

# Public perception of the management of medical B3 waste and wastewater at health centers in Rejang Lebong Regency

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**Abstract.** Final processing of medical B3 waste using an improper incinerator can produce GHG emissions and release pollutants into the air. Disposal of wastewater that does not meet quality standards or is not managed into the environment can pollute surface water and groundwater. This study examines public perceptions of the management of medical B3 waste and wastewater at health centers in Rejang Lebong Regency. The results of questionnaire data processing from 105 respondents stated that the public considered the health centers to have carried out good medical B3 waste management of 79.62%, and wastewater management of 72.76%. Efforts to improve the performance of medical B3 waste and wastewater management, namely: (a) increasing efforts to reduce, reuse and recycle, such as reusing hemodialysis jerrycans, recycling infusion bottles and PPE, and composting of sludge from IPAL processing; (b) increasing efforts to sort medical B3 waste; (c) adjusting the design of the B3 waste TPS and providing cold storage; (d) providing and repairing IPAL; (e) increasing the capacity of waste management officer; and (f) increasing the allocation of costs for environmental management and monitoring. Implementing these efforts can minimize the impact on health and the environment and help achieve SDGs 6 and 12.

## 1 Introduction

The environmental impact of health service activities is essential to be appropriately managed; environmental management and monitoring efforts can minimize these impacts. Rejang Lebong Regency has the most inpatient health centers in Bengkulu Province, which allows the amount of waste produced to be greater [1]. Based on the preliminary survey results, the waste produced from health services at health centers in Rejang Lebong Regency is domestic waste, medical Hazardous and Toxic Materials (B3) waste, non-medical B3 waste and wastewater. Regarding the management of medical B3 waste, health centers have made efforts to reduce, sort, temporarily store, transport and final process (third party) and report

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on the management of medical B3 waste. Meanwhile, for wastewater management, of the 12 health centers that have Wastewater Treatment Installations (IPAL), only five health centers have IPAL that can function correctly. For seven health centers whose IPAL are dysfunctional and nine health centers that do not have IPAL, wastewater is streamed to septic tanks. According to [2], More than half of the world's population is estimated to be at risk of environmental or public health threats from improperly managed healthcare waste. Some causes of improper waste management include a lack of awareness of the health hazards associated with healthcare waste, inadequate training in proper waste management, lack of infrastructure or energy, and lack of appropriate regulations or enforcement of existing rules. In addition, waste transport vehicles that use fossil fuels, inappropriate incinerator technology, or inappropriate incineration of materials result in Greenhouse Gas (GHG) emissions and release of pollutants into the air.

Disease transmission from medical waste can occur when humans come into direct contact with waste or are inhaled through the air. Based on research results [3], several healthcare facilities in Sudan do not have autoclaves or disinfection, and there are no needle-cutting tools, so used syringes are very likely to be reused. Based on research results [4], all types of medical waste, including cotton, expired drugs, and sputum bottles, are burned in a hole, which causes the groundwater around the waste disposal site to be contaminated with waste leachate. The residual waste from poor waste management will become a disease vector. Cancer, mutations, teratogenic effects on the eyes, respiratory disorders and skin infections can occur when exposed to expired drugs and mercury. Poor sharps waste collection methods can cause injuries that result in acute infections. According to [5, 6], the presence of nitrate compounds, chemicals, disinfectants, metals and phosphorus in medical waste causes contamination of underground aquifers and interferes with or damages plants and animals. According to [7], Wastewater disposal that exceeds quality standards or is not even managed in the environment can cause environmental pollution, especially in water sources, and become a medium for the growth of pathogenic microorganisms. Insects that can transmit diseases, especially cholera, dysentery, and *typhus abdominalis*. According to [2], efforts to minimize the impact of medical waste on health and the environment include reusing surgical equipment after autoclaving, recycling test kits, dialysis equipment, infusion bottles and hemodialysis jerrycans, and composting or anaerobic processing or pyrolysis of wastewater sludge. According to [8], waste masks and gloves can be processed through pyrolysis into oil for energy because they are thermoplastic with high oil content. Based on the above conditions, it is considered necessary to evaluate and study public perceptions of the management of medical B3 waste and wastewater carried out by health centers in Rejang Lebong Regency.

