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HOSPITAL WASTEWATER TREATMENT

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ABSTRACT: Bio medical waste is a major source of pollution which cannot be treated by general effluent treatment plants. This waste has a lot of chemical, biological and pathogens in its mix which can increase occurrences of disease outbreaks and newer phenomena of antibiotic resistant bacteria is increasing its effect on the society at large. These issues have prompted many different ways of treating hospital wastes. This project is geared at implementation of Submerged Membrane Bio Reactors (SMBR) as a technique for treating hospital wastes. Membrane bio reactors are widely used in Sewage treatment plants and effluent treatement plants at various places. These use a activated bacteria which would consume the chemical and organic matter within the waste water. SMBRs have been developed to be used in a much smaller scale and be more energy efficient. These aspects of treatment and further release of such water are the core of the project. The primary objective is to implement a SMBR based system in an hospital wise setting to see if it is viable and to determine the process by which such systems could be implemented. The project is geared towards the process of removing certain high risk effluents from within the hospital and check the end product before releasing back int hospital for usage in non essential requirements such as gardening, flushing, washing etc. the released water should achieve that level of reusability and that is being achieved at the end of the day.

Key words: Hospital waste water, SMBR, bio medical waste, reuse

INTRODUCTION: There are 60 to 80 thousand chemicals in regular use entering millions of different "environmental systems" (lakes, rivers, groundwater, soil, organisms). In 2005, EPA began studying environmental contamination by pharmaceuticals, detergents, natural and synthetic hormones, and other chemicals. These contaminants are commonly referred to collectively as contaminants of emerging concern. Many organic micropollutants are believed to enter municipal wastewater through numerous industrial, commercial and domestic applications (bathing, cleaning, laundry, and the disposal of unused pharmaceuticals and human waste). Normally, the hospital wastewaters (HWWs) are assimilated to urban wastewaters (UWWs) in many countries where they are discharged into municipal sewage and collected to a wastewater treatment plant (WWTP) where they are co-treated with urban or/and industrial effluents. This practice, considers that hospital and urban wastewaters are similar in terms of pollutants, concentrations and loads. Decidedly, this is not a correct assumption, because these HWWs are really different. As a result, the collection of hospital wastewater together with domestic wastewater has been criticised and a dedicated pre-treatment of hospital wastewater has been recommended (Verlicchi et al., 2010; Gupta et al., 2009; Pauwels and Verstraete, 2006). Persistent substances may pass the wastewater treatment plant (WWTP) unchanged. In addition, input of easy degradable substances occurs through WWTPs that are not state of the art and periodically through storm water or combined sewer overflows. If several WWTPs drain into the same water body, micropollutants can accumulate along the stretch or in lakes. Even groundwater used as drinking water may be contaminated by micropollutants from urban drainage via infiltration of polluted surface water. Micropollutants may have adverse effects on aquatic life even at very low concentrations. Usage, physical-chemical and ecotoxicological properties determine whether a substance causes problems in the aquatic environment. The concentration of a compound in the WWTP effluent is determined by the load into the wastewater treatment plant and the physico-chemical properties of the compound. Generally, substances that are water soluble and persistent are not removed in WWTPs and can therefore be detected in natural waters. High concentrations occur principally in small streams with a high fraction of treated wastewater. The comparison of the exposure with ecotoxicologically based thresholds allows to asses the risk to affect the aquatic life. In this detail we can really estimate the importance to research for another technology more effective as, by example, the membrane bioreactor (MBR). The membrane bioreactor (MBR) for wastewater treatment has been currently one of the new technologies for both municipal and industrial wastewater treatments, especially when the effluent is intended for water reuse (Chang et al., 2002). The membrane bioreactor technology has been available for around 40 years. But only the last 20 years that has seen a rapid growth on its implementation and subsequent significant penetration of the municipal market, coinciding with the introduction of the submerged configuration (SMBR) (Judd and Judd, 2006; Yamamoto et al., 1989). The use of Membrane Bioreactors (MBR) in hospital wastewater treatment has grown widely in the past decades. The MBR technology combines conventional activated sludge treatment with low-pressure membrane filtration, thus eliminating the need for a clarifier or polishing filters. The membrane separation process provided a physical barrier to contain microorganisms and assures consistent high quality reuse water. Few studies was found in the literature explained the efficiency of MBR in treating the hospital wastewater and removal the pharmaceutical s compounds. The wastewater treatment technologies analyzed included microfiltration, ultrafiltration, Nanofiltration, granular activated carbon, powdered activated carbon, reverse osmosis, electro dialysis reversal, membrane bioreactors, and combinations of these technologies in series. But, the principal problem concern the membrane bioreactor was the fouling which decreased the performance and increased the economic cost. Many studies were attributed to numbers of parameters and important one was presence the extracellular polymeric substances (EPS) and fouling rate. (Bourgeous et al., 2001; Bouhabila et al., 2001; Nagaoka et al., 1996).

