ANALYSIS OF INFECTIOUS MEDICAL WASTE MANAGEMENT IMPLICATION ON SUSTAINABLE AGRICULTURE DURING THE COVID-19 PANDEMIC - CASE STUDY OF ŠUMADIJA DISTRICT (REPUBLIC OF SERBIA)

Magdalena Nikolić[1], Vladimir Tomašević[2], Dragan Ugrinov[3], Brankica Pažun[4], Zlatko Langović[5]

**Corresponding author E-mail: magdalenanikolic3@gmail.com*

ARTICLE INFO

Original Article

Received: *28 October 2023*

Accepted: *06 December 2023*

doi:10.59267/ekoPolj23041059N

UDC 616-036.21:578.834
502.13:628.4.046(497.11 Šumadija)

Keywords:

sustainable agriculture, human health, financial stability, SARS-COV 2, infectious medical waste

JEL: *K5, K53,P28*

ABSTRACT

Agriculture is the world's most important industry. According to the structure, Šumadija district is mainly composed of arable land and gardens, which make up 69%. The increased amount of COVID-19 waste generated from medical activities in rural areas needs to be properly handled due to its contagious, even lethal properties. The aim of this study is an analysis of two drivers through the generation of COVID-19 waste, Central and local treatment site, proposed transport routes, and total cost in Šumadija district. Results showed the economic costs of transportation increased 2.5 times compared to before and after the emergence of the COVID-19 pandemic. Also, the increase in health risk was correlated to the increase in the per capita cost of transportation along the transportation routes. Analyses of human health risks and detailed financial calculations gave a clear insight in infectious waste management possible influence on agriculture.

1 Magdalena Nikolić, Ph.D., Associate Professor, University "Union - Nikola Tesla", School of Engineering Management, Vojvode Mišića Boulevard no. 43, 11000 Belgrade, Serbia, Phone: +381 11 41 40 423, E-mail: magdalena.nikolic@fim.rs, ORCID ID (https://orcid.org/0000-0002-2021-153X)

2 Vladimir Tomašević, Ph.D. Full Professor, University "Union - Nikola Tesla", School of Engineering Management, Vojvode Mišića Boulevard no. 43, 11000 Belgrade, Serbia, Phone: +381 11 41 40 423, E-mail: vladimr.tomasevic@fim.rs, ORCID ID (https://orcid.org/0000-0001-9845-2950)

3 Dragan Ugrinov, Ph.D., Assistant Professor, University of Economics Academy, Faculty of Europe "Kallos", Ratarski put no.8a, 11000Belgrade, Serbia, E-mail: ugrinov.dragan@gmail.com, ORCID ID (https://orcid.org/0000-0002-5387-820X)

4 Brankica Pažun Ph.D., Associate Professor, University "Union - Nikola Tesla", School of Engineering Management, Vojvode Mišića Boulevard no. 43, 11000 Belgrade, Serbia, Phone: +381 11 41 40 423, E-mail: brankica.pazun@fim.rs, ORCID ID (https://orcid.org/0000-0002-9452-5064)

5 Zlatko Langović Ph.D., Associate Professor, University of Kragujevac, Faculty of Hotel Management and Tourism, Vojvodjanska bb, 36210 Vrnjacka Banja, Serbia, Phone: + 381 36 515 0024, E-mail: zlatko.langovic@kg.ac.rs, ORCID ID: (https://orcid.org/0000-0002-0248-0453)

Introduction

The development of sustainable agriculture depends on knowledge, as a base for understanding how and why there is a need to conserve natural resources, which in developing countries are converted into agricultural land. Also, by protecting the environment, the value of arable land is maintained. This includes the economic factor one of the most important in sustainable agriculture, and its influence on markets and incentives for organic production (Stojić, Dimitrijević, 2020). Therefore, well well-being of inhabitants must be a prerequisite for success in any activity. We witness the emergence of SARS-CoV-2 in late 2019 and its epidemic potential. The rapid spread of this virus across the world in only 2 months highlights the necessity to strengthen infectious waste management in every healthcare institution (Weston, Frieman, 2020). The practice around the world is that medical waste and other forms of clinical waste are disposed of adequately and according to regulations in a sanitary landfill or burned as waste to obtain energy. In EU countries, the United Nations Basel Convention on the Transboundary Movement of Hazardous Wastes and their Disposal has provided instructions and guidelines on waste management amid the COVID-19 pandemic as an urgent and essential public service aimed at protecting human health and the environment(Sing et al., 2020a). However, developing countries are not able to implement this practice, so medical waste, together with solid municipal waste, is disposed of in badly managed landfills in the places of greatest infection (Nzediegwu, Chang, 2020). A good example is provided by China, which since 2003, following the outbreak of severe acute respiratory syndrome (SARS) in the region, has enacted, and is implementing more than 30 legal and emergency management orders on the environmentally sound management of medical waste. Therefore, carefully observing and applying this practice can contribute to the greater safety of people, and animals, and the preservation of the environment (Singh et al., 2020b). Medical waste disposal is a global issue since it is costly. This is supported by the fact that 3.5 million tones of medical waste per year generated in the USA, are disposed of at the cost of $790 per tone (Windfeld, Brooks, 2015). Although we are faced with a pandemic and the creation of infectious waste in all healthcare units, infectious medical waste is still being transported in Serbia. Health systems need to address the problem of pandemic mismanagement (Yusefi et al., 2022). In most medical institutions in Serbia, there is no possibility of sterilizing used syringes and needles, swabs, bandages, and other infectious waste. Therefore, the set is transported to nearby regional centers, and health facilities equipped with autoclaves for sterilization and shredders. Unfortunately, Serbia still does not have modern facilities for the treatment of infectious medical waste (IMW), especially incinerators, which are necessary today. For these reasons, the COVID-19 pandemic affects the quality of life of people living in rural areas, where agriculture is the primary industry. This practice is particularly dangerous for the part of the population that lives on the infectious transport routes of this type of waste (Babaee Tirkolaee ,Aydın, 2021; Behera, 2021). Also, the lack of financial support harms the effective management of medical waste in hospitals where there is a lack of medical waste technologies and its neutralization at the source. That refers to vehicle routing problems and transportation planning problems (Thakur, 2021; Stanojevic et al., 2022. In general, during the great pandemic, apart from public health, the waste sector was the most affected because of the role he then assumed (Barua and Hossain, 2021). That is to say, the increased amount of infectious medical waste contaminated with COVID-19 increased the risk of spreading without neutralization on site. Serbia is a developing country whose waste management practices during COVID-19 failed in many aspects (Cao et al., 2023). There are justified reasons for concern, being predominantly a rural country, rich in arable land, and unique rural tourism households (Dimitrijevic et al., 2022). The Šumadia region is synonymous with the fertile land of Serbia. According to the structure, it is mainly composed of arable land and gardens, which make up 69%. The area under cereals occupies 40.8% and orchards 9.2% of the total agricultural area of the region. Also, 64,062 inhabitants live in this part of Serbia, two-thirds of whom are actively engaged in agriculture. If we look at statistical data on the activities of the Republic of Serbia, the active agricultural population makes up 64.8% (Stojić, Dimitrijević, 2020).

