

Pharmaceutical Pollutants and Used Medical Devices Dumped Into the Environment, Ineffective Regulations and Impacts on Public Health: A Case Study in Dili city, Dili Timor-Leste

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Abstract

The disposal of pharmaceutical products, medical devices, and medicines after their expiration date must occur in locations compliant with established safety protocols. This requirement has evolved into an internationally recognized standard, regulated by the World Health Organization of the United Nations, concerning the disposal of tools, drugs, and materials utilized in the pharmaceutical and medical sectors following their use or expiration. The inherent characteristics of pharmaceutical and drug residues contribute to their resistance to environmental degradation, rendering ecosystems particularly susceptible to their adverse effects. This study seeks to examine the effects of improper disposal of pharmaceutical waste and medical devices after their usage, specifically focusing on instances where such materials are intentionally discarded into the environment without adhering to established protocols, and the subsequent impact on society and the environment. Qualitative methods, as described by Chasokela (2024), involve in-depth analysis of specific cases within a broader category of phenomena, commonly referred to as case studies. While this approach may not yield universally applicable insights, it can be a valuable tool in the early stages of research, facilitating the development of hypotheses that can be rigorously tested with a larger sample size. As highlighted by Kusumastuti et al. (2019), the current research adopts an exploratory approach to data collection, which requires direct data collection in the field or primary data generation to gain a deeper understanding of a particular subject, phenomenon, or issue. In this study, qualitative and quantitative analysis and descriptive statistics methods were used according to (Wahyuni, 2020). The findings of this investigation reveal that the pharmaceutical waste is improperly disposed of in the environment. For that, when seen from the location of pollution that occurred or was dumped on the ground of various types, there is a total of 374 pieces. This above-ground disposal is intentionally dumped by humans into public spaces without supervision, both from residents' homes, clinics, and hospitals. For river disposal sites seen from various types of pollutants there is a total of 181 pieces. Disposed of by people living around the lake shore who intentionally dump into the river without supervision by the authorities. For disposal sites in the lake seen from various types of pollutants there is a total of 120 pieces. Seeing the case of the presence of types of medical pollutants used into the river is caused by residents living around the lake who deliberately dump without supervision from local authorities. Meanwhile, for the disposal site on the beach due to is carried by floods during the rainy season, seen from various types of pollutants, there are a total of 76 pieces. The presence of medical pollutants on this beach is directly carried by floods during heavy rains, so that they are stranded on the shore due to being carried by sea waves. So that overall pollution by used medical equipment and expired pharmaceutical drugs over the past five years in the city of Dili seen from various types of pollutants, is a total of 720 pieces. Judging from these numbers, there is clear evidence, both physically and numerically, that the number will continue to increase in the coming years if no preventative measures are taken. Therefore, the results of the above study conclude that there is still a significant lack of public awareness due to the deliberate and irresponsible disposal of used medical pollutants into the environment without considering the impact on the environment and humans themselves.

Keywords: pharmaceutical pollutants, used medical devices, dumped into environment, ineffective regulations, impacts on public health

1. Introduction

The annual report from the World Health Organization of the United Nations reveals that, except in developed nations, the majority of pharmaceutical waste and used medical devices are disposed of directly into the environment without adequate treatment or adherence to proper protocols. This practice poses significant risks to both human health and the environment. Key factors contributing to the introduction of pollutants include insufficient solid waste disposal practices, ineffective waste treatment facilities, and the release of untreated waste into aquatic ecosystems. In addition to personal hygiene products, pesticides, and supplementary additives, pharmaceuticals constitute a novel category of contaminants that threaten environmental integrity (Aragão, 2018). Pharmaceuticals are intricate active compounds engineered to elicit specific biological responses in organisms. They can be administered through various routes, including oral ingestion, injection, or topical application. Once introduced into the body, these substances undergo processes of absorption, distribution, metabolism, and, ultimately, excretion via feces and urine (Lemos et al., 2009).

The disposal of pharmaceutical products, medical devices, and medicines after their expiration date must occur in locations compliant with established safety protocols. This requirement has evolved into an internationally recognized standard, regulated by the World Health Organization of the United Nations, concerning the disposal of tools, drugs, and materials utilized in the pharmaceutical and medical sectors following their use or expiration. Institutions such as hospitals, clinics, pharmacies, and warehouses storing medicines and medical devices are mandated to implement adequate and safe management and disposal systems to ensure public safety. Despite these regulations, numerous entities continue to fall short of the necessary standards for pharmaceutical waste disposal in accordance with safety protocols. Instances of pharmaceutical waste being improperly disposed of in the environment, such as in rivers, lakes, drainage systems, and public spaces, remain prevalent, particularly in developing countries. This situation exacerbates environmental and public health challenges due to the absence of stringent regulations that serve as a benchmark for compliance (Omokhapue et al, 2024).

In Timor-Leste, the improper disposal of pharmaceutical waste, such as expired medications, used pharmaceutical containers, packaging, and syringes, is often observed in public areas. This issue presents significant risks to both human health and the environment, particularly in the absence of stringent control measures, protocols, and oversight. The potential dangers are especially pronounced for children, who may inadvertently come into contact with such waste, leading to serious health implications. Currently, regulations concerning the disposal of medical devices and pharmaceutical waste in Timor-Leste are insufficient, particularly with respect to the management of expired pharmaceutical products and medical supplies. Furthermore, compliance with the disposal protocols set forth by the Timor-Leste Ministry of Health is lacking among various stakeholders. Therefore, it is imperative that the Ministry of Health implements rigorous oversight and that all relevant parties address this critical issue with the utmost seriousness.

