

SAFETY DURING MEDICAL WASTE TRANSPORT IN PRACTICE

Simona KLIŚ^{1*}, Jakub JĘDRYCZKA²

¹ Silesian University of Technology, Faculty of Organization & Management; simona.klis@polsl.pl,
ORCID: 0000-0001-5346-5651

² EKOMED Gospodarka Odpadami; biuro@ekomed-go.pl, ORCID: 0009-0003-4007-1399

* Correspondence author

Purpose: The aim of the article is to provide objective information about the classification of medical waste and its storage and transport based on the Silesian waste transport company – Ekomed. Generally, waste is very marginalized by society, therefore the article aims to present the further way of dealing with medical waste.

Design/methodology/approach: The basic research methods were the analysis of literature on the safety of transport of medical waste, along with their categorization based on the BDO system, by example of Silesian waste transport company – EKOMED.

Findings: Disposing of medical or chemical waste is a unique responsibility. Leaving such a sensitive procedure to the wrong companies or people who do not have adequate technical and personal resources may not only have dangerous consequences, but also be severely punished by applicable law. Therefore, it is worth trusting certified companies that not only have many years of experience, but also perfectly understand the responsibility of waste producers.

Research limitations/implications: In the future, research will be continued in the field of medical waste transport in context of safety, especially during pandemic.

Practical implications: This article provides an overview of quantitative research and diversity of medical waste from medical facilities in Poland. This review shows the importance and scale of the problem and allows for further continuation of research to manage the generated waste. The author has also noted that people generally forget about waste when they get into the bin. The main aim is to get people's attention what is happening later with the medical waste.

Originality/value: Based on empirical research, the article shows the scale of the problem that, through the new EU directives on the recycling and sustainable development, will be a forward-looking and important issue. Additionally, the article presents concepts for medical waste transport based on a Silesian company EKOMED. It's twenty years of daily practice of transporting medical waste to the place of its disposal allowed the development of effective logistic solutions for its safe transport, which turned out to be of invaluable value during the SARS-COV-2 virus pandemic.

Keywords: medical waste, transport, safety.

Category of the paper: Research paper.

1. Introduction

Very rapid economic and technological development has contributed to population growth around the world. As the population has increased, the amount of garbage they produce has also increased. Here we can distinguish municipal waste – originating from everyday human activities and industrial waste - coming from various types of companies, enterprises and production facilities or service facilities. Due to such a large diversity of companies and industrial facilities, a huge amount of waste is generated, differing in physical and chemical properties. The waste includes biodegradable waste, green waste, raw material waste (recyclable), mixed waste, waste electrical and electronic equipment, bulky waste, renovation waste and hazardous waste (Szołtysek, 2009; Kostecka, 2014). Hazardous waste is the most difficult to dispose of due to its toxic or infectious nature. In perspective of the large amount of waste generated and its different nature, the urgent issue is its transport for neutralization, recycling, or reuse.

The main goal of rational waste management is primarily to reduce the amount of waste generated, and in cases where its generation cannot be avoided, to minimize its negative impact on the environment or human and animal health. Proper waste disposal should lead to their neutralization (or - in certain cases - reuse of raw materials or energy) (Wąsowicz, 2018). Although the disposal and transport of any type of waste is a complicated process and involves many people, waste classified as hazardous, e.g., medical, chemical, or animal waste, is special. It should be noticed that this type of waste may pose a potential threat to health and the environment. For this reason, the collection and transport of e.g., medical waste is a big challenge. However, there are companies on the market that specialize in the transport and disposal of hazardous waste. One of such companies operating in the Silesian Voivodeship is EKOMED Gospodarka Odpadami Sp. z o.o.

