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Sektor neformalne reciklaže u Srbiji kroz perspektivu zdravlja

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Apstrakt: Iako su reciklaža, spaljivanje i druge metode tretmana otpada dostupne, deponije i dalje dominiraju odlaganjem otpada u Srbiji. Bez pravilnog upravljanja, brojne deponije predstavljaju ozbiljnu opasnost, kao što je primer požara na više deponija u Srbiji u avgustu 2021. Pored formalnih sistema za reciklažu otpada, oko 15 miliona ljudi učestvuje u neformalnoj reciklaži otpada, pre svega plastike, metala, stakla i papira, dok u Srbiji, prema procenama, učestvuje između 30 i 50 hiljada. Ovaj rad analizira nova pitanja javnog zdravlja, posebno povezana sa neformalnim sektorom reciklaže otpada u Srbiji. Iako neformalni recikleri doprinose reciklaži i ponovnoj upotrebi otpada, relativno rudimentarne tehnike koje koriste, u sprezi sa nepravilnim upravljanjem sekundarnim zagađivačima, pogoršavaju zagađenje vazduha, zemljišta i vode u životnoj sredini. Što je još gore, neadekvatne mere zaštite na radu izlažu radnike koji rade na otpadu u neformalnom sektoru raznim zagađivačima, povredama, respiratornim i dermatološkim stanjima, infekcijama i drugim značajnim zdravstvenim problemima koji doprinose niskom životnom veku. Integracija neformalnog sektora sa njegovim formalnim pandanima mogla bi poboljšati upravljanje otpadom, a istovremeno bi se bavila ovim ozbiljnim zdravstvenim i životnim pitanjima.

Ključne reči: upravljanje otpadom, zdravstveni rizici, odlagališta, deponije

Informal Recycling Sector in Serbia through a Health Perspective

Abstract: Even though recycling, incineration, and other waste treatment methods are available, landfills continue to dominate waste disposal in Serbia. Without proper management, numerous landfills pose grave dangers, as exemplified by the August 2021 fires at multiple landfills in Serbia. In addition to formal waste recycling systems, approximately 15 million people participate in informal waste recycling, primarily for plastics, metals, glass, and paper, while this figure in Serbia is estimated to be between 30 and 50 thousand. This review analyses emerging public health issues, particularly associated with the informal waste recycling sector in Serbia. Although informal recyclers contribute to waste recycling and reuse, the relatively rudimentary techniques they employ, in conjunction with improper management of secondary pollutants, exacerbate environmental pollution of air, soil, and water. Even worse, inadequate occupational health measures expose informal waste workers to a variety of pollutants, injuries, respiratory and dermatological conditions, infections, and other significant health problems that contribute to a low life expectancy. Integration of the informal sector with its formal counterparts could enhance waste management while simultaneously addressing these grave health and livelihood issues.

Keywords: waste management, health hazards, dumpsites, landfills

1. Introduction

With rapidly growing populations and unprecedented urbanization rates, waste generation is accelerating, notably in cities and in low- and middle-income nations (Plevris, 2019). Effective waste management, particularly of toxic materials, is a significant challenge for sustainable development on a global scale. There are numerous options for waste disposal and treatment, including landfilling, incineration, decomposition, and recycling (Latinović, 2018; Marković & Tomašević, 2022; Latinović, Al Dhaheri & Alhudaili, 2022, Nikolić, 2022). Due to its minimal cost, landfill disposal continues to be

the method of choice in Serbia (Tošić & Vasović, 2020), as well as other low- and middle-income nations. However, improper management can cause significant health and environmental issues (Ketin & Kostić, 2022). Particularly emerging risks include hazardous, inadequately managed landfill slides (Huang & Cheng, 2017). For instance, management failures led to the collapse of a landfill in Shenzhen, China on December 20, 2015, resulting in the deaths of 73 individuals (Gao, Yin, Li et al., 2019). A comparable collapse claimed 140 lives in Bandung, Java, Indonesia, in February 2005 (Lavigne et al., 2014).

