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Study on the Safety of Radioactive Waste Management in the Radiology Laboratory of Indonesian Hospital

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ABSTRACT

One of the uses of radioactive sources is in the field of health, where they are used in hospitals for radiotherapy, nuclear medicine, and radiodiagnostics. Nevertheless, the use of nuclear technology in the health sector produces radioactive waste substances that pose health and environmental risks, and have the potential to be misused by irresponsible groups and terrorists to create radiological weapons that are used in crimes and pose a threat to security. Any activity that utilizes radioactive substances must pay attention to radioactive waste management, which applicable regulations must appropriately manage. The research method used is descriptive research with a qualitative approach, and data collection techniques are used with literature review methods. Radioactive waste produces alpha, beta, and gamma radiation. Radioactive waste treatment techniques can be carried out by separation, storage, transportation, treatment, and final disposal. Governments, hospitals, relevant organizations, and communities should work together to improve the safety of radioactive waste management and protect the environment and human health. It is essential to understand the types of radioactive waste substances, comply with applicable rules and regulations, implement appropriate radioactive waste treatment techniques, and raise awareness about the dangers of radioactive waste substances

INTRODUCTION

Nuclear materials and radioactive sources are now being used in a variety of fields, including energy, petroleum, health, and agriculture. One of the utilization of radioactive sources is in the health sector, which is used in hospitals. Hospitals are health institutions that provide medical services to individuals, including inpatient, outpatient, and emergency departments. To provide professional, quality, and sustainable health services, hospitals must have the availability of medical equipment that meets the standards. This includes medical equipment for emergency rooms, outpatients, inpatients, intensive care, labor and delivery, surgery, radiology, pharmacy, clinical laboratory, etc.

Nuclear power in the health sector helps improve public health services through diagnostics, therapy, and research. Radiodiagnostic services include ionizing radiation diagnosis, such as conventional X-rays, mammography, and Computerized Tomography Scan (CT Scan). Many lives have been saved, and patients' quality of life has improved thanks to these nuclear technologies. However, nuclear technology in healthcare generates radioactive waste, a harmful by-product. The sources of this waste are diverse, such as:

- Radioactive substances remaining after use in diagnostic and therapeutic procedures.
- Consumables contaminated with radioactive substances, such as syringes, medical equipment, and protective clothing.
- Patient bodily fluids contaminated with radioactive substances, such as blood, urine, and other fluids.

Radioactive waste can pose health and environmental risks if not managed safely. Radioactive substances emit radiation that is harmful to humans and the environment, and excessive radiation exposure can increase the risk of cancer, genetic diseases, congenital disabilities, and other health problems. The negative impacts of environmental pollution by radioactive substances can contaminate water, soil, and air and harm flora and fauna in the environment.

Any activity that utilizes radioactive substances must pay attention to radioactive waste management. All radioactive waste generated from using radioactive substances must be managed appropriately per applicable regulations. This is because radioactive waste has radiation hazards that can adversely affect both humans and the environment. Radioactive waste refers to radioactive substances, materials, and equipment that have been exposed to radioactive substances or have become radioactive as a result of the operation of nuclear facilities that are no longer in use.

WHO (2005) states that, during the hospital waste treatment process, officers' actions are significant, starting from sorting, packaging, transportation, and storage to the final treatment or destruction. During the storage process, waste bags should not be complete. Waste collection officers must ensure that waste bags of the same color are combined and sent to the appropriate location. This is done to avoid the adverse effects that hospital waste treatment can have on employees, the environment, and the surrounding community. In addition, hospital waste treatment standards must consider security and safety at every step, such as using personal protective equipment (PPE), clear labeling of waste containers, and safe handling procedures (Muchtar et al., 2016).

In this journal, researchers will discuss the use of radioactive substances in the health sector that produces radioactive waste and regulations related to radioactive waste management. Researchers will also analyze the process of treating radioactive waste to make it safe. With a better understanding of radioactive waste management, it is hoped that the steps taken will have a security impact on radioactive substance waste management and reduce the use of radioactive waste by irresponsible groups or terrorists to create radiological weapons.

METHODS

The type of research used in the study is descriptive research with a qualitative approach. The authors used data collection techniques with the literature study method in this study. A literature study is a study of literature related to culture, values, and norms that develop socially in collecting data using materials in libraries such as books, magazines, documents, and others (Sugiyono, 2012).

RESULTS AND DISCUSSION

Types of Radioactive Waste

Radioactive waste comes from medical use or laboratory research related to radioactive substances. It is stored in red plastic bins (Kepmenkes RI, 2004). Radioactive waste should not be stored near corrosive, explosive, or flammable materials. However, it must be contained so that human health and the environment are protected. All radioactive waste stored during its decay must be put into appropriate containers to prevent the emission of waste inside (Raharjo, Rio; 2002).