This serves as a reminder that environmental pollution remains a significant issue, extending beyond general waste concerns to encompass the disposal of pharmaceutical products and injection needles. These items have not been adequately addressed as a primary concern, as evidenced by the careless disposal practices still prevalent among various stakeholders. Such negligence poses considerable risks, not only due to the nature of the tools and substances involved but also because of the potential negative impacts on land, river, lake, and marine environments. Irresponsible disposal can lead to serious health hazards for humans. This situation is particularly alarming given that hospitals, clinics, pharmacies, and health centers are governed by regulations established by the Ministry of Health. However, the persistence of disposal issues in public spaces highlights a troubling phenomenon that demands the attention of all stakeholders. A critical evaluation is necessary to enforce strict prohibitions against the improper disposal of pharmaceutical products and injection tools. The current practices raise significant concerns regarding the presence of these items in public environments, as they may end up in communal waste, rivers, lakes, drainage systems, or even be transported to the sea by floodwaters.

The potential for environmental pollution of soil and freshwater, along with the detrimental effects on aquatic biota resulting from contamination by pharmaceutical waste and used medical devices, emphasizes the necessity of addressing this pressing issue. In the absence of adequate follow-up measures, the environmental toxicity associated with pharmaceutical products, medications, and syringes could adversely affect water and soil quality. Moreover, emerging pollutants, including pharmaceutical products, devices, and medications that remain unregulated by national legislation, present substantial risks to ecosystems and human health in Timor-Leste. This situation frequently occurs without the implementation of preventative measures or sanctions against

individuals, organizations, or entities that intentionally discharge pharmaceutical waste into the environment. The presence of these pollutants signifies a gradual contamination of the environment with toxic substances. Consequently, the primary objective of this study is to illuminate the hazards linked to the discharge of pharmaceutical pollutants and syringes into the environment. Additionally, the study seeks to assess the extent of governmental action and the efficacy of existing regulations in addressing this issue, while also identifying optimal solutions to mitigate the problem.

2. Fundamental of Theories

Solid pharmaceutical waste and used medical devices can cause health problems and environmental pollution, especially if they contain pathogenic microorganisms or hazardous or toxic materials. The decomposition of solid waste produces a liquid called leachate. This leachate will eventually penetrate the soil layer and contaminate groundwater, which can negatively impact the health of those who consume that water. Furthermore, improperly stored solid waste can become a breeding ground for disease vectors and is unsightly (De Lucia, 2014).

Improper disposal of expired medications, syringes, used bottles, and packaging has a direct impact on environmental pollution, as unused medications are carelessly discarded and become environmental pollutants. Many households still have leftover and expired medications. Some people lack sufficient knowledge about the proper management of these medications. Some reasons for storing leftover medications at home include a lack of information on proper disposal methods, a lack of awareness of potential negative impacts, or a lack of knowledge about safe and environmentally friendly alternatives for managing leftover medications (Rahmadi et al., 2023).

Most pharmaceutical drugs are engineered to operate effectively at low concentrations that are safe for human or animal bodies, while also maintaining sufficient presence in the system to achieve the intended therapeutic effect. Additionally, pharmaceutical products and utilized medical devices that remain in the environment, subsequently contaminating water and soil or accumulating in flora and fauna, along with drugs that maintain stable environmental concentrations due to continuous release, may present risks associated with their toxicity or similar characteristics (ANVS, 2010).

Controlled sales and awareness of the proper disposal of these medications are becoming increasingly necessary to minimize environmental impacts, especially in the long term. Research is already underway to identify strategies that can eliminate these chemical compounds from water; however, because it involves complex processes and expensive equipment, it is still unfeasible on a large scale. Therefore, responsible consumption and proper disposal of antibiotics are essential, and there are pharmacies and drugstores that collect these and other medications, as well as their packaging. These materials can then be incinerated and pose no risk of contamination to the aquatic ecosystem (Ling et al, 2024).

The compounds contained in pharmaceuticals are biologically active elements designed to alter the body's physiological processes. Pharmaceuticals are persistent substances that, when released into the environment, exert a non-biodegradable effect, making them susceptible to its effects. Although found in small amounts, the impact of pharmaceutical waste on ecosystems and human health remains poorly understood due to limited information. The effects of exposure to pharmaceutical waste pollutants can be determined by: first, bioaccumulation in non-target organisms and possible ecotoxicological effects. The uptake of pollutants by biota depends on several factors: life cycle, reproduction, feeding, and habitat. They are considered and used as indicators of environmental conditions and, therefore, are useful in monitoring pharmaceutical residues in the environment (ANVS, 2010). Controlled sales and awareness of the proper disposal of these medications are becoming increasingly necessary to minimize environmental impacts, especially in the long term. Research is already underway to identify strategies that can eliminate these chemical compounds from water; however, because it involves complex processes and expensive equipment, it is still unfeasible on a large scale. Therefore, responsible consumption and proper disposal of antibiotics are essential, and there are pharmacies and drugstores that collect these and other medications, as well as their packaging. Thus, these materials can be incinerated and pose no risk of contamination to the aquatic ecosystem. Pharmaceutical residues are not susceptible to any type of treatment. They reach the soil and are consequently transported by surface waters or absorbed by groundwater. Pharmaceuticals used in aquaculture are disposed of directly into surface waters. By following these practices, the medications used and their residues do not undergo any type of treatment (Da Silva et al, 2023a).

The use of pharmaceuticals is increasing, and it has long been known that they can be found in the environment. One way they enter the environment is through improper disposal of expired or expired medications. Many medications that are no longer in use accumulate in homes and often end up discarded in household waste.

Because effluents from sewage treatment plants do not receive any type of treatment to neutralize the chemical compounds present in antibiotics, they are discharged into springs with residues of these medications. This impacts aquatic life. Although there is no information on the long-term effects, some researchers have identified that the sensitivity of algae is affected when exposed to these contaminants, which influences aquatic balance, since algae are the base of the food chain in this environment (Da Silva et al, 2023b).

