed, the wastewater may be pretreated (as in Italy).

Table 7 reports the ranges of indicator parameters for hospital effluents only for the member states that have a specific indication. As seen in the table, the indicators required are physic-chemical indicator, macropollutants (NH_4, NO_x, oil and grease, tensioactives, phosphorous, chlorines and others) and in some rare cases, microbiological indicators (typically *E.coli*).

Table 5 reports how special liquid wastes derived from special hospital activities (care, diagnostic tests, analysis and research activities) are treated in different member states. According to the source and the type of substance, the method of treatment changes. When the effluent isn't considered hazardous, it can be discharged in the foul sewer, as is the case for small quantities of blood or other bodily fluids. However, discharge in foul sewers is prohibited for all pharmaceutical residues. For other specific chemical substances, if the chemical is included on the list of hazardous substance of the European Decision n. 532, it will be treated as hazardous waste.

For radioactive excreta derived from patients treated with radioactive therapy, despite what is stated in the ICRP, every member state must adopt their own method of treatment, as shown in **Table 5**. Some countries permit discharge in the urban sewage system without a septic tank collection system (Spain, Great Britain, Republic of Ireland), but in the majority of cases only if it has been demonstrated that the radioactivity does not exceed the limits imposed by a competent authority of sanitary sewers (Rodrígez, 2012). For France, Germany, Northern Ireland, Lithuania, Luxemburg, and the Netherlands, effluents eliminated by patients should be collected in protected rooms and linked to a septic tank for delay and decay. Some of these countries require compliance with some reference limits before discharge into the sewer (Germany and Luxemburg 5 Bq/l and Northern Ireland 80 KBq/l), while other countries impose a time limit on storage (from 30 to 60 days for Lithuania, 210

days for Luxemburg or for up to 2 years for radionuclides with half-lives below 100 days for the Netherlands). In Italy, the Legislative Decree n. 230 of 17 March 1995 (Dlgs, 1995) on radioactive waste does not precisely indicate a method, but the excreta are usually stocked in specific septic tanks for approximately 10 hours for the decay of ^{131}I (Bagnato et al., 2003).

As seen in most other countries, hospital discharges require a specific consent issued by competent authorities (WWTPs) because they are considered to be industrial (China, India) or a facility that discharges only domestic sewage that required a specific licence. In Brazil, HWW is in a category of domestic and municipal wastewater that does not require specific limitations for discharge in WWTPs, only for discharge in surface water.

6. Conclusion

HWW is generated from all hospital activities, both medical and non-medical, and can be classified into two main categories: domestic wastewater (kitchens, laundries and patient of normal ward) and specific wastewater (generated by care, analysis and research activities). Over the past few years, different studies have provided information about the potential presence of hazardous substances in these discharges (disinfectants, detergents, contagious faeces/excretions, drug residues, metals, radioelements, acids, alkalis, solvents, benzene, hydrocarbons, colorants).

From these studies emerged differences in the physico-chemical parameters and faecal indicators. The differences between hospital effluent and UWW were not significant. Moreover, this information doesn't provide an indication on the hazard of these effluents. For hazardous chemical compounds, the most hazardous ones are considered to be waste and are treated as such (i.e., dental amalgam, pharmaceutically active medications). Antibiotics and other pharmaceutical residues that are discharged with the excreta of patients are the substances of greatest concern due to the high concentration of these substances in effluents. The concentrations can reach five-fold the UWW concentration, in particular for some of the following substances: Ofloxacin, 17α-ethinylestradiol, erythromycin and sulfamethoxazole (Al Aukidy et al., 2014). Their fate and behaviour in the environment and their interaction with other substances and/or microorganisms are in part unknown. In fact, several studies demonstrate that the majority of pharmaceutical and personal care products are not eliminated from the liquid phase during wastewater treatment, especially for substances with low lipophilicity (Castiglioni et al., 2005; Suarez et al., 2009). Releasing these substances in the environment can exceed their PNECs (Verlicchi et al., 2012) and can present a risk to the aquatic organisms and public health (i.e., endocrine disruptors), and they can interact with other substances, generating a synergistic effect (Sim et al., 2013).

