Hospital Wastewater: Prediction of Contaminat Characteristic and The Possibility of Hybride Membran Process

by Ian Kurniawan

Submission date: 03-Apr-2019 04:56PM (UTC+0700)
Submission ID: 1105065338
File name: Publikasi_1.pdf (451.65K)
Word count: 4910
Character count: 28880

ISBN 979-587-621-1

ENVIRONMENTAL SCIENCE AND TECHNOLOGY

ISBN 979-587-621-1
PROCEEDINGS
SRIWIJAYA INTERNATIONAL CONFERENCE ON ENGINEERING, SCIENCE & TECHNOLOGY

Hospital Wastewater: Prediction of Contaminant Characteristics and the Possibility of Hybrid Membrane Process

Ian Kurniawan*[1], Subriyer Nasir[2], Hermansyah[2], Mardiyanto[2]
[1]Doctoral Student of Environmental Sciences (Universitas Sriwijaya, Indralaya, Indonesia)
[2] Doctoral Program of Environmental Sciences (Universitas Sriwijaya, Indralaya, Indonesia)

Abstract: Hospital as one of the possible causes of water pollutants containing infectious, pathogens, toxic, biodegradable, radioactive contaminants, pharmaceutical product that can be a hazard agent in the environment. Wastewater treatment plant owned hospitals generally have not been able to eliminate with either of these compounds. National estimates of production wastewater 48.985,70 tons/day, which the total of hospitals in Indonesia as 2.410 hospitals with beds 295.035. The focus of hospital wastewater treatment in Indonesia is basically accordance with government regulations for reducing the chemical, physical, biological and radioactive materials from the wastewater. Climate of Indonesia is located in tropical regions may be produce additional types and other characteristics of wastewater. The Objective of this study to give an overview study of the new pollutant types of contaminants that require special processing through a hybrid membrane technology. The method used in this research were study literature of any membrane process in other countries and investigation of secondary data from multiple hospitals in Indonesia to determine the wastewater characteristics with government regulation. The study of result showed the characteristics of hospital wastewater of tropical region to provide suggestions scientifically for improvements government regulations that are currently used in Indonesia. The other result of this study can provide a picture of hybrid membrane technology in reducing the special waste with optimum process.

Keywords: Water Pollutans, Hospital Wastewater, Tropical Region, Hybrid Membrane.

e-mail: iankurniawan019@gmail.com*

1. INTRODUCTION

The frequency of water increased in a row with technological developments and population growth. [1] World Health Statistics reported in 2015 showed that about 85% of the population in Indonesia requires access to clean water for life. Accordingly, in recent decades the public is increasingly aware as the importance to solved environmental problems, especially the availability of clean water sources and sustainability of natural resources.

Environmental Technology Center through the Agency in 2010 [2] reported that the potential of water in Indonesia is currently estimated at 15,000 m^3/capita/year. In 2020 the total potential is estimated at 1200 m^3/capita/year, while the natural potential for a viable economy managed only 35%, so the real potential 400 m^3/capita/year, under of the UN minimum amounting to 1,000 m^3 /capita/ year.

Data in 2014 from the Ministry of Health reported [3] Indonesia has 2,410 hospital beds with 295.035. Sumatera Selatan has 55 hospitals in Palembang as many as 27 hospitals. [4] National estimates hospital solid waste product by 376.089 tons/day and wastewater excess 48.985,70 tons/day. [5] Organic, Inorganic chemicals and drugs used in hospital operations are potential sources of water pollution. [6,7,8,9,10,11,12] Hospital operations have the potential to produce waste caused environmental pollution. [13] Hospital including producers of hazardous wastes and toxic (B3) from specific sources waste code D.227. The wastewater effluent volume capacity of each hospital is different, it can be determined by the number of patients and the average water consumption.

Waste water management of the hospital is one way to ensure the sustainability of water resources and the environment. Wastewater treatment plant (WWTP) is one way that can be done to minimize contamination of hospital waste. WWTP is an instrument that is generally a combination of three wastewater treatment process of physical-mechanical, biological or chemical. Physical-mechanical processing and chemical essentially the same as wastewater treatment to get clean water. Biological wastewater treatment that many common is the activated sludge process.

[14] Hospitals have various substances and chemical reagents used for medical purposes such as diagnosis and research, once used for diagnostics, disinfection and pharmacy. It can't metabolized by the patient's body then gets mixed with hospital wastewater. Hospital as one of the causes emission of pollutants that generate waste of drugs. [15] Wastewater treatment plant owned hospitals generally have not been able to eliminate of these compounds.

[16] The problems that occurred that wastewater treatment technology the hospital has not degraded compounds are persistent in the environment effectively, especially wastewater containing drugs and micropollutans containing pathogenic bacteria. Pharmaceuticals and personal care products (PPCPs) are chemical pollutants with high solubility and bioactivity caused health complications in humans and living organisms. Pharmaceuticals and personal care products (PPCPs) were detected mainly through wastewater eventually reach the surface and ground water.