3. Method

Qualitative methods, as described by Chasokela (2024), involve in-depth analyses of specific cases within a broader category and phenomenon, commonly referred to as case studies. While this approach may not yield universally applicable insights, it can be a valuable tool in the early stages of research, facilitating the development of hypotheses that can be rigorously tested with a larger sample size. As highlighted by Kusumastuti et al. (2019), the current research adopts an exploratory approach to data collection, which requires direct data collection in the field or primary data generation to gain a deeper understanding of a particular subject, phenomenon, or issue. Case studies necessitate a comprehensive analysis of specific units, such as individuals or communities, with a particular emphasis on developmental factors within their environmental contexts. Consequently, this case study represents a meticulous examination of a unit, individual, or community, concentrating on the holistic dimensions of environmental development. This research was undertaken to investigate the disposal of pharmaceutical waste and used medical devices in public spaces and the surrounding environment, which, in this instance, has resulted in adverse effects on both the community and the environment.

3.1 Time of Research

This research was done on the first of October 01, 2024 to October 20, 2024 in Dili city, Dili, Timor-Leste.

3.2 Survey Sample

The sample in this study consisted of a portion of pharmaceutical waste and used medical devices that were discarded in public spaces within a certain period of time, in the city of Dili.

3.3 Strategy Analysis of Data

In this study, qualitative and quantitative analysis and descriptive statistics methods were used according to (Wahyuni, 2020).

4. Discussion

In accordance with the results of the research and the results of data collection, the following will discuss in depth the problem of pharmaceutical waste that is improperly disposed of into the environment, land, rivers, lakes and beach and highlight the absence of effective protocols and their negative impacts on public health, and this research is more about a case study in the city of Dili, Dili Timor-Leste. This research is expected to provide policy recommendations and best practices for pharmacies, dispensaries, clinics, and hospitals, the government, particularly the Ministry of Health, the Ministry of Environment, hospitals, and other stakeholders in efforts to improve the sustainability of land and water environments. This research will analyze various data and facts to identify problems and provide appropriate solutions.

Table 1. Types of used medical and pharmaceutical devices in physical form and expired pharmaceutical drugs between 2020 and 2025

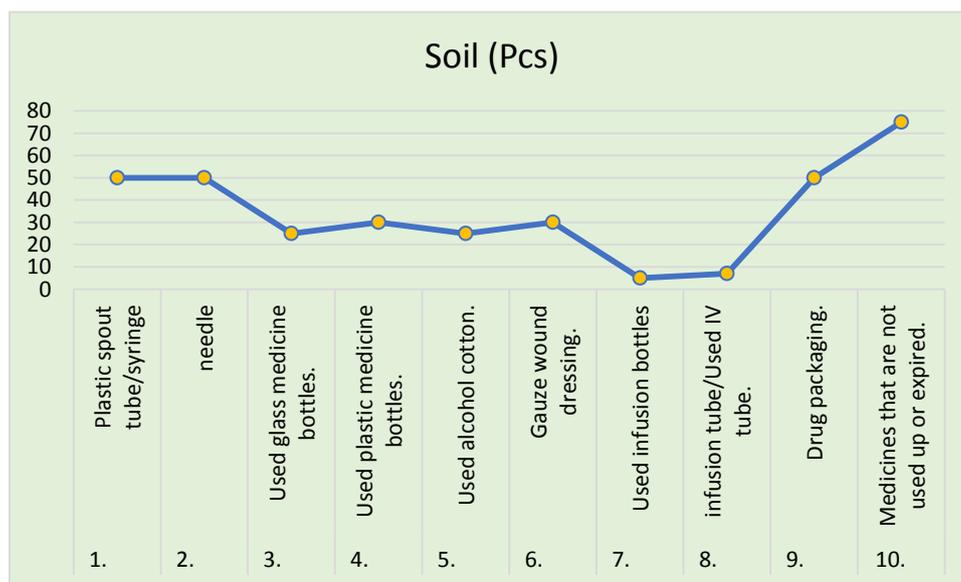
| Nu. | Type of Pharmaceutical waste and instruments medic waste usage | Soil (Pcs) | River (Pcs) | Lake (Pcs) | Beach (Pcs) | Sub Total |
|-----|--|------------|-------------|------------|-------------|-----------|
| 1. | Plastic spout tube/syringe | 50 | 20 | 15 | 10 | 95 |
| 2. | needle | 50 | 30 | 20 | 10 | 110 |
| 3. | Used glass medicine bottles. | 25 | 20 | 10 | 10 | 55 |
| 4. | Used plastic medicine bottles. | 30 | 20 | 15 | 12 | 77 |
| 5. | Used alcohol cotton. | 25 | 20 | 12 | 1 | 58 |

| | | | | | |
|--|-----|-----|-----|----|-----|
| 6. Gauze wound dressing. | 30 | 20 | 15 | 5 | 70 |
| 7. Used infusion bottles | 5 | 3 | 3 | 5 | 16 |
| 8. infusion tube/Used IV tube. | 7 | 3 | 3 | 5 | 18 |
| 9. Drug packaging. | 50 | 35 | 20 | 15 | 120 |
| 10. Medicines that are not used up or expired. | 75 | 10 | 7 | 3 | 95 |
| Total | 347 | 181 | 120 | 76 | 724 |

Source: research data between 2020 and 2025

The table above shows evidence of the disposal of used medical devices and expired pharmaceutical drugs into the environment, both on the ground, thrown into rivers, thrown into lakes, and carried by floods during rain until stranded on the beach. Based on evidence of an increase in the number of pollutants from this type of pollutant in the last five years seen from various types of used medical pollutants, it shows that there has been a gradual increase. For that, when seen from the location of pollution that occurred or was dumped on the ground of various types, there is a total of 374 pieces. This above-ground disposal is intentionally dumped by humans into public spaces without supervision, both from residents, homes, clinics, and hospitals. For the case of disposing of used medical equipment and remaining drug packaging that is thrown into the environment above ground, with the following graphs:

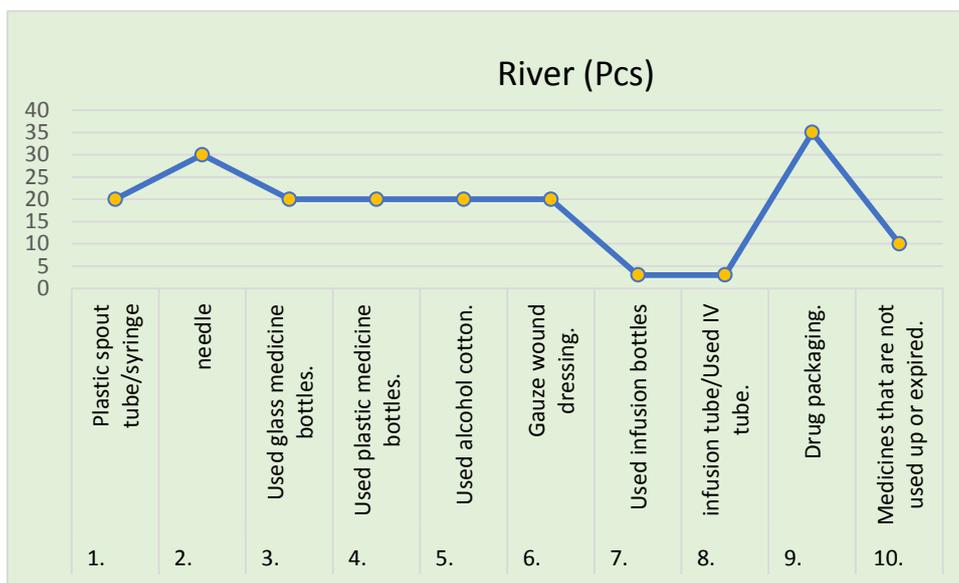
In the first graph regarding the disposal of used medical devices and used drug packaging thrown away in public spaces, it shows that the lowest value is used infusion bottles with a value of 5 pcs, while the highest value is medicines that are not used up or expired with a value of 75 pcs.



Graphic 1. Case of disposal of used medical equipment and remaining drug packaging thrown into the environment on the ground

Source: research data between 2020 and 2025.

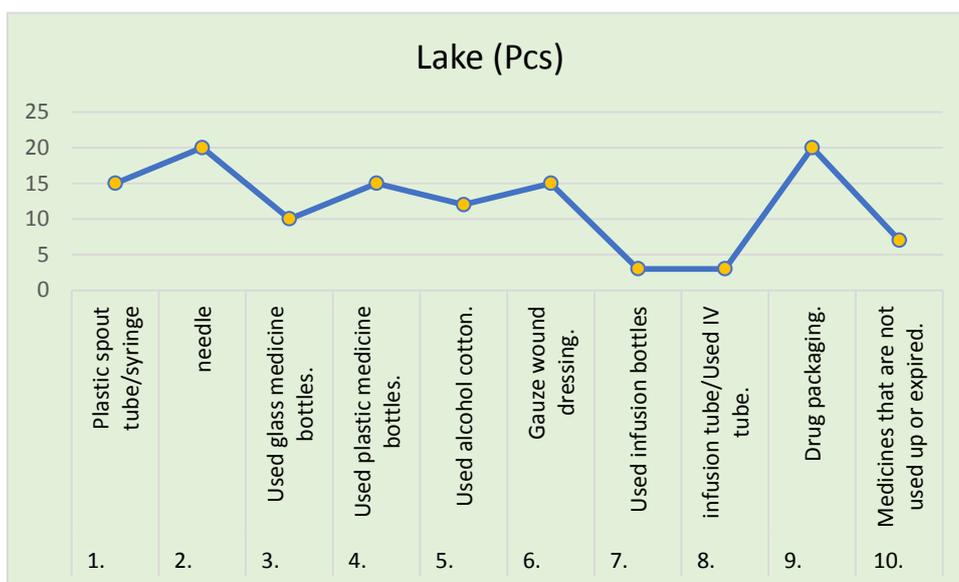
For river disposal sites seen from various types of pollutants there is a total of 181 pcs. In the second graph, the disposal of used medical devices and drug packaging thrown into the river shows the lowest value of used infusion bottles at 5 pcs, while the highest value is 35 pcs.



Graphic 2. Cases of disposal of used medical equipment and leftover drug packaging thrown into river environments

Source: research data between 2020 and 2025.

