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IMPACTS ESTIMATION OF DIOXIN EMISSION FROM MANAGEMENT APPLICATION OF MEDICAL WASTE INCINERATOR IN COMMUNITY HEALTH CENTERS AND HOSPITALS OF JAVA ISLAND, INDONESIA

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ABSTRACT

Java Island has 3557 community health centers and 1256 hospitals, which are generating medical waste in its operation. Furthermore, only 36% total of both community health center and hospital operates the incinerator correctly to obliterate the medical waste in accordance with the standard, which 64% are not in accordance with the standard. Many researchers evaluate the dioxin emission from the burning of medical waste by the incinerator. Dioxin is believed able to affect the human health, which in particular of cancer, reproductive disorder and birth defects. In the short term, it can cause the liver damage, loss weight and or the decrease of immune body. This research is aimed to evaluate the dioxin emission impacts generated from medical waste incinerators in community health centers and hospitals in Java Island. Java Island was selected as the research object due to its population density noted as the highest in number compared to other islands in Indonesia. The estimation calculation of incinerator emission impacts in Java Island was based on the total estimation of incinerator used by community health centers and hospitals up to the year 2019. The important characteristics were constructed on 7 criteria based on KepKaBapedal 56/1994. Based on the estimation calculation of the impacts, the dioxin emission generated by incinerator from medical waste in Java Island was categorized as large impact and important impact and therefore it must be managed and controlled by current 3577 community health centers and 1256 hospitals. The delegation authority of a monitoring institution from Minister of Environment and Forestry to city/regency EA by making a leaflet of Minister of Environment and Forestry. The fulfilled standard of incinerator has to operate in 1200^{0}C temperature in 14 days and they need to be given the operational permit by Minister of Environment and Forestry, while the one who did not achieve the standard needs to be imposed by the technical improvement requirement before they apply the operational permit.

KEY WORDS : Community Health Center, Hospital, Incinerator, Dioxin, Medical Waste

INTRODUCTION

According to 2014 data (Ministry of Health, 2015a) there are 3,577 community health centers and 1,256 hospitals operating in Java Island, Indonesia that generate medical waste. In detail, the distribution of community health centers in each province is as follows: Special Capital Region of Jakarta (340), West Java (1050), Central Java (875), Yogyakarta (121), East Java (960), and Banten (231). While the distribution of hospitals is as follows: Special Capital Region of Jakarta (158), West Java (293), Central Java (302), Yogyakarta (71), East Java (347), and Banten (85). According to Ministry of Health Strategic Plan 2015-2019 (Ministry of Health, 2015b), in 2014 only West Java Province which most of its cities/regencies around 96.3% have developed and managed their medical waste (26 out of 27 regencies/cities have developed and managed their medical waste). As for other provinces in Java, their achievements are 100%, i.e.: Special Capital Region of Jakarta (6 cities/regencies), Central Java (35