[17] Research in Saudi Arabia for wastewater hospitals to get the results of the 19 drugs investigated, four types of drugs - drugs (acetaminophen, metformin, norfluoxetine, atenolol) have been found in concentrations greater than the detection limit both in effluents and waste from WWTP. [18,19,20] Residual chemicals and pharmaceuticals from hospital wastewater that can't eliminate by the installation system in general will be a residue, viruses and bacteria transformed as agent multiresisten in the environment. [21,22, 23,24,25,26] Some of the studies that have been done concluded that the installation of effluent treatment owned by the hospital does not have the ability to reduce waste water containing medicines.

[27] Membrane technology as one of the installation of effluent treatment plants, developments and progress has been promising in the process with the principle of the separation and purification of drinking water. [28] Membranes can be defined as the process of separation of components of fluid flow, the

ISBN 979-587-621-1

membrane serves as a highly selective barrier between two phases and components. [29] Membranes based on particle size filtered consist of microfiltration, ultrafiltration, nanofiltration and reverse osmosis.

[30] The membrane process offers significant advantages due to the operational simplicity, flexibility, cost-effectiveness, reliability, low energy consumption, good stability, environmental compatibility, easy control, handling and scale with operating conditions such as temperature, pressure, and pH.

[31] The weaknesses of the processing use all kinds of membranes is the occurrence of fouling (clogging) caused by the interaction between the components, it can be anticipated with the optimization of the design and operating conditions (replacement membrane, backflushing, chemical cleaning).

[32] Membrane technology could be a solution in wastewater treatment hospital. The development of membrane can be combined (Hybrid Process) nanofiltration membrane and reverse osmosis. Hybrid Process nanofiltration and reverse osmosis membrane technology has not been used in hospital wastewater treatment. [33] Nanofiltration process combined with reverse osmosis can reduce impurity components have characteristics containing residues of drugs, the ability to eliminate the contaminants by 94% - 100%.

Further review of the system of WWTP in several hospitals in Indonesia, mostly using an activated sludge treatment system with a combination of aerobic and anaerobic pond. Most hospitals are not identifying drug compounds and other pathogenic bacteria from the WWTP effluent because the quality standards set by the government does not regulate in detail the components of other micropollutans.

2. HOSPITAL WASTEWATER

A. The Regulation of Indonesia

The Regulation of quality standards on of hospital wastewater effluent at Indonesia seen in Table 1 [34, 35, 36]. [37] The quality of the wastewater of hospital in the city of Malang and some reports a study of wastewater treatment quality hospitals in Indonesia (RS. Kelet Jepara, RS Dr. Muhammad Zein Painan West Sumatra, RS Permadi, RSU Prov. NTB, RS Dr. Wahidin Sudirohusodo South Sulawesi, RS PKT Bontang; RS Persahabatan) concluded the facts and data that are relatively the same aspects (physics, chemistry, biology and radioactivity) and does not focus on researching the content of medicines in the waste due to limitations of technology and the government regulations didn't set specifics.

B. Contaminant Characteristics of Hospital Wastewater

Review research on characteristics of hospital wastewater on aspects of physics, chemistry, biology and the radioactivity is visible on a summary table 2.

Specific research studies examining contaminants medicines, including studies conducted found some compound drugs such as Methamphetamines, Morpine, Codeine and Ketamine, which are present in wastewater effluents hospital after processing with the concentration of 1240, 378, 260 and 206 ng L – 1 [50]. [51] Antibiotic compounds such as Ciprofloxacin, Sulfamethoxazole, Ofloxacin, Clarithromycin, Azithromycin, Acetaminophen and Ibuprofen. [52] Antibiotic compounds classified in groups The Polar Organic Chemical Integrative Sampler (POCIS) compounds (Atenolol,Prednisolone, Methylprednisolone, Sulfamethoxazole, Ofloxacin, Ketoprofen). [53] Ciprofloxacin, Tamoxifen and Cyclophosphamide. Antibiotics Dexamethasone. [54] Carbamazepine. [55] Diclofenac, Amiodarone, Ritonavir, and [56] Amoxicillin, Ciprofloxacin, Fluoroquinolones, Arsenic, Mercury, Metracyclines, Sulfonamides and Penicillin G.

Table 1. Regulation of Hospital Wastewater in Indonesia

Parameter	Concentration
Physics	
Temperature	30^0 C
Chemical	
pH	6 - 9
BOD_5	30 mg/L
COD	80 mg/L
TSS	30 mg/L
NH_3	0,1 mg/L
PO_4	2 mg/L
Microbiology	
MPN **Coli**	10.000
Radioactivity	
^{32}P	7×10^2 Bg/L
S	2×10^3 Bg/L
^{45}Ca	3×10^2 Bg/L
^{51}Cr	7×10^4 Bg/L
^{67}Ga	1×10^3 Bg/L
^{85}Sr	4×10^3 Bg/L
^{99}Mo	7×10^3 Bg/L
^{113}Sn	3×10^3 Bg/L
^{125}I	1×10^1 Bg/L
^{131}I	7×10^1 Bg/L
^{192}Ir	1×10^4 Bg/L
^{201}Ti	1×10^6 Bg/L