This study aimed to show how bad infectious medical waste management can be improved from the learnings of COVID-19 (Jayasinghe et al., 2023). The main goal of this paper is: to provide information on the amount of COVID-19 infectious medical waste generated during the COVID-19 pandemic; to identify existing routes of transportation through densely populated agricultural areas as gaps in existing infectious medical waste management practices; and to indicate problems and solutions to prevent potential infection: to protect farmers, agricultural land and products to the greatest extent. Therefore, the calculation of the amount of COVID-19 infectious waste as well as the cost of transportation with the number of people affected by this practice, presents opportunities for improvement in post-pandemic waste infrastructure. Insufficient COVID-19 infectious waste management affects agriculture and food systems in multiple ways. This unique opportunity to address these challenges can accelerate the transition to a more sustainable food system (Rasul, 2021).

Materials and methods

This study presents an analysis of Infectious waste management during the COVID-19 pandemic and how Serbia can change and support a novel approach to sustainable management. When it comes to agriculture, there are several concerns and considerations regarding the handling of COVID-19 waste. Contamination of Agricultural Land: Improper disposal of infectious waste in or near agricultural areas can lead to soil and water contamination. This can potentially affect the quality and safety of crops and livestock. (Devi et al., 2019); Risk to Farm Workers: Farm workers may be at risk of exposure to infectious COVID-19 if it is not managed safely. Inadequate disposal practices can lead to accidents or direct contact with contaminated materials (Elbadri, 2021). Biosecurity Measures: Agricultural operations should implement biosecurity measures to prevent the spread of diseases, including those that might be associated with improper handling of infectious COVID-19 waste (Galanakis,2020; Fan et al., 2021; Obykhod et al., 2020)

Developing countries have poor infectious waste management, which directly increases the ratio of contaminated items to non-infectious fraction of medical waste. The average for developing countries is about 0.2 kg of infectious waste generated per day. During the COVID-19 pandemic, the assessment of healthcare waste can be conducted only by considering all medical waste generated within healthcare facilities as infectious. For this study, we use Mihai's (2020) formula for the calculation of COVID-19 waste in healthcare facilities in Šumadija district :

(At the national level)

Mw = Number of active cases of COVID-19 per day × Mwgr (kg • bed • day – 1),

where Mwgr = medical waste generation rate — 1 kg • bed • day − 1

number of active cases is available at https://www.worldometers.info/coronavirus/#countries at the national level.

(At the subnational level)

Mw = confirmed cases of COVID-19 per day × Mwgr (kg • bed • day − 1).

Therefore we calculated the amount of infectious COVID-19 waste by multiplying the number of active cases with the amount of infectious medical waste. The data used in this research was collected from the Institute of Public Health of Serbia "Dr. Milan JovanovićBatut"(Batut, 2023). The results are presented in Table 1.

Analytical Framework

Developing countries such as Serbia struggle with reliable public data on the amount of medical infectious waste during the COVID-19 pandemic. However, data collected worldwide indicate infectious waste generation in developing countries is 2.3 times higher than in the period before the pandemic crisis. Also, the starting point for any calculation is the city of Wuhan in China where citizens generated nearly 247 tons of medical waste per day at the height of the pandemic, about six times more with only infectious waste two times more than before the pandemic (Hossain et al., 2011; Sing, Ogunseitan, 2020a). The amount of infectious waste in China during the pandemic increased 12 times (Chen et al., 2021). There are many new methodologies developed to define influential medical indicators that reflect the effects of transporting infectious medical waste (Pažun et al., 2022; Valizadeh, Mozafari, 2021; Wei, 2020). Drivers for integrated waste management are helpful tools when conducting analysis and guaranteed improvement of waste management (Ilić, Nikolić, 2016). The analytical framework is built around two waste drivers, human health and financial stability. Research conducted in China during the pandemic showed that the impact of COVID-19 on China's agricultural economy was reflected in crop production and livestock production, employment of farmers, and the overall development of agriculture. (Pan et al., 2020).