MATERIAL AND METHODS

Collection of samples: Sterile 500 mL glass bottles were used to collect effluent sample from each stage of treatment like anaerobic, aeration and other tanks. Samples were collected twice a day (10a.m. and 2p.m.) during the study period. Duplicate samples were collected and stored in a refrigerator. After collection all the samples were processed. The pilot-scale system: The pilot-scale system was designed and installed in Tarbiat Modaress University with a treatment capacity of 40 L/dayB Bof Shevom Shaban hospital wastewater. The bioreactor was separated into three equal parts by a plate. The operational phase of the unit is given in Table 1 and was controlled by electric timers. The unit includes; aneronic, fixed film and suspended growth units. The anaerobic reactor tank was covered using strong fiberglass 15 mm thick shuttering. Aeration pipes were placed under the fixed film bioreactor to provide the oxygen for microorganisms and to create a mixed wastewater. The size of each biofilm media block was 0.3 m × 0.3 m providing a total media surface area in the tank. A single-phase kilowatt hour meter was fitted to the electricity supply to measure the power consumption by the motor. The hospital wastewater was transfer into bioreactor and treated to evaluate the system's performance. A pump was connected to the reactor tank through a motorized valve with a 3B mm Bdiameter pipe and act as the feed pipe to the reactor. A water level sensor was used to control the influent pump and to keep the water level in the bioreactor constant. An electric timer was fitted to this valve. When the timer was switched on, the reactor tank was fed with synthetic wastewater. The outlet was at a height of 0.8 m in the tank and was controlled by an electric timer. When the wastewater had settled after treatment the treated clarified water was allowed to flow to a pump sump.

Table 1: Operating for integrated anaerobic-aerobic fixed film bioreactor

Phase	Operation	Duration
Anaerobic	Insert of wastewater in anaerobic tank	6h
Aerobic	Aeration with diffuser	6 h
Settling	Settling of sludge	2 h

Operation of the unit: Two cycles per day was chosen and the phases used in the bioreactor. The pump pumped the hospital wastewater into the reactor tank to give an inflow of 40B LB per cycle. The system was operated for 3 months. In order to simplify sludge disposal, the reactor was de-sludged once on the 30th day.

Analytical methods: COD, BOD, turbidity, pH and temperature were measured in accordance with the standard methodsP [11]P. Filtered samples were obtained by filtering the wastewater through a Whatman filter paper (pore size 1.2 mm). Dissolved oxygen (DO) was measured in situ with an electrochemical a digital DO meter.

Bacterial counts in liquid wastewater: All the samples were vigorously shaken before preparation of dilutions. Serial tenfold dilutions of the different treatment stage samples were prepared in diluent. All the dilutions were made in Phosphate buffered saline (NaCl-8 gm L¯P 1 P, K2HPO4-1.21 gm L¯P 1 P, KH2PO4-0.34 gm L¯P 1 P with pH 7.3) containing 0.05% Tween 20. wastewater was crushed in sterile mortar and suspended in 100 mL diluent. Ten fold dilutions (100 mL) of samples were plated on nutrient agar plates in duplicate. Also, most probable number (MPN) tests were do for bacterial counts.