Table 2. Research based on Hospital Wastewater Parameter

Parameter	Concentration
[38] Conductivity, µS/cm	300–000
[22] pH	6–9
[39] Redox potential, mV	850-950
[40] Fat and oil, mg/L	50–210
[6] Chlorides, mg/L	80–400
[41] NH_4, mgNH_4/L	10 - 68
[40] Nitrite, mg NO_2/L	0.1 - 0.58
[42,43] Nitrate, mg NO_3/L	1 – 2
[39,40] Phosphate, mg P-PO_4/L	6 – 19
[44] Suspended solids, mg/L	120 – 400
[45,46] Microorganisms, MPN/100 mL E. coli	10^3–10^6
[45] Enterococci	10^3–10^6
[39] Total surfactants, mg/L	4–8
[47,48] Total disinfectants, mg/L	2–200
[49] Specific disinfectants :	
BAC_C12–18, µg/L	49
BAC_C12, µg/L	34
DDAC-C10, µg/L	102
[48] Antibiotics, µg/L	30–200
[48] Antiinflammatories, µg/L	5–1500
[48] Lipid regulators, µg/L	1–10
[48] Cytostatic agents, µg/L	5–50
[48] ICM, µg/L	0.2–2600
[48] Beta-blockers, µg/L	0.4–25

3. MEMBRANE PROCESS

A. The Characteristics of Membrane

[57] The membrane technology has a good ability as a filter barrier to contaminants or pollutant compounds that can be separated from the waste. Mechanism process model membranes have a good concept because only compounds that have a diameter smaller than the pores that can pass through a

ISBN 979-587-621-1

membrane filter. The membranes are in a process of becoming a selective separator filter with some substances that can pass through the membrane, while other substances maintained.

Membrane filtration can be used as an alternative technology wastewater purification in addition to flocculation, sediment purification techniques, adsorption, sand filters and activated carbon filters, ion exchange, extraction, and distillation. The concept of the performance of the membrane can be seen in Fig. 1 that only contaminant particles are smaller than the membrane pores that can pass through the membrane breaks.

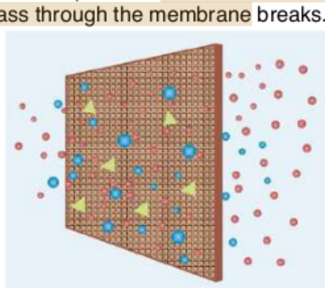


Fig. 1 Membrane Mechanism Process

Water treatment process is divided into several types, membrane microfiltration (MF), ultrafiltration (UF), reverse osmosis (RO) and nanofiltration (NF) membrane. [58] MF membranes that have pore sizes of the largest and usually reduce large particles and various microorganisms. UF membranes have smaller pores of the membrane MF, therefore in addition to large particles and microorganisms, they can resist bacteria and soluble macromolecules such as proteins. RO membranes are effectively non-porous and includes many elements of particles low molar mass such as salt ions and organic. NF membranes are relatively new as porous membranes, because the pores in the order of 10 angstroms or less. A comparison between some membrane technology, in his latest Membrane Technology and Engineering for Water Purification provides a comparison of membrane technology based on membrane pore size diameter [59] as shown in Fig. 2.

B. Hybrid Membrane Process

[60] Development of a high-pressure membrane processing technology (RO and NF) to eliminate compounds Soluble organic compounds (DOC), Polycyclic Aromatic Hydrocarbon (PAH), Trihalomethanes (THM), volatile Haloacetic Acids (HAA), Pharmaceutical Active Compounds (PhACs) and Endocrine Disrupting Compounds (EDCs). ECDs include a variety of micropollutants, namely xenoestrogens, phthalates, Polychlorinated biphenyls, alkilfenol, synthetic drugs, hormones and other chemicals produced by humans then enter into the environment. [61] Produces technology NF and RO which is capable of the reduction of Cyclophosphamide > 90%.

The comparison between the combination of processes that can be used in the reduction of contaminants in wastewater can be seen in table 3 [62]. The Hybrid Process using NF and RO membrane has a very good ability in the reduction of the typical hospital waste containing residues of medicines and other contaminants. The percentage reduction of contaminants that occur when processes demonstrates the ability of the average above 90%.

Table 4. Serves a wide range of research and previous studies ever done in the various countries regarding the reduction of hospital wastewater containing residues of medicines by using nanofiltrasi and the reverse osmosis system.