Therefore, the driver analysis provided guidelines for preventing infectious waste from reaching arable land and farmers in Šumadija district. Both drivers were analyzed through collected data to identify the amount of COVID-19 infectious medical waste and transportation routes in km and the number of inhabitants on route for COVID-19 transport through agricultural land.

Also, apart from analyses of drivers, it was found that one of the key directions to solving the problem of COVID-19 infectious medical waste transport is to establish values between 1 and 6, indicators of risk from COVID-19 spread (Nikolic et al., 2022). In a study conducted by Nikolic et al. (2022) values of waste are calculated as the quantity of waste being transferred per one route per week/number of citizens living along this route. As 5,3 times increased amount of COVID-19, IW is defined as value 6 for the highest health risk and value 1,3 for financial collapse. These values applied along with the data collected and calculated by Mihai (2020) give a clear picture of IMWS in the Šumadia district presented below.

The population living near the routes used to transport infectious waste is linked with a driver of the importance of human health. Highly infectious COVID-19 medical waste presents a direct threat to human health if not properly handled (Adyel, 2020; Borrelle et al., 2020). The value of this driver is in the amount of generated waste transferred per route in liters per week per the number of citizens living along this route. The range of numerically expressed significance is a value between 1 and 6 (the amount of waste in Wuhan increased 5.3 times). This indicator expresses the degree of threat to human health. Nikolic et al. (2022) defined that values from 1 to 2 are less good, values < 2 and > 3 mean very high risk values > 3 and < 6 mean extremely high risk, and values > 5 mean the risk of shock to the health society (Nikolic et al., 2022).

Financial support reflects a high-level financial problem for society as a whole. About 70% of the costs of the waste management system are allocated to the transport of waste. The financial aspect of sustainable waste management must be one of the main drivers of a sustainable system (Erdem, 2022). This driver is numerically expressed through the transport cost of the generated waste per the transfer route / the number of citizens to whom the waste was transferred for this route. The driver of financial support is a number whose volume can be greater than 1. Nikolic et al. (2022) determined that values between 1 and 1.3 mean high risk, values > 1.3 to 1.6 mean very high risk, and values >1.6 to 1.8 mean extremely high risk, while values > 1, 8 mean the risk of a shock to the financial society (Nikolic et al., 2022) The initiatives are clearly defined to find an adequate solution for the transportation of highly hazardous waste and the impact of the covid-19 infection. This research aims to improve the medical waste management system in Serbia, through a rapid assessment of potentially infectious covid-19 medical waste generated in rural areas. The endangered health of residents is clearly shown through the financial analysis of which waste is transferred for each route and to present the amount of waste that is transferred, representing a high risk for citizens who live along the transfer routes, on the example of the Šumadija administrative district.

Results and Discussion

The issue of a new category of IMW (COVID-waste) mishandled is a rising concern to public health and environmental sustainability, no matter whether the pandemic is over (Ilyas et al.,2020). Three CTSs/LTSs (Central treatment site /local treatment site) have been established/planned in the Šumadijja District.

1. CTS CHCKragujevac is in charge of eight additional places for waste collection.

2. CTS Central Clinic Kragujevac also includes the Institute of Public Health Kragujevac, the Institute for Emergency Medical Assistance, and the Institute for Dentistry.

3. In addition, an additional LTS was established in the Aranđelovac General Hospital with 130 beds. This treatment facility is responsible for the treatment of waste from the Aranđelovac Health Center.

The amounts of infectious medical waste in the Šumadija administrative district, by healthcare institutions of exemplary healthcare, are given in *Table 1.*

Table 1. Quantities of infectious waste generated in primary healthcare institutions

Collecting site (Municipality/ Community Health Centers)	**The population treated in CHC**	**Amount of infectious medical waste (kg/ day)**	**Amount of infectious medical waste (l/day)**	**Amount of infectious medical waste (l/week)**	**Number of containers with a volume of 240 l per week**
CHC Batočina	91659	3	30	210	1 x 240l (2x120l)
CHC Knić	102291	3	30	210	1x 240l (2x120l)
CHC Lapovo	58026	2	20	140	1x 240l (2x120l)
CHC Rača	152232	4	40	280	2x 240l
CHC Topola	250000	7	70	490	3 x 240l
Institute for Workers' Health Protection (IWHP)	291612	10	100	700	5 x 240l

Source: Author's calculations

Transportation of waste is always complex due to its hazardous nature, raising the question of how to tackle this issue the best way possible with the financial aspect taken into account (Fedotkina et al., 2019). An important role is also played by the distance (distance) of health institutions from the place for the treatment of infectious medical waste. Data on the distance are given in *Table 2.*

Table 2. Distance of medical institutions from the place of treatment (km)

Distance (km)	CTS (Central treatment site)	CHC Batočina	CHC Knić	CHC Lapovo	CHC Rača	CHC Topola	IWHP workers
CPT (central place for treatment)	**0**	27	17	16	19	40	3,5
CHC Batočina	27	**0**	50	4	17	67	30.5
CHC Knić	17	50	**0**	54	49	63	30
CHC Lapovo	16	4	54	**0**	19	47	19.5
CHC Rača	19	17	49	19	**0**	41	22.5
CHC Topola	40	67	63	47	41	**0**	43.5
IWHP	3.5	30.5	20.5	19.5	22.5	43.5	0

Source: Author's calculations

For the waste to reach the place of treatment, it takes a certain time, and the routes that the transport vehicle takes. Each country has its one regulations when it comes to infectious waste transportation. In Korea, medical waste is transported up to approximately 350 km, while in Germany and Japan hazardous waste(infectious and toxic) is transported up to approximately 100 km (Yoon et al., 2022). *Table 3*. shows the time required from the primary institution to CTS waste.