Selective bacterial counts: Tenfold dilutions (100 mL) of samples were plated on Mackonkey agar plates in duplicate for coliform and fecal enterococcal counts. Mackonkey agar was selected since it allows differential growth of both coliforms and enterococci.

RESULTS AND DISCUSSION

In hospital a variety of substances besides pharmaceuticals are in use for medical purposes as diagnostics and disinfectants. Besides the active substances, formulation adjuvants and in some instances, pigments and dyes are also drug components. Disinfectants, in particular are often highly complex products or mixtures of active substances. After pplication, many drugs are excreted non-metabolised by the patients and enter into wastewater. After their use and disinfectants also reach the wastewater. The different substances, which are not biodegradable, may finally enter surface water by wastewater treatment plants effluents and enter groundwater after the application of sewage sludge as fertilisers. The composition of the wastewater from Sevom Shaban hospital is presented in Table 1. Hospitals consume an important volume of water a day. In Sevom shaban hospital, the average needs in water was estimated at 1000 L/bed/dayP [12]. Indeed the consumption of domestic water, is on average 100 L/person/day, while the value generally admitted for hospitals varies from 400 to 1200 L/day/bed. In France, the average needs in water of a university hospital center is estimated at 750 L/bed/dayP [1] . This important consumption in water of hospitals gives significant volumes of wastewater loaded with microorganisms, heavy metals, toxic chemicals and radioactive elements [4]. As a result the hospitals generate hybrid wastewater, at the same moment domestic, industrial and effluents of care and medical research. Efficient treatment of hospital sewage should include the following operations: (I) Primary treatment, (II) Secondary biological purification; Most helminths will settle in the sludge resulting from secondary purification, together with 90-95% of bacteria and a significant percentage of viruses; the secondary effluent will thus be almost free of helminths, but will still include infective concentrations of bacteria and viruses, (III) Tertiary treatment; The secondary effluent will probably contain at least 20 mg L¯P1P suspended organic matter, which is too high for efficient chlorine disinfection. It should therefore be subjected to a tertiary treatment, such as lagooning; if no space is available for creating a lagoon, rapid sand filtration may be substituted to produce a tertiary effluent with a much reduced content of suspended organic matter (<10 mg L¯P1P), (IV) Chlorine disinfection; To achieve pathogen concentrations comparable to those found in natural waters, the tertiary effluent will be subjected to chlorine disinfection to the breakpoint. This may be done with chlorine dioxide (which is the most efficient), sodium hypochlorite, or chlorine gas. Another option is ultraviolet light disinfection. Disinfection of the effluents is particularly important if they are discharged into coastal waters close to shellfish habitats, especially if local people are in the habit of eating raw shellfish. The sludge from the sewage treatment plant requires anaerobic digestion to ensure thermal elimination of most pathogens. Alternatively, it may be dried in natural drying beds and then incinerated together with solid infectious healthcare waste. On-site treatment of hospital sewage will produce a sludge that contains high concentrations of helminths and other pathogens. According to the relevant WHO guidelines, the treated wastewater should contain no more than one helminthes egg per litre and no more than 1000 faecal coliforms per 100Ml if it is to be used for unrestricted irrigation. The sludge should be applied to fields in trenches and then covered with soil. Integrated anaerobic-aerobic fixed-film reactor with arranged media, fed with hospital wastewater, achieved organic matter removal efficiencies of 95.1%. These results were consistent with the conclusions obtained by other working with integrated anaerobic/aerobic bioreactor, who pointed out that the main function of the non-aerated zone was the conversion of slowly biodegradable matter into short chain fatty acids, easily oxidized in the anoxic and aerobic processes. Anyway, it is possible that the anaerobic COD removal was underestimated because a part of methane was probably stripped in the aerobic zone.