From the point of view of biological hazards, there is an important shortcoming in assessing pathogen concentration in these effluents. Several studies demonstrate that commonly used bacterial indicators are unreliable in terms of detecting pathogen contamination, and often no correlation between levels of enteric bacteria, enteric viruses and other pathogens has been found (Ahmed et al., 2013; Haramoto et al., 2006; Muela

et al., 2011; Ottoson et al., 2006). Furthermore, WWTPs are not suitable systems for the total removal of pathogens present in these effluents (Prado et al., 2011).

The lack of information on the chemical and pathogen characteristics of these wastewaters is in part due to the absence of specific guidelines. The major industrial countries have their own methods of treatment for these effluents, but none have a specific pharmaceutical residue and pathogen limitation before discharge in WWTPs or in surface water.

The frequency of detection and quantification of these substances, and in particular for pathogens, could be variable according to pathogen type, the different health care centres effluents are derived from, geographic regions and the epidemiological community profile (Prado et al., 2011). For these reasons, it would be appropriate from the perspective of public health, water and environment protection and for a possible reuse of the wastewater, for every country to monitor their own pathogen circulation, concentration of pharmaceutical residues and bacteria resistance in the hospital effluent and in WWTPs. The risk of contamination depends on the dilution factor, which is the volume of hospital effluents in the total UWWs, and on dilution factor of the surface water (Verlicchi et al., 2012). However, from a hygienic point of view, it is important not to underestimate the hazard for the promotion of public health.

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Figure 1. Representation of the levels where EPA effluent guidelines operate.

Table 1. Mean values of physico-chemical indicators of HWW and UWW, from the reviewed studies.

	References	Country	Beds/ Population equivalent	Flow Rate [m^3/d]	pH	TSS (Total Suspended Solid) [mg/L]	COD [mg/L]	BOD_5 [mg/L]	NH_4^+ [mg/L]	Total P [mg/L]	Fats and Oils [mg/L]	Total Detergents [mg/L]
HWW	Verlicchi et al. 2010b	Italy	300						33	4		4.9
	Galletti et al. 2011	Italy	300	180		227±57	480±125	240±82	42±9	6±2		
	Nafo 2012	Germany	560	90±21.4	6.8±0.2	97±33	709±280	325±112		8.3±1.3		
	Suarez et al . 2009	Spain	750	429±63	8.1	191.7	970.7				22.5	
	Varela et al. 2014	Portugal	1120	1000		305	622	278				
	Prayitno et al. 2013	Indonesia			8.1	61.1	198.5	143.7				0.63
	Chagas et al. 2011	Brasil		432	7.5		379.9	100	11.1			
	Prado et al. 2011	Brasil		325.7	7		221.3	68	9			
	Sarafraz et al. 2007	Iran		43	7.42	231.25	628.1	242.25				
	Liang 2007	China			6-9	170	320	150				
	Periasamy et al., 2013	India			7.5	126.6	662.9	129.3				
	Verlicchi et al. 2012	Italy			8	160	650	200	30	5	25	4.5
	Tahiri et al. 2012	Marocco			8		318	76.6				
UWW Inlet	Galletti et al. 2011	Italy	5000	1200		41±15	180±74	70±43				
	Galletti et al. 2011	Italy	230000	35000	7.6	85	109	72	26	3		
	Varela et al. 2014	Portugal	200000	1100000		334	699	488				
	Muela et al. 2011	Spain	500000	120000	7.8	65.8	210.6	123.6	28.2			
	Zhou et al. 2012	China	412500	200000		216.7	415.2	197.5				
	Verlicchi et al. 2012									4-10	50-150	4-8
	Mungray et al., 2011	India		71500		238	803	243.5				

Table 2. Microbiological characteristics of the HWW and of the UWW from the reviewed studies.