## 2 Research Methods

### 2.1 Evaluation of medical B3 waste and wastewater management

Researchers evaluated medical B3 waste and wastewater management uses qualitative description (primary and secondary data). Primary data were obtained through interviews with sanitarians and Regional Environmental Supervisory Officer (PPLHD) of the Environmental Service Department (DLH) of Rejang Lebong Regency, field observations, and wastewater quality checks. Secondary data were in the form of supervision reports on nine health centers published by the DLH of Rejang Lebong Regency.

## 2.2 Public perception of medical B3 waste and wastewater management

The population in Rejang Lebong Regency is considered to be the population. Referring to the Slovin formula in [9], the sample size is determined using a formulation technique based on the level of accuracy, namely:

$$n = \frac{N}{1+Ne^2} \quad (1)$$

Note:

n is a sample,

N is the population,

e is the precision (accuracy), which is set at 0.1

Based on [10], the population of Rejang Lebong Regency is 281,281 people, using the Slovin formula then:

$$n = \frac{N}{1+Ne^2} = \frac{281,281}{1+281,281(0.1)^2} = \frac{281,281}{2,813.81} = 99.96$$

The number of samples was found to be 99.96, which rounded up to 100 people. Because the number of health centers in Rejang Lebong Regency is 21 health centers, the number of samples for each health center:

$$n \text{ (each health center)} = \frac{100}{21} = 4.76$$

The number of samples was 4.76, rounded up to 5 people/health center.

To study the public perception of medical B3 waste and wastewater management in health centers, primary data were obtained through interviews using questionnaires with five respondents for each health center. Thus, the total number of respondents for public perception was 105 people. Respondents were visitors and residents whose homes were close to the health center.

Researchers conducted data analysis using a Likert scale to determine the public perception of the management of medical B3 waste and wastewater. As a benchmark from the disagree to strongly agree scale, including scores:

1 = Disagree

2 = Less agree

3 = Normal

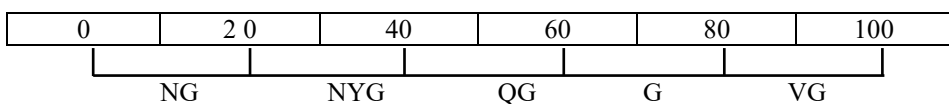
4 = Agree

5 = Strongly agree

Respondents give a score to each statement. Then, the summation of all the scores is done; from the total public perception score, the percentage value of the public perception level will be calculated. Then, the percentage value of the level of public perception of each statement is interpreted into the criteria of not good to very good. Referring to [11], the level of public perception is calculated using the following formula:

$$\text{Public perception level} = \frac{\text{total public perception score}}{\text{total maximum score}} \times 100\% \quad (2)$$

Interpretation of value (%):



The explanation of the criteria for interpreting the public perception level (%) are:

- 0 – 20 = NG (Not good)
- 21 – 40 = NYG (Not yet good)
- 41 – 60 = QG (Quite good)
- 61 – 80 = G (Good)
- 81 – 100 = VG (Very good)

## 3 Results and Discussion

### 3.1 Evaluation of medical B3 waste and wastewater management

#### 3.1.1 Medical B3 waste

Based on the results of interviews, the officer responsible for B3 waste management do not yet have adequate competence. However, to reduce medical B3 waste, all health centers have used digital thermometers and tensimeters. Mercury thermometers and tensimeters were submitted to the Health Office to be submitted to the Ministry of Environment and Forestry (KLHK). In addition, all health centers have implemented the principle of *first in first out* (FIFO) and *first expired first out* (FEFO) in drug management, although expired drugs were still found in small quantities. For the sorting of medical B3 waste, all health centers have carried out sorting when the waste is generated. Each service room has containers for non-sharp infectious waste (lined with yellow bags) and containers for sharp infectious waste (safety boxes). However, the sorting carried out in most health centers has not been effective because domestic waste is still found in containers lined with yellow bags. Based on [12], it was reported that in Sri Lanka, Timor Leste and Bangladesh, health workers had a low level of awareness of the risks associated with poor medical waste management. For waste sorting to be carried out properly, according to [4, 13], labelling and colour coding schemes are applied to waste containers (black for general waste, yellow for infectious waste and brown for hazardous waste). The benefits of good medical waste sorting, according to [14, 15], are that it makes the capacity of medical waste storage optimally used and can reduce the cost of medical waste management.