2. Conceptual background

2.1. Medical waste

The Waste Act of 2022 defines the concept of medical waste as "waste generated in connection with the provision of health services and conducting research and scientific experiments in the field of medicine" (Dz.U., 2023). Therefore, medical waste will appear in hospitals (general, psychiatric), rehabilitation sanatoriums, addiction centers, hospices, medical and educational facilities, care and educational facilities, clinics, health centers, clinics, and individual medical and nursing practices. Medical waste can be divided into 2 groups: hazardous waste (infectious waste, special waste) and non-hazardous waste. These wastes may

occur as solid substances (syringes, needles, limbs), liquid substances (blood, plasma, vomit) and gaseous substances. Since medical waste encounters the patient's blood and secretions, it may be dangerous to human health. Primarily because the patient may be a carrier of various types of diseases or pathogens such as viruses, bacteria or fungi that may cause AIDS, hepatitis C or the plague (Topolska, 2017).

Hazardous medical waste is generated at virtually every stage of a medical facility's operations. During the admission and diagnosis of a patient, medical waste may appear, such as: dressing materials, surgical gloves, sponges, cotton swabs, sticks, spatulas, pharmaceuticals, syringes, and needles. At the stage of conducting research, including laboratory tests, medical waste appears in the form of e.g., needles, pipettes, human tissues, or blood. Most hazardous medical waste occurs during surgery. During and after surgery, waste such as used surgical equipment (needles, scalpels, etc.), human remains and tissues, and blood are generated (Zalewska, 2019).

In order to classify waste, not only medical waste, an online waste database (BDO) was established and launched in 2018. Its main goal was to seal the waste management system. The main tasks of BDO are (BDO, 2023):

- collecting information on packaging and products in packaging introduced in Poland,
- collecting information on the achieved levels of recovery and recycling of waste from packaging and products,
- obtaining information on cross- border movement of waste,
- waste classification,
- keeping waste records based on submitted reports,
- control of the waste management market.

According to the Regulation of the Minister of the Environment of January 2, 2020 on the waste catalogue (Dz.U., 2020) medical and veterinary waste was classified in group 18 in accordance with Table 1.

The waste catalog is a collection of all waste divided into groups, subgroups, and types of waste, depending on the source of their generation. Additionally, the catalog lists hazardous waste that poses a particular threat to human health and life and the environment, marked * (Dz.U., 2020, item 10). According to the waste catalog, medical waste is classified in group 18 and subgroup 01 (waste from diagnosis, treatment, and medical prevention).

Table 1.

List of medical and veterinary waste classified in the waste catalogue

Waste code	Description
18 01 01	Surgical and treatment tools and their remains (except 18 01 03)
18 01 02*	Body parts and organs, as well as a container for blood and preservatives used to store it (except 18 01 03)
18 01 03*	Other waste that contains live pathogenic microorganisms or their toxins and other forms capable of transferring genetic material that are known or there are reliable grounds for believing that they cause diseases in humans and animals (e.g. infected diapers, sanitary pads, pads), except 18 01 80 and 18 01 82

Cont. table 1.

18 01 04	Waste other than those mentioned in 18 01 03
18 01 06*	Chemicals, including chemical reagents, containing hazardous substances
18 01 07	Chemicals, including chemical reagents, other than those mentioned in 18 01 06
18 01 08*	Cytotoxic and cytostatic drugs
18 01 09	Medicines other than those mentioned in 18 01 08
18 01 10*	Dental amalgam waste
18 01 80*	Used peloids after treatments performed as part of medical activities with infectious properties
18 01 81	Used peloids after treatments performed as part of medical activities, other than those mentioned in 18 01 80
18 01 82*	Leftovers from feeding patients in infectious diseases wards

Source: Waste catalog, Dz.U. 2020.

The specific nature of the work of medical facilities is related to constant contact with hazardous substances. Improper contact with blood or surgical waste may pose a risk of infection. Improper storage or transport of medical waste, or even worse, a complete lack of proper management of this type of waste, may lead to the release of potentially hazardous substances into the environment and, consequently, to contact with them by unaware third persons. In the event of improper storage of waste (e.g., in a common garbage container), hazardous compounds may spread even through animals, such as rats or cats, which is why it is so important to properly handle waste at the stage of storage. Due to the potentially dangerous impact of medical waste on the environment, it should be properly segregated and stored at the initial stage of its production. This is the first and very important step in the entire process of safe transport and waste disposal.