	References	Country	Total coliforms MPN/mL	Faecal coliforms MPN/mL	*E.coli* MPN or CFU/mL
HWW	Verlicchi et al. 2012	Italy			10^5-10^7 [1]
	Korzeniewska et al., 2012	Poland			3×10^6- 1.6×10^7 [2]
	Prayitno et al., 2013	Indonesia		$1.3x10^3$	
	Chagas et al., 2011	Brasil	$7.4x10^5$	$0.8x10^5$	
	Liu et al., 2010	China			
	Periasamy et al., 2013	India	$1.3x10^3$	$2.2x10^2$	
	Tahiri et al., 2012	Marocco	2×10^4	1.5×10^3	
	Galvin et al., 2010	Ireland			5.4×10^6 [1]
	Brechet et al., 2014	France			3.5×10^5 [2]
	Kwak et al., 2015	Sweden			3.7×10^4 [2]
	Oberlè et al., 2012	France			8.3×10^4 [2]
UWW Inlet	Verlicchi et al., 2012	Italy	10^7-10^8	10^6-10^7	10^6-10^7 [1]
	Korzeniewska et al., 2012	Poland			5.5×10^7 [2]
	McLellan et al., 2010	USA			1.1×10^6 [2]
	Levantesi et al., 2010	Europe			2.4×10^5- 3.6×10^6 [2]
	Mungray et al., 2011	India	$5.4x10^{12}$	$1.5x10^{12}$	
	Brechet et al., 2014	France			7.5×10^5 [2]
	Kwak et al., 2015	Sweden			7.4×10^4 [2]
	Oberlè et al., 2012	France			3.9×10^6 [2]

[1] MPN/mL
[2]CFU/mL

Table 3. Concentrations of different types of pharmaceuticals in the HWW and in the UWW from the reviewed studies.

		Antibiotics [ng/L]					Anti-infiammatories drugs [ng/L]				β-blochers [ng/L]	Psychiatric drugs [ng/L]
References	Beds	**HWW**										
		Ciprofloxacin	Clarithromycin	Erytromycin	Ofloxacin	Sulfamethoxazole	Diclofenac	Ibuprofen	Salicylic Acid	Ketoprofene	Atenolol	Carbamazepine
Galletti et al. 2011	300	11768	59	165	18605	4240	304	1674	1320	5027	5131	733
Galletti et al. 2011	900	13487	6589	127	20032	1921	395	1813	1745	1289	4409	956
Varela et al. 2014	1120	880			590	890						
Santos et al. 2013	350	4093	59.4	575	6543	1351	58	4964	1419	369	858	445
Passerat et al. 2010		n.d.			2200	1800						
Kovalova et al. 2013	346	15700±8000	1280±840	140			858±186				23±24	235±128
Diwan et al. 2013	350-570	1025			218	535						
Gros et al. 2013	400	6411.5	543		6673	132.5						
Chang et al. 2010		121.3		137	2905	623						
Sim et al. 2011		1980		330		25300	1920	nd	126000			827
Sim et al. 2013						21000	1120	813		299	43000	227
	Population equivalent	**UWW Inlet**										
Galletti et al. 2011	230000	2212	308	58	1004	443		1026	498	168	2081	581
Varela et al. 2014	200000	440			340	830						
Santos et al. 2013	213000	221 ± 88	22.2 ± 17.8	92.7 ± 77.9	946 ± 1790	912 ± 391	69.7 ± 89.4	1596 ± 1715	51.8 ± 92.6	458 ± 112	522 ± 132	565 ± 74
Passerat et al. 2010		n.d.			2200	1800						
Gros et al. 2013	112575	529	408.5		343	285.5						

Aukidy et al. 2012	120000	154.5	192.5			94	502			22	264	182.5
Chang et al. 2010		458±78		206±47	780±132	2020±368						
Sim et al. 2011		182		23		254	237	nd	176000			1920
Sim et al. 2013						108	403	1880		928	14600	50
	Type of Factory	**Factory effluent**										
Chang et al. 2010	Swine nursery	nd		nd	8±2	nd						
Chang et al. 2010	Slaughter house	11±1		nd	24±3	212±43						
Sim et al. 2011	Livestock wastewater	nd		139		7950	nd	nd	313			167
Sim et al. 2013	Livestock wastewater					4310	109	12800		nd	nd	3320

Table 4. Infectious agents present in untreated domestic wastewater (EPA, 2012), in UWW and in HWW, from the reviewed studies.