All officers manually carriage medical B3 waste from the service room to the TPS using their hands. Still, they have also used personal protective equipment (PPE) such as masks, gloves, and medical aprons. According to [16], in health service facilities in North Toraja Regency, carriage of medical solid waste is carried out by hand without using PPE or transportation equipment. According to [6], internal carriage should use a means of transportation in the form of a stroller or a special container that is strong and does not leak, and the transportation equipment should be cleaned every day. All health centers do not have technical details for temporarily storing B3 waste. Based on the provisions in Chapter V of the Attachment to the Regulation of the Minister of Health Number 2 of 2023, the B3 waste TPS and B3 waste processing equipment, incinerators, and other B3 waste processing equipment/facilities in health service facilities must be equipped with technical approval from the authorized government agency. The B3 waste TPS in 19 health centers is a non-permanent building, namely walls and roofs made of plywood, walls made of light steel in the form of cages, floors made of wood or even dirt floors. Referring to Article 60 Paragraph (2) of the Minister of Environment and Forestry Regulation Number 6 of 2021, B3 waste storage facilities in the form of buildings must meet the requirements, including design and construction that can protect B3 waste from rain and be covered, a roof made of non-flammable materials and a waterproof and non-wavy floor.

All health centers have collaborated with PT. Artama Sentosa Indonesia is a transporter and final processor of B3 waste that has a permit and recommendation from the Ministry of Transportation and KLHK. Medical B3 waste produced from October 2023 to June 2024 has been transported and processed by PT. Artama Sentosa Indonesia in June 2024. So, the storage time for medical B3 waste at the TPS is  $\pm$  8 months at room temperature. Referring to Chapter V of the Attachment to the Regulation of the Minister of Health Number 2 of 2023, the storage provisions: (1) medical waste in the infectious, pathological, and sharps categories must be saved at the TPS with a temperature of less than or equal to 0°C for up to 90 days; and (2) medical waste in the infectious, pathological, and sharps categories can be saved at the TPS with a temperature of 3 to 8°C for up to 7 days. Research results [16], 15 health service facilities in North Toraja Regency save the solid medical waste at room temperature because they do not have cold storage or freezers. And due to cost constraints, in 1 (one) month, solid medical waste processing is only carried out 2 to 3 times.

PT. Artama Sentosa Indonesia processes medical B3 waste using incinerators and electrocoagulation. According to [17], the incineration system functions to destroy medical waste materials that are hazardous to the environment, kill pathogenic bacteria, and reduce the volume of medical waste by up to 99.95%. However, the incineration process produces gas, unburned residue and ash. According to Kilgroe (1996) in [18], two methods can be used to control dioxin emissions from the incineration process: cloth filters and dry *scrubbers* combined with electrostatic precipitators. While mercury emissions can be controlled by injecting activated carbon powder into the exhaust gas stream, the carbon particles are removed using a cloth filter or electrostatic precipitator. In addition, reducing incinerator emissions can be done through medical product manufacturers, where manufacturers make medical products that can be burned but do not produce dioxin and/or mercury.

### 3.1.2 Wastewater

It is known that five health centers have IPAL that can function correctly, seven health centers whose IPAL are dysfunctional and nine health centers that do not have IPAL. For seven health centers whose IPAL is dysfunctional and nine health centers that do not have IPAL, wastewater is streamed to septic tanks and/or infiltration wells. It is known that four health centers have technical approval for the utilization and management of wastewater application to the ground published by DLH. Researchers conducted wastewater quality checks at two health centers that have technical approvals. The results of the wastewater quality checks can be seen in table 1.

