FLASH Technology: Full-Scale Hospital Waste Water Treatments Adopted in Aceh

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Abstract. A Hospital waste water contains a complex mixture of hazardous chemicals and harmful microbes, which can pose a threat to the environment and public health. Some efforts have been carried out in Nangroe Aceh Darussalam (Aceh), Indonesia with the objective of treating hospital waste water effluents on-site before its discharge. Flash technology uses physical and biological pre-treatment, followed by advanced oxidation process based on catalytic ozonation and followed by GAC and PAC filtration. Flash Full-Scale Hospital waste water Treatments in Aceh from different district have been adopted and investigated. Referring to the removal efficiency of macro-pollutants, the collected data demonstrate good removal efficiency of macro-pollutants using Flash technologies. In general, Flash technologies could be considered a solution to the problem of managing hospital waste water.

1 Introduction

Hospital waste water pollution is a major environmental problem in the world, and usually, it is associated with hazardous chemicals and harmful microbes [1][2][3]. Hazardous chemicals sources could be come from pharmaceutical active compounds (PhACs), heavy metals, detergents, X-ray contrast media, and disinfecting agents [4] while harmful microbes sources come from pathogenic microorganisms such as viruses, bacteria, fungi, protozoan, and helminthes [5]. Hospital waste water pollution in the environmental is one of the major quality issues in many countries because maintenance of water quality and sanitation infrastructure did not increase along with population and urbanization growth [4].

Hazardous chemicals contributed threat to public health and environment due to its potential toxicity as well from highly infectious potential that releases contamination [6]. Harmful microbes in hospital waste water pollution have also been associated with pathogen dissemination and in antibiotic resistance spread into the environment. As hazardous chemicals are non-biodegradable and accumulative in environment, the elevated hazardous chemicals and their deposition over time can lead to the contamination of the surface environment [7][8].

Nangroe Aceh Darussalam (Aceh) is chosen as a focus in this study with the objective of treating hospital waste water effluents on-site before its discharge. Flash Full-Scale Hospital waste water Treatments in Aceh from different district have been adopted and investigated [9]. Flash technology uses physical and biological pre-treatment, followed by advanced oxidation process based on catalytic ozonation and followed by GAC and PAC filtration [9]. This efforts have been carried out in Aceh considered as community health centre (Puskesmas) which government-mandated community health clinics, whereas provide healthcare for population on sub-district level. Puskesmas becomes a mini hospital which provided maternal and child health care, general outpatient curative and preventative health care services, pre- and postnatal care, immunization, and communicable disease control. With an increase of Puskesmas growth, hospital waste water around Aceh area will produce more hazardous chemicals, harmful microbes and other types of pollution [10].

It is significant to note that macro-pollutants level are indicate of pollution levels [5]. Some macro-pollutants parameter were identified from the smell, color, taste, pH, turbidity, COD, BOD_5, and heavy metal content, as well as total coliform as be measured for hospital waste water treatments [11]. However, the macro-pollutants level is sensitive to technology which used for hospital waste water treatments [12]. The objective of the study is to determine the removal efficiency of macro-pollutants in Flash Full-Scale Hospital waste water Treatments in Aceh from different district. The results can also be used to determine whether Flash technologies could be considered a solution to the problem of managing hospital waste water.

2 Materials and Method

Hospital waste water pollution including both the hazardous chemicals and harmful microbes have a

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particular significant in contamination, since they are highly persistent and have all the potential to be toxic to living organisms. The macro-pollutants that are generally determined from effluent of flash full-scale hospital waste water treatments in Aceh include physical parameters (temperature, dissolved solids, suspended solids), chemical parameters (pH, COD, BOD, oils and fats, MBAS, ammonia nitrogen, heavy metals), and biological parameters (total coliform). Six sampling Puskesmas were chosen from 21 (twenty-one) districts in Aceh as shown in Fig. 1. Three sampling Puskesmas (Puskesmas 1, 3, 4) were located at the east area of Aceh, Puskesmas 2 was in the south of Aceh and Puskesmas 5 was in the north of Aceh and Puskesmas 6 was located at the west of Aceh.