Radioactive waste produces radiation, such as :

- Alpha, which has low penetrating power and cannot penetrate the skin.
- Beta has greater penetration power than alpha, but it can still be stopped by thin aluminum.
- Gamma has the highest penetrating power and can penetrate the human body.

There are three types of radioactive waste based on their physical form: solid, liquid, and gaseous waste. These wastes are generated from various equipment and processes, such as:

- Solid: Syringes, medical equipment, contaminated protective clothing, gauze, tissue paper, etc.
- Liquid: Blood, urine, feces, vomit, and other body fluids contaminated with radioactive substances.
- Gas: Radon gas from the decay of radium used in cancer therapy.

Radioactive Waste Management Rules or Regulations

Radioactive waste management safety regulations are critical to ensuring public and environmental safety when using nuclear technology. The regulations governing nuclear are contained in Law No. 10 of 1997 concerning Nuclear Power in Chapter VI of Radioactive Waste Management, which states the objectives of management, waste classification, which institution is responsible for management, including the disposal of high activity waste, and financing. The law needs to be improved because several things have not been included, and some are deemed necessary to be changed by changing times. For example, no article lists the final fate of low and medium activity waste because there is only sustainable storage of high activity waste.

The Nuclear Energy Regulatory Agency (BAPETEN), BATAN, and other stakeholders created a government regulation as an extension of the Law, namely Government Regulation No. 27 of 2002 on Radioactive Waste Management, which was later strengthened by Government Regulation No. 61 of 2013.

Laws and regulations related to radioactive waste management in Indonesia:

1. Government Regulation No. 54/2012 on Nuclear Facility Safety and Security
2. Government Regulation No. 58/2015 on Safety Radiation Security in the Transportation of Radioactive Substances
3. Government Regulation No. 101/2014 on Hazardous and Toxic Waste Management
4. Government Regulation No. 33/2007 on Ionizing Radiation Safety and Radioactive Source Safety
5. Government Regulation No. 29/2008 on Licensing of Utilization of Ionizing Radiation Sources and Nuclear Materials
6. BAPETEN and BATAN Regulations related to Radioactive Waste Management and Spent Fuel
7. Government Regulation No. 11 of 1975 concerning Occupational Safety against Radiation
8. Government Regulation No. 12 of 1975 concerning Permits for the Use of Radioactive Substances or Radiation Sources
9. Government Regulation No. 13 of 1975 on Transportation of Radioactive Substances
10. Law No. 17 of 2004 concerning Nuclear Energy
11. Government Regulation No. 72 of 2014 concerning Radioactive Waste Management
12. Regulation of the Nuclear Energy Agency Number 9 of 2014 concerning Safety Guidelines for Radioactive Substance Waste Management in Radioactive Substance Utilization Installations
13. Nuclear Energy Agency Regulation Number 10 of 2014 concerning Technical Guidelines for Radioactive Substance Waste Management in Radioactive Substance Utilization Installations

14. Government Regulation No. 61 of 2013 concerning Radioactive Waste Management defines radioactive waste management as a series of activities that include collecting, classifying, processing, transporting, storing, or disposing of radioactive waste.

Radioactive Waste Treatment Techniques

Radioactive waste in hospitals comes from various medical activities that use radioactive substances, including diagnosis and radioactive therapy. Radioactive waste must be managed in a safe and responsible manner to protect the environment and human health. Some methods of radioactive waste treatment in hospitals are as follows:

1) Separation

To ensure that radioactive substance waste is managed safely and appropriately, the first step is to separate the waste based on its type, activity level, and physical form. Radioactive substance waste is separated based on the type of radiation emitted, namely alpha, beta, and gamma. Meanwhile, radioactive substance waste is separated based on the level of radioactive activity, namely low, medium, and high. The physical form of radioactive substance waste is separated into solid, liquid, and gas.

2) Storage

Radioactive substance waste must be stored in appropriate and safe containers made of radiation- and leak-proof materials. The containers must be clearly labeled to indicate the type, level of activity, and physical form of the radioactive substance waste.

Storage containers for solid waste must be made of durable and radiation-resistant materials, such as stainless steel or tin-plated plastic. Containers for liquid waste must be made of non-leaking and corrosion-resistant materials, such as glass or stainless steel. Moreover, waste gas storage containers must have pressure-resistant and non-air-absorbing materials, such as steel tubes or unique plastic bags.