**Table 1.** Summary of wastewater test result data.

Parameter	Unit	A		B		Maximum level
		Inlet	Outlet	Inlet	Outlet	
pH	-	6.92	6.69	6.29	6.61	6 – 9
BOD	mg/L	5	$\leq$ 1.96	10	3	30
COD	mg/L	14	8	70	12	100
TSS	mg/L	$\leq$ 2.5	$\leq$ 2.5	7	$\leq$ 2.5	30
Oil & Fat	mg/L	0.1	0.3	0.1	0.1	5
Ammonia	mg/L	16	11.6*	177	0.05	10
Total Coliform	Amount/100mL	5800	5800*	$\geq$ 18980	7600*	3000

Note: \* = Does not meet the Quality Standard limits based on the Regulation of the Minister of Environment and Forestry Number: P.68/Menlhk/Setjen/Kum.1/8/2016

At the health center A, the parameters that did not meet the quality standards were ammonia of 11.6 mg/L and total coliform of 5800/100mL. While at the health center B, the parameters that did not meet the quality standards were total coliform of 7600/100mL. Based on the results of interviews and field observations, it was found that there was not additional treatment of wastewater during the processing at the IPAL. The study's results [19], the IPAL of the Roemani Muhammadiyah Hospital Semarang has been efficient in reducing TSS, BOD, COD and NH<sub>3</sub> but has not been efficient in reducing the parameters of coliform bacteria. According to [20], the parameters of microbiological indicators, especially total coliform, can decrease due to the IPAL holding tank unit (outlet) endpoint and have gone through a chlorination process. The use of chlorine is to break down the permeability, enzymes and nucleic acids in bacterial cells. According to research results [21], the reduction in ammonia (NH<sub>3</sub>-N) values was caused by adding chlorine to the wastewater during the extraction process so that it could reduce ammonium well.

In addition to the absence of additional treatment in the wastewater treatment process at the IPAL, less than optimal operation of the IPAL is also the cause of the wastewater quality failing to meet quality standards. The IPAL at the health center is operated twice a week or once a week, not operated 24 hours a day, because (a) health centers with a small amount of wastewater, the blower at the IPAL can burn if the IPAL is operated with wastewater conditions that have not reached the minimum limit; (b) health centers with sufficient wastewater, limited budgets cannot finance the high use of electricity for operating the IPAL. The study's results [22], the IPAL unit and unique materials used to reduce ammonia levels at the Abdul Wahab Sjahranie Hospital include blowers, blower pipes, aeration tanks, *AquaMate* and bio enzymes. The blower will operate for 24 hours to supply oxygen to the wastewater in the aeration tank. The aeration tank is a unique tank that provides oxygen to aerobic bacteria that will degrade and break down ammonia. According to [23], UV light is quite effective in killing bacteria and viruses in wastewater containing organic nitrogen, better than chlorination. According to [2], wastewater treatment sludge can be composted, processed anaerobically, or pyrolyzed.

### ***3.1.3 Implementation of sustainable medical B3 waste and wastewater management practices***

The Conference of Parties Special Report on Climate Change and Health (2021) states that climate change has significantly impacted health. Climate change causes diseases and deaths in various ways, such as more frequent extreme weather events (heat waves, storms and floods), disruption of food supply chains, increased vectors and zoonoses carrying diseases, and mental health problems. Four priority disease groups are negatively affected by climate change, namely vector-borne diseases (Dengue and Malaria), airborne diseases (Pneumonia, acute respiratory infections and Tuberculosis), waterborne diseases (Diarrhea) and malnutrition (stunting, wasting and underweight) [24]. The laboratory analysis results of ash from burning medical waste showed a high heavy metal content. In addition, in burning medical waste using incinerators, NO<sub>2</sub>, CO<sub>2</sub>, SO<sub>2</sub>, and Pb gases in the ambient air mostly come from the combustion of diesel fuel used. NO<sub>2</sub> concentrations between 50-100 ppm can cause pneumonia, and NO<sub>2</sub> concentrations between 150-200 ppm can cause compression of the bronchioles (*bronchiolitis fibrosis obliterans*), which can cause death in people within 3-5 weeks after exposure [6]. It is concluded that the disposal of medical B3 waste and wastewater that does not meet quality standards from improper waste processing or even without any processing into the environment can increase disease and even death and worsen environmental pollution and/or damage.