The water samples were processed for analysis in the laboratory of Baristand Industri Aceh. Heavy metals were determined using Atomic absorption spectroscopy (AAS) Shimadzu. Other parameters were analysed using Ultraviolet-visible spectroscopy (UV / Vis) and standard method according to Indonesian National Standard (SNI). Evaluation removal efficiency of macro-pollutants can be known from the analysis of physical, chemical, and microbiological parameters. The results of this analysis are then compared to water quality standards in accordance with their designation stipulated by regulation of the Minister of Environment Republic of Indonesia number 5:2014 about quality of waste water quality.

Fig. 1. Location of seven effluent FLASH sampling in Aceh.

3 Results and Discussion

Thirty-one of parameters were analysed from the water samples which were collected from the seven sampling Puskesmas (Puskesmas 1 in aceh tamiang = P1, Puskesmas 2 in aceh selatan = P2, Puskesmas 3 in Kota Lhokseumawe = P3, Puskesmas 4 in Kota Langsa = P4, Puskesmas 5 in Pidie = P5, Puskesmas 6 in Nagan Raya = P6) in the Aceh such as physical parameters (pH, temperature, total dissolved solids = TDS, total suspended solids = TSS), chemical parameters (COD, BOD, oils and fats, MBAS, Ammonia, iron, Manganese, barium, copper, zinc, Hexavalent chromium, Chromium, cadmium, Mercury, lead, Arsenic, Selenium, nickel, Cobalt, cyanide, sulphide, Fluoride, Chlorine free, nitrate, Phenol, Nitrite), and biological parameters (total coliform). Each of them will be described as follows.

3.1 Physical parameters

The range of pH at six sampling puskesmas was from 7.04 to 8.24, which the highest (8.24) was recorded at P3 and the lowest (7.04) was recorded at P4 as shown in (Fig. 2a). The value of pH from six sampling puskesmas in the study area was still below the maximum threshold value of 9 (P0) and above the minimum threshold value of 6.

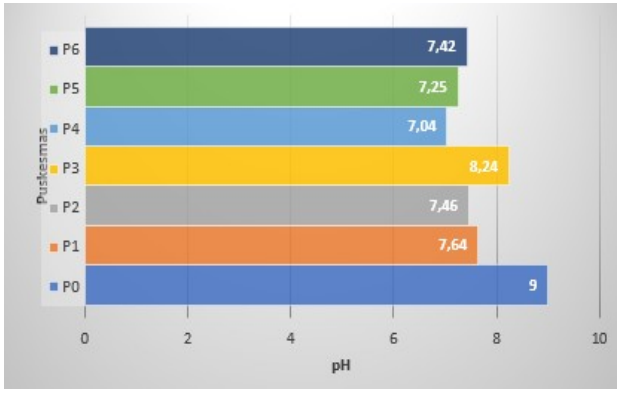

Fig. 2a pH values at six sampling puskesmas

The range of temperature at six sampling puskesmas was from 27.8 to 30.3, which the highest (30.3) was recorded at P3 and the lowest (27.8) was recorded at P1 as shown in (Fig. 2b). The value of pH from six sampling puskesmas in the study area was still below the maximum threshold value of 38 (P0).

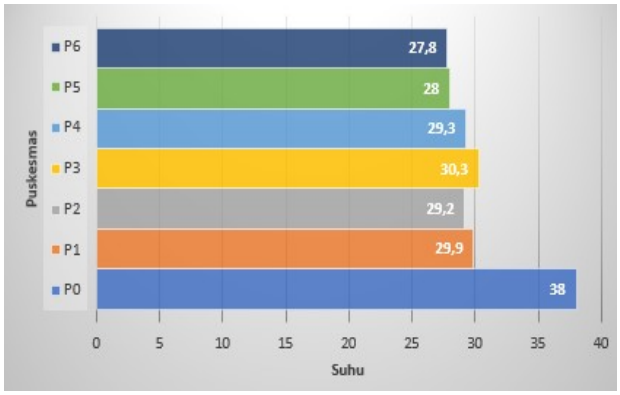

Fig. 2b Temperature values at six sampling puskesmas

The range of TSS at six sampling puskesmas was from 8.57 to 130, which the highest (130) was recorded at P5 and the lowest (8.57) was recorded at P4 as shown in (Fig. 2c). The value of pH from six sampling puskesmas in the study area was still below the maximum threshold value of 200 mg/L (P0).