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cities/regencies), Yogyakarta (5 cities/regencies), East Java (38 cities/regencies), and Banten (8 cities/regencies). Although most of provinces in Java have conducted development and management activities for medical waste in their health service facilities, in the same document we can find that the number of cities/regencies that have state own hospital which have certificate from national accrediting agency is quite few. There are only 10 hospitals which have that certificate in 2014 and that number is going to be increased according to the plan until 481 hospitals in 2019. Medical waste generated from hospital activities includes liquid waste and solid waste which both need to be managed so as not to cause environmental impacts. Liquid waste needs to be managed by installing wastewater treatment plan (WWTP). In choosing the WWTP, one needs to consider quality and quantity aspects of the wastewater (Razif *et al.*, 2015a), and its prediction (Razif *et al.,* 2015b; 2015e). Liquid waste that is not well managed can cause impact to the recipient river (Razif *et al.,* 2015c), therefore consideration is needed in assessing the environmental impact of the chosen WWTP (Razif *et al.*, 2015d). Environmental impact assessment (EIA) process surely requires public involvement (Persada *et al.,* 2015 dan Nadlifatin *et al.*, 2015a dan 2015b). As for the solid waste from medical waste, it usually applies extermination method utilizing an incinerator. Ecolabel principle consideration is surely expected when utilizing extermination method with incinerator, as has been implemented in several countries (Lin *et al.*, 2015a). The number of district which has at least one accreditation certified community health center in Indonesia is 0 in 2014 and the number is going to be increased according to the plan to become 5,600 community health center until 2019. One of the reason of lack of accreditation certification hospitals and community health centers is likely due to medical waste treatment problems. According to the planned program, it can be seen that the percentage of hospitals that perform medical waste management according to the standard in 2014 is only 5% and the percentage is planned to be increased gradually to become 10% (2015), 15% (2016), 21% (2017), 28% (2018) and 36% (2019). Assuming that there are 36% hospitals fulfill the standard, then there are 64% hospitals that have not fulfilled the standard in term of medical waste management. As for community health centers there is no plan in regard to medical waste management, however the situation is not different than hospitals. For example, in Surabaya city from 53 operating community health centers only 15 of them (or 28%) have incinerator. Therefore, in Surabaya there are 72% community health centers that have not operated incinerator in 2014. It is not certain whether those operated incinerators have fulfilled the medical waste management standard. With an assumption that 28% of community health centers which use incinerator will fulfill the medical waste management standard and the number increase to 36% in 2019, then the percentage of community health centers that have not fulfilled the standard is identical with hospital in the amount of 64% as average value in Java Island. Currently the incinerator operational permit for hospital and community health centers is still issued by local health department as founding agency and not centralized from Ministry of Environment and Forestry (MEF) as an institution that have a right to issue incinerator operational permit in Indonesia. The aim of this research is to estimate the magnitude and significance impact of dioxin emission from medical waste incinerator generated by community health centers and hospitals in Java Island. Java Island is chosen as research object since it has the highest population density compare with other islands in Indonesia.

Literature Review

There have been many researchers who study the emission impact of waste generated from medical facilities. The majority of them fear the emission of dioxin and furans generated from operating incinerator below 1,200 ^{0}C. Dioxin compound is the most dangerous pollutant of combustion process. Dioxin compound cause several health disorder such as cancer, immune system disorder, damage to reproductive system and hormones, as well as growth disorder (NTP, 2001). World Health Organization (WHO) have enacted criteria for incinerator which fulfill the requirement including the temperature to incinerate solid waste must reach 1,000 ^{0}C. However, in order to dissolve dioxin into carbon dioxide, water and hydrogen chloride then the temperature to incinerate must be higher than 1,200 ^{0}C. Dioxin gas is formed from the combustion of medical waste containing chlorine, plastic/polyvinyl chloride (PVC) or bleach. To maintain sterility, much hospital equipment is disposable (single use) thus generate high number of solid medical waste containing plastic.

Incinerator Temperature

Incinerator generally operates at a temperature between 400^0C – 600^0C (an ideal temperature to generate dioxin), if the incinerator temperature is raised in to higher than 800^0C then higher operational cost is necessary, since the amount of necessary fuel is also high. Besides that, incinerator equipment will quickly be broken and rusty due to high temperatures, if the incinerator uses refractory stone, then that stone will easily break or crack, thus the maintenance cost of incinerator would be very high (Laju Nusantara, 2009). Many incinerator developers provide false information, that their incinerator is able to incinerate waste at the temperature higher than 800^0C. However, if we pay attention in detail, it turns out the thermometer is placed in a way that it measures the combusting point and not the waste gas temperature generated by the combustion process. Surely this is ironic, since dioxin is produced inside waste gas resulted from combustion results especially inside the fly-ash, therefore the requirement of high temperature above 800^0C is for the waste gas temperature, not only the temperature of the combustion process. This high temperature must be maintained when the new medical waste material is inserted in the incinerator. Usually, when the new medical waste material is inserted then the incinerator temperature will decline drastically, when there is a temperature fluctuation the incinerator will generate dioxin. Another incinerator expert said, in order to reduce dioxin pollutant in waste gas emission a special filter is needed to be added. Note that special filter for dioxin is very expensive, and it has to be replaced periodically as it can be clogged and saturated quickly, and this will increase the incinerator operational cost. However, the main problem is, as soon as the dioxin accumulated in the filter where will it be disposed, since dioxin is the number one most poisonous substance in the world.

