ICASH-A23

COST EFFECTIVENESS AND EFFICIENCY ANALYSIS OF HOSPITAL WASTEWATER TREATMENT PLANT: A SYSTEMATIC REVIEW

Catherine Maname Uli Nainggolan[1,2,*] , Vetty Yulianty Permanasari[3]

[1] *Hospital Administration Study Program, Faculty of Public Health, University of Indonesia*
[2] *Hosana Medica Hospital, Lippo Cikarang, Indonesia*
[3] *Department of Health Policy and Administration, Faculty of Public Health, University of Indonesia*

*Corresponding email's author: catherine.maname@gmail.com

ABSTRACT

Backgrounds: *Hospital waste management had become an international attention. One of the first meeting by Solid Hazardous Waste was related to domestic waste and medical waste. The previous study showed that nationally hospital solid waste expectedly reach 376.089 ton per day and the volume of wastewater was 48.985,70 ton per day.*
Aims: *The purpose of this study is to examine the literatures on analysis of the cost effectiveness and efficiency hospital Wastewater Treatment Plant.*
Methods: *This systematic review was based on Protocol Prisma. Literature searches were conducted using the electronic databases Google Scholar (2011 to present), SpringerLink, and Proquest.Over a total of 3.834 potential articles, 9 met all inclusion criteria.*
Results: *Cost problems were founded due to there was no good financial planning, maintenance costs, and the wastewater quality supervision. The budget of wastewater treatment only focuses to the cost of damage, but only enough for one time laboratory examination. Moreover, we also highlighted another factors affected to effectiveness and efficiency where there was no regular training for sanitarian, and as the results, sanitarian cannot determine the best effective method, finally the budgets were only for authoritarian system. This paper also reviews methods and applications to reduce the cost in electrical, chemical, and maintenance, by new wastewater treatment alternatives. If compared the two techniques, extended aeration and sequencing batch reactors, evidently, sequencing batch reactor had lower cost than extended aeration.*
Conclusions: *The cost effectiveness and efficiency of wastewater management can be achieved by good management systems, good knowledge about waste, and different methods result different efficiency too.*

Keywords: *Cost effectiveness, efficiency, hospital wastewater treatment plan.*

INTRODUCTION

The hospital waste management had become an international attention and one of the important International meeting agenda. One of the first meeting in Bangkok by Solid Hazardous Waste that continued about waste that related to domestic waste and medical waste [1]. Indonesia Health Ministry surveyed waste managements in 88 hospitals. Based on World Health Organization (WHO), the especially infectious waste (15% until 25%) from total of waste produced by the hospital. However, in Indonesia reached 23.3% [2].

In the Indonesia health profile based on Indonesia Riskesdas (Basic Health Research), Health Department, 2015, it was said that total of Indonesia hospitals were 2.488 with 121 beds in 1000 peoples [3]. The analysis results for 100 hospitals in Java and Bali showed that the average of waste productions were 3.2 kr for one bed per day. Expected nationally, hospital wastewater were 48.985,70 ton per day. From those descriptions, how big the hospital potencial to pollute and for the possibility of incurring accident and transmission of diseases [4].

The wider types of services that are given by hospitals tend to produce more waste in numbers and in diversity because they were more complex than other industries. Hospital wastes consist of some organic materials, hazardous materials, radioactive, even bacteries, or pathogenic microba can make nosocomial infections. The hospital wastes is like the others have the organic and anorganic materials that the composition levels can be measured by water test, such as BOD, COD, TSS, PO4, pH, temperature, and free NH3 or ammoniac as a quality standard based on PERMENLH no.5/2014 [5].

Based on Government Regulation No.101/2014 about Toxic Hazardous Material Waste Management, the hospital in Indonesia must manage the wastes [6]. The solid waste can be managed by incinerator. While, wastewater must be processed first by Wastewater Treatment Plant, so the waste pollute level can't undermine the environment and public health. The wastewater that was resulted by Wastewater Treatment Plant will be flowed to river, to land, or can be recycled again. Hospitals waste management have many problems. The main problems are the high management cost because related to high technology, operational mechanism, and waste monitoring and maintenance [7].