In the case of medical waste, its initial segregation and - more importantly - proper protection against the environment mainly concern waste such as:

- used dressings, syringes, surgical tools,
- waste from treatment and operating rooms,
- used and expired medicines.

To store medical waste (depending on the type of waste) plastic bags or hardened containers may be used. What type of container should be used depends primarily on the characteristics of individual medical waste. In the case of waste with sharp edges, e.g., needles or scalpels, hardened containers should be used. The proper selection of the agent and method of storage allows you to minimize the risk of potentially dangerous situations for the environment or for people who have direct contact with the waste, e.g., during its storage or transport. Hardened containers are resistant to most mechanical damage, moisture, and certain chemical reactions. Containers and bags for medical waste are delivered in different colors, depending on the target type of waste to be stored in them. Figure 1 shows examples of bags and containers for storing and transporting medical waste.



Figure 1. examples of bags and containers for storing and transporting medical waste.

Source: [https://www.seni24.pl/...](https://www.seni24.pl/)

The following types of containers can be distinguished (Regulation of the Minister of Health of October 5, 2017, on the detailed method of dealing with medical waste (Dz.U., 2017; EKOMED, 2023):

- **red containers** – intended for collecting waste with codes: 18 01 02*, 18 01 03*, 18 01 80*, 18 01 82*, e.g., residues from feeding people from infectious disease wards, blood, waste containing toxins or microorganisms,
- **yellow containers** – intended for collecting waste with codes: 18 01 06*, 18 01 08*, 18 01 10*, e.g., chemical reagents – containing dangerous substances, cytotoxic drugs,
- **different colour containers e.g., blue** – intended for collecting waste with codes: 18 01 01, 18 01 04, 18 01 07, 18 01 09 18 01 81, e.g., surgical and treatment tools, dressings, including plaster casts, bedding.

It is important to note that the containers are not designed with reusability. After filling, each container should be tightly closed in a way that prevents it from being opened again without leaving a clear trace. Professional containers used by companies are created in such a way that once closed, the container guarantees the waste producer that it cannot be reopened by unauthorized persons. Containers should be filled with no more than $\frac{2}{3}$ of their volume – this allows them to maintain appropriate properties of containers and resistance to damage, which is crucial for the safety of the waste producer due to his responsibility. An equally important element is the proper marking of the container or bag with waste – each of them should have an appropriate marking containing, among others: waste code or time of its closure.

It is worth remembering that the choice of a reliable company dealing with the transport and disposal of medical waste, which can provide and provide appropriate means of transport, is crucial for the safety of outsiders and the waste producer, because he is responsible for the waste generated.

2.2. Storage and transport of medical waste

Proper waste management is becoming particularly important in the case of hazardous waste (e.g., medical waste) that may contain dangerous substances or microorganisms that, if released into the environment, could lead to contamination of water, air, or soil. Medical waste may also contain infectious or genotoxic material, which - in case of direct contact - may contribute to the development of cancer or infectious diseases. Proper collection of medical waste and its proper disposal minimize the potential risks associated with it. In the case of non-hazardous waste, its management should primarily lead to effective recycling, i.e., recovery of secondary raw materials or energy. This not only reduces environmental pollution, but also reduces production costs and reduces the degree of exploitation of natural resources.

The first stage of medical waste management is its appropriate storage. Each medical facility should have its own procedure for dealing with medical waste. The key issues in effective waste management are (Topolska, 2017; Rosik-Dulewska, 2000):

- segregation of waste on an ongoing basis as it is generated,
- division of waste depending on the risk level,
- knowledge of the chemical and physical composition of waste, which will help in subsequent recovery or disposal waste,
- knowledge of the rules regarding waste allocation, quantity in a container and the arrangement and labelling of containers.

Instructions on waste segregation rules should be posted at workstations. The key is to recognize a type of waste and place it in the right bag or container. Disposable bags should be placed on racks with a closed flap or immediately in containers. The way the bag is placed in the container is also important, the upper part of the bag should be rolled up by approximately 20 cm so that it's outer space does not get contaminated.