For environmental sustainability and public health, it is necessary to carry out sustainable waste management. To control air pollution due to the burning of medical waste using an

insinerator, a condenser can be used, air pollution control technology (APC) consisting of a *quencher, spray dry absorber, bag filter, ID fan*, and chimney, and plasma technology consisting of a plasma reactor and high voltage *Direct Current* [17]. To avoid the production of furan and dioxin in medical waste containing chlorine, medical waste is processed by pyrolysis. Pyrolysis is a thermal degradation process of biomass that occurs without oxygen, producing biochar, bio-oil and gas. Masks and gloves can be processed into oil for energy through pyrolysis because they are thermoplastic with high oil content [8]. Using ash from incinerator combustion as a mixture for making ceramics effectively reduces the levels of metals leached in ceramics due to stabilizing heavy metals against silica, the primary ceramic material. The effect of silica on leaching is due to the transformation reaction of oxide compounds to form crystalline compounds [25].

In addition to the incineration process, there are other more environmentally friendly and cheaper medical waste treatments, namely disinfection using microwave ovens and autoclaves. The microwave processing system uses microwave frequencies of around 2450 MHz to decontaminate medical waste. The advantages of this system are the short process time and fast and uniform heating [26]. In addition, sharp medical waste can be destroyed with a needle burner or processed using an autoclave, which can then be disposed of as non-infectious sharp waste [27, 28]. Some waste sterilized using an autoclave can be recycled, such as plastic containers, plastic packaging, hazmat suits and masks [29]. At Pasaman Barat Regional Hospital, the infusion tube processing managed to save costs Rp 168.89 million/year, and the sale of plastic blocks from processing infusion tubes to recycling producers increased income [30]. Types of hospital medical waste such as HDPE and polypropylene plastic, PPE, and disinfected polypropylene masks can be recycled by extrusion at 170°C to produce plastic pellets [31]. The domestic wastewater treatment system is equipped with a reuse system [32]. There is wastewater processing in the bio-digestion system which produces methane gas, which can be used as fuel in the facility [2]. Reuse and recycling of medical B3 waste can help achieve target 12.4 of Sustainable Development Goal (SDG) 12, which is to “achieve environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with an agreed international framework and significantly reduce the release of such chemicals and wastes to air, water and land in order to minimize adverse impacts on human health and the environment”. For wastewater reuse, converting wastewater to fuel and composting sludge from wastewater treatment can help achieve target 6.3 of SDG 6, which is to “improve water quality by reducing pollution, eliminating discharges and minimizing releases of hazardous materials and chemicals, halving the proportion of untreated wastewater and significantly increasing recycling and the safe reuse of recyclables globally”.

## 3.2 Public perception of medical B3 waste and wastewater management

### 3.2.1 Respondent characteristics

Age level affects a person's ability to carry out activities and thinking concepts. The respondents' age composition from the data processing results shows that the most significant number of respondents are in the age range of 25-34 years, which is 30.48%, and the fewest are at the age of  $\geq 55$ , 14.29%. The gender composition of respondents from the results of data processing shows that most respondents are female, which is 80%. The composition of education levels from the data processing results shows that the most significant number of respondents are respondents with a high school/equivalent educational background, 49.52%, and respondents with an Academy/University educational background, 19.05%. Meanwhile, regarding the type of respondent's work, the results of data processing show that the most significant number of respondents are farmers, which is 30.48%. And there are three types

of respondents' jobs have the same percentage of 8.57%: respondents who work as traders, civil servants/PPPK, and students/college students.

### 3.2.2 Public perception

#### A. Medical B3 waste

The study results showed that 61.90 % of respondents agree that it is essential for every officer responsible for B3 waste management to have competence related to B3 waste management. Meanwhile, regarding the importance of the availability of B3 waste TPS in health centers, 52.38 % of respondents agree, and 45.71 % strongly agree. The statement of the importance of using PPE when managing B3 waste, especially medical B3 waste, showed that 71.43 % of respondents agree. Meanwhile, regarding the statement of the importance of health centres having a cooperation contract with the transporter and final manager of B3 waste when the health centre cannot process its own B3 waste, it showed that 59.05 % of respondents agree and 40 % of respondents stated that they strongly agree. The statement of the importance of health centers making efforts to handle and overcome pollution and/or health problems due to B3 waste showed that 60 % of respondents agree. Meanwhile, the statement about the importance of holding a joint dialogue to find a solution if there are public complaints due to B3 waste shows that 49.52 % of respondents strongly agree and agree. For the last statement, namely that the health center has managed B3 waste well, the study results showed that 84.76 % of respondents agree, 8.57 % stated that they were normal, and 6.67 % said they strongly agree. This statement's public perception index figure is classified as good, at 79.62%.