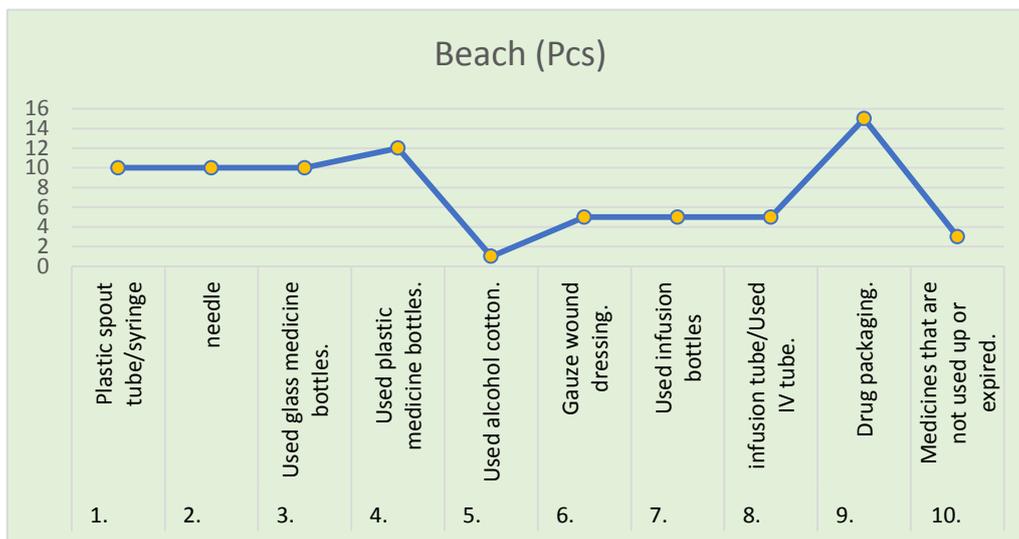
Disposed of by people living around the lake shore who intentionally dump into the river without supervision by the authorities. For disposal sites in the lake, seen from various types of pollutants there is a total of 120 pcs. Seeing the case of the presence of types of medical pollutants used into the river is caused by residents living around the lake who deliberately dump without supervision from local authorities. In the third graph, the disposal of used medical devices and drug packaging thrown into the lake, the lowest value is used infusion bottles and infusion tube/used IV tube with a value of 5 pcs, while the highest value is drug packaging with a value of 20 pcs.



Graph 3. Case of disposal of used medical equipment and leftover drug packaging thrown into the lake environment

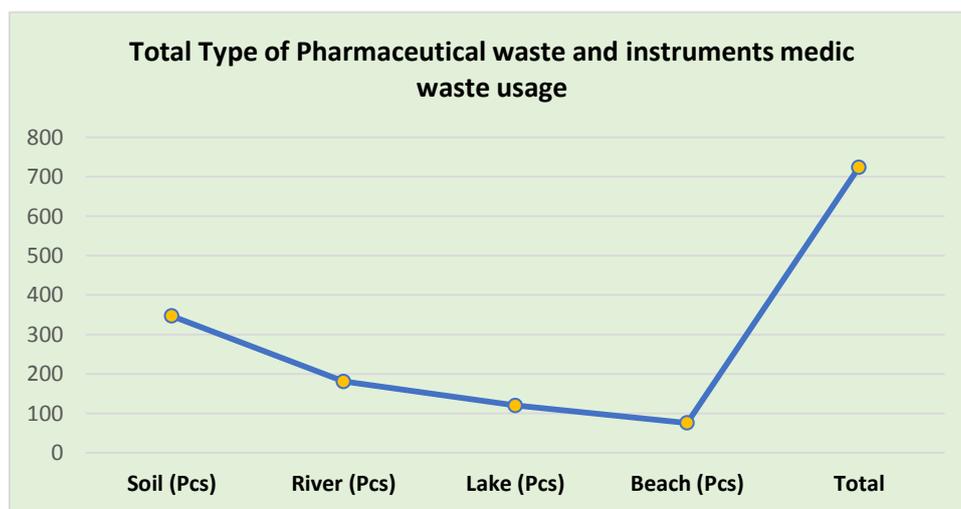
Source: research data between 2020 and 2025.

The presence of medical pollutants on this beach is directly carried by floods during heavy rains, so that they are stranded on the shore due to being carried by sea waves. Meanwhile, for the disposal site on the beach due to is carried by floods during the rainy season, seen from various types of pollutants, there are a total of 76 pieces. The presence of medical pollutants on this beach is directly carried by floods during heavy rains, so that they are stranded on the shore due to being carried by sea waves. In the fourth graph, Cases of disposal of used medical equipment and leftover drug packaging thrown into the coastal environment, the lowest value is used alcohol cotton with a value of only 1 piece, while the highest value is drug packaging with a value of 15 pieces.



Graph 4. Cases of disposal of used medical equipment and leftover drug packaging thrown into the coastal environment

Source: research data between 2020 and 2025.



Graph 5. Type of Pharmaceutical waste and medical instruments waste usage

Source: research data between 2020 and 2025.

So that overall pollution by used medical equipment and expired pharmaceutical drugs over the past five years in the city of Dili seen from various types of pollutants. In the fifth graph, the total results of all types of pollutants are the highest value of 720 pieces, while the lowest value is 76 pieces. Judging from these numbers, there is clear evidence, both physically and numerically, that the number will continue to increase in the coming years if no preventative measures are taken. Therefore, the results of the above study conclude that there is still a significant lack of public awareness due to the deliberate and irresponsible disposal of used medical pollutants into the environment without considering the impact on the environment and humans themselves. In addition, this occurs due to the lack of adequate supervision from the Ministry of Health, as well as the lack of publicly disseminated protocols and socialization to the community. Considering this occurred in the city of Dili, the capital of Timor-Leste, it is certainly a challenge in itself because it is very risky if not immediately addressed.



Figure 1. These are several types of syringes, medicine bottles, and drug and pharmaceutical packaging that are discarded into the environment after use, disobeying medical waste protocols

Source: research data, November 2024.

Research findings indicate that there is no single, universally applicable solution to address pharmaceutical, clinical, and hospital waste. Each type of waste requires a specific approach based on its chemical characteristics, toxicity, and potential environmental impact. For example, liquid waste containing active pharmaceutical compounds requires a combination of physicochemical processes such as coagulation, adsorption, or advanced oxidation with biological treatment to achieve adequate purification. Meanwhile, hazardous solid waste often requires specialized methods such as high-temperature incineration or stabilization before disposal in a specially designed landfill.