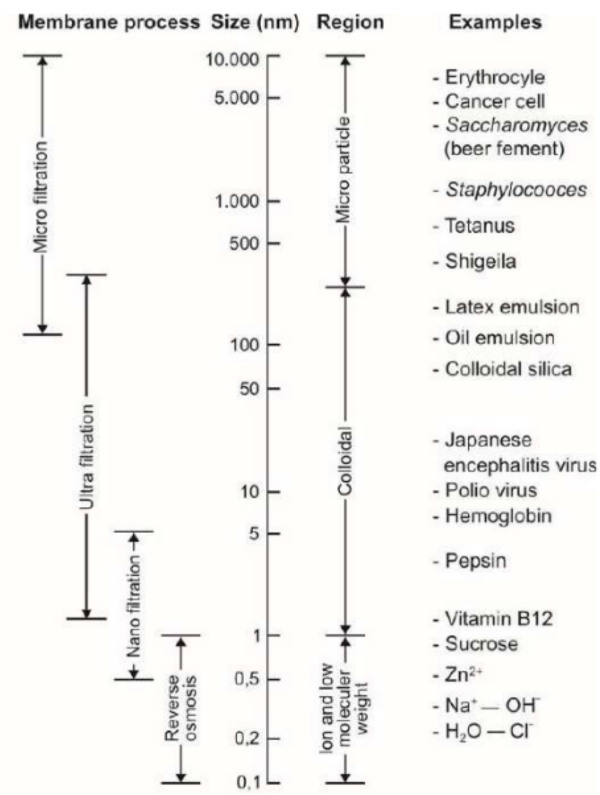


Fig. 2 Comparison of Membrane Process

Table 3. Comparison of Membrane Process

Type Process	MF/UF	NF/RO
Used	Particle and microorganism	Sea water, Micropollutans, *Natural organic matter* (NOM)
Contaminant	Partikel	*Dissolved solutes*
Membrane module	*Hollow fiber*	*Spiral wound*
Flow Type	*Dead end*	*Cross-flow*
Material	Polymer, ceramic	Polymer

4. CONCLUSIONS AND RECOMMENDATIONS

Reality of circumstances, WWTP still leaves many problems and obstacles. The magnitude of the location where the instrument processing and cost required either for installation or maintenance can cause an economic burden on hospitals will increase. The resulting effluent from the WWTP still require further processing, so it will take the energy and the high cost.

The content of these contaminants is influenced by the type of hospitals, the amount of beds, amount of patients and the climate of a country. That fact can be proved by a study of the literature on several previous countries concluded that existing systems are not able to reduce to the maximum content of hospital wastewater. The Government should develop and revise regulations in order to improve the system of governance in hospital wastewater treatment.

The technology of wastewater treatment by hybrid process combines two processes nanofiltration membrane and reverse osmosis in Indonesia based on the literature search has not been done in the reduction of hospital wastewater containing residues of medicines. The climate of the region that have tropical characteristics, make a possibility additional types and characteristics of hospital wastewater.

Hospital wastewater has potential polluters that are very harmful to the environment, so that should the contaminants are reduced by a latest technology that is effective, efficient and able to reduce these contaminants to the maximum. The recommmendation is wastewater treatment system in hospitals by using nanofiltrasi membrane technology and reverse osmosis can reduce contaminants existing polluters in the wastewater of the hospital. An important use of the latest technology developed the installation of hospital wastewater treatment to replace the current technology because it still finds some compounds micropollutans after passing through the WWTP process.

Table 4. The Ability of Hybrid Membrane Process

Contaminant	% Reduction
Endocrine disrupting compounds (EDCs) and pharmaceutically active compounds (PhAC)	>90% [63]
Bezafibrate, bisoprolol, carbamazepine, klaritromisin, ciprofloxacin, diklofenak, ibuprofen, metronidazol, moksifloksasin, telmisartan dan tramadol	70% [45]
Pharmaceutical active compounds (PhACs), carbamazepine (CBZ) and diatrizoate (DTZ)	Variation of a % reduction, [64]
Pharmaceuticals Waste (sulfamethoxazole, trimethoprim, ciprofloxacin, dexamethasone, and febantel)	94 - 100%. [33]
Enrofloxacin	> 92%. [65]
Endocrine disrupting compound, bisphenol A (BPA)	> 98% [66]