The hospitals are not only producing organic and anorganic waste, but also infectious waste that have Toxic Hazardous Materials. The other economic aspect can be seen also in deciding chemical materials that cheaper but have same function in wastewater management system. Operational unit cost wastewater management in hospitals are estimated based on electric cost need and routine maintenance cost for Wastewater Treatment Management [7]. Accordingly, a systematic review on the cost effectiveness and efficiency hospital Wastewater Treatment Plant become important to be known the extent to which it is implemented. Thus, the purpose of this study was to examine the literatures on analysis of the cost effectiveness and efficiency hospital Wastewater Treatment Plant review the finding systematically, and assess the implementation of this measurement.

METHODS

This systematic review was based on Protocol Prisma. Literature searches were conducted through November 7th 2016 using the electronic databases Google Scholar, springerLink, and Proquest (2011 to present). The author independently evaluated the articles for inclusion. The downloading process was valued independently by author. Restriction was placed on type of language, document type, subject, classification and organization. Additional studies were identified by searching bibliographies from a systematic review.

Using SpringerLink, the keywords "cost effective, advanced wastewater treatment" result 3237 documents. By changing keywords become"cost effective" and "advanced wastewater treatment" result 109 documents. After read all of documents, 1 document appropriate for Systematic Review. By Proquest, the keywords "hospital Wastewater Treatment Plant" result 32 documents. By changing keywords become"hospital Wastewater Treatment Plant" AND "efficiency" result 15 documents. After read all of documents, 1 document appropriate for Systematic Review.

Through Google Scholar, the keywords "hospital Wastewater Treatment Plant" result 357 documents. By changing keywords become "hospital Wastewater Treatment Plant" AND "cost effectiveness" result 9 documents. After read all of documents, 1 document appropriate for Systematic Review. By changing keywords become "hospital Wastewater Treatment Plant" AND "efficiency" result 208 documents. After read all of documents, 1 document appropriate for Systematic Review. By using Google Scholar, the keywords "*Instalasi Pengolahan Air Limbah Rumahsakit"* result 2 documents. By changing the keywords "*Instalasi Pengolahan Air Limbah Rumahsakit"* AND "efektivitas biaya" result 1 document. "*Air Limbah Rumahsakit"* result 2 documents. By changing the keywords "*Instalasi Pengolahan Air Limbah Rumahsakit"* AND "*efisiensi*" result 1 document. For the second keywords "*efektivitas biaya IPAL RS*" result 197 documents. After read all of documents, 1 document appropriate for Systematic Review. Keywords "*efisiensi IPAL RS*" result 310 documents and 2 documents appropriate for Systematic Review.

Included Studies

Criteria of eligibility documents for systematic review, such as the relation with topics, the results related to analysis of the cost effectiveness and efficiency hospital wastewater treatment plant.

Excluded Studies

Because of the systematic review analysis purpose was about analysis of the cost effectiveness and efficiency hospital wastewater treatment plant, so the articles that did not discuss about analysis of the cost effectiveness and efficiency hospital wastewater treatment plant (12 articles) were excluded. Then the articles that were not from journal websites also excluded (10 articles).

RESULTS

The analysis of the cost effectiveness and efficiency hospital wastewater treatment plant from 9 included journals, 4 journals [**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**] research about hospital wastewater cost effectiveness, and 5 journals [**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**] research about hospital wastewater efficiency.

From one research, Evaluation Of Solid And Waste Water Management At Rsud Mimika, showed that the high wastewater management cost can be reduced by management systems. Misgiono, Onny Setiani, and Budiyono, 2014 said that by carried on good management functions: planning, organizing, implementation, and supervising can minimize budget for wastewater. The examples of cost problems were founded in Mimika Hospital, with no good financial planning, the budget of wastewater treatment in 2011 IDR 59.346.000, only for the cost of damage. There were not maintenance costs. The wastewater quality supervision budgeting IDR5.500.000 for laboratory examination for 4 times in one year was insufficient because for one time examination was needed IDR 5.420.000. It was caused by not good financial planning and the sanitarian did not get regular training, so that the budgets were only by otoritarian system. The sanitarian leader did not have good knowledge in work program and budget planning [8].

