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Development of Infectious Waste Sterilization and Neutralization System

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Abstract – Infectious waste is around 39.51 kg per day by waste products of independent practice facilities for midwives, health centers and maternity clinics. Most of the infectious waste is contaminated with bacteria, viruses, toxins, and radioactive materials that are harmful to humans and other creatures around them. To prevent the negative impact of infectious waste (underpad, cotton, bandages, and tissue), special handling of infectious waste materials is required. Based on the washing machine principle, we have designed the Infectious Waste Sterilization and Neutralization System, using three types of chemicals and 5 filter elements with a capacity of 5 kg. By using this system, the disposal of infectious waste contaminated with bacteria and viruses can be cleaned within 40 minutes so that it will be safer for the community and the sanitation of the environment around the disposal site and the manufacturing cost is not too expensive.

Keywords *– Infectious Waste, Sterilization, Neutralization, Filter*

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I. INTRODUCTION

Independent Midwife Practice (PMB) is a place for implementing a series of midwifery service activities carried out by individual midwives, article 1 paragraph 5 Regulation of the Minister of Health of the Republic of Indonesia, No. 28 of 2017 concerning the permit and implementation of the practice of midwives [1]. The services provided at the Independent Midwife Practice include health counseling, Family Planning (KB) counseling, assisting births, postpartum care, baby care, family planning services (IUD, AKBK, injections, pills), immunization (mother and baby), adolescent reproductive health, post-abortion care.The high demand from the community for the active role of midwives in providing services continues to increase. This is proof that the existence of Midwives in the community is increasingly gaining trust, recognition and respect. And the negative impact of this independent practice of midwives is the generation of solid waste in the form of cotton, tissue, bandages, underpads that are still mixed with blood which is called infectious waste. In this case, the health services at PMB generate an infectious waste generation of about 39.51 kg per day [2].

Infectious waste is material suspected of containing pathogens (bacteria, viruses, parasites or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. This category includes: waste contaminated with blood or other body fluids, cultures and stocks of infectious agents from laboratory work, waste from infected patients in isolation wards[3]. If the handling of infectious waste is not appropriate, it has the potential to cause harm to human health, other living things, and the environment.

Midwives as providers of midwifery care are very likely to be infected and transmit germs from and to their clients that can cause infection. Based on the results of observations on 12 Independent Midwife Practices (PMB) in Sukabumi Regency and Depok City in November–December 2021[4]. In terms of processing or destroying solid medical waste, midwives are still very dependent on the role of third parties (health care facilities such as hospitals or health centers and medical waste management institutions) to destroy solid medical waste, while the ability of health service facilities and medical waste management institutions to carry out medical waste does not meet the requirements of 2 x 24 hours. This is caused by the distance of health care facilities and the ability of medical waste transport services as well as the limited capacity of waste treatment. In addition, the practice of holding infectious waste that is not adequate in the independent practice of midwives is a potential risk that can

affect individual health conditions, public health, and the environment so that alternatives are needed so that infectious waste management practices can be carried out comprehensively and as early as possible by midwives.

To overcome and reduce medical waste, the Indonesian government in government regulation No. 47 of 2016, concerning technical management of medical waste generated by health care facilities, including health care facilities, pharmacies, and the practice of independent midwives[5] and through the ministry of health issued regulation no. 27 of 2017 article 1 paragraph (1) infection prevention and control, hereinafter abbreviated as PPI, is an effort to prevent and minimize the occurrence of infections in patients, officers, visitors, and the community around health care facilities [6] and regulation no. 28 of 2017 article 38 paragraph (1) Independent Practice Midwives must carry out medical waste management and paragraph (2) cooperate with institutions that have waste management installations**.**

In previous studies, a prototype system for a medical waste treatment system has been designed [7]. The test results show that the system works well for cleaning medical waste materials such as cotton / dirty sanitary napkins / sanitary napkins that are contaminated with bacteria and viruses. The purpose of this research is to carry out further development in the design of medical waste treatment systems so that they can be used in health centers and maternity clinics so as to prevent disease transmission for patients, staff and visitors caused by an unhealthy service environment and reduce pollution that will be released to the environment.

