Efficiency Analysis of CBA Full-scale Hospital Waste Water Treatments in Indonesia Using Combined Biological AOP System: Investigation on Operating Conditions, Treatment Efficiency and Energy

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Abstract. Combined biological AOP system, or CBA, are increasingly being used in Indonesia to treatment hospital waste water, that are otherwise difficult to treatment in conventional methods. CBA catalytic ozonation are now used for over 579 hospitals, making this tool a major phenomenon for high adopt hospital waste water treatments in Indonesia, and one that has experienced great expansion over the past three years. The question of whether the CBA is a good or a bad tool for the treatment hospital waste water depends on many parameters. To respond to this question, it is necessary to investigate on operating conditions, but it is also very important to gather more data and conduct further research on treatment efficiency and energy. In this paper, we examined and discuss to gain a better understanding of the CBA environmental technology and of its impacts. About 100 CBA Full-scale Hospital waste water treatments have been investigated, and it was in Indonesia from eight provinces. CBA demonstrate good removal efficiency of macro-pollutants from hospital waste water and meet the requirements as per LH R.I. Number 5 Year 2014 on Wastewater Quality Standard and LHK R.I. Number P.68 / Menlhk / Setjen / Kum.1 / 8/2016 Concerning the Quality Standards of Domestic Waste Water. Various parameters of macro-pollutants such as pH, temperature, TDS, TSS, BOD 5, COD, oil fat, and MBAS also amonia nitrogen and total coliform were analysed to identify the performance of CBA. We obtained the average energy consumption per cycle is 0.504 kWh, capacity ¾ m^3/hours which treatment cost Rp 1.478/m^3 and 60,96%-94,00% removal efficiency of macro-pollutants. CBA catalytic ozonation reported here is very efficient and environmental friendly for treatment hospital waste water.

Keywords: **CBA; efficiency; operating conditions; treatment; energy.**

1 Introduction

The hazardous chemicals and the harmful microbes contents are a most pollutant type found in hospital and community health centre [1–3]. The hazardous chemicals sources usually come from pharmaceutical active compounds (PhACs), heavy metals, detergents, X-ray contrast media, and disinfection agents [4–7]. Harmful microbes sources could come from the pathogenic microorganisms such as viruses, bacteria, fungi, and protozoans. They not only cause a major environmental problem, but also threat human health due to its potential toxicity and highly infectious contamination [1–3,8,9]. Waste water treatment is required to prevent severe contamination in human health suffering from toxicity and infectious. As hazardous chemicals and the harmful microbes have difficult to treatment in conventional methods, are non-biodegradable and accumulative in environment and have an increased risk of pathogen dissemination and in antibiotic resistance which spread into the environment, it is highly important to adopt alternative strategies of advanced waste water treatment.

CBA is a technology that uses the advanced oxydation process, as the main process [10,11]. CBA produces a strong oxidizing hydroxyl radical, a free radical that has a very high oxidation potential (2.8 eV), far exceeding ozone (2.07 eV) which is very effective for decomposing organic contaminants, killing harmful microbes and destroying hazardous chemicals. Radical Hydroxyl is produced from the reaction between Ozone (O_3) and catalyst at the present of water. As a final result of CBA

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is only water and a small amount of carbon dioxide will be obtained [12–14].
Combined biological advanced oxidation processes system, or CBA, are increasingly being used in Indonesia to treatment hospital waste water, that are otherwise difficult to treatment in conventional methods. CBA bases catalytic ozonation are now used for over 579 hospitals, making this tool a major phenomenon for high adopt hospital waste water treatments in Indonesia, and one that has experienced great expansion over the past three years. CBA full-scale hospital and community health centre wastewater treatments in Indonesia uses the biological and the physical pre-treatment, followed by advanced oxidation process and then followed by granulated activated carbon (GAC) and powdered activated carbon (PAC) filtration [10,11,15]. This efforts have been carried out in Indonesia and considered as community health centre which provides healthcare for population on sub-district level. CBA represent not only produce hydroxyl radical, but are themselves determined as fast direct treatment for hospital and community health centre wastewater.