In Serbia, in 2015 there were large fires in landfills of the city of Kragujevac and the city of Paraćin, while August 2021 was marked by fires in two of the largest landfills in Serbia, the capital city of Belgrade and the second largest city in Serbia, Novi Sad (Ilić, Ilić-Kosanović & Najdić, 2022). In high-income countries, the formal, government-funded sector is responsible for the majority of refuse collection and treatment services. However, in many low- and middle-income countries, limited resources prevent the formal sector from keeping up with the rapid increase in refuse production. As a result, the informal sector (so-called refuse pickers and scavengers in some countries) has expanded (Gbedemah & Zaneti, 2021). In almost all low-income and middle-income countries, informal recyclers collect, transport, and trade refuse (Bermudez, Montoya-Ruiz & Saldarriaga, 2019). It is estimated that more than 15 million people globally are supported by the informal waste sector (Medina, 2008; Binion & Gutberlet, 2012), while in Serbia, the number of those who direclty deal with waste is estimated to be between 30 and 50 thousand people, while the number of those who are supported by this economy is substantially bigger (EKOlist, 2020).

Informal waste recyclers are subsistence workers who use primitive technologies to process and recycle a wide range of refuse materials, including plastics, food waste, cardboard, steel, copper and other metals. For example, in an unhygienic Roma settlement, in Vuka Vrcevica street, 2 kilometres from the centre of Belgrade, waste car tires or waste furniture is burned in a bonfire for the recovery of different metallic materials (Figure 1), which are then sold at a nearby purchase point for secondary raw materials. This is always accompanied by poisonous smoke that spreads over the densely populated, urban area of Belgrade. Although there are more sophisticated, almost non-hazardous, but still, simple techniques for recycling automotive tires, such as pyrolysis, in which, in addition to steel, gasoline and diesel fractions are also recovered (Latinović, 2019; Latinović, Jurčić, Al Marhouba, 2022), in lack of education and resources, informal recyclers in the aforementioned case recover only steel with a large environmental and health cost.

Figure 1. Unhygienic Roma settlement, in Vuka Vrcevica street, 2 kilometres from the centre of Belgrade, with the exact GPS coordinates. Armchair is being burned while children are playing with marbles right next to it. Source: author.

These informal recyclers indeed, can play a crucial role in the recycling of materials, but insufficient regulation frequently results in an increase in environmental pollution due to the discharge of a variety of secondary pollutants (Tong, Huynh & Khong, 2021). Moreover, these people are exposed to a number of health-damaging factors due to insufficient occupational health. With rapid urbanisation and the diversification of waste, particularly refuse electrical and electronic equipment (WEEE), the toxin-

related health risks for informal waste recyclers are growing (Vaccari, Vinti, Cesaro et al., 2019). In Guiyu, e.g., South China, the so-called "electronics graveyard of the world," laborers in the waste industry are experiencing a rise in novel health-related issues. Several studies on informal waste recyclers and WEEE have been conducted, whereas plastic waste pollution, especially microplastics, has received more attention in recent years (Kirby, 2019). This study focuses on emerging public health challenges confronting informal recyclers, particularly in Serbia. In addition, it describes the future challenges facing the informal refuse sector.

1.2 Increasing waste generation with expanding urbanization and increasing populations

Human activities continually generate waste. Sources of solid waste include the industrial, construction, commercial, service, and residential sectors, as well as individual households. In response to the prevalent human activities taking place, the waste generated will vary from location to location and over time in terms of its composition. Globally, approximately 2.3 to 3.1 billion tonnes of municipal waste, and more than 11 billion of solid waste were produced in 2021 (Maalouf & Mavropoulos, 2022). Increasing populations, rapid urbanization, and economic development in low- and middle-income countries have led to an unprecedented increase in refuse production. China and India are the most populous nations, and their urban and periurban waste problems are among the most severe. Municipal solid waste frequently exceeds the capacity of society to manage it safely. Expanding urban infrastructure, such as roads, bridges, and rapid transit systems, generates a rise in construction and demolition waste (CDW). Similar trend is recorded in Serbia in 2021. As a result of the rapid development of information and communications technology, WEEE is one of the fastest-growing pollutants worldwide (Vaccari et al., 2019). In 2019, approximately 53.6 million tonnes of WEEE were generated globally (Ghimire & Ariya, 2020) while in 2021 this number is estimated at 57.4 million tonnes (WEEE Forum, 2021). It is estimated that about 7 kilograms of electronic waste per inhabitant is generated in Serbia (Radovanović, Đorđević, Radić & Redžić, 2021). This is almost five times more than Romania, a member of the European Union, but it is slightly less than the European average, which is near 10.5 kg (Baldé, D'Angelo, Luda, Deubzer & Kuehr, 2022). While the global population is projected to increase by approximately 8% between 2021 and 2030, the total and per capita WEEE generation are expected to increase by approximately 47% and 34%, respectively (Guo & Zhong, 2021).