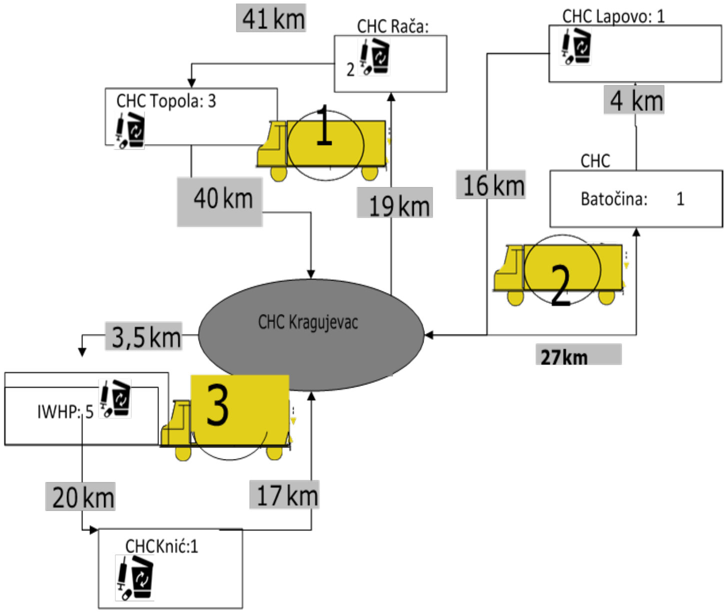
Table 3. Time required for transporting infectious waste to CTS

Transport time (min)	CPT	CHC Batočina	CHC Knić	CHC Lapovo	CHC Rača	CHC Topola	IWHP
CPT	**0**	40	26	25	30	60	10
CHC Batočina	40	**0**	70	10	30	80	40
CHC Knić	26	70	**0**	70	60	80	30
CHC Lapovo	25	10	70	**0**	30	65	31
CHC Rača	30	30	60	30	**0**	60	32
CHC Topola	60	80	80	65	60	**0**	60
IWHP	10	40	30	31	32	60	**0**

Source: Author's calculations

The movement of special vehicles is defined by the routes as well as the calculation of the time of transportation of infectious medical waste to the place of treatment. A schematic view is given in *Figure 1.* It is obvious that in the Šumadija district distance is approximately 80km, which follows developed country regulations.

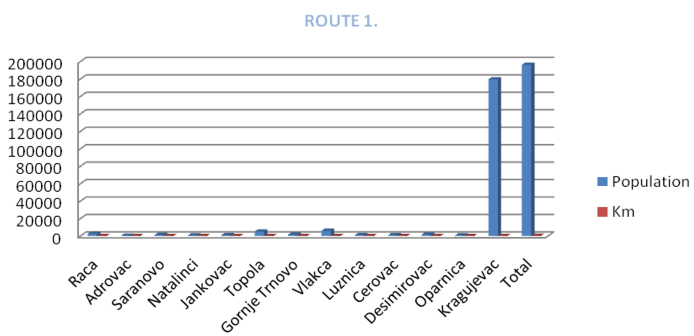
Figure 1. Proposed transport route in Šumadija district



Source: Author`s analysis

Transport route 1 traces the path from CHC Rača via Topola to Kragujevac. On the given route, it passes through populated areas on the route. *Figure 2.* shows an overview of the populated places it passes through with the gravitating population and the total mileage of the route.

Figure 2. Number of citizens endangered by infectious waste from CHC Rača via Topola to Kragujevac



Source: Author`s analysis

IMW transport route from Rača via Topola to Kragujevac with a length of 80.2 km.

The vehicle used to transport IMW is a Renault Kango with a cost price of 13,516 €.

Route: 160.4 km x 8 tours per month

1283.2 km x 5.2 l (average fuel consumption) – 66.73 l derivatives

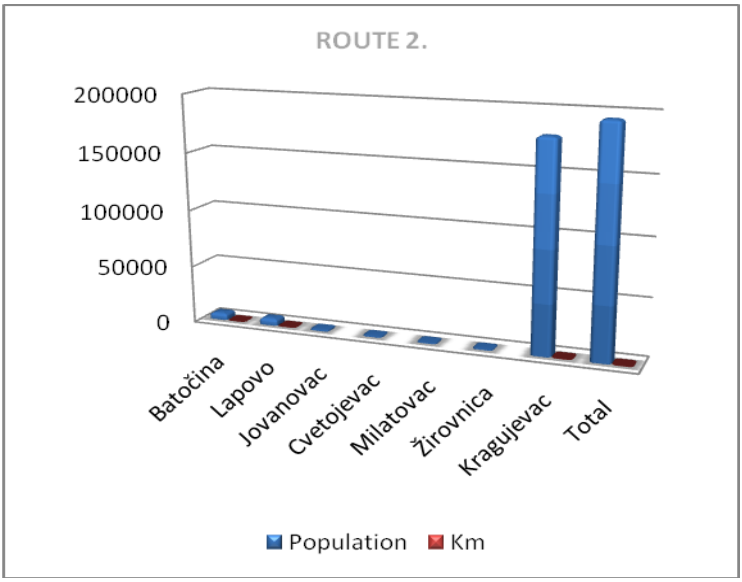
66.73 l x 129.9 din/l - 8668.00 din / 74.20 €

Need for oil and lubricant - 2580 din/ 22 €

Regular service and maintenance of vehicles without breakdowns, breakdowns, and accidents is for 6 months and amounts to a total of 17,050 din/ 145€.