In recent years, hospital and community health centre have gained most of interest in the wastewater pollution as they increase and produce much more hazardous chemicals, harmful microbes and other type of pollutions and are associated with threat human health concern.
The question of whether the CBA is a good or a bad tool for the treatment hospital waste water depends on many parameters. To respond to this question, it is necessary to investigate the treatment hospital and community health centre wastewater that meet the the requirements as per LH R.I. Number 5 Year 2014 on wastewater quality standard and LHK R.I. Number P.68 / Menlhk / Setjen / Kum.1 / 8/2016 concerning the quality standards of domestic waste water from full-scale CBA system. This study aimed to investigate on operating conditions of CBA, and it is also very important to gather more data and conduct further research on treatment efficiency and energy. In this paper, we examined and discuss to gain a better understanding of the CBA as environmental technology and of its impacts.

2 Materials and Method

2.1 Operating conditions of CBA

The full-scale CBA from workshoop of manufacturer (kindly provided by BUMA) and CBA systems that have been operated on hospitals and community health centre waste water treatments have been choosed to investigate on operating conditions.

2.2 Treatment efficiency analysis of CBA

The Various parameters of macro-pollutants such as pH, temperature, TDS, TSS, BOD_5, COD, oil fat, and MBAS also amonia nitrogen and total coliform were analysed to identify the performance of CBA. About 100 CBA Full-scale hospitals and community health centre waste water treatments have been investigated, and it The content of pollutants in from 100 wastewater was analyzed as understanding the removal efficiency of macro-pollutants from hospital waste water. For all CBA parameters analyses, from input before treatment CBA and output after treatment CBA were determined according the requirements as per LH R.I. Number 5 Year 2014 on Wastewater Quality Standard and LHK R.I. Number P.68 / Menlhk / Setjen / Kum.1 / 8/2016 Concerning the Quality Standards of Domestic Waste Water.

2.3 Assessment of efficiency energy from CBA

For gather more data and conduct further research on efficiency energy of CBA, all energy consumption from unit of CBA were determined. Analysis was performed base quantity of power and time elapsed during one cycle of CBA process.

3 Results and Discussion

3.1 Operating conditions of CBA

Pre-treatment and post-treatment used to degrade before and after advanced oxidation processes are consistent with CBA used for the destruction of hazardous chemicals and the harmful microbes contents from hospitals and community health centre waste water [16–19], as we have described below (Fig. 1). The full-scale CBA from workshoop of manufacturer (Fig. 2) and CBA systems that have been operated on hospitals (Fig. 3) and community health centre waste water (Fig. 4).

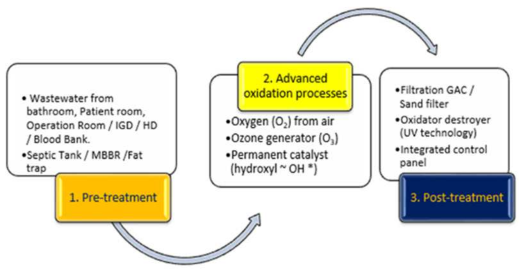

Fig. 1. Schematic representation of the process stages from CBA.

Fig. 2. The full-scale CBA from workshoop of manufacturer.

Fig. 3. The full-scale CBA from hospitals.

Fig. 4. The full-scale CBA from community health centre.

Methods / Workflow from Wastewater Treatment using CBA include:

3.1.1 Pre-treatment

Before the waste water enters the AOP system, wastewater must meet some conditions acceptable to the system. Some things that can disrupt the performance of the AOP system must be neutralized first, such as excessive solid / inorganic waste [20,21]. For that need to be installed box colector and filter. Then the pump to drain the waste water from mini colector to equalization tank. The pump working system is affected by the water level sensor so that if the water is less then the pump will stop. Pre-treatment stage serves to eliminate solid waste and reduce the value of COD, BOD_5, TDS, and TSS and other contaminants.