REFERENCES

[1] World Health Organization. Indonesia : WHO Statistical Profile. (2015).
[2] BPPT.Pengelolaan Limbah Rumah Sakit Menuju Green Hospital. (2012).
[3] Depkes RI. Data dan Informasi Profil Kesehatan Indonesia 2014. (2015)
[4] M. Dhani, T. Yulinah. Kajian Pengelolaan Limbah Padat Jenis B3 Di Rumah Sakit Bhayangkara Surabaya: Surabaya. (2011)
[5] D. Zhang, R.M. Gersberg, W. Jern, S. Keat. Removal of pharmaceuticals and personal care products in aquatic plant-based systems : A review. Environmental Pollution. (2013). http://doi.org/10.1016/j.envpol.2013.09.009
[6] E. Emmanuel, Y. Perrodin, G. Keck, J. Blanchard, P. Vermande. Ecotoxicological risk assessment of hospital wastewater : a proposed framework for raw effluents discharging into urban sewer network. Journal of Hazardous Materials, 117, (2005). 1–11. http://doi.org/10.1016/j.jhazmat.2004.08.032
[7] M.R. Sarafraz, K.Y. Khani. Quality and Quantity Survey of Hospital Wastewater in Hormozgan Province. Iran Journal Environmental Heatlh Science Engineering, 4, (2007) 43–50.
[8] A.R. Mesdaghinia, K. Naddafi, R. Nabizadeh, R. Saeedi, M. Zamanzadeh. Wastewater Characteristics and Appropriate Method for Wastewater Management in the Hospitals. Iranian Journal Public Health, 38(1), (2009) 34–40.
[9] A. Amouei, H.A. Asgharnia, A.A. Mohammadi, H. Fallah, R. Dehghani, R. Investigation of hospital wastewater treatment plant efficiency in north of Iran during 2010-2011. International Journal of Physical Sciences. (2012). http://doi.org/10.5897/IJPS12.322
[10] R. Mahmoudkhani, A.M. Azar, M.R. Khani. A Survey of Tehran Hospitals Wastewater. In International Conference on Future Environment and Energy (Vol. 28, pp. 56–60).(2012)
[11] O.A. Ojo, I.F. Adeniyi. The Impacts of Hospital Effluent Discharges on the Physico-chemical Water Quality of a Receiving Stream at Ile-Ife , Southwestern Nigeria. Journal of Sustainable Development, 5(11). (2012). 82–92. http://doi.org/10.5539/jsd.v5n11p82
[12] M. Kotti, E. Piliouris, A. Vlessidis, A New Method for Comparing Hospital and Municipal Wastewater. Journal of Environmental Science and Engineering, 2. (2013). 141–146.
[13] Presiden RI. Peraturan Pemerintah No. 85 Tahun 1999 Tentang : Perubahan Atas Peraturan Pemerintah No. 18 Tentang Pengelolaan Limbah Bahan Berbahaya Dan Beracun.
[14] P. Gupta, N. Mathur, P. Bhatnagar, P. Nagar, S. Srivastava. Genotoxicity evaluation of hospital wastewaters. Ecotoxicology and Environmental Safety, 72(7),(2009).http://doi.org/10.1016/j.ecoenv.2009.05.012.
[15] P. Verlicchi, M.A. Aukidy, E. Zambello. Occurrence of pharmaceutical compounds in urban wastewater : Removal , mass load and environmental risk after a secondary treatment - A review. Science of the Total Environment,429.(2012).123–155. http://doi.org/10.1016/j.scitotenv.2012.04.028
[16] P. D. Austin, K.S. Hand, M. Elia. Systematic review and meta-analysis of the risk of microbial contamination of parenteral doses prepared under aseptic techniques in clinical and pharmaceutical environments : an update. Journal of Hospital Infection, 44. (2015) http://doi.org/10.1016/j.jhin.2015.04.007
[17] A. Shraim, A. Diab, A. Alsuhaimi, E. Niazy, M. Metwally, M. Amad, A. Dawoud. Analysis of some pharmaceuticals in municipal wastewater of Almadinah Almunawarah. Arabian Journal of Chemistry (2012) http://doi.org/10.1016/j.arabjc.2012.11.014
[18] J.R. Ottosson, M. Doctor, T.A. Stenstro. A longitudinal study of antimicrobial resistant faecal bacteria in sediments collected from a hospital wastewater system. (2012) 1, 1–7. (http://doi.org/10.3402/iee.v2i0.7438
[19] B. Yamina, B.Tahar, M.Lila, H.Hocine, F.M. Laure,. Study on Cadmium Resistant-Bacteria Isolated from Hospital Wastewaters. Advances in Bioscience and Biotechnology. (2014). 718–726.
[20] Q.Yuan, M.Guo, J.Yang. Fate of Antibiotic Resistant Bacteria and Genes during Wastewater Chlorination : Implication for Antibiotic Resistance Control. PLOS One. (2015) 1–12. http://doi.org/10.1371/journal.pone.0119403.
[21] S. Zorita, L. Mårtensson, L.Mathiasson. Occurrence and removal of pharmaceuticals in a municipal sewage treatment system in the south of Sweden. Science of The Total Environment, 407(8), (2009) 2760–2770. http://doi.org/10.1016/j.scitotenv.2008.12.030
[22] C.I. Kosma, D. Lambropoulou, T. Albanis. Occurrence and removal of PPCPs in municipal and hospital wastewaters in Greece. Journal of Hazardous Materials, 179(1-3). (2010).

804–17. http://doi.org/10.1016/j.jhazmat.2010.03.075.

[23] S.K. Behera, H.W. Kim, J.E.Oh, H.S. Park. Occurrence and removal of antibiotics, hormones and several other pharmaceuticals in wastewater treatment plants of the largest industrial city of Korea. Science of the Total Environment (Volume 409) . Elsevier B.V.(2011). http://doi.org/10.1016/j.scitotenv.2011.07.015

[24] A. M. Deegan, B. Shaik, K. Nolan, K. Urell, J.Tobin, A. Morrissey. Treatment options for wastewater effluents from pharmaceutical companies. International Journal Science Technology, 8(3). (2011). 649–666.

[25] A. Jelic, M. Gros, A. Ginebreda, R. Cespedes-Sánchez, R., F. Ventura, M.Petrovic, D.Barcelo, Occurrence, partition and removal of pharmaceuticals in sewage water and sludge during wastewater treatment. Water Research, 45(3) (2011). 1165–1176. http://doi.org/10.1016/j.watres.2010.11.010

[26] E. Gracia-lor, J.V. Sancho, R. Serrano, F. Hernández. Occurrence and removal of pharmaceuticals in wastewater treatment plants at the Spanish Mediterranean area of Valencia. Chemosphere, 87(5), (2012). 453–462. http://doi.org/10.1016/j.chemosphere.2011.12.025

[27] M. Bodzek, K. Konieczny, A. Kwieci, A. Application of membrane processes in drinking water treatment – state of art. Desalination and Water Treatment. Taylor and Francis, (December). (2012). 37–41.

[28] M. Mulder. Basic Principles of Membrane Technology, Edisi 2, Kluwer Academic Publishers, Dordrecht. (1996).