#### B. Wastewater

The study results showed that 60.95 % of respondents agree that it is essential for every officer in wastewater pollution control to have competence related to water pollution control. Regarding the statement that wastewater needs to be treated first before being discharged into surface water bodies or applied to the ground, the study's results showed that 68.57 % of respondents agree. For the statement that wastewater needs to be discharged into surface water bodies or applied to the ground to meet the wastewater quality standards set by the government, the results of the study showed that 54.29 % of respondents agree. The statement that it is essential for laboratory services that conduct wastewater quality testing to be accredited and registered showed that 75.24 % of respondents agree. The statement that the surrounding community needs to know if there is river pollution from wastewater from health service activities showed that 50.48 % of respondents strongly agree.

Regarding the statement of the importance of the health center making efforts to handle and overcome if there are health problems due to wastewater from health service activities, the results of the study showed that 54.29 % of respondents agree. The statement of the importance of holding a joint dialogue to find a solution if there are complaints from the community due to wastewater from health service activities showed that 53.33 % of respondents strongly agree. And for the last statement, namely that the health center has carried out good wastewater treatment of its health service activities, the results of the study showed that 45.71% of respondents stated that they were normal, 41.90% of respondents stated that they agree, 11.43% of respondents stated that strongly agree. One person whose house was right next to one of the health centers stated that they disagree. The public perception index figure regarding this statement is 72.76%, so the value is classified as good because even though the health center has IPAL that dysfunctional or does not have IPAL, wastewater is streamed to septic tank and/or infiltration well so that there has been no direct impact that has occurred and is detrimental to patients/visitors/the community whose houses are close to the health center building.

## 4 Conclusion

The activity of disposing of medical B3 waste and wastewater without processed into the environment or managing it but not by the provisions, can cause an increase in vectors and zoonoses carrying diseases and worsen pollution and/or environmental damage caused by climate change. Therefore, it is necessary to carry out sustainable waste management, namely efforts to reduce, reuse and recycle waste that can reduce the amount of waste potentially generated from health service activities. With sufficient knowledge and high concern for environmental sustainability, medical B3 waste sorting activities will be able to run well and impacted on reducing the cost of final waste processing. The residue of final waste processing can also be utilized, such as ash from incinerator combustion as a mixture for making ceramics and sludge from wastewater processing, which is processed into compost. Due to the lack of knowledge of waste management officer about sustainable medical B3 waste and wastewater management and the minimal budget for waste management cause the management of medical B3 waste and wastewater is not optimal.

Several efforts to improve the management of medical B3 waste and wastewater, namely: (a) increasing efforts to reduce, reuse and recycle, such as reusing hemodialysis jerry cans into safety boxes, recycling infusion bottles, recycling HDPE and polypropylene plastic, PPE and polypropylene masks into plastic pellets, utilization of ash from incinerator combustion as a mixture for making ceramics and composting sludge from IPAL processing; (b) increasing efforts to sort medical B3 waste; (c) adjusting the design of B3 waste TPS and providing cold storage; (d) providing and improving IPAL; (e) increasing the capacity of waste management officer; and (f) increasing the allocation of costs for environmental management and monitoring. By implementing the above management performance improvement efforts, the impact of medical B3 waste and wastewater on health and the environment is expected to be minimized and can help achieve SDG 6 and SDG 12.

Regarding the public perception of the management of medical B3 waste and wastewater that has been carried out by the Rejang Lebong Regency health center, from the results of the questionnaire data processing of 105 respondents, it was stated that the public considered the health center to have carried out good B3 waste management of 79.62%, and wastewater treatment of 72.76%. To increase innovation in the management of more sustainable medical B3 waste and wastewater, it is hoped that future research can examine the development of a circular economy model in healthcare facilities and *blockchain* technology development, which can be used to improve the identification and tracking of various wastes produced, guarantee waste disposal, and accelerate the provision of waste management services.

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