3.1.2 Advanced oxidation processes (AOP)

This system is equipped with several pumps, namely inlet pump, serves to drain the waste water from equalization tank to Reaction tank. The working system is affected by the water level sensor so that if the waste water is less then the inlet pump will stop. Circulatory pumps to distribute wastewater present in Primary tanks to the Catalytic Ozone system. Performance of Catalytic Ozone System will be effective when ozone (O_3) is mixed with wastewater in the presence of a permanent catalyst which will produce a hydroxyl radical (OH *). The diffuser / venturi as an injection system will increase the contact surface area between the waste water, ozone (O_3), and the catalyst to produce a maximum hydroxyl radical. This hydroxyl radical (OH *), is essential in the process of decomposition and destruction of chemical / medicinal chemicals, pathogenic microbes, and organic contaminants in wastewater [1,14,22]. Oxygen (O_2) with a high concentration used as an ozone generating unit (O_3) input is supplied from free air using Oxygen generating units (O_2). The transfer pump serves as a means of distributing wastewater which has mixed hydroxyl radical (OH *) in the previous stage into the Secondary tank to complete the reaction of decomposition process and the destruction of contamination in the waste water.

3.1.3 Post-treatment

The filter pump for draining the water coming from the Secondary tank to the filtration process according to the final output specification. Filtration serves to reduce metal / inorganic contamination. Then flowed to the oxidizer destroyer for the process of removing the remaining oxidizer (O_3). The filter pump may also serve as a clean water distributor for the washing requirements of the filtration unit.

3.2 Treatment efficiency analysis of CBA

Removal efficiency of macro-pollutants from hospital and community health centre waste water were analyzed from parameters value according to the requirements as per LH R.I. Number 5 Year 2014 on Wastewater Quality Standard and LHK R.I. Number P.68 / Menlhk / Setjen / Kum.1 / 8/2016 Concerning the Quality Standards of Domestic Waste Water such as pH, temperature, TDS, TSS, BOD_5, COD, oil fat, and MBAS also amonia nitrogen and total coliform, etc. About 100 CBA Full-scale Hospital waste water treatments have been investigated, and it was in Indonesia from eight provinces (Central Java, West Sumatra, NTB, East Java, West Kalimantan, West Java, DKI Jakarta, Bangka Belitung).

Table 1. Analysisis of macro-pollutants in 100 CBA Full-scale hospital and community health centre waste water.

Parameter	Standard	Input	Output	Decrease efficiency	Average efficiency decrease
a.Dissolved solids (TDS) (mg / L)	2000	2918	285	90.23%	60.96 %
b.Suspended solids (TSS) (mg / L)	30	171	2	98.83%	77.21 %
c.BOD_5 (mg / L)	50	208	3.14	98.49%	80.28 %
d.COD (mg / L)	80	595	10.91	98.16%	71.24 %
e.Oil and fat (mg / L)	5	8.22	2.07	74.82 %	74.82 %
f.Ammonia nitrogen (mg / L)	10	59.34	3.45	94.18%	77.70 %
g. Total coliform (MPN / 100ml)	3000	9×10^6	220	99.99%	94 %

Evaluation removal efficiency of macro-pollutants from the input to output was analyzed on CBA systems manufacturer (Table. 1). Results are shown as the highest input, output, decrease efficiency, and average efficiency decrease from 100 CBA systems. (a) Dissolved solids in the output decreased until 90.23%, to 285 mg/L from highest input 2918 mg / L in waste water and 60.96% in average efficiency decrease. (b) Suspended solids decreased from 171 mg/L to 2 mg/L and 98.83% in decrease efficiency and average efficiency decrease 77.21%. (c) The number of BOD_5 from input decreased from 208 mg/L to 3.14 mg/L on output. Whilst the decrease efficiency 98.49% and average efficiency decrease 80.28%. (d) Also, the COD from input decreased from 595 mg/L to 80 mg/L. The amount of total chemical generated waste water was significantly higher, with 387 mg/L. Whilst the decrease efficiency COD 98.16% and average efficiency decrease 71.24 %. (e) Oil and fat decreased from 8.22 mg/L to 2.07 mg/L and 74.82% in decrease efficiency and average efficiency decrease. (f) The number of ammonia nitrogen from input decreased from 59.34 mg/L to 3.45 mg/L on output. Whilst the decrease efficiency 94.18% and average efficiency decrease 77.70%. (f) Total coliform from the waste water on input decreased in huge (99.99%). In total 9×10^6 can be decreased per 100 mL into 220, which corresponds to 94% average efficiency decrease per input. The amount of total coliform decreased in wastewater was significantly higher.