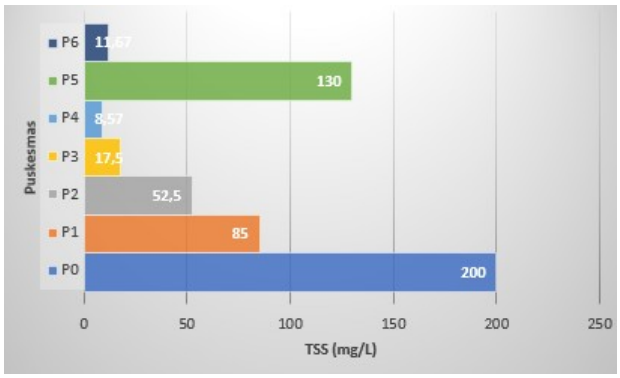

Fig. 2c TSS values at six sampling puskesmas

The range of TDS at six sampling puskesmas was from 121.2 to 389, which the highest (389) was recorded at P5 and the lowest (121.2) was recorded at P6 as shown in (Fig. 2d). The value of pH from six sampling puskesmas in the study area was still below the maximum threshold value of 2000 mg/L (P0).

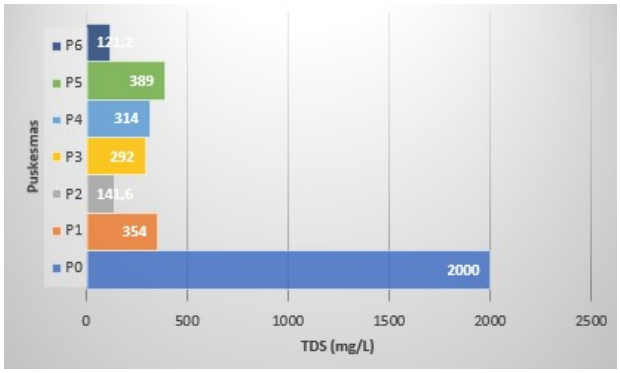

Fig. 2d TDS values at six sampling puskesmas

Physical parameters showed that there were no significant differences between six sampling Puskesmas. Based on value of pH, temperature, TSS, TDS, the level of parameters is classified as safety. This value contributed to the environment through water conditions is not threatening the lives of living things, especially microorganisms that play a role in the balance of environmental ecosystems.

3.2 Chemical parameters

The range of BOD_5 at six sampling puskesmas was from 3.84 to 9.49, which the highest (9.49) was recorded at P2 and the lowest (3.84) was recorded at P5 as shown in (Fig. 3a). The value of BOD_5 from six sampling puskesmas in the study area was still below the maximum threshold value of 50 mg/L (P0).

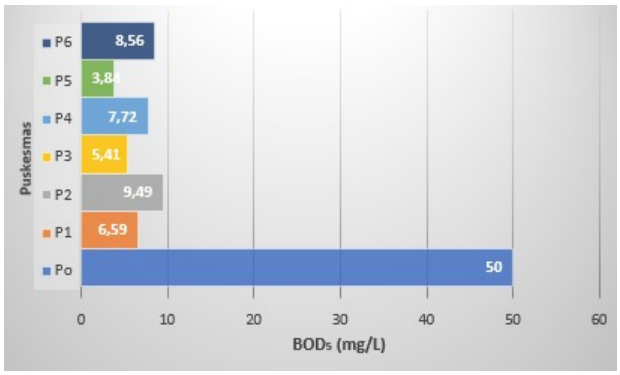

Fig. 3a BOD_5 values at six sampling puskesmas

The range of COD at six sampling puskesmas was from 16.09 to 56.34, which the highest (56.34) was recorded at P2 and the lowest (16.09) was recorded at P3 as shown in (Fig. 3b). The value of COD from six sampling puskesmas in the study area was still below the maximum threshold value of 80 mg/L (P0).