In Meylinda Mulyati and JM Sri Narhadi's paper, 2014 found one new wastewater treatment technical from wastewater treatment instruments in RK Charitas Hospital, 2014, such as clarifier tank and buffer tank changed by biodetox, whereas polishing tank and treated water tank changed by chlorination tank. Two filtrations in RK Charitas Hospital can be reduced one filtration because of the same functions. The reasine filter in tube that contained salts and fire soda changed by active carbon media. So, in RK Charitas was founded that there were a reduction from IDR 7.120.000 to IDR

6.720.000 in electrical cost, chemical cost from IDR 1.126.000 reduce to IDR535.000, and for maintenance, IDR 400.000 to IDR 300.000 [7].

The other reference also talked about wastewater technical treatment influenced the cost effectiveness [9]. In Iran compared two technical, extended aeration and sequencing batch reactors. Evidently, sequencing batch reactor had lower cost than extended aeration.

Table 1. The comparison of treatment system: extended aeration system and SBR (Adapted from (9))

Treatment system	Operation cost (dollar/m^3 of treated wastewater)	Electric cost (dollar/m^3 of treated wastewater)	Construction cost (dollar/m^3 of treated wastewater)
Extended aeration system	0,25	0,040	667
SBR	0,17	0,013	600

The study in Table 1 supported another study carried out in Amouei *et al.*, 2012 on the quality of hospital wastewater using the extended aeration method, 74.3, 79.6, and 76.5 percent of BOD, COD, and TSS was removed, respectively [10]. The factors that influenced the efficiency of a wastewater treatments consisted of some physics and chemistry parameters, and bacteriology indicators. BOD, COD, TSS, PO4, pH, temperature, and free NH3 or ammoniac, the parameters were measured in two sample points and two different times in Abd Gafar research in Haji Makassar Hospital [11]. Based on laboratory results for Haji Makassar Hospital wastewater sample, BOD 50% (efficient enough), COD 50% (efficient enough), and PO4 (efficient). The average levels for outlet 1,47 mg/L, but inlet PO4 7,48 mg/L.

Besides those parameters, Cahyono Eko Prastiyo Research showed that some indicators had been set to assess wastewater management quality. The indicators were *E. coli* and coliform nonfecal such Enterobacter aerogenes [12]. The sample was taken in 2 days at 08.00, 09.00, 10.00, 11.00, 12.00, 13.00 and 14.00. The MPN Coliform effluent rate in first day was 17.000, in second day was 17.000. For the wastewater treatment, Panti Wilasa Citarum Hospital used Decentralized Wastewater Treatment Systems.

The other journal, showed that Inlet WWTP Tulehu Hospital, the average levels for BOD5 are 28,042 mg/l, COD are 56,428 mg/l, pH are 8.10, temperature are 25,92^{0}C and MPN Coliform are 4,186,028 colony/100 ml. Outlet of WWTP Tulehu Hospital, for BOD5 parameter are 21,708 mg/l, COD are 43,842 mg/l, pH are 7.62, temperature are 24,12^{0}C, and MPN Coliform are 507,601 colony/100 ml. These results were founded from Tulehu Hospital wastewater treatment by biofilter aerob process [13].

In another research, Iran had offered the utilization of environmentally friendly and eco-safe wastewater treatment plan. In one study, had founded the results revealed that the hybrid constructed wetlands are effective to remove organic matter (BOD5, COD) and suspended solid, while in terms of nutrient removal such as N and P components, the removal efficiencies were depending to system properties and operational condition. Heidari, et.al in Iran also discussed about sequencing batch reactor was recommended because of better efficiency and lower cost in investment than the other [14].

Shahryar Jafarinejad said that results demonstrated that increase of MLSS decreases the total project construction, material and amortization costs of WWTPs containing EAAS and CAS. These results depicted that the WWTP containing CAS process is cost effective. Besides, increase of MLSS does not affect costs of WWTP containing SBR, but increase of this value decreases the total project construction, material and amortization costs of WWTPs containing EAAS and CAS. However, this study was in Tehran city, Iran, not hospital as specific [15].