4.1 Expired Drug Waste and Used Medical Equipment

Expired drug waste, used syringes, and used drug bottles from pharmacies, clinics, hospitals, and other pharmacies are leftover drugs and injection equipment that no longer meet safety, efficacy, or quality standards because they have passed the manufacturer's expiration date or are used. These drugs can be pills, capsules, liquids, ointments, or other pharmaceutical preparations that are no longer recommended for consumer use. Meanwhile, used equipment such as syringes, syringes, and drug bottles are pharmaceutical industry products are widely used throughout the world. Used medical devices and expired medications are not limited to their use when new, but after their expiry date, they become a serious concern, requiring special treatment in accordance with clinical methods to prevent their spread. This also applies to pharmaceutical products stored in hospitals, clinics, pharmacies, and other healthcare facilities. It should be emphasized that devices and medications past their expiration date are not automatically useless; however, their effectiveness is likely to decrease, and the potential for harm increases. Furthermore, the risk is even greater if they are not stored or disposed of according to their classification and specifications after use (WHO, 2006).

Expired drug waste, injection equipment, and used drug bottles are an environmental and health issue that has yet to receive serious attention in Timor-Leste. This is due to the lack of clear regulations governing the disposal of used drug waste, injection equipment, and bottles by the government. The Ministry of Health has not yet issued nationally campaigned regulations regarding this issue. Meanwhile, in practice, expired drugs, syringes, and used bottles and packaging are frequently intentionally dumped into public spaces, rivers, and lakes. This waste, if not promptly controlled, will eventually hurt the environment. As the number of drugs used by the public increases, the number of unused and expired drugs also increases. This waste not only has the potential to pollute the environment but also harms humans and other living things, both on land, in lakes, rivers, and even in the sea, if not managed properly. Therefore, a thorough understanding of expired drug waste and used medical devices is crucial to prevent potential negative impacts.

4.2 Risks and Impacts of Expired Drug Waste and Injection Equipment, Used Drug Bottles and Packaging

Expired pharmaceutical waste and used medical devices are complex issues that require serious attention from all parties, including the government, specifically the Ministry of Health and the Ministry of Environment of Timor-Leste, the pharmaceutical industry, healthcare facilities, and the public. Proper management of this waste not only protects the environment from hazardous chemical contamination but also safeguards public health from the risk of side effects and drug resistance. Educating the wider public to understand and understand strict regulations and preventative measures is key to effectively addressing the issue of expired pharmaceutical waste, given the lack of funding and professional staff. With collective awareness and action, pharmaceutical waste management can be effective and support environmental sustainability and public health.

Expired pharmaceutical waste and used medical devices are complex issues that require serious attention from all parties, including the government, specifically the Ministry of Health and the Ministry of Environment, the pharmaceutical industry, healthcare facilities, and the public. Proper management of this waste not only protects the environment from hazardous chemical contamination but also safeguards public health from the risk of side effects and drug resistance. Educating the wider public to understand and understand strict regulations and preventative measures is key to effectively addressing the issue of expired pharmaceutical waste, given the lack of funding and professional staff. With collective awareness and action, pharmaceutical waste management can be effective and support environmental sustainability and public health (Sarla, 2020).

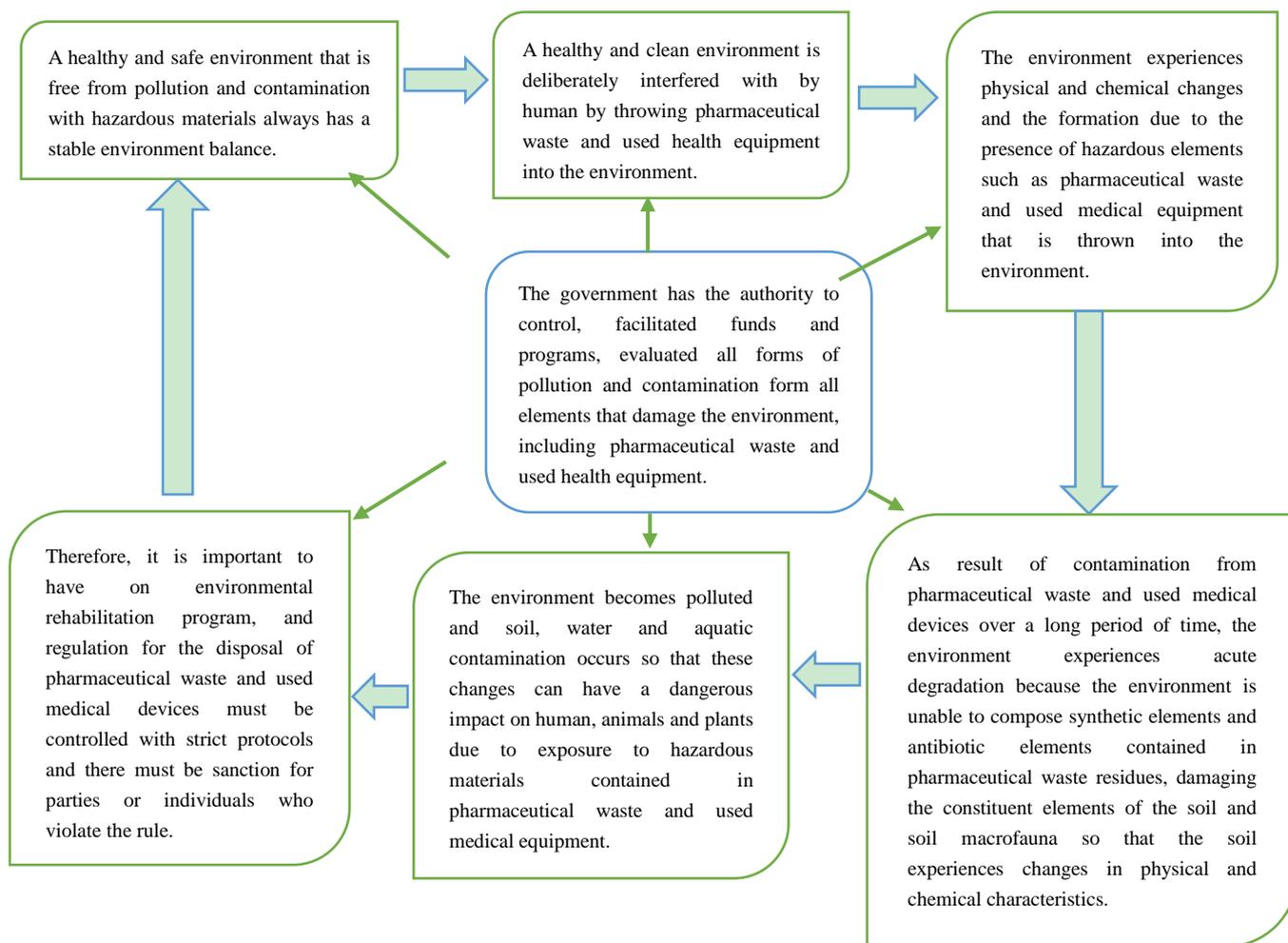
Expired drug waste and used medical equipment should not be underestimated because they pose various risks and negative impacts, both for humans, animals, and the environment. Therefore, the risks involved must be categorized: 1. Impact on the Environment, Land, and Water. Waste from drugs and medical equipment, including used bottles and packaging, that are disposed of carelessly, can pollute the soil, water, and air. Chemicals from drugs can disrupt the ecosystem and threaten the survival of living organisms in the surrounding area. Plastic takes a long time to decompose, and stainless steel is even more difficult to decompose, requiring a considerable time to decompose. Therefore, it is important to store them specifically for recycling purposes and not dispose of them in the environment. 2. Health Risks for Humans, Animals, and Plants. Reusing expired drugs can cause serious side effects. If disposed of in the environment, it poses a risk to the environment itself and is dangerous for children, who can be harmed by toys. Meanwhile, used medical equipment, including syringes, bottles, and packaging, is also highly hazardous to humans and the environment if not disposed of in designated recycling areas. If pharmaceutical waste and medical devices are disposed of carelessly, drug residues can contaminate drinking water and food sources. 3. Bacterial Resistance and Control Issues. It is important to note that poorly managed antibiotic waste can lead to the emergence of antibiotic resistance in the community, complicating the treatment of future infections. Used medical devices, on the other hand, can harbor specific disease-causing contaminants from their use on patients. If not properly managed, they are extremely dangerous and can transmit infectious diseases if not disposed of according to proper recycling protocols (Bashaar et al., 2017).