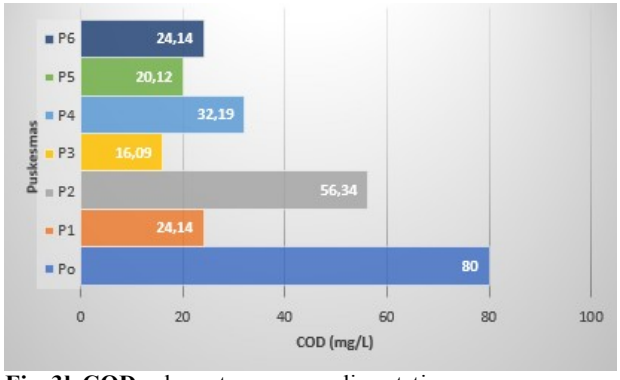

Fig. 3b COD values at seven sampling stations

The collected data of other chemical parameters such as oils and fats, MBAS, ammonia, iron, manganese, barium, copper, zinc, hexavalent chromium, chromium, cadmium, mercury, lead, arsenic, selenium, nickel, cobalt, cyanide, sulphide, fluoride, chlorine free, nitrate, phenol, nitrite show all still below the maximum threshold value. Chemical parameters showed that there were no significant differences between six sampling Puskesmas. Based on the value of chemical parameters in the study area is classified as safety to environment.

3.3 Biological parameters

The range of Total coliform at six sampling puskesmas was from 50 to 1600, which the highest (1600) was recorded at P2 also P3 and the lowest (50) was recorded at P6 as shown in (Fig. 4). The value of total coliform from six sampling puskesmas in the study area was still below the maximum threshold value of 5000 APM/100 mL (P0).

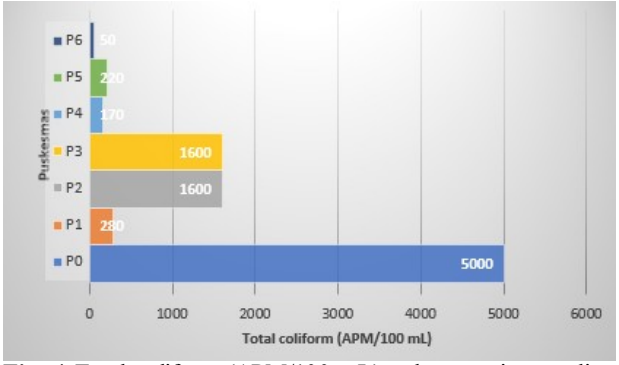

Fig. 4 Total coliform (APM/100 mL) values at six sampling puskesmas

Biological parameters as total coliform analysis showed that there were no significant differences between six sampling puskesmas. Based on the value of total coliform, the level of total coliform is classified as low. With respect to the value of total coliform, the study reveals that there are expected additions of quantities of coliform effluents in P2 and P3 that are particularly associated with the air quality in the area of waste water treatments. Air is another pathway by which coliform enters the water in open space via the dust surface and the coliform becomes bound to the surfaces of dust or other particles [13].

Fig. 5 Flash technology

Flash technology uses physical and biological pre-treatment, followed by advanced oxidation process based on catalytic ozonation and followed by GAC and PAC filtration as shown in (Fig. 5). The Catalyst System ozonation system as one of the advanced oxidation process (AOP) methods is based on ozone decomposition and the formation of stronger and reactive hydroxyl radicals than ozone. The AOP process can be carried out with the use of ozone together with some chemicals or combination with UV radiation and some chemicals [O_3 / H_2O_2, O_3 / UV, O_3 / H_2O_2 / UV] as well as catalytic ozonation [14][7][11]. Ozone that does not react with the catalyst will decompose the contaminants directly or decompose back into the oxygen gas in the waste water as shown in (Fig. 6).