Table 2 Summaries of Parameter Journals

Authors	Title	Methods	Variables	Results
A. Amouei, H. A. Asgharnia, A. A. Mohammadi, H. Fallah, R. Dehghani and M. B. Miranzadeh (2012)	Investigation of Hospital Wastewater Treatment Plant Efficiency in North of Iran During 2010-2011	Cross-sectional Descriptive Study	the influent and effluent of hospital WTP during 2010 to 2011 and Efficiency removal of TSS, BOD, COD and TC	The wastewater treatment system in studied hospitals were activated sludge with extended aeration. The concentration of TSS, BOD, COD and TC in the effluent of the studied hospitals was more than the Iranian reuse standard which indicates inefficient removal of pollutants in mentioned hospital wastewater treatment plant. Thus, for effluent reuse in irrigation more efficient wastewater treatment process is required.
Abd. Gafur (2014)	Efficiency a Wastewater Treatment on The Quality of Liquid Waste Haji Makassar Hospital In 2014	Observational Descriptive Study	Inlet, outlet, sampling times and efficiency of BOD, COD, and PO4	Haji Makassar Hospital used aeration activated sludge system. The efficiency showed wastewater treatment was able to decrease BOD 50% (efficient enough), COD 50% (efficient enough), and PO4 80% (efficient)
Arezoo Heidari, Mahdi Sadeghi, Abotaleb Bay, Jalal Keihanpour, Elham Omidi, Khadijeh Bay, Mahmoud Tabatabaei (2011)	Comparison of Technical and Economic Efficiency of Extended Aeration and Sequencing Batch Reactors Processes in Hospital Wastewater Treatment	Descriptive Analitical Study	Extended aeration system, sequencing batch reactor, influent and effluent of BOD, COD,TSS, pH, residual chlorine	This study demonstrates good performances of the extended aeration activated sludge system and the SBR system in terms of reduction of pollution load to its standard limits for agriculture and irrigation purposes. However, due to slightly better efficiency, lower cost of investment, and operation compared to other methods, the SBR system is recommended.
Ali Arsad Kerubun, Makmur Selomo, Ruslan (2014)	Study of Liquid Waste Quality in General Hospital of Tulehu Province of Maluku	Observational Descriptive Study	Sampling times, inlet and outlet of BOD, COD, pH, temperature, MPN Coliform	General Hospital of Tulehu's wastewater system was anaerob-aerob biofilter. Quality of liquid waste of WWTP Hospital of Tulehu from Physical and Chemical parameters meet the requirement, while the bacteriology parameters is below the standars exception in days four and days five after treatment process meet the requirement and standards.
Meylinda Mulyati, JM Sri Narhadi (2014)	Evaluation a Wastewater Treatment in RK Charitas Hospital Palembang	Case Study	New design, old design, chemistry materials, wastewater treatment quality of pH, TSS, BOD, COD, NH3, PO4	From the RK Charitas Hospital wastewater resulted evidently, this wastewater still had NH3 and PO4 which did not fulfill requirements. PO4 2,134-2,213 mg/L were more than requirements 2 mg/L and NH3 0,174-0,186 more than requirements 0,1 mg/L.
Cahyono Eko Prastiyo (2012)	The Effectiveness of Hospital Wastewater Treatment with The DEWATS System in Reduce Coliform Bacteria in Panti Wilasa Citarum Semarang Hospital	Cross Sectional Descriptive Study	Sampling times, influent, effluent, and efficiency of MPN Coliform	Panti Wilasa Citarum Semarang Hospital used DEWATS (Decentralized Wastewater Treatment Systems). There is not significant difference between the degree of MPN Coliform before and after being processed at wastewater processing unit of Panti Wilasa Citarum Semarang Hospital (p=0,618)

Authors	Title	Methods	Variables	Results
M.H. Sayadi, R. Kargar, M.R. Doosti, H. Salehi (2014)	Hybrid Constructed Wetlands for Wastewater Treatment: A Worldwide Review	Worldwide Review	C/N ratio, four hybrids CW, influent and removal efficiency of BOD, COD, N, P	The results revealed that the hybrid constructed wetlands are effective to remove organic matter (BOD5, COD) and suspended solid, while in terms of nutrient removal such as N and P components, the removal efficiencies were depending to system properties and operational condition.
Misgiono, Onny Setiani, Budiyono (2014)	Evaluation of Solid and Wastewater Management at Rsud Mimika	Qualitative Study	Waste management, medical solid wastes, non-medical solid wastes	Mimika Hospital used anaerob biofilter system. The research resulted in as follows: The hospital produced 35.56 m^3/day of waste water and excessive 9.11 mg/L NH3-free waste water.
Shahryar Jafarinejad (2016)	Cost estimation and economical evaluation of three configurations of activated sludge process for a wastewater treatment plant (WWTP) using simulation	Cross Sectional	Wastewater parameters and values. Depth (m), Coefficient of permeability, Porosity, Particle diameter (cm), Shape factor, Specific gravity and Layer I, Layer II, Layer III, Layer IV	Results demonstrated that increase of MLSS decreases the total project con-struction, material and amortization costs of WWTPs containing EAAS and CAS.