Global Incinerator Regulations

In several countries, there have been massive rejection towards incinerator usage. In 1980s, in the US, due to landfill crisis impact, large-scale incinerator development has been encouraged. However, the application of incinerator subsequently receive rejection because environmental activist demand stricter emission standard. Finally, the US government shutdown the incinerator industry at the end of 1990s. Japan, a country that is the most intense in applying incinerator, also received rejection from hundreds of anti-dioxins group nationally. Public pressures have caused more than 500 incinerator closed in recent years. In Japan today, the use of incinerator to incinerate solid waste is prohibited, may be used but with strict supervision while waiting for a technology replacement. Ministry of Health and Welfare, Japan (1999) has surveyed 5,886 industries that process their solid waste by using incinerator. The result was that 2,046 industries were proven to generate dioxin, so that 1,393 industries were ordered to shutdown permanently, while the rest 653 industries were gradually closed. There have been 15 countries that prohibit the use of incinerator, and international convention has accommodated the problematic incinerator. Bamako Convention strictly explained that incinerator is an option that is not in accordance with prevention practice and clean production. As for Stockholm Convention, even though it does not clearly state the prohibition of incinerator usage, it limits the incinerator usage. Four out of twelve chemical compounds listed in the Stockholm Convention constitute as byproduct of incinerator, and the convention called for the reduction and elimination of them. In the year 2000, WHO recommended that the tolerable amount of dioxin to enter human body per day as for not causing harm is around 1 – 4 picogram (10-12 gram) per kilogram of body weight. It is very difficult to detect the dioxin since its amount is very small, therefore a very sensitive instrument, i.e.: GCMS (Gas Chromatograph Mass Spectrometer)-High Resolution is needed. In Indonesia there is not even a single laboratory that has a competency to analyze that.

Incinerator Management Regulation in Indonesia

In Indonesia, incinerator management which is related to hazardous and toxic substance waste (B3 waste) management (including medical waste) with thermal processing (including incinerator) has been regulated in Government Regulation No. 101, 2014. Article 125 mentioned that before obtaining the permit to manage B3 waste, activities need to have environmental permit and an approval to do the B3 waste treatment test from the Minister of Environment and Forestry, related to testing of equipment, technology, and or B3 waste treatment facility. The procedure for processing test is regulated by the valid Regulation of the Minister of Environment and Forestry. Related to the

environmental permit, it requires environmental studies which include environmental impact assessment or environmental management efforts (UKL) – environmental monitoring efforts (UPL).

Incinerator Management Experience

Yang *et al.* (2015) wrote that when an incinerator is turned on, it will generate emission in form of polychlorinated diphenyl ethers (PCDEs) in the amount of 1.01–3.08 mg. Mininni *et al.* (2007) wrote that the total polycyclic aromatic hydrocarbons (PAH) emission factor (91–414 μg kg^{-1} burnt garbage) is in the range of values reported for municipal waste incinerators and industrial waste. Buonanno and Morawska (2015) identified that only a few studies measure the existence of emission of fine particle (ultrafine) on incinerator. Kim et al (2008) wrote that in Korea, after the regulation for dioxin emission was issued in 2003, the dioxin emission concentrate from municipal and industrial incinerator declined. The average concentration emitted from municipal solid waste incinerators and garbage reduced from 15:25 ng TEQ Nm^{-3} and 12.86 ng TEQ Nm^{-3} to 5:53 ng TEQ Nm-3 and 4.96 ng TEQ Nm^{-3} in 2001 and 2004. Nzihou *et al* (2012) wrote that all Municipal Solid Waste Incinerator (MSWI) in France operates under European Union and French standard in the amount of 0.1 ng TEQ Nm^{-3} (nanograms toxic equivalent per meter cubic standard) and total emissions of dioxin / furan reduced from 435 g TEQ in 1997 to 1.2 g in 2008. Khumsaeng *et al.* (2013) has generated total dioxins/furans of 4.4, 3.4, and 8.4 ng I-TEQ/m^3 at the starting point, run test part 1 and run test part 2, which above internationally accepted emission level. Lin *et al* (2015) research found that with the addition of pyrite (FeS_2), the reduction of PCDD/Fs can reach 94%, with PCDD/Fs residual concentrate at the flue gas in the amount of 0.13 ng TEQ N m^{-3}. Bunsan *et al* (2013) wrote that the active carbon injection frequency is a very significant factor in dioxin emission. Meneses *et al.* (2004) wrote that cancer risk because of PCDD/F emission from incinerator around 1.07E–07 has been reduced to 3.08E–09 after the installation of air purifier. On the other hand, the risk of cancer caused by PCDD/F emission in other areas is around 5.54E-06 and reduced to 1.86E-06. The total cancer risk caused by PCDDs/F emission of the population living around MSWI is around 1.3E-04 and reduced to 4.25E-05 (67.6% reduction). Zhong *et al.* (2006) have examined the dioxin removal from the municipal solid waste combustion with incinerator. By utilizing the absorption tower with 1% limestone slurry absorption, and 3-point recirculating ratio, 5-15 m/s jet rate, 99.35% dioxin removal efficiency was obtained, the concentration of dioxin in the treated gas is around 0.1573×10^{-13} kg/Nm^3 and the concentration of oxygen is 11%. Chang and Lin (2001) wrote that dioxin removal efficiency from existing municipal waste incinerator (MWI) located in Taiwan increased from 26.9% to 96.6% after performing injection of 115 kg/day activated carbon (AC) on air pollution control device (APCD) at the first year, and increased to 98.7% at the second year with the injection of activated carbon continuously. Kuo *et al.* (2008) have conducted a study toward 22 incinerators in Taiwan that incinerate around 23,250-ton municipal waste per day. It is found that incinerator emission pollutant such as heavy metal (Pb, Cd, dan Hg), acid gas (NO_x, SO_x, CO, dan HCl), and dioxin is still below the standard regulated by the Taiwan Environmental Protection Administrative (TEPA) due to the APCD usage in incinerator operation.