The percentage decreased of other parameter, as well as to meet the requirements as per LH R.I. Number 5 Year 2014 on Wastewater Quality Standard and LHK R.I. Number P.68 / Menlhk / Setjen / Kum.1 / 8/2016 Concerning the Quality Standards of Domestic Waste Water such as pH, temperature, and MBAS, etc., were slightly decreased in output compared to standard. These data further indicate that CBA full-scale in hospital and community health centre are functional. The performance of CBA demonstrate good removal efficiency of macro-pollutants from hospital waste water and meet the requirements as government regulation.

3.3 Assessment of efficiency energy from CBA

For gather more data and conduct further research on efficiency energy of CBA, all energy consumption from unit of CBA were determined. Analysis was performed base quantity of power and time elapsed during one cycle of CBA process (Table. 2).

Table 2. Analysis energy consumption base quantity of power and cycle time during one cycle of CBA process.

Name of equipment	Power (kW)	Cycle time (hours)	Power consumption (kWh)	Cost (Rp) 1.467/kWh
Inlet pump	0.300	10/60	0.050	73.35
Circulating pumps, Ozone generating units (O3) Oxygen generating unit (O2)	1.275	15/60	0.319	467.97
Transfer pump	0.425	7/60	0.050	73.35
Filter pump and destructor	0.425	12/60	0.085	124.70

The capacity of the unit at the pre-treatment and post-treatment stage is adjusted to the characteristics of raw materials and final product specifications. AOP system is adjusted as needed by calculation based on ozone dose requirement, process flow, and product type. . Adjust ozone capacity is a typical feature of CBA, which ozone capacity 10 g / h (5 g / m3 = 5 mg / L = 5 ppm) showed that wastewater treatment capacity = 60/44 x 500 liter = 682 liter / hour and Wastewater treatment capacity = 6 x 5 (44/60) x 500 liter = 11,000 liters / day ~ 11 m^3 / day (5 breaks for 22 minutes). Operating price of CBA systems revealed a Rp 1.478 / m^3. These data indicate that CBA systems consumed very low energy in the treatement of hospitals and community health centre waste water.

Summary

Altogether, we have presented a portable compact platform to treatment large numbers of hospital waste water, with reduced work-load, handling steps, and operational costs. This system is easily scalable and can be adapted to automatization and online tagging. CBA demonstrate good removal efficiency of macro-pollutants from hospital waste water and meet the requirements as per LH R.I. Number 5 Year 2014 on Wastewater Quality Standard and LHK R.I. Number P.68 / Menlhk / Setjen / Kum.1 / 8/2016 Concerning the Quality Standards of Domestic Waste Water. Various parameters of macro-pollutants such as pH, temperature, TDS, TSS, BOD_5, COD, oil fat, and MBAS also amonia nitrogen and total coliform were analysed to identify the performance of CBA. We obtained the average energy consumption per cycle is 0.504 kWh, capacity ¾ m3/hours which treatment cost Rp 1.478/m3 and 60,96%-94,00% removal efficiency of macro-pollutants. CBA catalytic ozonation reported here is very efficient and environmental friendly for treatment hospital waste water. Electricity consumption for CBA operations is relatively low compared to conventional installed technology so that it can be an alternative in the effort to realize the development of low carbon communities in the wastewater treatment process.

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