Another important issue regarding medical waste is time and storage. Packaging, i.e., appropriate bags and containers, should be replaced as often as conditions allow, but - in accordance with generally applicable law - at least every 72 hours (in the case of highly infectious waste, this time has been shortened to 24 hours). As a rule, waste may remain at the place of its creation (e.g., a treatment room) for a maximum of 72 hours from the time of its production. A similar time was introduced by the Legislator for the initial storage of waste - it should be noticed that the place of waste generation and the place of initial waste storage are not the same places, as evidenced by regulation by the Legislator of the issue of internal transport of medical waste from the place of its generation to the place of its initial storage. It should be assumed that the period during which medical waste can be initially stored should be treated and counted regardless of the duration of storage of medical waste at the place of its generation. The period during which specific waste can be initially stored will depend largely on the place and conditions in which such a process will take place - this time, however, cannot be longer than 30 days. Due to the high cost of preparing a place for the initial storage of medical

waste (which will meet the stringent requirements set by the Legislator), the need to allocate space for such a room and the rising prices of energy carriers necessary to maintain the proper temperature inside, such action may turn out to be unprofitable in the long run. In such circumstances, choosing an experienced and reliable partner providing waste transport and disposal services becomes even more important. The guarantee of continuity and timeliness of collections, while maintaining the necessary safety measures, allows for comfort in minimizing the risk of liability for the waste generated (EKOMED, 2023).

Due to the nature of medical waste, especially its transport should be carried out in accordance with applicable legal regulations. The issue of hazardous waste transport is regulated, among others, by the European ADR agreement on the road transport of goods and dangerous cargo, and Polish law, which determines the method of transport of medical waste, which in a specific part is classified as hazardous waste. Appropriate marking of waste transport means is only one of the factors ensuring the safety of the entire process - equally important is their appropriate equipment and qualified personnel with specific training in the proper handling of medical waste during its transport.

Moreover, the regulations clearly specify that a vehicle intended for transporting medical waste should be closed. This means that medical waste cannot be transported on uncovered trailers. The previously mentioned special containers are also necessary, marked in accordance with applicable regulations and practice. Transport of certain categories of medical waste may take place in disposable bags, but they are still required to be properly secured and described aimed at increasing the safety of the entire process of their transportation and disposal.

Medical waste management requires exceptional knowledge, care and safety of people working in its collection, transport, and disposal. The ecological aspect is also extremely important, which is why so much importance is attached to proper labeling and segregation of waste. It is therefore worth entrusting issues related to waste collection and disposal to experienced specialists who have the knowledge and permits required by law to conduct this type of activity. Ultimately, the safety of the entire waste transport and disposal process, and therefore the safety of its producer, depends on the proper selection of an entrepreneur specializing in the transport and disposal of waste (EKOMED, 2023; Siekierski, 2021).

3. Practice based on EKOMED experience

Over the last twenty years, the process of managing medical waste and other hazardous waste, especially the process of its transport, has become far-reaching professionalized. The daily practice of transporting medical waste to the place of its disposal allowed the development of effective logistic solutions for its safe transport, which turned out to be of invaluable value during the SARS-COV-2 virus pandemic. As indicated by the President of the Management Board of EKOMED Gospodarka Odpadami Sp. z o.o. – one of the leading companies in the field of transport of medical and hazardous waste in the Silesian Voivodeship – Mrs. Anetta Jędryczka, high standards introduced in the field of employee training, quality of packaging, protective measures used, appropriate human and material reserves, and finally technical facilities intended for direct waste transport enabled (and continues to enable) continuous and uninterrupted transport of waste to the place of waste disposal, even in the event of intensification of its production and volume, thus enabling medical facilities to operate uninterrupted - which was not an easy task at all. The increased hospitalization of the population was not only a test of the limits of endurance of medical staff, but also of the technical support and people responsible for the current transport and disposal of medical waste. In her opinion - as a practice - solutions introduced in recent years aimed at intensified recording of waste generated, both in terms of quantity and quality (including in the form of the BDO System), at the same time allow for far-reaching control of the entire waste management process, which in As a consequence, it resulted in its "tightening" and the elimination from the market of a significant number of entities whose activities consisted in disposing of hazardous waste in an illegal manner.