II. MATERIALS AND METHOD

A. *Description of Infectious Waste Sterilization and Neutralization System.*

This laboratory scale research, the system consists of: washing tank 50 cm high with a diameter of 30 cm, an infectious waste tank with a height of 40 cm in a diameter of 20 cm, a sterile tank with a height of 50 cm in a diameter of 35 cm, a water tank with a height of 48 cm in a diameter of 27 cm, neutral tank measuring height 48 cm diameter 27 cm, chemical liquid tube measuring length 50 cm wide 60 high 5 cm, bacterial starter tube measuring length 50 cm wide 30 high 5 cm, electric motor is used to rotate infectious waste tube, water pump is used to transfers water from tank to tank, water level sensor, solenoid valve is used to regulate water from tank to tank and faucet is used to drain sterile and neutral results, shown in Figure 1.

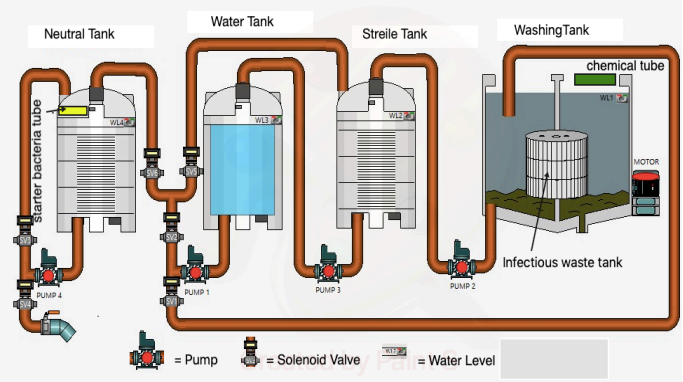


Fig. 1. Infectious Waste Sterilization and Neutralization System

This system uses the filter method [8-9] in the infectious waste management process with the function of the filter layer material in the sterile tank and neutral tank as shown in table 1.

Table 1. Bahan Lapisan Penyaring Steril dan Netral

No	Filter Material	Function
1	Cotton	to hold and filter impurities
2	Zeolite stone [10]	for molecular filters, ion exchangers, adsorbents and catalysts
3	Activated Carbon Sand [10]	absorb dissolved organic matter, color, odor, taste and other substances. and purify water from cloudy colors and eliminate unpleasant odors
4	Ceramic ring [11]	Biological filtration media serves to convert nitrite to nitrate.
5	Bioball[12]	as a living place for bacteria, bacteria in this case are beneficial bacteria that are useful for water sterilizing systems

B. *Infectious waste washing process*

The infectious waste tank is made with holes around it so that water can enter when washing the waste by the stirrer motor (figure 2). This washing process is to remove organic and inorganic materials or impurities present in infectious waste with the main aim of eliminating conditions that allow the growth of microorganisms. And provide disinfectant [13] (table.2) to remove pathogenic microorganisms that live in infectious waste. This is done after the cleaning activity to ensure that all other organic matter has been removed.

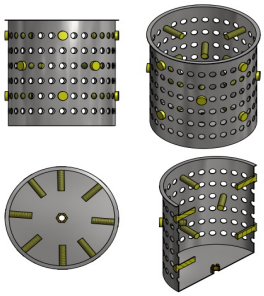


Fig.2. Infectious waste collection tank with holes and smell of rubber

Table 2. disinfectant materials

No	Chemical Material	Function
1	Chlorine[14]	for deactivation of microorganisms
2	Alcohol[15]	to kill microorganisms
3	Hydrogen Peroxide[16]	remove blood stains

C. *Infectious waste water sterilization process*

The results of the infectious wastewater washing process in the washing tank are sucked by pump-1 into the sterile tank through 10 layers of filter (Fig. 3) sequentially consisting of (1) filter cotton, (2) japmat filter cotton, (3) activated carbon sand , (4) filter cotton, (5) black filter cotton, (6) zeolite stone, (7) filter cotton, (8) japmat filter cotton, (9) ceramic ring, (10) filter cotton. Infectious waste water resulting from the sterilization process is then sucked in by pump-3 which is then flowed into the water tank.