4.3 The Difference Between Pharmaceutical Waste and Waste From Used Medical Equipment, Bottles and Used Drug Packaging

In Timor-Leste, there are no regulations that explicitly separate types of waste and medical pollutants, and used medical equipment. This is evident in public spaces and public facilities that are not yet well provided for separating types of waste. This has an impact on the public interest, which demands regulations considering that there is already evidence of waste and medical pollutants being dumped in various places without any control from competent parties. Therefore, this study found various evidence and obstacles faced when regulations do not exist and certain parties or individuals dispose of medical pollutants without binding sanctions.

Pharmaceutical waste in the form of expired medications falls under the category of pharmaceutical waste, which encompasses all pharmaceutical materials that are no longer needed and potentially pose a risk, including those used in clinics and hospitals. Meanwhile, medical device waste, including used bottles and packaging, is hazardous if not handled properly and appropriately. It is often found scattered in various places, including public spaces. Therefore, it is necessary to classify pharmaceutical waste, used medical devices, and their derivatives, which can include: Medical pharmaceutical waste (remaining drugs, active ingredients, pharmaceutical preparations). Clinical pharmaceutical waste (used syringes, hazardous chemicals). Expired pharmaceutical waste. Pharmaceutical waste management must comply with strict regulations due to its hazardous nature. Understanding expired pharmaceutical waste is important because its impact not only affects individuals but also the environment and society at large. Ignorance or improper management can increase health risks and pollute ecosystems. The main impacts of expired pharmaceutical waste include: very risky to human

health. The accidental use of expired drugs can cause side effects that are difficult to control, antibiotic resistance due to excessive use, or even poisoning due to overdose. While Risks to the environment Include Improper disposal of pharmaceutical waste, which can cause contamination of groundwater, surface water, and soil, ultimately affecting flora, fauna, and other biotic organisms. Threats to the ecosystem: active pharmaceutical ingredients that enter the environment can disrupt the life cycle of organisms and cause the development of microbial resistance and microbes that are difficult to decompose (OECD, 2022).



Scheme for Disposal of Pharmaceutical Waste and used Health Medicines in public spaces that have a risky impact on humans, animals, plants and the environment

Source: Source: research data between 2020 and 2025

4.4 Common Problems in the Management of Expired Drug Waste and Used Medical Equipment in Timor-Leste

It has become a common phenomenon in public spaces regarding the problem of medical pollutants and used medical equipment due to the lack of serious attention from the Ministry of Health, not enforce regulations and safety protocols regarding the disposal of medical pollutants into the environment before processing. Despite numerous regulations in place, the management of expired pharmaceutical waste and the disposal of used medical equipment still face various challenges in Timor-Leste, including: 1. Indiscriminate disposal by the public due to a lack of awareness and understanding. Many people still dispose of expired medications in household trash, toilets, or rivers. This is often triggered by a lack of knowledge and limited access to pharmaceutical waste disposal facilities. 2. Lack of Infrastructure for Pharmaceutical Waste and Used Medical Equipment Management. Adequate pharmaceutical waste treatment facilities are still limited, especially in remote areas. This results in waste being poorly managed and potentially polluting the soil and water

environment. 3. Lack of Awareness and Education from the government, especially the Ministry of Health and the Ministry of Environment. The public and healthcare workers lack understanding of the dangers of expired pharmaceutical waste, resulting in inadequate management due to a lack of adequate information from the Ministry of Health. 4. Lack of funding and a system for managing pharmaceutical waste and used medical equipment. High levels of waste management, as well as a lack of facilities provided by the Ministry of Health. Pharmaceutical waste processing requires high costs and specialized technology, so pharmaceutical companies, pharmacies, hospitals, clinics, and government agencies are sometimes reluctant to manage it optimally due to a lack of strict oversight.