	Pathogens	N° in Domestic Wastewater [per L]	UWW Inlet	HWW
Bacteria	*Shigella*	$>10^4$		
	Salmonella	$>10^5$	10^3-10^6 copies/100mL(7)**	
	Campylobacter	$>10^4$		
Protozoa [(oo)cysts/L]	*Giardia*	$>10^5$	10^3 (2)	
	Cryptosporidium	$>10^4$	5 (2)	
Elminths [eggs/20L]		$>10^3$	0-2 (4)	
Viruses [genomic copies/L]	Enterovirus	$>10^6$	10^4 (2)* $2.7x10^5$(6)**	
	Norovirus		$1.6x10^2$ (2)*	$2.4x10^6$(1)**
	Adenovirus	$>10^6$	$1.6x10^2$ (5)**	$2.8x10^6$ (1)**
	Rotavirus	$>10^5$	2x10 (5)**	$1.9x10^6$ (1)**
	Hepatitis A Virus		10^2 (3) $5.5x10^5$ (6)**	10^4 (1)**

(1) Prado et al. 2011
(2) Ottoson et al. 2006
(3) Villar et al. 2007
(4) Levantesi et al. 2010
(5) Hellmér et al. 2014
(6) Kamel et al. 2011
(7) Zhang et al. 2013
*RT-PCR method
**qRT-PCR method

Table 5. How special liquid wastes are treated in different countries in Europe.

	WHO GUIDELINE	Italy	UK	Spain	Germany	France
Disinfection of wastewater	Disinfection by chlorine is only recommended if it can be ensured that the organic matter is below 10 mg/l.	Not obligatory		-		Established from comunal laws but recommended for infectious diseases wards
Automated analyser systems		Collect waste liquids in plastic reservoir containers must not be discharged to the drain but collected by specialist waste contractors for recovery or disposal.	Collect waste liquids in plastic reservoir containers must not be discharged to the drain but collected by specialist waste contractors for recovery or disposal.	-		Collect waste liquids in plastic reservoir containers must not be discharged to the drain but collected by specialist waste contractors for recovery or disposal. Liquid body fluids residuos must be discharged.
Reagents (crystal violet, iodine and neutral red or dilute carbol fuchsia etc..)	Liquid laboratory hazardous waste (colorants, formalin) should be collected separately.		Disposal of these reagents is via dilution with tap water to foul sewer is permitted	-		Established from comunal laws
Liquid body fluids	Small quantities of blood can be discharged in the sewer without pretreatment.	The discharge of small quantities of blood are permitted if they aren't contained in a container (Indirect discharge, considered like a waste). Faeces and urines are discharged in foul sewer without a pre-treatment	The Sewerage Undertakers* permit the discharge of bodily fluids to foul sewer under normal working conditions	The discharge of bodily fluids to foul sewer is permitted but is required a pre-treatment if the hospital is not connected to municipal treatment plant. In some municipality into a quantity of 100 ml is permitted the discharge in foul sewer	Bulk blood and blood products may be decanted into a sewer system connection (sinks, drains, etc.) after disinfection	Excretions of invective enteric patients must be disinfection before the discharge