[29] G. Fane, C.Y. Tang, R. Wang. Membrane Technology for Water: Microfiltration, Ultrafiltration, Nanofiltration, and Reverse Osmosis. Treatise on Water Science (2011) 301–335.http://doi.org/http://dx.doi.org/10.1016/B978-0-444-53199-5.00091-9

[30] S.S. Madaeni, N. Ghaemi, H. Rajabi,. Advances in polymeric membranes for water treatment. Advances in Membrane Technologies for Water Treatment. (2015). http://doi.org/10.1016/B978-1-78242-121-4.00001-0

[31] C.Charcosset. Membrane Systems and Technology. Comprehensive Biotechnology (Sec. Edition). (2011). http://doi.org/http://dx.doi.org/10.1016/B978-0-08 088504-9.00131-8.

[32] R. Singh. Hybrid Membrane Systems for Water Purification: Technology, Systems Design. Elsevier Science & Technology Books.(2006)

[33] D. Dolar, T. Ignjati. Membrane treatment of veterinary pharmaceutical wastewater : comparison of results obtained on a laboratory and a pilot scale. Environmental Science and Pollution Research, (2012). 1033–1042. http://doi.org/10.1007/s11356-012-0782-7

[34] Keputusan Menteri Negara Lingkungan Hidup. 1995. Nomor : KEP-58/MENLH/12/1995 tentang Baku Mutu Limbah Cair Kegiatan Rumah Sakit

[35] Peraturan Gubernur Sumsel. 2012. Nomor : 8 Tentang Baku Mutu Limbah Cair

[36] Peraturan Daerah Kota Palembang. 2003. Nomor : 2 tentang Baku Mutu Air Sungai dan Baku Mutu Limbah Cair.

[37] Prayitno, Z. Kusuma, B. Yanuwiadi, R.W. Laksmono, Study of Hospital Wastewater Characteristic in Malang City. International Journal of Engineering and Science, 2(2). (2012). 13–16.

[38] C. Boillot, C. Bazin, F. Tissot-guerraz, J.Droguet, M. Perraud, J.C. Cetre,). Daily physicochemical, microbiological and ecotoxicological fluctuations of a hospital effluent according to technical and care activities. Science of The Total Environment, 3. (2008).http://doi.org/10.1016/j.scitotenv.2008.04.037

[39] P. Verlicchi, A. Galletti, M. Petrovic, D. Barceló, Hospital effluents as a source of emerging pollutants: An overview of micropollutants and sustainable treatment options. Journal of Hydrology, 389(3-4), (2010).416–428. http://doi.org/10.1016/j.jhydrol.2010.06.005

[40] M.A.I. Al-hashimia, Y.I. Jasema. Performance of Sequencing Anoxic / Anaerobic Membrane Bioreactor (Sam) System in Hospital Wastewater Treatment and Reuse. European Scientific Journal, 9(15), (2013), 169–180.

[41] Wen, X., Ding, H., Huang, X., & Liu, R. 2004. Treatment of hospital wastewater using a submerged membrane bioreactor. Process Biochemistry, 39, 1427–1431. http://doi.org/10.1016/S0032-9592(03)00277.

[42] R. López-roldán, M. López, D. Alda, M. Gros, M. Petrovic, J. Martín-alonso. Advanced monitoring of pharmaceuticals and estrogens in the Llobregat River basin (Spain) by liquid chromatography – triple quadrupole-tandem mass spectrometry in combination with ultra performance liquid chromatography – time of flight-mass. Chemosphere. 80. (2010). 1337–1344. http://doi.org/10.1016/j.chemosphere.2010.06.042.

[43] S. Venditti, C.K Kohler. Membrane bioreactor process as a pre- treatment of hospital effluent. (2011).Researchgate.

[44] P. Verlicchi, A. Galletti, M. Petrovic. Micro-pollutants in Hospital Effluent : Their Fate , Risk and Treatment Options,(2012).http://doi.org/10.1007/698

[45] S.Beier, C. Cramer, C. Mauer, S. Köster, H.F. Schröder,, J.Pinnekamp. MBR technology : a promising approach for the pretreatment of hospital wastewater. Water Science & Technology, (2012). 1648–1654. http://doi.org/10.2166/wst.2012.880

[46] U. Nielsen, C. Hastrup, M.M. Klausen, B.M. Pedersen, G.H. Kristensen, J.L.C. Jansen, J. Tuerk. Removal of APIs and bacteria from hospital wastewater. Water Science and Technology. (2013).854–863. http://doi.org/10.2166/wst.2012.645

[47] K. Kummerer. Drugs in the environment : emission of drugs , diagnostic aids and disinfectants into wastewater by hospitals in relation to other sources Chemosphere, (2011).45.

[48] P. Verlicchi, M.Al. Aukidy, A. Galletti, M. Petrovic, D. Barceló. Hospital effluent : Investigation of the concentrations and distribution of pharmaceuticals and environmental risk assessment. Science of the Total Environment. 430. (2012). 109–118. http://doi.org/10.1016/j.scitotenv.2012.04.055.

[49] L. Kovalova, H. Siegrist, H. Singer, A.M.C. Wittmer. Hospital wastewater treatment by membrane bioreactor : performance and efficiency for organic micropollutant elimination . PubMed Commons. Environmental Science Technology. 46(3). (2012).1–2. http://doi.org/10.1021/es203495d.