DISCUSSION

Efficiency hospital wastewater

Hospital wastewater contains pathogenic microorganisms, pharmaceuticals, hazardous chemicals, etc., which may have an impact on the environment and public health. Hospital effluents in the visited facilities are generally discharged towards the urban sewer network, towards septic tanks coupled to wastewater disposal well, or to open drains, tertiary treatment (physical, biological, or chemical processes to remove nutrients such as nitrogen and phosphorus, and carbon adsorption to remove chemicals); chlorine disinfection; sludge treatment (anaerobic digestion, natural drying beds and incineration) [16]. The standard quality of wastewater plant treatment that determined by Indonesia government can be seen in PERMENLH No.5/2014. Many Indonesia hospitals still did not fulfill this standard quality, such as in Mimika Hospital, the hospital produced 35.56 m^3/day of waste water and excessive 9.11 mg/L NH3-free waste water [8].

Cost effectiveness of wastewater treatment

The cost effectiveness can be seen by comparing (ratio) between concentration reduction cost per parameter unit. Cost effectivity ratios were showed by all wastewater treatment cost compared by the benefits. The benefits were lower consentration on every parameters. The lowest ratio showed good cost effectiveness. The ideal concept in cost effectiveness implementation for wastewater management if the hospitals have had a financial planning. The financial planning was influenced by sanitation installation work programs. From RSUD Mimika can be learned if there were not good financial planning and the sanitarian did not get regular training, so that the budgets were only by otoritarian system. The sanitarian leader did not have good knowledge in work program and budget planning [8].

In RK Charitas Hospital, Mulyati M and Nurhadi designed new hospital wastewater treatment plant which using method from the old design, they reduce clarifier tank and buffer tank changed by biodetox, whereas polishing tank and treated water tank changed by chlorination tank. All this time, the there were 2 filtration in RK Charitas Hospital can be reduced one filtration because of the same functions. So the cost can be reduce too [7].

The cost effectiveness is an ability that must be had by management. Therefore training must be given to sanitation staffs and management regularly, as said Misgiono, Onny Setiani, and Budiyono in their journal that the hospital must have the budgets for waste management training [8]. The factors that influenced hospital wastewater treatment plant performances to result good quality waste, such as: hospital wastewater treatment plant spaces, management fee, water sources, waste recycling, discharging disinfectant, the amount of labors, education, and training.

The hospital wastewater treatment plant performances in wastewater management can be measured from concentration reduction on each parameters. In Shahryar Jafarinejad's study, 2016, there were three configurations containing conventional activated sludge (CAS), extended aeration activated sludge (EAAS), and sequencing batch reactor (SBR) processes for a wastewater treatment plant in Tehran city were proposed and the total project construction, operation labor, maintenance, material, chemical, energy and amortization costs. In addition, increase of this value increases the total operation, maintenance and energy costs, but does not affect chemical cost of WWTPs containing EAAS and CAS [15].

These studies can explain that in Indonesia, the wastewater cost problem can be varied depend on the type hospitals and the abilities hospital management in wastewater treatment. Moreover, if it was compared by another country, like Iran, this study can compile information in a variation. However, included studies that have reported cost effectiveness and efficiency did not have same standards. All influenced the management competencies, the methods, and regulations for wastewater treatment plants. Besides, the research methodology also influenced because one study gave the redesigning wastewater plant solution, but others only observed existing plant. Therefore, it could not be studied what best methods that can influenced the most effective cost.

Further research is needed to inform strategies for cost effectiveness and efficiency wastewater achievement by considering research methodology. Those strategies covers management system functions, the best effective waste water treatment methods, and how to make economic benefits from recycling to help the government preserve environment.