3) Transportation

Special vehicles with adequate licensing and security are required to transport radioactive substance waste. In addition, radioactive substance waste vehicles must be designed to prevent leaks and accidents, and the personnel must be trained in managing radioactive substance waste. Radioactive substance waste vehicles should be equipped with radiation shields to protect drivers and others in the vicinity from radiation exposure. Similarly, employees who handle radioactive substance waste must be trained in safety and health procedures for radioactive substance waste transportation.

4) Treatment

Radioactive substance waste can be treated in various ways to reduce its volume and hazard with several radioactive substance waste treatment methods commonly used in hospitals, such as:

a) Decontamination is the process of removing radioactive contamination from objects or people through various methods, such as washing with detergents and water, using special chemicals, or scraping.
b) Solidification is the process of converting liquid or gaseous radioactive substance waste into solid form through various methods, such as evaporation, cementation, or absorption.
c) Combustion is the process of burning solid radioactive substance waste to reduce its volume. The burning of radioactive substance waste must be carried out in a special incinerator equipped with an air filtration system to prevent the release of radioactive substances into the atmosphere.

5) Final Disposal

Waste radioactive substances must be disposed of in a safe final storage area designed to prevent radiation leakage into the environment and monitored regularly to ensure safety.

Challenges and Solutions for Radioactive Waste Management in Hospitals

In reality, radioactive substance waste management still faces several challenges, among others:

1. Rules and regulations on radioactive substance waste management in Indonesia must be strengthened and better enforced.
2. Hospital staff and the public must be aware of the dangers of radioactive substance waste and the importance of safe management.
3. Lack of adequate infrastructure owned by hospitals for radioactive substance waste management, such as storage areas, vehicles, and treatment equipment.
4. Lack of medical personnel and technicians trained in handling radioactive substance waste in hospitals.

To overcome these challenges, comprehensive solutions are needed. Here are some solutions that can be implemented:

1. The government must strengthen rules and regulations on radioactive substance waste management and ensure they are well enforced.
2. Conduct research and development to develop safer and more efficient radioactive substance waste treatment technologies.
3. The government and hospitals must work together to improve radioactive substance waste management infrastructure by building safe storage areas, providing appropriate transport vehicles, and equipping hospitals with modern radioactive substance waste treatment equipment.
4. Training should be conducted for all hospital staff on the hazards of radioactive substance waste and how to manage it safely. In addition, the public also needs to be educated about the hazards of radioactive substance waste and the importance of safe management.

Radioactive Weapons and How to Prevent Radioactive Substances from Falling into Terrorist Hands

Radioactive weapons are a type of nuclear weapon created to spread dangerous nuclear material into enemy territory. These weapons cannot explode like fission or fusion bombs, but they can contaminate many areas, killing many people. However, concerns about nuclear terrorism have increased because of this type of weapon. Since the early 1990s, the threat of criminal acts or use of radioactive materials has increased. This has been reinforced by several incidents around the world involving the use of radioactive materials in attacks.

In some countries, irresponsible groups have also stolen radioactive materials, which could raise concerns about the use of radioactive materials in terror attacks. The use of radiation sources by terrorists or criminal groups can lead to the manufacture of radiation dispersal devices used in crimes. The spread of certain nuclear materials or radioactive substances can accelerate the spread of nuclear explosive devices or conventional explosive devices, which can threaten nuclear security.

Due to the many crimes against nuclear security mentioned above, the state must make various efforts to realize a safe, secure, and peaceful environment. This refers to Indonesia's national goals, which are stated in the Preamble to the Republic of Indonesia's Constitution of 1945. Tackling the threat of nuclear terrorism is a complex global issue that requires comprehensive efforts from various parties. Here are some efforts that can be made to prevent radioactive substances from falling into the hands of terrorists:

1. Strict Supervision of Radioactive Materials

This involves government agencies, nuclear authorities, and security agencies intending to strictly supervise radioactive materials, including their transportation, storage, and use. The Indonesian government has compiled efforts to improve nuclear security through Ministries/Institutions, such as strengthening national legislation, improving radioactive material surveillance systems through supervision of imported and exported goods, using radioactive material monitoring systems to determine the presence of radioactive sources used on a mobile basis so that BAPETEN can be monitored in real time to prevent misuse of radioactive sources.

2. Training and Awareness

Training for personnel dealing with radioactive materials is essential. Awareness about risks and preventive measures must be instilled in all parties involved, starting from encouraging community participation in efforts to prevent nuclear terrorism and building a solid reporting culture to encourage the public to report suspicious activities related to nuclear materials.

3. International Cooperation

Countries must cooperate in exchanging information and intelligence related to radioactive materials. This cooperation involves government agencies, intelligence agencies, and international organizations that develop international standards and regulations for nuclear security and non-proliferation and provide technical assistance programs for countries developing nuclear programs to ensure security and non-proliferation.