[50] Lin, A. Y., Lin, C., Tsai, Y., Lin, H. H., Chen, J., Wang, X., & Yu, T.Fate of selected pharmaceuticals and personal care products after secondary wastewater treatment processes in Taiwan. Water Science & Technology. (2010). 2450–2458. http://doi.org/10.2166/wst.2010.476

[51] L.H.M.L.M. Santos, M. Gros, S. Rodriguez-Mozaz, C. Delerue-Matos, A. Pena, D. Barceló, M.C.B.S.M. Montenegro. Contribution of hospital effluents to the load of pharmaceuticals in urban wastewaters: Identification of ecologically relevant pharmaceuticals. Science of The Total Environment. 461-462.(2013). 302–316. http://doi.org/10.1016/j.scitotenv.2013.04.077

[52] E. Bailly, Y. Levi, S. Karolak. Calibration and field evaluation of polar organic chemical integrative sampler (POCIS) for monitoring pharmaceuticals in hospital wastewater. Environmental Pollution, 174. (2013).100 – 105.

[53] N. Mater, F. Geret, L. Castillo, V. Faucet-marquis, C. Albasi, A. Pfohl-leszkowicz. In vitro tests aiding ecological risk assessment of cipro fl oxacin , tamoxifen and cyclophosphamide in range of concentrations released in hospital wastewater and surface water. Environment International. 63. (2014). 191–200. http://doi.org/10.1016/j.envint.2013.11.011

[54] C.M. Nan, B. Jin. Photocatalytic treatment of high concentration carbamazepine in synthetic hospital wastewater. Journal of Hazardous Materials, 199-200, (2012). 135–142. http://doi.org/10.1016/j.jhazmat.2011.10.067

[55] B.I. Escher, R. Baumgartner, M. Koller, K. Treyer, J. Lienert, C.S. Mcardell. Environmental toxicology and risk assessment of pharmaceuticals from hospital wastewater. Water Research, 45(1). (2010). 75–92. http://doi.org/10.1016/j.watres.2010.08.019

[56] A.R. Varela, O.C. Nunes, M. Manaia, A. Rita, S. Andre. The relationship between antimicrobial residues and bacterial populations in a hospital-urban wastewater treatment plant system. Water Research, 4. (2014) http://doi.org/10.1016/j.watres.2014.02.003

[57] L.R. Bennedsen. Chemistry of Advanced Environmental Purification Processes of Water. (2014). http://doi.org/10.1016/B978-0-444-53178-0.00002-X.

[58] V.S. Frenkel. Planning and design of membrane systems for water treatment. Advances in Membrane Technologies for Water Treatment. Elsevier Ltd. (2015). http://doi.org/10.1016/B978-1-78242-121-4.00010-1

[59] R. Singh. Membrane Technology and Engineering for Water Purification. Butterworth-Heinemann. (2015).

[60] M. Bodzek. Membrane technologies for the removal of micropollutants in water treatment. Woodhead Publishing Series in Energy. Elsevier Ltd. (2015). http://doi.org/http://dx.doi.org/10.1016/B978-1-78242-121-4.00015-0

[61] L. Wang, C.Albasi, V. Faucet-marquis, A. Pfohl-leszkowicz, C.Dorandeu, B.Marion, P. Sabatier. Cyclophosphamide removal from water by nanofiltration and reverse osmosis membrane. Water Research, 43(17). (2009). 4115–4122. http://doi.org/10.1016/j.watres.2009.06.007

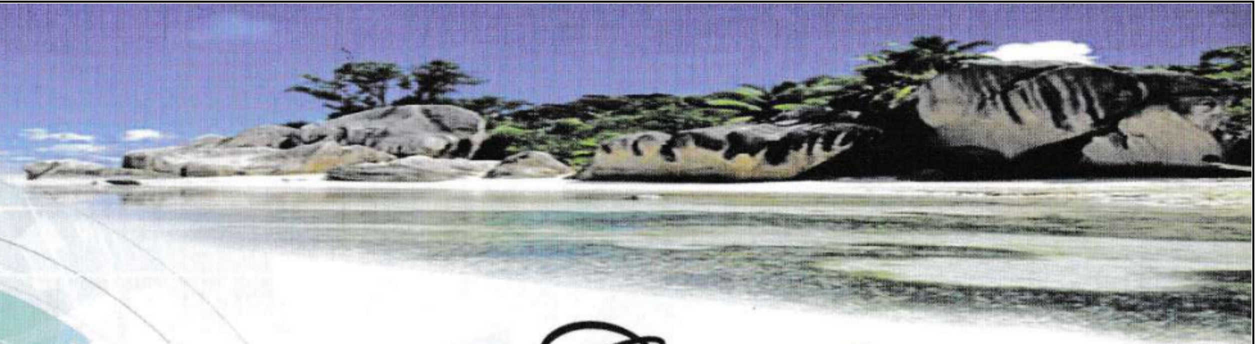
[62] J.R. Crittenden T.D. Rhodes, K.J. Hand. Membrane Filtration 12-1. In Water Treatment: Principles and Design, Third Edition (pp. 819–902).(2012).