CONCLUSIONS

The cost effectiveness and efficiency of wastewater management can be achieved by good management systems: planning, organizing, leading, and controlling. Planning how to identify and explain the problems. The example problems are no incinerator operators, no training for waste workers, no Standard Operational Procedures, operational technical did not fulfill requirements, and incomplete infrastructures. Remember to make problem priorities, from the problems above choose one as the most priority. Make purposes success indicators, for example: wastewater already fulfill the requirements. Then review problems, for example: the number of human resources, training, and infrastructure problems. Finally, create operational work plans. Organizing is about an organization structure can make a delegation mechanism from installation leader to staffs based on job descriptions. Leading is about the success of management function development. It is influenced by sanitation installation leader gives motivations to staffs.

For controlling how to assess the gaps, analyze cause factors, and plan and give solutions to problems, tt needs the abilities to analyze the steps of wastewater treatment effectively so that can choose the good wastewater treatment technical which are effective and efficient. If more effectively the cost, then the concentration reduction cost ratio will be less and vice versa. It can show that cost effectiveness will influence good quality waste. The hospital management need to train hospital sanitarian regularly, set unit daily cost and utilization of wastewater to reduce pollution and economic benefit. The government is suggested make Extended Producer Responsibility (EPR) policy about wastes recycling.

REFERENCES

[1] WHO. High Level Meeting on Environmental and Health South-East and East Asian Countries. 2013;120:87–8.
[2] KEMENKES RI. Profil Data Kesehatan Indonesia tahun 2013. Jakarta: Kementerian Kesehatan RI. 2014.
[3] KEMENKES RI. Data & Informasi profil kesehatan Indonesia 2015. Jakarta: Kementerian Kesehatan RI.2016.
[4] Asmadi. Pengelolaan limbah medis rumah sakit. Yogyakarta: Gosyen Publishing. 2012.
[5] KEMENLH RI. Baku Mutu Air Limbah. Kementerian Lingkungan Hidup Republik Indonesia. 2014;(1815):56.
[6] Pemerintah RI. PERATURAN PEMERINTAH no. 101/2014. Jakarta: Pemerintah Republik Indonesia. 2014.
[7] Mulyati M, Narhadi JMS. EVALUASI INSTALASI PENGOLAHAN AIR LIMBAH RUMAH SAKIT RK CHARITAS PALEMBANG. 2014;12(2):66–71.
[8] Misgiono, Onny Setiani B. Evaluasi Manajemen Limbah Padat Dan Cair Di Rsud Mimika Evaluation Of Solid And Waste Water Management At Rsud Mimika. 2014;13(1).
[9] Heidari A, Sadeghi M, Bay A, Keihanpour J, Omidi E. Comparison of technical and economic efficiency of extended aeration and sequencing batch reactors processes in hospital wastewater treatment. 2015; 4(1): 54-61.
[10] Amouei A, Asgharnia HA, Mohammadi AA, Fallah H, Dehghani R, Miranzadeh MB. Investigation of hospital wastewater treatment plant efficiency in north of Iran during 2010-2011. Int J Phys Sci. 2012;7(31):5213–7.
[11] Gafur A. Efisiensi Instalasi Pengolahan Air Limbah Terhadap Kualitas Limbah Cair Rumah Sakit Haji Makassar Tahun 2014. 2014;1
[12] Prastiyo CE. EFEKTIVITAS PENGOLAHAN LIMBAH CAIR RUMAH SAKIT DENGAN SISTEM DEWATS DALAM MENURUNKAN ANGKA BAKTERI COLIFORM DI RS PANTI WILASA CITARUM SEMARANG. 2012;1.
[13] Kerubun AA, Selomo M. STUDI KUALITAS LIMBAH CAIR DI RUMAH SAKIT UMUM DAERAH TULEHU PROVINSI MALUKU Study of Liquid Waste Quality in General Hospital of Tulehu Province of Maluku Balai Teknik Kesehatan Lingkungan Ambon Bagian Kesehatan Lingkungan Fakultas Kesehatan Masyarakat. 2014;1–9.
[14] Sayadi MH, Kargar R, Doosti MR, Salehi H. Hybrid constructed wetlands for wastewater treatment: A worldwide review. Proc Int Acad Ecol Environ Sci. 2012;2(4):204–22.
[15] Shahryar J. Cost estimation and economical evaluation of three configurations of activated sludge process for a wastewater treatment plant (WWTP) using simulation. Appl Water Sci 2016.
[16] PAIMAN. Hospital waste management & environmental assessment in Pakistani selected facilities. 2006.