Research Method

Method used in this research are as follows:

1. Calculating the magnitude of emission impact estimation generated by incinerator operating in Java Island based on the estimation of total incinerator used by community health centers and hospitals in Java Island until the year 2019.
2. Determining impact significant characteristics based on seven criteria in accordance with KepKa Bapedal 56/1994
3. Preparing management and monitoring solution proposal to minimize the impact magnitude and impact significant characteristics.

Method to Calculate the Magnitude of Impact

The approach to calculate impact magnitude is based on the description in the background i.e. 64% of hospitals and community health centers is predicted to operate incinerator that do not meet the standard until 2019. The magnitude of dioxin emission from each incinerator is forecasted based on operating experience in many countries particularly in South Korea (Kim *et al.*, 2008) with some dioxin emission approaches. Those approaches are high dioxin emission: 15 ng TEQ Nm^{-3}, low dioxin emission: 5 ng TEQ Nm^{-3}, and average dioxin emission: 10 ng TEQ Nm^{-3} which will be used as basis for dioxin emission calculation in

each incinerator. Total emission in Java Island is obtained by multiplying the number of incinerator predictions in Java Island with each incinerator average dioxin emission. To determine the scale of impact magnitude, threshold criteria is made with impact scale as follows:

1. Very low (Scale no. 1): Average total dioxin <1.000 ng TEQ Nm^{-3}
2. Low (Scale no. 2): Average total dioxin (1.000-5.000) ng TEQ Nm^{-3}
3. Moderate (Scale no. 3): Average total dioxin (>5.000-10.000) ng TEQ Nm^{-3}
4. High (Scale no. 4): Average total dioxin (>10.000-15.000) ng TEQ Nm^{-3}
5. Very High (Scale no. 5): Average total dioxin >15.000 ng TEQ Nm^{-3}

Method to Determine Significant Impact Characteristic

Based on seven criteria of significant impact characteristic determination from Kep Ka Bapedal 56/1994, threshold criteria is made with scale of significant impact as follows:

Method to Propose Solutions for Environmental Management and Monitoring

Method to propose solutions for environmental management and monitoring for dioxin emission from incinerator management is based on PP101/2014 guidance with the proposed approaches that can be done by the MEF so that this regulation can be implemented in Indonesia, particularly in Java Island.