4. Nuclear Facility Security

Nuclear facilities must have strict security systems, including surveillance, physical security, and sensor technology. This involves security personnel, security technology, and facility management, including regular training for security personnel to deal with emergencies and terrorist threats and improving accounting and control of nuclear materials to prevent theft or diversion.

CONCLUSION

Radioactive waste is a by-product of the use of nuclear technology in the health sector, such as diagnosis and therapy. Radioactive waste can be in the form of solid, liquid, and gaseous waste. Radioactive waste has varying levels of radioactive activity. Safe and responsible management of radioactive waste is essential to protect human health and the environment. Several radioactive substance waste management challenges are faced, such as rules and regulations that need to be strengthened, lack of adequate infrastructure in hospitals, limited trained human resources, and low awareness of the dangers of radioactive substance waste.

Hospital radioactive substance waste management in Indonesia still needs to be improved. The government, hospitals, related organizations, and communities should collaborate to improve the safety of radioactive waste management while also protecting the environment and human health. It is essential to understand the types of radioactive substance waste, comply with applicable rules and regulations, apply appropriate treatment techniques, and raise awareness about the hazards of radioactive substance waste. With safe and responsible radioactive substance waste management, the benefits of nuclear technology in the health sector can be optimized without endangering the environment or human health. Misuse of radioactive substances by irresponsible groups can also be done with various efforts, such as strict supervision, training and awareness, international cooperation, and securing nuclear facilities.

REFERENCES

Afridiyanti, Candra, L., & Efendi, A. S. (2021). Analisis Kinerja Petugas Diinstalasi Radiologi Rumah Sakit Lancang Kuning Pekanbaru. *Media Kesmas (Public Health Media)*, *1*(2), 474–483. Doi:10.25311/kesmas.vol1.iss2.23

Alfarasyi, A. R., Octavian, A., & Zulkarnain. (2020). Penilaian Ancaman Radiological Nuclear Terhadap Keamanan Maritim Dengan Pendekatan Bibliometrik. *Jurnal Teknologi Persenjataan*, *2*(1), 65-78. Doi:10.33172/tsj.v2i1.579

Basri, T. H. (2014). Sejarah Dan Perkembangan Senjata Nuklir. *Jurnal Seuneubok Lada*, 1(2), 96–105.

Dartini. (2007). *Pengembangan Implementasi Sistem Manajemen Keselamatan Radiasi Dan Pengendalian Bahan Kimia Berbahaya Di Laboratorium Jurusan Teknik Radiodiagnostik Poltekkes Semarang*. Retrieved from UNDIP Institutional Repository.

Firdaus, N. (2021). Analisis Pengolahan Limbah Padat Rumah Sakit Bhayangkara Kota Palangka Raya Kalimantan Tengah. *Sultan Agung Fundamental Research Journal*, *2*(1), 41–64. Doi:10.30659/safrj.2.1.41-64

Handayani, Y. T., Sugito, & Mulyono, N. P. N. (2017). Tinjauan Sistem Manajemen Pemanfaatan Tenaga Nuklir Dalam Pelaksanaan Praktikum Penanggulangan Kedaruratan Radiologi. *Widyanuklida*, *16*(1), 29–40. Retrieved from https://karya.brin.go.id/id/eprint/230

Hidayah, F. N. (2023). Perkembangan Pengaturan Hukum Limbah Bahan Berbahaya Dan Beracun (Limbah B3) Di Indonesia. *Jurnal Indonesia Sosial Teknologi*, *4*(2), 211–225. Doi:10.36418/jist.xxxx.xxx

Jumpeno, B. Y. E. B. (2005). Upaya Pencegahan Terjadinya "Illicit Trafficking" Pada Sumber Radioaktif. *Buletin Alara, 6*(3), 157-162.

Mamat, M., & Kautsar, A. (2016). Komitmen Pemerintah Indonesia Dalam Memperkuat Keamanan Nuklir. *Conference: Nuclear Safety.* (pp. 281-286). Jakarta: Direktorat Pengaturan Pengawasan Instalasi dan Bahan Nuklir – BAPETEN.

Nugraheni, M. W. (2016). Pentingnya Pengaturan Mengenai Keamanan Nuklir Dalam Suatu Undang-Undang. *Conference: Nuclear Safety.* (pp. 201-207). Jakarta: Badan Pengawas Tenaga Nuklir.

Rahmiyati, A. L., Kulsum, D. U., & Hafidiani, W. L. (2019). Analisis Penyelenggaraan Sistem Pemeliharaan Alat Radiologi Rumah

Silmi, N. I. (2016). *Strategi Pengelolaan Limbah Radioaktif Di Indonesia Di Tinjau Dari Konsep Cradle To Grave*. Retrieved from Academia.