In normal traffic conditions and road conditions concerning legal speed limits, the duration of the transport is 2 hours. Breakdowns, breakdowns, and accidents cannot be predicted. Transport route 2 traces the route from CHCBatočin via Lapovo to Kragujevac. On the given route, it passes through populated areas on the route. *Figure 3.* shows an overview of the populated places it passes through with the gravitating population and the total mileage of the route.

Figure 3. Number of citizens endangered by infectious waste from CHC Batočin via Lapovo to Kragujevac



Source: Author`s analysis

IMW transport route from Batočina via Lapovo to Kragujevac with a length of 33.1 km.

The vehicle used to transport IMW is a Renault Panther with a cost price of 15,210 €.

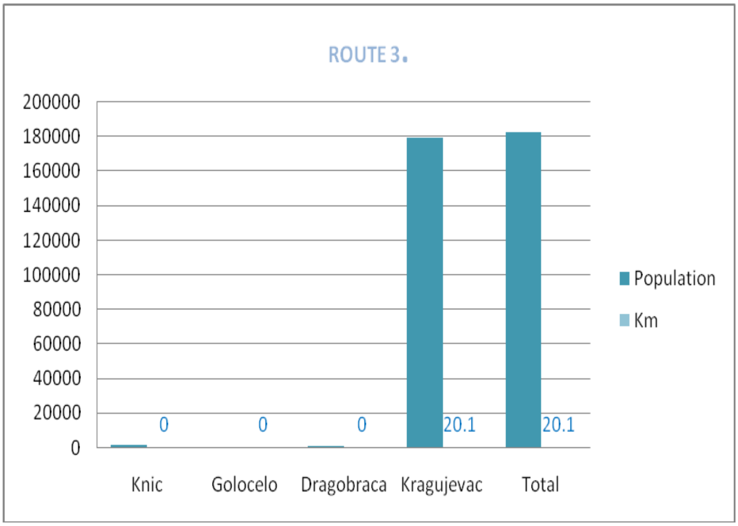
Route: 66.2 km x 8 tours per month

529.6 km x 6.5 l (average fuel consumption) – 34.5 l derivatives

34.5 l x 129.9 din/l - 4472.00 din / 38.20 €

Need for oil and lubricant - 4300 din/ 36.75 €

Figure 4. Number of citizens endangered by infectious waste from CHC Knić to Kragujevac



Source: Author`s analysis

Regular service and maintenance of vehicles without breakdowns, breakdowns, and accidents is for 6 months and amounts to a total of 17,050 din/145€. In normal traffic conditions and road conditions, concerning legal speed limits, the duration of the transport is 1 hour. Breakdowns, breakdowns, and accidents cannot be predicted. Transport route 3 traces the route from CHC Knić to Kragujevac. On the given route, it passes through populated areas on the route. Figure 4. shows an overview of the populated places it passes through with the gravitating population and the total mileage of the route.

IMW transport route from Knić to Kragujevac with a length of 20.1 km. The vehicle used to transport IMW is a Renault Boxer with a cost price of 25,590 €.

Route: 40.2 km x 8 tours per month

321.6 km x 7.9 l (average fuel consumption) – 25.4 l derivatives

25.4 l x 129.9 din/l - 3300.00 din / 28.20 €

Need for oil and lubricant - 4300 din/ 36.75 €

Regular service and maintenance of vehicles without breakdowns, breakdowns, and accidents is for 6 months and amounts to a total of 19,656 din/ 168 €.

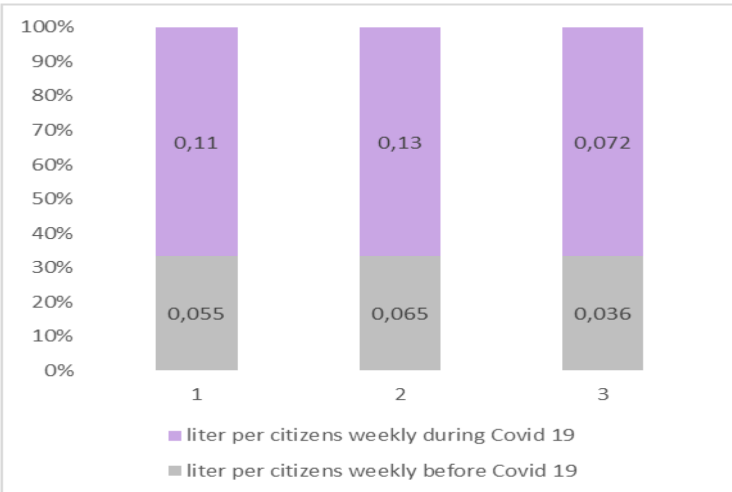
Under normal traffic conditions and road conditions, with compliance with legal speed limits, the duration of the transport is 45 minutes. Breakdowns and accidents cannot be predicted. Transporting through urban areas, infectious pathways of medical waste affect residents and the environment along transport routes. According to the selected operational model, the institutions/places for the treatment of infectious medical waste (IMW) are divided into two categories:

(1) a central treatment site (CTS), which processes its waste, as well as waste from assigned health facilities;

(2) a local treatment site (LTS), responsible for the safe treatment of one's waste. CTS / LTS institutions have also been tasked to collect waste from other health institutions in the district. Institutions whose infectious waste is taken for treatment are called MS institutions (institutions located at the place of origin and whose waste is transported to the place of treatment). Each administrative region has at least 1 CTS. It is usually a general hospital in the central town of the district. The exception is the districts where there are institutions of the new tertiary level of health care - clinical centers, where the CTS function is taken over by a health center or public health institute. The increased number of COVID-19 patients increases the amount of infectious waste.

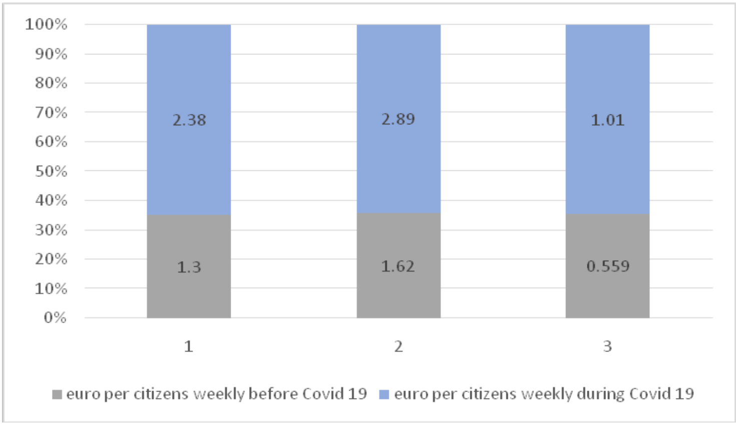
We confidently claim that the transportation of medical waste covid 19 increases the risk of spreading the COVID-19 virus among the population in the Šumadija district. It is obvious that during the pandemic, health indicators, as well as infectious covid-waste, based on the calculation of health indicators for all three directions of the Šumadija region, doubled. Figure 5. clearly shows us the health risk index with a growing trend before and during the covid 19 pandemic.

Figure 5. Input values for calculation of health indicators before and during a Covid pandemic.



Source: Author`s analysis

Figure 6.Analyses of economic indicators before and during a Covid pandemic.



Source: Author`s analysis

As the health risk increases, so does the per capita cost of transportation along the transportation routes. Figure 6 shows an overview of financial risk per capita with cost prices before and during the COVID-19 pandemic.

Conclusions

This paper aims to show COVID-19 infectious medical waste mismanagement in the Šumadija district. The Covid-19 pandemic has led to an increase in infectious waste generation. As a result, the amount of infectious medical waste transported through populated areas and transport routes through the Šumadija administrative district increases. Through direct analysis, it was included that both health and financial risks are doubled. It has been found that there was a 2 to 3-fold increase in the amount of infectious medical waste before and after the emergence of the COVID-19 pandemic. Additionally, the costs of transporting the waste and the cost price of IMW transport have increased by 2.5 times compared to before the pandemic. This entails a doubled risk of accidental situations, thus doubling the risk of contamination of the environment. This can potentially affect the quality and safety of crops and risk to farm workers. Inadequate disposal practices can lead to accidents or direct contact with contaminated materials. Although the length of routes within the district is below the recommended km by developed countries, no more than 80km, about 197000 inhabitants were directly exposed to the virus. The projected growing amount of medical waste in the observed District requires an increase in existing treatment and neutralization capacities and the application of new sustainable solutions. In line with the fact that Šumadija district is rich with fields, orchards, vegetable beds, vineyards alternate..., waste management should be a priority. Overall, the management of infectious COVID-19 waste affects agriculture and it should prioritize the safety of farmers, the integrity of agricultural products, and compliance with relevant regulations to prevent environmental contamination and public health risks. Proper education and adherence to guidelines are critical to achieving these goals. Therefore, recommendations include:

-The capacity of installed autoclaves can be increased by increasing their working time, to avoid additional investments.

-By decentralizing the place for treatment at the local level, the spread of the Covid-19 virus will be prevented.

- Such a general epidemiological situation could not be predicted, and therefore the solvency of the healthcare institution was put in serious jeopardy due to the incurred costs, as they must be reimbursed from their funds because they are not contracted with the Republic Fund.

Based on the results of this research, the following recommendations can be considered for future research:

To prevent the occurrence of possible accidents on the route of transportation. An integrated model to evaluate COVID-19 medical waste transportation risk by integrating an extended type-2 fuzzy total interpretive structural model (TISM) with a Bayesian network (BN) can be taken into consideration (Tang et al., 2023)

To improve the medical waste management system, quantitative statistical analysis by using the method of peer-reviewed publications originating from different geographical areas can be taken into consideration (Achuthan et al., 2022; Visser et al., 2021).

Conflict of interests

The authors declare no conflict of interest.