Therefore, after twenty-five years of independence, Timor-Leste must have a system for managing pharmaceutical and used medical waste to prevent toxic pollutants from entering the environment. If this is not addressed now, it is feared that in the future, it could cause serious problems for the environment and humans. This is already evident, as evidenced by the dumping of pharmaceutical waste and used medical equipment into the environment and public spaces.

4.5 Important Steps to Overcome Expired Drug Waste and Proper Disposal of Used Medical Equipment With Solutions

In Timor-Leste, effective management of pharmaceutical waste and used medical devices still faces challenges. This requires a multifaceted approach, from public education to strict regulations and adequate processing facilities. First, public education and outreach are crucial because the public is the primary consumer and target of healthcare services. Given the general nature of the problem, Timor-Leste needs to be educated about the dangers of improper disposal and the importance of awareness. Educational campaigns can be conducted through mass media, schools, and healthcare facilities. Second, the provision of waste bins for expired drugs and used medical devices, along with special official return regulations, is crucial for specific waste categories. Facilities such as pharmacies, clinics, and hospitals must provide dedicated containers for pharmaceutical waste and inform the public about return procedures. Once collected, it must be controlled according to protocols and regulations for recycling or burial. 3. Strengthening Regulations and Supervision: Widespread outreach must be carried out to various parties, especially at all levels of society and pharmacies, clinics, and hospitals. The government needs to tighten oversight and impose strict sanctions for violations of pharmaceutical waste management. Regulations must be accompanied by increased waste processing capacity. 4. Provision of facilities and technology for processing expired pharmaceutical waste and used medical equipment must be a primary concern and made a priority program by the Ministry of Health and the Ministry of Environment to form cooperation in addressing environmental pollution and public health issues. Investment in environmentally friendly and efficient pharmaceutical waste processing technology is crucial. Technologies such as autoclaves, special pharmaceutical waste incinerators, and certain chemical processes can ensure waste is processed safely (WHO, 1999).

4.6 The Impact That Could be Caused in the Future

The findings of the research survey reveal that, over the past five years, there has been a notable increase in the disposal of pharmaceutical waste and used medical devices in public areas. Consequently, it is imperative that the government, particularly the Ministry of Health, enforces stringent oversight and that all stakeholders engage in a comprehensive public awareness campaign across all societal levels to mitigate the improper disposal of these materials. If the Ministry of Health fails to take decisive action, there is a significant concern that within the next five to ten years, the repercussions will pose serious risks to human health, wildlife, and the environment. Furthermore, it is essential to establish safety protocols and provide adequate disposal facilities, complemented by specialized processing centers for pharmaceutical waste and used medical devices, to prevent careless disposal practices. Additionally, there should be governmental educational initiatives emphasizing the necessity of living free from substances that are detrimental to health and the environment. Lastly, it is crucial to implement environmental rehabilitation efforts for areas contaminated by pharmaceutical waste and used medical devices.

This study recommends the need to develop an integrated waste management system that combines various technical approaches with safety principles and protocols. The concept of recycling and recovering valuable materials from pharmaceutical waste has the potential to not only reduce environmental impacts but also create additional green ecological value for the environment. Further research is needed to develop more efficient processing technologies, more accurate methods for monitoring medical waste and disposing of used medical devices, and specifications for categories.

5. Conclusion

The evidence of the disposal of used medical devices and expired pharmaceutical drugs into the environment, both on the ground, thrown into rivers, thrown into lakes, and carried by floods during rain until stranded on the beach. Based on evidence of an increase in the number of pollutants from this type of pollutant in the last five years seen from various types of used medical pollutants, it shows that there has been a gradual increase. For that, when seen from the location of pollution that occurred or was dumped on the ground of various types, there is a total of 374 pieces. This above-ground disposal is intentionally dumped by humans into public spaces without supervision, both from residents' homes, clinics, and hospitals. For river disposal sites seen from various types of pollutants, there is a total of 181 pieces. Disposed of by people living around the lake shore who intentionally dump into the river without supervision by the authorities. For disposal sites in the lake seen from various types of pollutants there is a total of 120 pieces. Seeing the case of the presence of types of medical pollutants used into the river is caused by residents living around the lake who deliberately dump without supervision from local authorities. Meanwhile, for the disposal site on the beach due to is carried by floods during the rainy season, seen from various types of pollutants, there are a total of 76 pieces. The presence of medical pollutants on this beach is directly carried by floods during heavy rains, so that they are stranded on the shore due to being carried by sea waves. So that overall pollution by used medical equipment and expired pharmaceutical drugs over the past five years in the city of Dili seen from various types of pollutants, is a total of 720 pieces. This study recommends the need to develop an integrated waste management system that combines various technical approaches with safety principles and protocols. The concept of recycling and recovering valuable materials from pharmaceutical waste has the potential to not only reduce environmental impacts but also create additional green ecological value for the environment. Furthermore, it is essential to establish safety protocols and provide adequate disposal facilities, complemented by specialized processing centers for pharmaceutical waste and used medical devices, to prevent careless disposal practices. Additionally, there should be governmental educational initiatives emphasizing the necessity of living free from substances that are detrimental to health and the environment.

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