Organic matter concentration in the effluent was approximately constant, around 450 mg L¯P1 P COD and 270 mg L¯P1P BOD5, independent from feed concentration and organic loading rate. Consequently, it can be considering that organic matter removal takes place simultaneously by aerobic oxidation, anoxic and anaerobic processes. It was found out that most of the COD was removed through aerobic oxidation (85%), while the anaerobic removal stood only for 15%. These results were consistent with the conclusions obtained by other working with integrated anaerobic-aerobic bioreactor, who pointed out that the main function of the non-aerated zone was the conversion of slowly biodegradable matter into short chain fatty acids, easily oxidized in the anoxic and aerobic processes. Anyway, it is possible that the anaerobic COD removal was underestimated because a part of methane was probably stripped in the aerobic zone. The main reason for the low extension of the anaerobic process was the high mixing pattern existing in the integrated reactor, which justified that the in situ measure of dissolved oxygen concentration in the samples taken from the bottom of the anaerobic zone were dissolved oxygen, which seriously limited the anaerobic process. In fact, the biomass accumulated at the bottom of the aerated zone did not present any nitrifying activity, according to the respirometry tests.

Table1: Feed and effluent wastewater characteristics

	COD	BOD5 (mg L^{-1})	NH4+-N (mg L^{-1})	Turbidity (NTU)	*T* (C)	pH	Coliforms (number/100 mL)	*E. coli* (number/100 mL)
Influent	450	270	18	95	24	6-8	4 × 103	>1600
Effluent	80	30	2.5	<5	24	7.2	400	<30

Competition for dissolved oxygen inside the biofilm will depend strongly on the biofilm thickness and the distribution of heterotrophic and autotrophic populations. Biofilm showed an autotrophicheterotrophic activity accumulation. The hospital effluents have generally a very weak microbiological load resulting from the regular use of disinfectants. These bactericides can have a negative influence on the biological processes of the wastewater treatment plant. Even by considering that these effluents are diluted after their discharge towards the municipal wastewater treatment plant, it remains evident that it is not necessary to neglect the possibility that certain substances present in the wastewater treatment plant effluents can generate by cumulative effect a biological imbalance in aquatic ecosystem. To protect the natural environment against the phenomenon of excess load in the processes of the wastewater treatment plant, it seems important to consider upstream treatments of hospital wastewater before their discharge in the municipal sewage systemP [13]P. Indeed, the contact of hospital pollutants with the elements of the aquatic ecosystems puts in evidence a danger which is bound to the existence of hazardous substances, i.e., which have the potentiality to exercise negative effects on the environment and the living speciesP [14]P. In case the environmental conditions allowing the degradation of these substances are not gathered, hospital pollutants risk to be present for a long time in the natural environment and can represent a risk in short, middle and long term for the living species of the ecosystems. The risk is the probability of appearance of toxic effects after the exposure of the living organisms to hazardous objects. The existence of a possible exposure of biological, chemical and radioactive substances released by hospital effluents conducts to take into account, the eventuality of a radioactive chemical and microbiological risk for the abiotic system and the living species which populate them. The characterisation works realized on the microbiology of the hospital effluents put in evidence in a systematic way the presence of germs having acquired the characters of resistance in antibioticsP [2]P. Concentrations of bacteria flora from 2,4×103/100mL to 3×105/100mL are deducted for the hospital effluents. These concentrations are lower than that of the 108/100mL generally present in the municipal sewage system was deducted for the hospital wastewater [14,15]P. Markers of viral pollution of surface water, such as enterovirus and other viruses such adenovirus, were identified in the hospital effluents. Enterovirus appears in important quantity in wastewater. Their presence, as marker of viral pollution, in the hospital effluents is to correlate to that of other viruses. Besides, the HIV, causal agent of the AIDS, was isolated from biological liquids and excretions of infected persons. These liquid effluents, directly rejected in the network drainage of research laboratories and hospitals, can contribute under certain physico-chemical conditions to the presence of the virus in the urban sewer networks and in the wastewater treatment plant). Hospital wastewater reveals the presence of molecules chlorinated in high concentrations and in a punctual way the presence of heavy metals such as mercury and silver. Wastewater composition refers to the actual amounts of physical, chemical and biological constituents present in wastewater. Depending on the concentration of these constituents, municipal wastewaters are classified in strong, medium or weak [9]. On the basis of this information, Chitnis have compared the average concentrations obtained for the hospital effluents with the medium values of the municipal wastewater [3]. This comparison allows appreciating the strong content in pollutants of the hospitable effluents.

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