References

1. Achuthan, K., Nair, V. K., Kowalski, R., Ramanathan, S., & Raman, R. (2023). Cyberbullying research—Alignment to sustainable development and impact of COVID-19: Bibliometrics and science mapping analysis. *Computers in Human Behavior*, *140*, 107566. https://doi.org/10.1016/j.chb.2022.107566
2. Adyel, T. M. (2020). Accumulation of plastic waste during COVID-19. *Science*, *369*(6509), 1314-1315. https://doi.org/10.1126/science.abd9925
3. Babaee Tirkolaee, E., & Aydın, N. S. (2021). A sustainable medical waste collection and transportation model for pandemics. *Waste Management & Research*, *39*(1_suppl), 34-44. https://doi.org/10.1177/0734242X211000437
4. Barua, U., & Hossain, D. (2021). A review of the medical waste management system at Covid-19 situation in Bangladesh. *Journal of Material Cycles and Waste Management*, *23*(6), 2087-2100. https://doi.org/10.1007/s10163-021-01291-8
5. Batut, 2023. Institute of Public Health of Serbia "Dr. Milan Jovanović Batut", Reports, (2020) COVID-19 statistic in Serbia,
6. Available from: https://covid19.data.gov.rs/infectedhttps://data.gov.rs/sr/datasets/covid-19-dnevni-izveshtajinstituta-za-javno-zdravlje-srbije-ozarazhenim-litsima-na-teritoriji-republikesrbije/ Access date:16.02.2023.

7. Behera, B. C. (2021). Challenges in handling COVID-19 waste and its management mechanism: A Review. *Environmental nanotechnology, monitoring & management*, *15*, 100432. https://doi.org/10.1016/j.enmm.2021.100432
8. Borrelle, S. B., Ringma, J., Law, K. L., Monnahan, C. C., Lebreton, L., McGivern, A., ... & Rochman, C. M. (2020). Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. *Science*, *369*(6510), 1515-1518. https://doi.org/10.1126/science.aba3656
9. Cao, C., Xie, Y., Liu, Y., Liu, J., & Zhang, F. (2023). Two-phase COVID-19 medical waste transport optimization considering sustainability and infection probability. *Journal of Cleaner Production*, *389*,135985. https://doi.org/10.1016/j.jclepro.2023.135985
10. Chen, C., Chen, J., Fang, R., Ye, F., Yang, Z., Wang, Z., ... & Tan, W. (2021). What medical waste management system may cope With COVID-19 pandemic: Lessons from Wuhan. *Resources, Conservation and Recycling*, *170*, 105600. https://doi.org/10.1016/j.resconrec.2021.105600
11. Devi, A., Ravindra, K., Kaur, M., & Kumar, R. (2019). Evaluation of biomedical waste management practices in public and private sector of health care facilities in India. Environmental Science and Pollution Research, 26, 26082-26089. http://dx.doi.org/10.1007/s11356-019-05785-9
12. Dimitrijević, M., Ristić, L., & Bošković, N. (2022). Rural tourism is a driver of the economic and rural development in the Republic of Serbia. *Hotel and Tourism Management*, 10(1), 79-90. doi: 10.5937/menhottur2201079D
13. Elbadri, N. (2021). Developing a Risk Assessment Framework for Evaluating and Mitigating Occupational Exposure of Migrant Farmworkers to Enteric Pathogens in Canada's Seasonal Agricultural Worker Program (Master's thesis, University of Waterloo).
14. Erdem, M. (2022). Designing a sustainable logistics network for hazardous medical waste Collection a case study in the COVID-19 pandemic. *Journal of Cleaner Production*, *376*, 134192. https://doi.org/10.1016/j.jclepro.2022.134192
15. Fan, S., Teng, P., Chew, P., Smith, G., & Copeland, L. (2021). Food system resilience and COVID-19–Lessons from the Asian experience. *Global Food Security*, *28*, 100501 https://doi.org/10.1016/j.gfs.2021.100501
16. Fedotkina, O., Gorbashko, E., & Vatolkina, N. (2019). Circular economy in Russia: Drivers and barriers for waste management development. *Sustainability*, *11*(20), 5837. https://doi.org/10.3390/su11205837
17. Galanakis, C. M. (2020). The food systems in the era of the coronavirus (COVID-19) pandemic crisis. *Foods*, 9(4), 523. http://dx.doi.org/10.3390/foods9040523
18. Jayasinghe, P. A., Jalilzadeh, H., & Hettiaratchi, P. (2023). The Impact of COVID-19 on Waste Infrastructure: Lessons Learned and Opportunities for a Sustainable Future. International Journal of Environmental Research and Public Health, 20(5), 4310. .https://doi.org/10.3390/ijerph20054310
19. Hossain, M. S., Santhanam, A., Norulaini, N. N., & Omar, A. M. (2011).

Clinical solid waste management practices and its impact on human health and environment–A review. *Waste management*, *31*(4), 754-766. https://doi.org/10.1016/j.wasman.2010.11.008