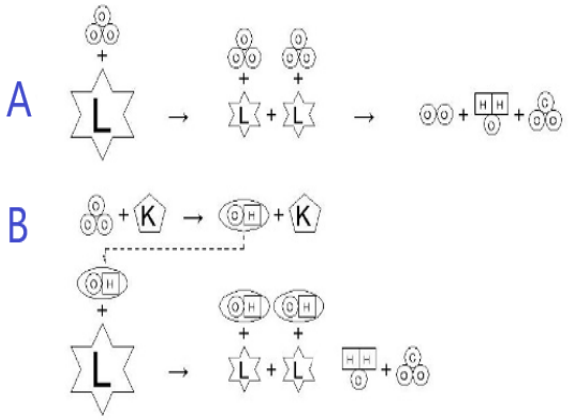

Fig. 6 Mechanism of ozonation reactions: (A) directly, (B) catalytic [*15*]

Data analysis showed that there were significant difference between values of water from output of six sampling Puskesmas adopted Flash Full-Scale Hospital waste water treatments and the maximum threshold value. Referring to the removal efficiency of macro-pollutants, the collected data demonstrate good removal efficiency of macro-pollutants using Flash technologies from six sampling Puskesmas.

The result of Flash technologies is in accordance with some study data, ie O_3 + PAC + sand filtration can process micropollutants (including PhACs), and in the study carried out in a HWWTP in the Netherlands, none of the PhACs (32 different compounds) were detected in the Effluent after tertiary treatment based on GAC + ozone [16]. Biological treatment CAS and MBR is the most widely used worldwide especially in indonesia. However, biological treatment of hospital wastewater does not provide some of the compounds such as pharmaceuticals / PhACs and some pathogenic microbes. Only additional advanced steps like ozonation, activated carbon, or AOPs will enable a better elimination of these compounds [16]. Flash technologies should be adopted for better removal of macro pollutants, harmful bacteria and PhACs. In general, Flash technologies could be considered a solution to the problem of managing hospital waste water around Aceh.

4 Conclusions

The results of the analysis of the thirty-one at the six sampling Puskesmas from Aceh could be concluded that the value of all parameters still below the maximum threshold value. Based on the analyses show that the removal efficiency of macro-pollutants, the collected data demonstrate good removal efficiency of macro-pollutants using Flash technologies. Flash Full-Scale Hospital waste water treatments in Aceh from different district have been adopted and investigated. Referring to in general, Flash technology could be considered a solution to the problem of managing hospital waste water. Monitoring should be carried out from time to time of the hospital waste water treatments to control and prevent contamination as well to identify macro-

pollutants, especially to those that can have a direct impact on environmental pollution.

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References

1. J. Ferre-aracil, Y. Valcárcel, N. Negreira, M. L. De Alda, D. Barceló. Sci. Total Environ. **556**, 70–79 (2016).
2. A. Arslan, S. Veli, D. Bingöl, Sep. Purif. Technol. **132,** 561–567 (2014).
3. T. Azuma et al., Sci. Total Environ. 548–549, 189–197 (2016).
4. T. Chonova, F. Keck, J. Labanowski, B. Montuelle, Sci. Total Environ. **542**, 965–975 (2016).
5. P. Verlicchi, M. Al Aukidy, E. Zambello, Sci. Total Environ. **514,** 467–491 (2015).
6. M. Umar, F. Roddick, L. Fan, H. A. Aziz, Chemosphere. **90,** 2197–2207 (2013).
7. L. Blaney, Ozone Treatment of Antibiotics in Water. Water Reclam. Sustain. (2014), doi:10.1016/B978-0-12-411645-0.00012-2.
8. M. Escolà et al., Sci. Total Environ. 530–531, 383–392 (2015).
9. Bartec Utama Mandiri, Annual report 2015 (2015).
10. A. Tridecima, "FLASH: WWT Catalyst System" (Bartec Utama Mandiri, 2017).
11. R. Kıdak, Ş. Doğan, Ultrason. Sonochem. (2017), doi:10.1016/j.ultsonch.2017.01.033.
12. Y. Lee, L. Kovalova, C. S. Mcardell, Water Res. **64**, 134–148 (2014).
13. N. F. Gray, Ozone Disinfection (Elsevier, Second Edition., 2014; http://dx.doi.org/10.1016/B978-0-12-415846-7.00033-0).
14. K. M. S. Hansen et al., Chem. Eng. J. **290**, 507–514 (2016).
15. Rame, A. Purwanto, A. Budiarto, Res. J. Ind. Pollut. Prev. Technol. In Press, (2017).
16. E. cooperation Project, "Pharmaceutical residues in the aquatic system: a challenge for the future" (Gelsenkirchen, 2012), (available at www.pills-project.eu).