Research on the mass of collected waste was conducted in two hospitals in the Silesian Voivodeship, in the years 2019 to 2022, during the pandemic. The first hospital was a large district, general specialist hospital (Hospital 1). The second hospital was a Covid hospital - a district hospital, also a general specialist hospital (Hospital 2).

Medical waste was collected daily from both hospitals, taking all precautions. Figures 2 and 3 show the masses of medical waste collected from a large children's hospital, and Figures 4 and 5 from a large Covid hospital in all analyzed years, broken down by month.

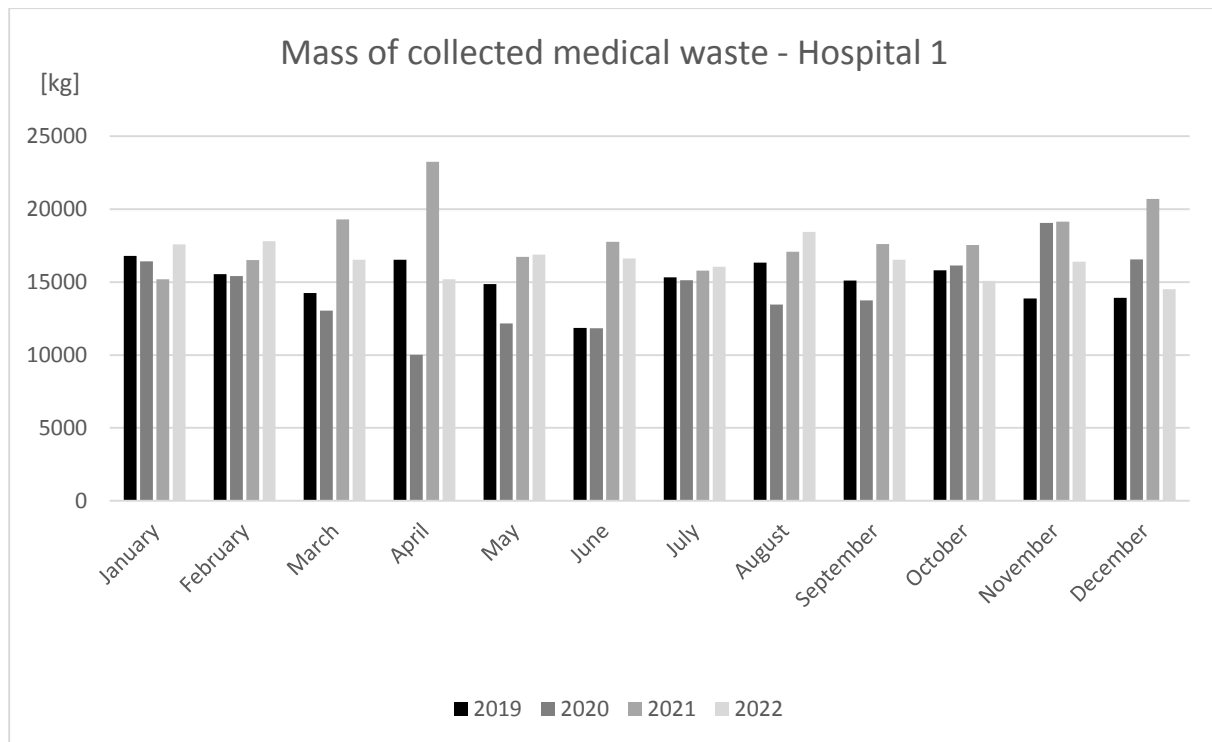


Figure 2. Mass of collected medical waste from Hospital 1.

Source: own work.