Globally, both governments and the general public are alarmed by the severity of problems associated with WEEE disposal. A further concern is the excessive use of plastics and the resulting plastic waste. Since the 1990s, global plastics and polymer consumption has increased by an average of 10% per year. Economies with low and moderate incomes experience the greatest growth rates (Farrelly & Green, 2020). In 2021, approximately 390.7 million tonnes of plastic waste were generated in the world while more than 15 million tonnes are estimated to have entered the ocean in the same year (Peng, Wu, Schartup & Zhang, 2021). Without improvements in refuse management, plastic waste production is projected to increase by a factor of ten by 2025. Researchers and the general public are becoming increasingly concerned about the threats posed by plastic refuse, particularly microplastics (plastic debris up to 5 mm in diameter), to marine life and human health.

3. Informal waste recycling

In the swiftly expanding cities of many low-income and middle-income countries, a lack of funding has led to extensive informal waste recycling (Esae, Sarah & Mofe, 2020). In contrast to the formal sector, informal waste recycling is conducted without government funding and may not be recognized as providing a valuable service by the general public. Similarly to formal waste management, the informal sector includes players at various phases of waste recycling. For instance, waste collectors select and collect valuable items from domestic, commercial, and industrial waste sourced locally or from waste imported from abroad. These scavengers constitute the foundation of the informal waste sector and are typically members of disadvantaged, vulnerable, or marginalized social groups. They are characterized by low levels of organisation, technology, and capital, in addition to noncompliance with tax, minimum wage, worker safety, and environmental protection regulations. In spite of the fact that informal waste recycling is typically not recognized as a legal occupation in many nations, it offers substantial societal benefits in terms of waste management and reducing the pressure on the resources used in the production of material products. The majority of the estimated >15 million individuals involved in

informal waste recycling reside in low- and middle-income nations (Medina, 2008), while in Serbia, according to estimations, their number is near 50 thousand (EKOlist, 2020).

3.1 Scope of materials recycled by the informal sector

Paper and cardboard, discarded metal (especially aluminium, steel, and tin), glass, plastic (polyethylene terephthalate (PET)) bottles, rubber, wood, textiles, and food waste are the materials recycled most frequently by the informal sector, although there are regional and national variations (Latinović, 2018; Latinović, Al Dhaheri & Alhudaili, 2022). Due to their high recycling potential and lengthy lifespans, metal, paper, and PET are typically favoured. The informal sector recycles an increasing amount of WEEE due to the potentially high value of the materials that can be recovered. Nonetheless, WEEE poses some of the greatest health dangers to informal recyclers due to recycling techniques and poor occupational health. The informal recycling of WEEE is widespread and practiced in many parts of the globe, despite the fact that toxic exposure patterns vary according to recycling methods and processes.

Aforementioned Guiyu, e.g., an agglomeration of four villages in Guangdong, South China, is a notorious global example of non-formal WEEE recycling. Since 1995, approximately 6000 family enterprises have annually processed approximately 1,6 million tonnes of WEEE (Kirby, 2019). Guiyu has become the largest WEEE dismantling and recycling facility in the globe. Workers painstakingly disassembling and stripping electronic components for reuse, including chips and valuable metals. Workers 'cook' circuit boards to remove chips and burn cables and other plastics to liberate metals like copper. Along the riverbanks, extremely hazardous acid solutions are used to extract gold from microchips. However, in Serbia, the majority of informally recycled materials are metals, paper and plastics. Informal recyclers can readily collect and sell plastic, primarily bottles. In many cities, such as Belgrade and Novi Sad, waste plastic commerce is well-established and supported by numerous processing facilities. However, the majority of this plastic is recycled crudely by informal organizations. Heavy metals, bromine, and antimony are added as pigments, additives, UV stabilisers, and flame retardants to polymers (Rodrigues, Abrantes, Gonçalves et al., 2019). The improper recycling of plastic waste risks contaminating these substances.

3.2 Environmental hazards of informal recycling sector

Methods that do not adequately protect the environment can generate secondary pollutants. Air, water, and soil are contaminated by the various toxicants and levels of exposure resulting from informal waste recycling. Near informal recycling sites, contamination is widespread and can reach exceedingly high concentrations (Fujimori et al., 2012).

3.3 Health risks

Those who work in the informal waste sector face a vast array of health concerns. Working on garbage dumps and landfill sites is inherently hazardous, and accidents, such as fires, explosions, and debris slides, such in Shenzhen, occur frequently. Due to the relatively high cost and lack of risk awareness, the majority of informal refuse recyclers do not wear protective gear such as gloves and boots. Even in the industry sector, with protective measures, workers get sick when exposed to certain toxic substances (Latinović & Marjanović, 2021). In the informal sector it is much more pronounced. For greater tactility, many recyclers prefer to work barehanded, but they run the risk of sharp injuries, particularly from glass and medical waste containing syringes (Cunningham, Simpson & Keifer, 2012).