RESULTS AND DISCUSSION

The emission impact magnitude calculation result is shown in Table 2 which derived from the 64% of incinerator which do not meet the standard. Based on calculation results in Table 2, total dioxin emission impact magnitude scale from hospitals and community health center (CHC) in Java Island is categorized as very high (scale no. 5)

By using the 7 criteria of significant impact then results obtained are as follows:

1. The number of human affected by the impact. Majority of them live in high density residential in city area, and with the assumption of dioxin distribution from the incinerator would expose area around each district community health centers and around city hospitals, then it is estimated that the total number of human affected is in the range of 21-30% population in Java Island and based on the criteria, it belongs to the moderate category (scale no. 3)
2. The area of impact distribution is estimated should only be influential in the region adjacent to hospitals and community health centers especially in densely populated urban area, thus the impact area estimated is 21-30% in residential area of Java Island, therefore it is moderate category (scale no. 3)
3. The impact duration calculated from the daily solid waste combustion in incinerator, for hospital the process could go on for 10-14 hours a day, while for community health center it

Table 1. Scale of Significant Impact

No	1	2	3	4	5
A	0-10	11-20	21-30	31-40	>40
B	0-10	11-20	21-30	31-40	>40
C	0-4	5-9	10-14	15-19	>19
D	<1000	1000-5000	5000-10000	10000-15000	>15000
E	None	1	2	3	>3
F	Not	>12	5-11	1-4	<1
G	<1	1-4	5-8	9-12	>12

Notes:

A. The number of humans affected (% population of Java Island)
B. The impact distribution area (% of Java Island area)
C. The duration of impact (hours per day)
D. The intensity of average total dioxin impact (ng TEQ Nm^{-3})
E. The amount of other components impact
F. The cumulative nature of impact
G. The reverse or not of an impact (month)

could go on for 0-4 hours a day, therefore on average the operational time of incinerator is approximately 5-9 hours a day which is belong to short category (scale no. 2)

4. The incinerator emission impact intensity refers to the result of the estimated impact, therefore it categorized as very high (scale no. 5)
5. The other impacted components due to air quality decreasing caused by dioxin emission is only public health components, therefore based on criteria it belongs to low category (scale no. 2)
6. Impact cumulative nature from dioxin is carcinogenic that if exposed everyday there will be cumulative of dioxin inhaled, therefore it is expected that there will be very short time cumulative (scale no. 5)
7. The nature of dioxin effects that cause cancer thought to be very difficult to recover, therefore it tend to be recovered in more than one year time, and according to the criteria it belong to un-reverse condition (scale no.5)

Based on the criteria of 1 to 7, then it can be concluded that the impact characteristic is an important negative impact.

Environmental Management and Monitoring Solutions

Some of the problems that have to be solved related to incinerator management in hospitals and community health centers in Indonesia is as follows:

1. Operating license aspects which issued by the Minister of Environment and Forestry, fact in the field shows the majority of community health centers and hospitals in Java have not obtained a license yet, they are only having a license from the local health department alone.
2. To apply for incinerator operation license, the requirements are: having environmental impact assessment documents and environmental permit in advance, where in that EIA document the study of the used incinerator.
3. Actually, hospitals and community health centers are very serious for applying the operating license from Minister of Environment and Forestry, but there are technical requirements (which is regulated by existing MEF regulation) that are very difficult to be fulfilled, for example:

a. The requirements for incinerator specification should mention name of the manufacturer and the model number, this alone is difficult because there might be many hospitals or community health centers that are not buying the incinerator directly from the factory but buying from the market (through internet)
b. Combustion trial for 14 days continuously will make it difficult for community health center which operates the incinerator once in a week since the amount of medical wasted generated every day is not too many.
c. The most difficult part obviously is the obligation to measure the contents of POHCs, PCBs, PCDFs, PCDDs etc. from the incinerator stack. Not all cities and districts in Java Island have environmental laboratory which has the ablility to measure dioxin.
d. The incinerator owner must also measure stack emission every day and has an obligation to report the result for the last 3 months and must be retested every three years to maintain the minimum value of DRE (destruction and removal efficiency according to the quality standard for dioxins to be 99.9999%).
e. During 14 days of combustion tests that have to be monitored by Minister of Environment and Forestry staff, how many Minister of Environment and Forestry staff have the ability to monitor thousands of incinerator operating in Java Island for 14 days continuously.
f. Expensive fuel cost often cause the combustion only be done to a temperature of 800^0C, not to mention the high cost of laboratory analysis to measure the quality of the incinerator chimney stack emission continuously.