Preservatives and fixatives (alcohols, acetones and others)	Photochemicals, aldehydes (formaldehyde and glutaraldehyde), colorants and should not be discharged into wastewater	-	Alcohols, acetone, and fixative is may be safely discharged to foul sewer in small quantities with considerable dilution. Petroleum spirit (benzene, toluene, ethyl benzene etc..) is statutorily prohibited	-		Established from comunal laws
Laboratory smalls		Must not be discharged to foul sewer	Must not be discharged to foul sewer	-		Must not be discharged to foul sewer
Pharmaceutically active medications	Should not be discharged into wastewater	Must not be discharged to foul sewer	Must not be discharged to foul sewer	-	Must not be discharged to foul sewer	May be required a specific authorization
Non-pharmaceutically active medications (ex. glucose solution, saline solution, liquid nutritional feeds and supplements)		-	May be discharged to sink in small quantities (less than 1 litre)	-		Established from comunal laws
Radioactive aqueous discharges and radio contrasting compounds	Radioactive wastewater from radiotherapy (e.g. urine of patients undergoing thyroid treatment) should be collected separately and stored in a secured place until the levels of radioactivity have decreased to background concentrations. After the required storage time, the wastewater can be disposed of into a sewer.	Radioactive effluents eliminated by patients should be collected in protected rooms and linked to a septic tank for the delay and the decay.	May be discharged to foul sewer if the radioactivity not exceed limits imposed from Sewerage Undertakers. Radio Contrasting Compounds (barium sulphate) not be discharged	Excretion of patients can be discharged before 48 hours from the cytotoxic treatment		Urines of patients treated with radioelements with short half-life time must be collected in protected rooms and linked to a septic tank for the delay and the decay but radioelements with long half-time must be treated from specific agencies
Autopsy theatre		-	Bodily fluids, blood and urine, stomach contents, faecal matter and water of cleaning and disinfection may be discharged to foul sewer	-		Must be pre-treatment before the discharge
Operating theatre	Small quantities of rinsing liquids, body fluids and the contents of suction	-		-		Wastewater of clining may be discharged to foul sewer

	systems from non-infectious patients from theatres, operating theatre and intensive care can be discharged in the sewer without pretreatment. While stool, vomit and mucus from highly infectious patients (e.g. cholera patients) should be collected separately and thermally treated before disposal (e.g. by an autoclave reserved for waste treatment).			
Dental amalgam	Wastewater from the dental department should be pretreated by installing an amalgam separator in sinks, particularly those next to patient treatment chairs.	Dental liquid wastes containing amalgam don't be discharge into public sewer lines	Dental liquid wastes containing amalgam shall be discharged into public sewer lines only if a discharge license has been issued by the appropriate German Federal State authority	Wastewater from the dental department should be pretreated by installing an amalgam separator in sinks

* Sewer Undertaken: the water company appointed by the Secretary of State or as the sewerage undertaker for a particular area

Table 6. Guidelines about the limitations of health-care facilities wastewaters.

			Limitations		
Guideline	Source	Year	For hospital effluents before the discharge in municipal WWTP	For the effluent from hospital WWTP	Direct unloading on surface water
Effluent Guidelines and Standards (CFR 40) (with updatings)	EPA	2013	Local limits established from WWTP autority	●pH = 6.0-9.0 ●BOD_5 [kg/1000 occupied bed] 33.6 ●TSS [kg/1000 occupied bed] 33.8	Not indicated
Safe management of wastes from healthcare activities	WHO	2013	No limitation	●no more than one helminth egg per litre in the digested sludge	Not indicated

Table 7. Limits of indicator parameters from guidelines, European Directives and the legislation of member states that have a specific indication for hospital effluents (or for categories that include hospital facilities).