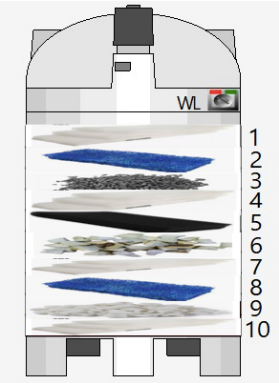


Fig. 3. Arrangement of filter layers in a sterile tank

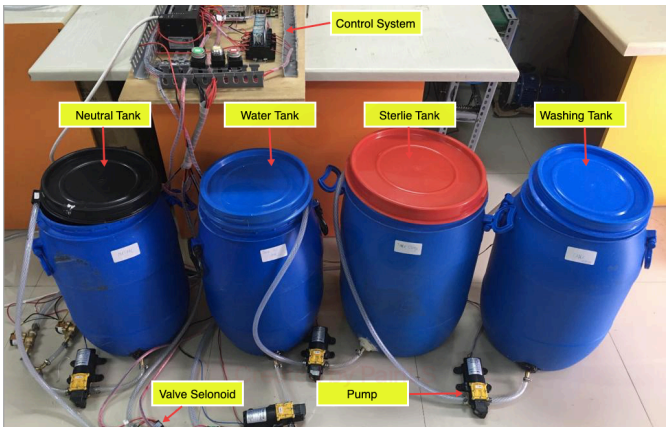
D. *Infectious waste water neutralization process*

The results of the sterilization process for infectious waste water in the water tank are sucked in by the 1st pump and flowed into the neutral tank for the neutralization process by adding starter bacteria from the starter bacterial tube, then the neutralization process is carried out.Infectious wastewater neutralization process is flowed through 9 (nine) filter layers (Fig. 4) sequentially consisting of (1) filter cotton, (2) filter cotton, (3) japmat filter cotton, (4) zeolite stone, (5) filter cotton, (6) activated carbon sand, (7) filter cotton, (8) ceramic ring, (9) bioball. Infectious wastewater resulting from the neutralization process is sucked by pump-4 to the valve to be discharged into the environment.

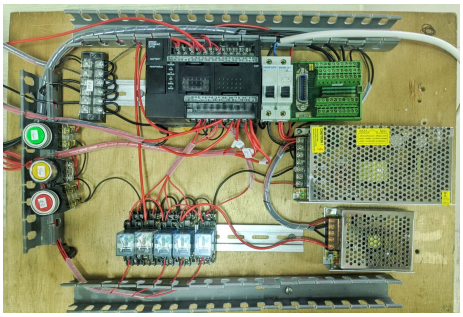
Fig. 4. The arrangement of the filter layers in the neutral tank

III. RESULTS

Figure 5 shows the design of an infectious waste treatment system with a control system using a PLC device. The process of sterilization and neutralization of infectious waste using chemical disinfection methods.



(a)



(b)

Fig. 5. a. The design of Infectious Waste Sterilization and Neutralization System b. Control system using a PLC device

The process of sterilization and neutralization of infectious medical waste starts with 50 liters of clean water entering the water tank. After that pump-1 flows clean water to the valve from the water tank into the washing tank. The washing tank holds 100 liters of clean water, so 50 liters of clean water in the water tank is filled 2 times in the filling process so that the total 100 liters of clean water that flows to the washing tank is fulfilled. The infectious waste washing process is carried out in a washing tank using a stirrer motor by adding a disinfectant consisting of 90% chlorine, 70% alcohol and 3% hydrogen peroxide.