[63] A.M. Comerton, R. Andrews, D.M. Bagley, C. Hao. The rejection of endocrine disrupting and pharmaceutically active compounds by NF and RO membranes as a function of compound and water matrix properties, Journal of Membran Sciences. (2008). 323–335. http://doi.org/10.1016/j.memsci.2008.01.021.

[64] S. Gur-reznik, I. Koren-menashe, L. Heller-grossman, O. Rufel, C.G. Dosoretz. Influence of seasonal and operating conditions on the rejection of pharmaceutical active compounds by RO and NF membranes, Desalination. (2011). 250–256. http://doi.org/10.1016/j.desal.2011.04.029.

[65] D. Dolar, K. Košutić, M. Periša, S. Babić, Photolysis of enrofloxacin and removal of its photodegradation products from water by reverse osmosis and nanofiltration membranes. Separation and Purification Technology, 115. (2013).1–8. http://doi.org/10.1016/j.seppur.2013.04.042.

[66] S. Yüksel, N. Kabay, M. Yüksel. Removal of bisphenol A (BPA) from water by various nanofiltration (NF) and reverse osmosis (RO) membranes. Journal of Hazardous Materials.(2013).http://doi.org/10.1016/j.jhazmat.2013.05.020.



SICEST

Certificate
for Participation

We certify that Ms/Mr

Ian Kurniawan

has participated as

Oral Presenter

in the Sriwijaya International Conference on Engineering, Science & Technology held in Bangka Island, Indonesia 8-10 November 2016

Dean

Prof. Subriyer Nasir, Ph.D.

Executive Chairman

Dr. Muhammad Faizal

Faculty of Engineering Sriwijaya University

Hospital Wastewater: Prediction of Contaminat Characteristic and The Possibility of Hybride Membran Process

ORIGINALITY REPORT

15%	7%	11%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	P. Verlicchi, M. Al Aukidy, E. Zambello. "What have we learned from worldwide experiences on the management and treatment of hospital effluent? — An overview and a discussion on perspectives", Science of The Total Environment, 2015 Publication	2%
2	Submitted to Higher Education Commission Pakistan Student Paper	2%
3	candra.unsri.ac.id Internet Source	1%
4	Submitted to School of Business and Management ITB Student Paper	1%
5	S.S. Madaeni, N. Ghaemi, H. Rajabi. "Advances in polymeric membranes for water treatment", Elsevier BV, 2015 Publication	1%
6	Submitted to Universiti Malaysia Pahang Student Paper	1%
7	www.researchinventy.com Internet Source	1%
8	Gupta, V.K., and I. Ali. "Water Treatment by Membrane Filtration Techniques", Environmental Water, 2013. Publication	1%

9	Henrik Tækker Madsen. "Membrane Filtration in Water Treatment – Removal of Micropollutants", Elsevier BV, 2014 Publication	1 %
10	Bodzek, MichaÅ,, Krystyna Konieczny, and Anna KwieciÅ„ska. "Application of membrane processes in drinking water treatmentâ€“state of art", Desalination and Water Treatment, 2011. Publication	<1 %
11	Emilie Bailly, Yves Levi, Sara Karolak. "Calibration and field evaluation of polar organic chemical integrative sampler (POCIS) for monitoring pharmaceuticals in hospital wastewater", Environmental Pollution, 2013 Publication	<1 %
12	fountainmagazine.com Internet Source	<1 %
13	geomatejournal.com Internet Source	<1 %
14	Amjad Shraim, Atef Diab, Awadh Alsuhaimi, Esmail Niazy, Mohammed Metwally, Maan Amad, Salim Sioud, Abdulilah Dawoud. "Analysis of some pharmaceuticals in municipal wastewater of Almadinah Almunawarah", Arabian Journal of Chemistry, 2017 Publication	<1 %
15	Ran Hu, Rui Tang, Jiyang Xu, Feng Lu. "Chemical nanosensors based on molecularly-imprinted polymers doped with silver nanoparticles for the rapid detection of caffeine in wastewater", Analytica Chimica Acta, 2018 Publication	<1 %

16	Schrotter, Jean-Christophe, and Bengu Bozkaya-Schrotter. "Current and Emerging Membrane Processes for Water Treatment", Membrane Technology Volume 4 Membranes for Water Treatment, 2010. Publication	<1 %
17	ruja.ujaen.es Internet Source	<1 %
18	ses.library.usyd.edu.au Internet Source	<1 %
19	Comerton, A.M.. "The rejection of endocrine disrupting and pharmaceutically active compounds by NF and RO membranes as a function of compound and water matrix properties", Journal of Membrane Science, 20080410 Publication	<1 %
20	M. Bodzek. "Membrane technologies for the removal of micropollutants in water treatment", Elsevier BV, 2015 Publication	<1 %
21	ar.scribd.com Internet Source	<1 %
22	upcommons.upc.edu Internet Source	<1 %
23	www.tandfonline.com Internet Source	<1 %
24	Siswanta Kaban, M. Edi Armanto, M. Rasyid Ridho, Poedji L. Hariani. "Rapid Assessment of Water Quality in Teluk Lake by Using Macroinvertebrates (A Family Level Biotic Index)", E3S Web of Conferences, 2018 Publication	<1 %
25	aaltodoc.aalto.fi Internet Source	

		<1%
26	thesesups.ups-tlse.fr Internet Source	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		