Law	Source	Year	For hospital effluents before the discharge in municipal WWTP	For the effluent from hospital WWTP	Direct unloading on surface water after a pretreatment
Directive 91/271/CEE on hazardous waste (modified from Dir. 27-2-1998 n. 98/15/CE)	UE	1998	Not indicated	Not indicated	Not indicated
DPR n. 227/2011 on simplification on environmental law	Italy	2011	**To avoid the pretreatment (Domestical wastewater):** ●Flow rate [m3/d] ≤15 ●pH 5.5-9.5 ●T°C ≤30 ●Color not perceptible with diluition 1:40 ●Material roughness absent ●TSS [mg/L] ≤700 ●BOD5 [mg/L O2] ≤300 ●COD [mg/L O2] ≤700 ●COD/BOD ≤2.2 ●P tot [mg/L] ≤30 ●NH4 [mg/L] ≤50 ●NO2- [mg/L] ≤0.6 ●NO3- [mg/L] ≤30 ●Oil and grease [mg/L] ≤40 ●Tensioactive [mg/L] ≤20 ●*E.coli* UFC/100ml <5000 (advised)	Not indicated	Not indicated
DLgs n.152/2006 on environmental protection	Italy	2006	Not indicated	Not indicated	●pH 5.5-9.5 ●T°C ≤35 ●Color not perceptible with diluition 1:20 ●Material roughness absent ●TSS [mg/L] ≤80 ●BOD5 [mg/L O2] ≤40 ●COD [mg/L O2] ≤160 ●COD/BOD ≤2.2

					●P tot [mg/L] ≤10 ●NH4 [mg/L] ≤15 ●NO2- [mg/L] ≤0.6 ●NO3- [mg/L] ≤20 ●Oil and grease [mg/L] ≤20 ●Tensioactives [mg/L] ≤2 ●Total hydrocarbons [mg/L] ≤5 ●Fenols [mg/L] ≤0.5 ● Aldehydes[mg/L] ≤1 ● Organic aromatic solvents [mg/L] ≤0.2 ● Organic nitrogen solvents [mg/L] ≤0.1 ●Pesticides phosphorus [mg/L] ≤0.1 ●Total Pesticides [mg/L] ≤0.05 ●Chlorinated solvents [mg/L] ≤1 ●Total cyanides [mg/L] ≤0.5 ●Sulphites [mg/L] ≤1 ●Sulphurs [mg/L] ≤1 ● Sulphates [mg/L] ≤1000 ● Fluorines [mg/L] ≤6 ● Active free clorine [mg/L] ≤0.2 ●*E.coli* UFC/100ml <5000 (advised) ●Acute toxicity test: sample not excepted if after 24h the organisms death are≥50% [2]

Decreto n.26042-S-MINAE on management of discharges and reuses of effluents	Spain	1997	**All categories of activities:** ●T [C°] ≤40 ●pH 6-9 ●BOD5 [mg/L] ≤300 ●COD [mg/L] ≤1000 ●SS [mg/L] ≤500 ●Oil and grease [mg/L] ≤100 ●Cyanides [mg/L] ≤2 ●Sulfates [mg/L] ≤500 ●Fluorines [mg/L] ≤10 ●Clorines [mg/L] ≤500 ●Organophosphorates [mg/L] ≤0.1 ●Carbamates [mg/L] ≤0.1 ●Organochlorines [mg/L] ≤0.05 [2]	Not indicated	**All categories:** ●T [C°] 15-40 ●pH 5-9 ●Sedimental Solids [mg/L] ≤1 ●Floating Material [mg/L] Absent ●Total cyanides [mg/L] ≤1 ●Sulphites [mg/L] ≤1 ●Sulphurs [mg/L] ≤25 ●Fluorines [mg/L] ≤10 ●Clorines [mg/L] ≤1 ●Organophosphorates [mg/L] ≤0.1 ●Carbamates [mg/L] ≤0.1 ●Organochlorines [mg/L] ≤0.05 For Hospital also: ●Fecal Coliforms [CFU/100 ml] ≤1000 [2]
Decreto 57/2005 (that modifies the annexes of the Law 10/1993 on industrial effluents)	Spain	2005	**Sanitary activities**: ●T [C°] ≤40 ●pH 6-10 ●BOD5 [mg/L] ≤1000 ●COD [mg/L] ≤1750 ●SS [mg/L] ≤1000 ●Oil and grease [mg/L] ≤100 ●Cyanides [mg/L] ≤5 ●Conductivity [µS/cm2] ≤7500 ●Total cleaning [mg/L] ≤30 ●Fluorines [mg/L] ≤15 ●SO4- [mg/L] ≤1000 ●H2S [mg/L] ≤5 ●Toxicity [(1/ CE50)x100] ≤25 ●AOX [mgCl/L] ≤5 ●P tot [mgP/L] ≤40 ●N total [mgN/L] ≤125 [2]	Not indicated	Not indicated
Urban Waste Water Treatment Regulation	England and Wales	1994	Not indicated	●BOD5 [mg/L O2] 25 ●COD [mg/L O2] ≤125 ●P tot [mg/L P] ≤2 (10.000 - 100.000 e.i.) ≤1 (>100.000 e.i.)	Not indicated