Analyzing the data obtained from the Hospital 1, the monthly amount of medical waste collected does not vary much. You can see the largest amount of waste collected in April 2021, which was probably caused by the wave of the pandemic that came in mid-March 2021. It can also be noted that, in general, the amount of medical waste collected during the pandemic years (2020-2022) was higher in almost every month than in 2019 - before the pandemic. The smallest amount of waste collected was recorded in April 2020. This was due to the lock down after the first wave of the pandemic in Poland.

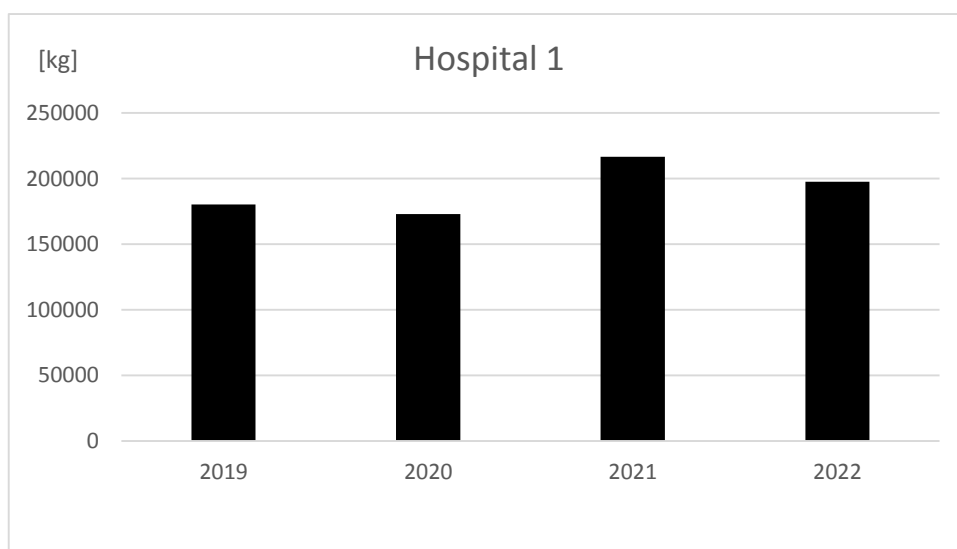


Figure 3. Total mass of collected medical waste from Hospital 1.

Source: own work

Analysis of the graph of the annual collected mass of waste showed that the amount of waste during the pandemic increased, especially in 2021 and 2022. In 2020, a smaller mass of waste was collected than before the pandemic, which was probably related to the lock down, fewer patients, and therefore a smaller number of treatments, which resulted in less waste produced.