Based on above problems, there are several solution measures that can be done by the Minister of Environment and Forestry so that the license can be issued as soon as possible and the stipulation in

Table 2. Average Dioxin Emission Forecast from Medical Waste Incinerator in Java Island

Services in Java Island	Unit	64% incinerator	ng TEQ Nm^{-3}	Significant Impact Scale
Hospitals	1256	804	8040	3
CHC	3577	2289	22890	5
Total	4833	3093	30930	5

PP101/2014 can also be fulfilled, including:

1. Incinerator operational monitoring to be delegated from Minister of Environment and Forestry to environmental agency (EA) at the city/regency level by using circular letter from Minister of Environment and Forestry
2. Monitored aspect at the first stage should only be operational temperature, especially the exhaust gas temperature generated from combustion.
3. Incinerators that have fulfilled the operational temperature of 1200^0C for 14 days are directly given operational license based on monitoring report from city/regency EA.
4. Incinerators that have not fulfilled the operational temperature of 1200^0C enter the list of incinerators that needs to be technically improved, and they are given time for 3 months to do the repairmen, and after that they can be monitored for 14 days by the city/regency EA.
5. If the city/regency EA has limited human resources, they are allowed to co-operate with local universities that can assign their students to do the incinerator combustion exhaust gas monitoring for 14 days.
6. For incinerators that have obtained operational license, they are subjected to conditions to complete the report based on the valid minister environment and forestry regulations.
7. If incinerator that have to be technically improved are quite many, city/regency EAs are allowed to co-operate with universities or experts that have the ability to give counseling to keep the exhaust temperature of incinerator combustion always at around 1200^0C.
8. Every incinerator manager should be given a counseling to utilize incinerator combustion exhaust emission controller such as wet scrubber and adsorb column, the manager can co-operate with universities or experts that have the abilities to give counseling regarding exhaust gas reduction tools.

If these 8 solutions can be implemented, then it is hoped that environmental management to absorb the exhaust gas can be done and it can be expected that the result of monitoring cannot find dioxin from incinerator emission anymore. Given the danger and losses caused by the use of incinerator in terms of economic social and environmental destruction impact, then it should be considered and studied more in depth and in detail about the use of incinerators for medical waste incineration for the long term in Indonesia. If only the location of health centers and hospitals are not in the adjacent to residential area, then the emission impact from incinerator can be detected by using Gauss equation (Mursid *et al*, 2014). Policy makers or related agencies for example Minister of Environment and Forestry are expected to issue stricter regulation regarding incinerator and if possible, the use of it is prohibited if the replacement technology has been discovered. Incinerators that have been operated should be strictly monitored and they are obligated to use emission processing tool system, like dry system such as electric precipitator and cyclone as well as wet system such as wet scrubber and absorber, so that the environmental pollution can be reduced as low as possible. Behind the failure of existing incinerator system, in reality this is an opportunity as well as threat for Indonesian researchers to be able to develop and create an innovative medical waste processor that is technologically advance, innovative, efficient, energy saving, cheap maintenance cost and most importantly environmental friendly.

CONCLUSION

1. Based on the emission estimation impact, dioxin emission from medical waste combustion using incinerator in Java Island belongs to high and significant impact category so that it needs to be managed and monitored by 3,577 community health centers and 1,256 hospitals that have already and will use incinerator.
2. There is a necessity for authority delegation regarding incinerator monitoring from Minister of Environment and Forestry to city/regency EA by composing circular letter of Minister of Environment and Forestry.
3. Incinerators which have fulfilled the operational requirement with 1200^0C temperature for 14 days to immediately granted operational licenses by the Minister of Environment and Forestry, and those which do not fulfill the requirements are subject to technical improvements, before re-applying operating licenses.

Suggestions

1. There is a necessity to compose regulation in relation to the obligation to create air quality controller tools for the dry system or the wet system by every incinerator user so that the

environmental pollution could be reduce as low as possible.

2. There is a necessity of incinerator usage review for medical waste in the long run in Indonesia by finding alternative technology that is safer for human health.

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