				●N [mg/L N] ≤15 (10.000 - 100.000 e.i.); ≤10 (>100.000 e.i.)	
Waste Water Ordinance (AbwV)	Germany	2004	Not indicated	**Domestic and communal wastewater category (i.e. Hospitals):** ●BOD5 [mg/L] 15-40 ●COD [mg/L] 75-150 ●TSS [mg/L] ≤35 ●NH4 [mg/L] ≤10 ●N total [mg/L] 13-18 ●P total [mg/L] 1-2	
Integrated Wastewater Discharge Standard (GB8978-88) and m.	China	1998	***Industrial categories:*** ●pH 6-9 ●SS [mg/L] 0*-400 ●BOD5 [mg/L] 0*-300 ●COD [mg/L] 0*-500 ●Fluoride [mg/L] ≤20 ●Phosphorus [mg/L] ≤0.3 ●AOX (as Cl) [mg/L] ≤8 ●Fecal coliform [indivudual/L] 1000**-5000 ●Total Clorine after disinfection >2 or >5** (contact time ≥1h) [3]	Not indicated	***All categories:*** ●pH 6-9 ●Color [mg/L] 50-80 ●SS [mg/L] 70-200 (70-150)b ●BOD5 [mg/L] 30-60 (20-30)b ●COD [mg/L] 100-150 ●Ammonia nitrogen [mg/L] 15-25 ●Fluoride [mg/L] ≤10 ●Phosphate [mg/L] 0.5-1.0 ●Phosphorus [mg/L] 0.1-0.3 ●Fecal coliform [individual/L] 500-1000 and 100**-500** ●Total Clorine after disinfection <0.5- >3 (contact time ≥1h) and >5**- >6.5**(contact time ≥1.5h) [3]

Resolução n.430/2011	Brazil	2011	Not indicated	●pH = 5-9 ●T°C <40 ●TSS [mg/L] ≤1 ●Flow 1.5 time mean flow ●BOD5 [mg/L] ≤120 ●Oil and grease [mg/L] ≤100	**All categories**: ●pH = 5-9 ●T°C <40 ●TSS [ml/L] ≤1 ●Flow 1.5 time mean flow ●BOD5 -60% of untreated sewage ●Mineral Oil [mg/L] ≤20 ●Grease [mg/L] ≤50 [3]
S O 630 E 20/7/1998 The Bio Medical Waste Management and Handling Rules	India	1998	***Industrial category (ex. Hospitals):*** ●pH = 5.5-9.0 ●BOD3 (3 days at 27°C) [mg/L] <350 ●COD [mg/L] <250 ●SS [mg/L] <600 ●Oil and grease [mg/L] ≤20 ●Ammonical Nitrogen (N) [mg/L] ≤50 ●Radioactive materials [Curie/ml] 10-6-10-7 ●Bio-assay test 90% survival of fish after 96 hours in 100% effluent.	Not indicated	**Hospital category:** ●pH = 6.3-9.0 ●BOD5 [mg/L] <30 ●COD [mg/L] <250 ●SS [mg/L] <100 ●Bio-assay test 90% survival of fish after 96 hours in 100% effluent.

*for urban secondary sewage treatment plant
** from the contagious hospital
[1] eutrophic area
[2] other heavy metals
[3] for others parameters view the law