Furthermore, 50 liters of infectious waste water from the washing is sucked up by pump-2 and then flowed into a sterile tank that holds 50 liters. The process for sterilizing infectious wastewater from washing is carried out in a sterile tank and then flows through 10 (ten) layers of filter (Fig. 3). Infectious medical waste water resulting from the first sterilization process is 50 liters and then sucked by pump-3 which is then flowed into the water tank. The same treatment for infectious waste water from washing, the remaining 50 liters is sucked by pump-2 to flow into a sterile tank. The sterilization process for the first 50 liters has been completed and then carried out again for the infectious waste water from washing the next 50 liters. The sterilization process cycle is carried out 3 (three) times to obtain sterile infectious wastewater.

Infectious wastewater from the sterilization process in the amount of 50 liters is sucked up by pump-3 to flow into the water tank. Medical waste water resulting from the sterilization process is sucked in by the 1st pump then goes to the neutral tank which holds 50 liters for the neutralization process by adding starter bacteria from the starter bacteria tank, then the neutralization process is carried out. The process of neutralization of infectious wastewater flows through 9 (nine) layers of filter (Fig. 4). Infectious medical waste water resulting from the neutralization process is sucked by pump-4 to the valve for 3 (three) cycles of the neutralization process. Infectious medical waste water has been sterilized and neutralized and then transported to the disposal site. The following table shows the test results of the infectious waste treatment system.

A. *Infectious waste testing process:*

- Waste before washing contains blood stains, pus, saliva, wound medicine attached to the waste so that the waste contains harmful microorganisms or bacteria, so the waste is said to be dirty

- Waste after washing with water and washing solution (chlorine, hydrogen peroxide, alcohol) becomes clean and sterile, it is said to be clean and sterile because blood stains, pus, and wound medicine attached to cotton, bandages, and tissue are lost because of the function of hydrogen peroxide as bleach. To kill germs from types of bacteria, fungi, protozoa and viruses contained in the waste using alcohol and chlorine. So the waste is said to be clean. Waste testing after washing is done by testing the biological properties of the waste simply for 5 days.

(a) (b)

Fig. 6. Infectious waste a. Before washing b. After washing

B. *Water testing process*

- Water before being filtered or water used to wash waste contains high chemicals (chlorine, hydrogen peroxide, alcohol), blood, pus, wound medicine mixed with water . Dirty water mixed with tea water changes color very quickly and there are lots of gas bubbles, so the water contains very high chemicals.
- The water after filtering is said to be quite clean (suitable for further washing, not for consumption) because the water still contains chemicals but contains very little or low levels. The filtered water is mixed with tea water for 1 day, the water does not change color and only a few gas bubbles occur. The water contains very low chemicals, so the water is suitable for use in subsequent washing. The water can only be used 2 times, after that the water must be replaced with new so that the waste washing process works properly.

(a) (b)

Fig. 7. Testing Water Samples a. Before and b. After Filtering Using Tea Water

IV. DISCUSSION

The results of this study indicate that the sample of the apparatus designed for decontamination of infectious waste by chemical methods and combined filtration, as presented in Figure 5, corresponds to the test results obtained in the reduction of all microorganisms in the effluent. Due to its original technology and short decontamination cycle and low production cost, it can be a good choice to replace other devices in use. In general, the results of the waste disposal experiments show that the simultaneous use of filtration and chemical methods can be an appropriate method to replace the conventional disposal system. This system is ready to be fabricated and used in the midwife's independent practice

V. CONCLUSION

The test results concluded that the infectious waste treatment system was functioning properly. The working principle of the system is like a washing machine, where the washing process is sterile and neutral for infectious waste using chemicals, namely chlorine, alcohol and hydrogen peroxide and bacteria starter. For filter elements in sterile and neutral using cotton, zeolite stone, activated carbon sand, ceramic ring and bioball. Infectious waste disinfection in this study was carried out on waste in the form of cotton, cloth, bandages and paper towels. The maximum capacity of the tank in the decomposition tube is 5 kg and the washing process to clean infectious wastewater takes 40 minutes. By using this system, the disposal of infectious waste materials will be safer for the community and the environment around the disposal site and the manufacturing costs will be less expensive.

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Authors' Contributions

The authors' contributions to the paper are equal.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The authors declare that this study complies with Research and Publication Ethics

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