20. Ilić, M., & Nikolić, M. (2016). Drivers for development of circular economy–A case study of Serbia. *Habitat International*, *56*, 191-200. https://doi.org/10.1016/j.habitatint.2016.06.003
21. Ilyas, S., Srivastava, R. R., & Kim, H. (2020). Disinfection technology and strategies for COVID-19 hospital and bio-medical waste management. *Science of the Total Environment*, *749*, 141652. doi: 10.1016/j.scitotenv.2020.141652
22. Mihai, F. C. (2020). Assessment of COVID-19 waste flows during the emergency state in Romania and related public health and environmental concerns. *International Journal of Environmental Research and Public Health*, *17*(15), 5439. https://doi.org/10.3390/ijerph17155439
23. Nikolic, M., Tomasevic, V., Kranjac, M., Pazun, B., & Ugrinov, D. (2022). GIS ANALYSIS OF SARS-CoV-2 SPREADING MINIMIZATION VIA INFECTIOUS MEDICAL WASTE TRANSPORTED THROUGH DENSELY POPULATED AREAS. *Fresenius Environmental Bulletin*, *31*(4), 4525-4535. ISSN 1018-4619
24. Nzediegwu, C., & Chang, S. X. (2020). Improper solid waste management increases potential for COVID-19 spread in developing countries. *Resources, conservation, and recycling*, *161*, 104947. https://doi.org/10.1016/j.resconrec.2020.104947
25. Obykhod, H., Khvesyk, Y., & Malkov, M. (2020). Impact of coronavirus on the state of food security and treatment of medical waste. Економіка природокористування і сталий розвиток. http://dspace.nbuv.gov.ua/handle/123456789/183377
26. Pazun, B., Nikolić, M., Grujčić, Ž., Ugrinov, D., & Langović, Z. (2022). Optimization Model of Infectious Medical Waste Disposal Using It Tools Case of Serbia. *Fresenius Environmental Bulletin*. ISSN 1018-4619. http: https://www.prtparlar.de/download_feb_2022/
27. Pan, D., Yang, J., Zhou, G., & Kong, F. (2020). The influence of COVID-19 on agricultural economy and emergency mitigation measures in China: A text mining analysis. PloS one, 15(10), e0241167. https://doi.org/10.1371/journal.pone.0241167
28. Rasul, G. (2021). Twin challenges of COVID-19 pandemic and climate change for agriculture and food security in South Asia. *Environmental Challenges*, *2*, 100027. https://doi.org/10.1016/j.envc.2021.100027
29. Singh, N., Tang, Y., & Ogunseitan, O. A. (2020a). Environmentally sustainable management of used personal protective equipment. *Environmental science & technology*, *54*(14), 8500-8502. https://doi.org/10.1021/acs.est.0c03022
30. Singh, N., Tang, Y., Zhang, Z., & Zheng, C. (2020b). COVID-19 waste management: Effective and successful measures in Wuhan, China. *Resources, conservation, and recycling*, *163*, 105071. https://doi.org/10.1016/j.resconrec.2020.105071
31. Stanojević, K., Radovanović, G., Makajić-Nikolić, D., Savić, G., Simeunović, B., & Petrović, N. (2022). Selection of the optimal medical waste incineration

facility location: A challenge of medical waste risk management. *Vojnosanitetski pregled*, *79*(2), 125-132. https://doi.org/10.2298/VSP200521072S

32. Stojić, V., & Dimitrijević, M. (2020). Consumers'intentions to use of organically produced food in the sumadija region. *Економика пољопривреде*, *67*(1), 253-267. doi:10.5937/ekoPolj2001253S
33. Tang, J., Liu, X., & Wang, W. (2023). COVID-19 medical waste transportation risk evaluation integrating type-2 fuzzy total interpretive structural modeling and Bayesian network. *Expert Systems with Applications*, *213*, 118885. https://doi.org/10.1016/j.eswa.2022.118885
34. Thakur, V. (2021). Framework for PESTEL dimensions of sustainable healthcare waste management: Learnings from COVID-19 outbreak. *Journal of cleaner production*, *287*, 125562. https://doi.org/10.1016/j.jclepro.2020.125562
35. Valizadeh, J., & Mozafari, P. (2021). A novel cooperative model in the collection of infectious waste in COVID-19 pandemic. *Journal of Modelling in Management*, *17*(1), 363-401. SSN: 1746-5664
36. Visser, M., Van Eck, N. J., & Waltman, L. (2021). Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative science studies*, *2*(1), 20-41. https://doi.org/10.1162/qss_a_00112
37. Visser, M., Van Eck, N. J., & Waltman, L. (2021). Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative science studies*, *2*(1), 20-41. https://doi.org/10.1162/qss_a_00112
38. Windfeld, E. S., & Brooks, M. S. L. (2015). Medical waste management–A review. *Journal of environmental management*, *163*, 98-108. https://doi.org/10.1016/j.jenvman.2015.08.013
39. Weston, S., & Frieman, M. B. (2020). COVID-19: knowns, unknowns, and questions. *Msphere*, *5*(2), 10-1128. https://doi.org/10.1128/msphere.00203-20
40. Wei, G. (2020). Medical waste management experience and lessons in covid-19 outbreak in Wuhan." Chongqing: Gient Heating Industry Co.[Google Scholar]. Available from: https://www.waste360.com/medicalwaste/medical-waste-management-experienceand-lessons-covid-19-outbreak-wuhan
41. Yoon, C. W., Kim, M. J., Park, Y. S., Jeon, T. W., & Lee, M. Y. (2022). A review of medical waste management systems in the Republic of Korea for hospital and medical waste generated from the COVID-19 pandemic. *Sustainability*, *14*(6), 3678. https://doi.org/10.3390/su14063678
42. Yusefi, A. R., Sharifi, M., Nasabi, N. S., Rezabeigi Davarani, E., & Bastani, P. (2022). Health human resources challenges during COVID-19 pandemic; evidence of a qualitative study in a developing country. *PloS one*, *17*(1), e0262887. https://doi.org/10.1371/journal.pone.0262887