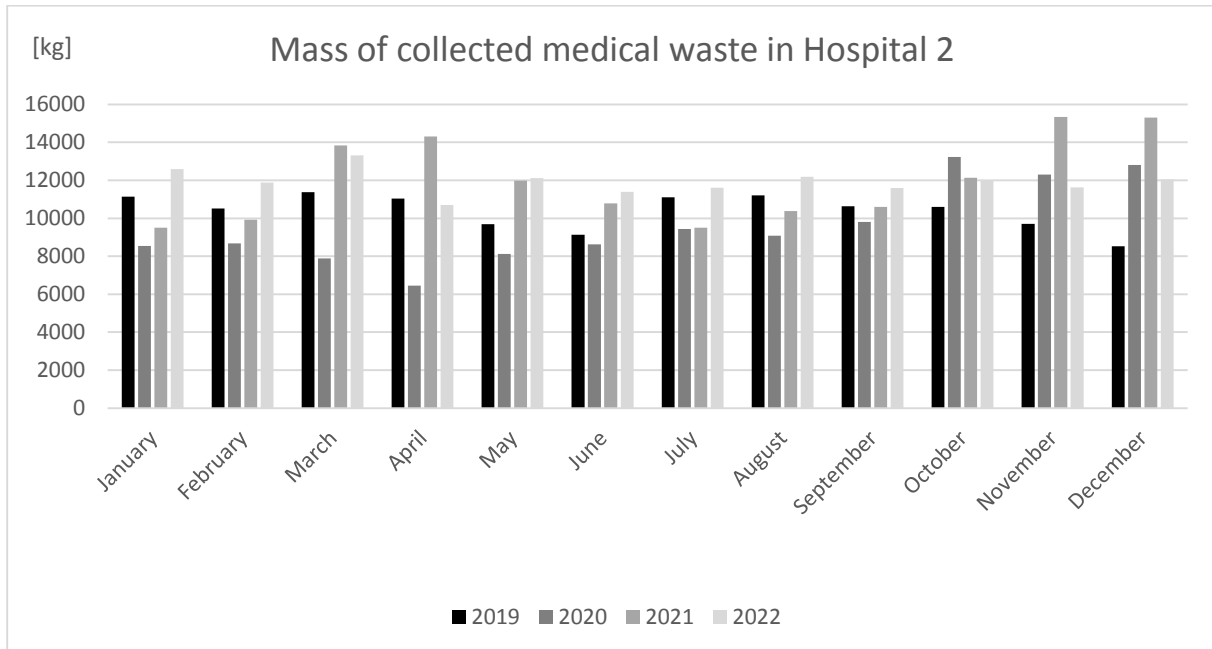


Figure 4. Mass of collected medical waste from Hospital 2.

Source: own work.

Interpreting the results obtained from the Hospital 2 - covid, it can be clearly seen a decrease in the amount of medical waste collected in the first quarter of 2020 compared to 2019. This decrease was most likely caused by the lock down and the beginning of the pandemic. In the later months of the year, there is a clear increase in the amount of waste (May 2020 – December 2020), which was caused by the further development of the pandemic. In 2021, there were three waves of the pandemic - in March, August, and December, which was, of course, reflected in the amount of waste collected - in March, April, November and December, the largest amounts of waste collected can be seen. After the December Covid wave, an increase in the amount of waste could be seen in January and March 2022. When the waves of the pandemic stopped, life slowly returned to its normal course, so patients appeared in the Hospital 1, and then medical waste also occurred.

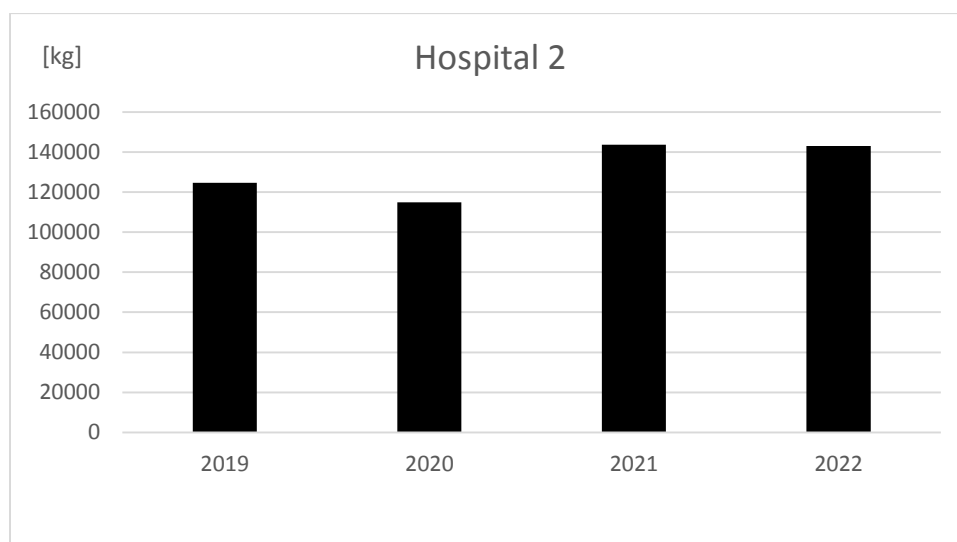


Figure 5. Total mass of collected medical waste from Hospital 2.

Source: own work.

Analyzed data show that the total amount of collected medical waste during the pandemic increased, especially in years 2021 and 2022. In 2020, a smaller mass of waste was collected than before the pandemic, which was probably related to the lock down, fewer patients, and therefore a smaller number of treatments, which resulted in less waste produced.