Scavengers frequently come into contact with toxic substances and human/animal refuse. Particular attention has been paid to the health hazards associated with heavy metals for informal waste workers and their families. Recyclers who labour in landfills have elevated lead levels in their blood. Higher concentrations of lead and dioxin-related compounds have been found in the breast milk of female waste recyclers (Alam, Ang & Bondoc, 2018). Children and developing foetuses are especially susceptible to the effects of heavy metals (Soomro et al., 2019). For instance, the stillbirth rate in the aforementioned Guiyu, for which there are available data, was 4.6 times that of control sites, whereas blood lead concentrations in newborns were 4.8 times those of control sites (Xu et al., 2012). For Serbia, unfortunately, such data are still not available.

Nevertheless, exposure to hazardous plastic additives, such as brominated flame retardants (BFRs) and heavy metals, has been linked to problems with the nervous and reproductive systems, alterations in behaviour, and cancer (Park et al., 2012; AbouDonia, 2016). Informal waste laborers are also susceptible to inhaling gaseous emissions, bioaerosols, and microorganisms (e.g., car exhaust, dust, and fungus spores). In landfills, waste collectors may be exposed to gas emissions such as methane (CH_4) and hydrogen sulphide (H_2S), as well as vehicular emissions, which can cause respiratory, dermatological, and ocular issues (Wachinou et al., 2022). They are also more susceptible to prevalent illnesses (such as influenza, bronchitis, and ulcers), musculoskeletal issues, and diseases transmitted by vermin.

Due to unhygienic working conditions and a lack of washing facilities, informal waste recyclers may transport toxins to their residences and families. Landfills and garbage sites are breeding grounds for pathogenic organisms that cause dengue, leishmaniasis, diarrhoea, typhoid, anthrax, cholera, malaria, and a variety of skin disorders (Nicholas, 2017; Tadzhibaev, Murtazoev & Pulotov, 2019; Sahdev & Kumar, 2020). Moreover, the majority of informal waste laborers and their families are marginalized and socially excluded. Combined with financial insecurity, perceived shame, and humiliation, this can result in severe psychological harm that has far-reaching consequences for local communities (Yadav, 2021).

Table 1. Principal health risks for informal recyclers. Adopted from (Binion & Gutberlet, 2012; Yohannessen, et al., 2019; Wittmer, 2021; Dong et al., 2021; Gbedemah & Zaneti, 2021; Singhal, Lyngdoh & Prabhakaran, 2021)

Health risk	**Overview**
Chemical	Toxic substances, such as heavy metals and brominated flame retardants.
Hygienic	Lack of hand-washing facilities or adequate restrooms.
Disease	Headache, respiratory issues, dermatological problems, eye infections, influenza, bronchitis, ulcers, high blood pressure, musculoskeletal injuries (ie, chronic back ache and soreness in arms, legs and shoulders), typhoid fever, tuberculosis, dysentery, poliomyelitis, malaria, dengue, leishmaniasis, diarrhoea, anthrax, cholera
Accident	Accidental falls and other incidents resulting in lacerations and bone fractures, waste-related fires, explosions, landfill slides, needle pricks, and lacerations.
Psychological	insecurity, perceived embarrassment, and humiliation

3.4 Measures of improvement of the informal waste recyclers' welfare

A number of policy, economic, and industrial hygiene measures can enhance the health of informal recyclers. Green chemistry, enhanced product recyclability, and the elimination of toxic substances prior to recycling are of fundamental importance. It is essential to alleviate poverty by adequately financing the services provided by informal recyclers. Therefore, modernizing waste management systems will need to incorporate informal waste systems more and more. To prevent scavengers from entering toxic waste sites, proper management of landfills is crucial. In addition, the informal sector must implement new low-cost technologies designed to minimize health risks during waste recycling. Using pyrolysis instead of open flame scrap tire burning is one of the examples (Latinović, 2018).