4. Summary and conclusion

The specific nature of the work of medical facilities is related to constant contact with hazardous substances. Improper contact with blood or surgical waste may pose a potential risk of infection. Improper storage or transport of medical waste, or even worse, a complete lack of proper management of this type of waste, may lead to the release of potentially hazardous substances into the environment and, consequently, to contact with them by unaware third parties. In the event of improper storage of waste (e.g., in an ordinary garbage container), hazardous compounds could spread even through animals, such as rats or cats, which is why it is so important to properly handle waste at the stage of storage. Disposing of medical or chemical waste is a unique responsibility. Leaving such a sensitive procedure to the wrong companies or people who do not have adequate technical and personal resources may not only have dangerous consequences, but also be severely punished by applicable law. Therefore, it is worth trusting certified companies that not only have many years of experience, but also perfectly understand the responsibility of waste producers. As emphasized by the Chairman of the Management Board of EKOMED Gospodarka Odpadami Sp. z o. o. constant supervision of the entire waste management process and the implementation of new solutions while consolidating the developed positive habits leads to increased safety of the entire process not

only for the producer himself, but above all for the general population and the natural environment. EKOMED Gospodarka Odpadami Sp. z o. o., constantly monitors the implementation of the latest solutions for the safety of his contractors. Obtained data showed, that the total amount of all collected medical waste in both hospitals were higher during and after the pandemic, than before it. It can be related with fact, that many people were treated and diagnosed for Covid in hospitals, so a lot of medical waste were produced.

References

1. BDO (2023). <https://bdo.mos.gov.pl>, 29.09.2023.
2. Dz.U. z 2017 r., poz. 1975. Rozporządzenie Ministra Zdrowia z dnia 5 października 2017 r. w sprawie szczegółowego sposobu postępowania z odpadami medycznymi. Dz.U. z 2017 r., poz. 1975.
3. Dz.U. z 2020 r., poz. 10. Rozporządzenie Ministra Klimatu z dnia 2 stycznia 2020 r. w sprawie katalogu odpadów. Dz.U. z 2020 r., poz. 10.
4. Dz.U. z 2023 r., poz. 1587, 1597. Obwieszczenie Marszałka Sejmu Rzeczypospolitej Polskiej z dnia 7 lipca 2023 r. w sprawie ogłoszenia jednolitego tekstu ustawy o odpadach. Dz.U. z 2023 r., poz. 1587, 1597.
5. EKOMED Gospodarka Odpadami Sp. z o.o. (2023). <https://ekomed-go.pl/pojemniki-na-odpady-medyczne-co-powinnismy-wiedziec-o-ich-wlasciwym-przechowywaniu/>, 29.09.2023.
6. Kostecka, J., Koc-Jurczyk, J., Brudzisz, K. (2014). Waste Management in Poland and European Union. *Archives of Waste Management and Environmental Protection*, 16(1), pp. 1-10.
7. Rosik-Dulewska, C. (2000). *Podstawy gospodarki odpadami*. Warszawa: PWN.
8. Siekierski, M., Majewska, K., Podsiadło, S. (2021). Gospodarka odpadami. Termiczne przekształcanie odpadów – spalarnie i współspalarnie. *Mazowsze Studia Regionalne*, 38, pp. 29-50
9. Szoltysek, J. (2009). *Logistyka zwrotna*. Poznań: Instytut Logistyki i Magazynowania.
10. Topolska, K. (2017). Zarządzanie odpadami medycznymi jako problem globalny. *Logistyka*, 12, pp. 1658-1661.
11. Wąsowicz, K., Famielec, S., Chelkowski, M. (2018). *Gospodarka odpadami komunalnymi we współczesnych miastach. Monografia*. Kraków.
12. [www1. https://www.seni24.pl/worki-i-pojemniki-na-odpady-medyczne/](https://www.seni24.pl/worki-i-pojemniki-na-odpady-medyczne/), 29.09.2023.
13. Zalewska, J. (2019). System gospodarowania odpadami w Polsce – stan aktualny i kierunki doskonalenia. *Ekonomika i Organizacja Logistyki*, 4(1), pp. 103-113.