Governmental or non-profit funding can provide apparatus like battery-powered handcarts, hand tools, protective clothing, and uniforms. Uniforms and identification cards formalize the appearance of informal workers, fostering an improved relationship with the public that can boost the self-esteem and confidence of informal workers. Government training of informal sector employees can impart more professional recycling knowledge, such as standardised classification and processing methods for various waste, recycling laws and regulations, and system development plans. The strengthening of these cooperatives and group networks can facilitate the transfer of knowledge regarding appropriate waste management and processing, relevant regulations and laws, environmental protection, sanitation, and hygiene. Such cooperatives also legitimize the work as a public service, making it possible to finance social programs like extended healthcare and child care. In some nations, cooperatives have merged to form larger regional or national movements. Solid Waste Collection and Handling, a

cooperative of roughly 1,500 waste collectors serving 200,000 households in Pune, India (Shankar & Sahni, 2018).

3.5 Collaboration between informal and formal sectors

Effective integration can enhance recycling rates, livelihoods, occupational and environmental health, and reduce waste management costs (Gerdes & Gunsilius, 2010). According to research conducted in Brazil, Egypt, and India, integration can increase informal sector revenues and decrease formal sector total waste system costs. A study of the cutting-edge 'InteRa' model for integrating the informal sector into waste management systems in low- and middle-income countries discovered similar win-win outcomes. Beyond the formal and informal waste management sectors, the successful development of integrated systems requires the participation of numerous stakeholders, such as the state, and local governments, environment/development agencies and non-governmental organizations (NGOs), academicians, and financiers.

9. Challenges and future research

Improving the health of informal waste sector workers is a significant challenge. International cooperation, such as through the Sustainable Development Goals (SDGs), will be essential for enhancing waste management, including addressing environmental contamination issues, and for enhancing the welfare of informal waste recyclers. Several relevant documents and guidelines have been adopted in Serbia. A Roadmap for circular economy in Serbia is intended to get to know, promote and put together the recognized stakeholders able to contribute by their knowledge, innovativeness and creativity to a faster transition to circular economy. This document is also a guidance for transition to a model of circular economy focusing, apart from the profit, to the protection of the environment and preservation of resources while focusing on the economic, social and ecological dimension as equally valuable. Although this is an initial document to start a dialogue between the decision-makers and representatives of industry, academic sector and civil society, it is a step towards defining future actions and a time framework for the transition. Furthermore, European Union has adopted a set of documents that provide guidance to the member states for a transition from the linear to circular economy.

The Green Deal and The Action Plan for Circular Economy are the last in this set. Since the Republic of Serbia is a country candidate for the EU membership, these documents will be complying with the recommendations in this regard in the forthcoming period, involving a series of activities including, among others, a draw-up of the Roadmap 2.0 for circular economy. In spite of the fact that there are optimistic plans for integrating the informal sector with formal waste management, these initiatives are still in their infancy in Serbia. Increasing awareness of the issues confronting the informal sector and altering attitudes toward waste pickers in Serbian culture is likely the greatest obstacle. Government and the media must recognize the often-crucial role that the informal sector plays in waste recycling.

Changed attitudes would contribute to the establishment of worker support programs, improved integration of informal employees into waste management, and the establishment of professional informal sector recycling businesses. Current regulatory trends and capital expenditures facilitate the operation of large recycling companies. Small companies are consequently excluded from the industry. Increasing pressure for automation and modernized sorting techniques make it much harder for small businesses to compete, and informal employees are excluded from waste sites. There are undeniable health and safety benefits, but displaced informal employees must either be integrated into new business schemes or compensated to alleviate poverty. Decisions regarding waste management should also consider who would gain the most from the sale of recyclables and how to enhance the disposal of non-recyclable, frequently toxic, material. High market prices can increase the incentives for informal recycling and the accumulation rates of recyclable materials, while also benefiting the livelihoods of numerous individuals through the creation of jobs. In contrast, low prices present difficulties for informal waste recyclers.

10. Conclusion

With growing populations and economic development, the amount of refuse produced is rapidly increasing, posing a variety of management and environmental challenges. Due to insufficient

financing for the formal waste sector in many low- and middle-income countries, approximately 35-50 thousand people in Serbia sort, collect, transport, and trade waste. This informal sector contributes significantly to refuse recycling and reuse. Metals, plastic, and paper are the primary materials recycled by informal waste recyclers. Unfortunately, relatively rudimentary recycling methods are the cause of significant environmental pollution and human health issues. Some efforts have been made to integrate the informal refuse sector with the formal sector. Despite the services it provides, the informal sector is still considered objectionable and a nuisance in many countries, as well as in Serbia. It is necessary to increase public awareness of the informal sector's contributions and alter public attitudes toward those involved. Improving waste management and the well-being of those involved in informal waste recycling will necessitate international collaboration, such as through the SDGs.

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