

ANALYSIS OF THE REPRESENTATION OF EE-DEVICES AS POTENTIAL EE-WASTE IN THE AREA OF THE CITIES BIHAĆ AND KLJUČ

PROFESSIONAL PAPER

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DOI: 10.51558/2232-7568.2023.16.2.1

RECEIVED
2023-07-13

ACCEPTED
2023-12-19

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ABSTRACT:

Nowadays, EE-waste represents a big problem, but also a danger for the environment and the population. Many households use various EE-devices that end up as EE-waste after their expiration date. The objectives of the research within this work for the cities of Bihać and Ključ were to determine: the total amount of EE-devices; percentage representation of the three most represented/least represented devices; total weight of EE-devices as a potential waste; the total amount of EE-waste per household and estimate the annual amount of EE-waste per inhabitant. To realize the goals, survey and comparison method were used. The results of the research showed that in the area of cities of Bihać and Ključ the quantitative representation (about 1 775 pieces); the percentage representation (mobile phones and TV) and the average age (about 5 years) of EE-devices were approximately the same. The differences were in the total weight of EE-devices as potential waste (38 853–39 316.4 kg); the total amount of EE-waste (5 942.9–6 971.7 kg) and the annual amount of potential EE-waste for Bihać which varied 0.12–0.13 kg/inhabitant and for Ključ 1.09–1.21 kg/inhabitant (Ključ municipality from 0.35 to 0.39 kg/inhabitant).

KEYWORDS: EE-devices, EE-waste, representation in cities, Bihać, Ključ

INTRODUCTION

The waste is one of the urgent issues in environmental protection, especially when it comes to waste production, insufficient utilization of waste as secondary raw materials and inadequate waste management, including landfilling. There are several types of waste, solid waste, liquid waste, gaseous, non-hazardous, hazardous, etc., including the electrical and electronic waste (EE-waste). If it is handled inadequately, the EE-waste has a negative impact on the environment. It originates from electrical and electronic equipment (EEO). EE-equipment is equipment whose normal operation depends on electric current or electromagnetic field and equipment for production, transmission and measurement of electric current or magnetic field, intended for use at voltage up to 1000 V alternating current and 1500 V direct current [1]. Regarding

electrical and electronic waste (EE-waste) in Bosnia and Herzegovina, there is a legal regulation at the entity level, i.e.: Federation of Bosnia and Herzegovina, Republic of Srpska and Brčko District. In general, EE-waste exist as a result of the digital revolution and the modern way of life, and at the same time became a potential danger to the environment and the humanity. It is one of the fastest growing types of waste in the EU, and only about 40% is recycled¹.

It is estimated that in 2020 the amount of EE-waste amounted to 10.5 kg/per inhabitant, while the average amount of EE-equipment placed on the market in the period 2017–2019 was about 22.9 kg/per inhabitant². In the EU, this waste is collected, and it is estimated that the rate of its collection is around 45%³. EE equipment, which is in 10 categories, i.e. [1]: Large household appliances; Small household appliances; IT and telecommunications equipment; Consumer

¹Source:

<https://www.europarl.europa.eu/news/hr/headlines/society/20201208STO93325/e-otpad-u-eu-u-cinjenice-i-brojke-infografika>

² Source:

https://ec.europa.eu/eurostat/statisticsexplained/images/d/d2/EEE_put_on_the_market_in_the_three_preceding_years_%28201720

[19%292C_waste_EEE_generated_in_2020_and_waste_EEE_collected_in_2020_%28kilograms_per_inhabitant%29_V2.png](https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Waste_statistics_electrical_and_electronic_equipment#Electrical_and_electronic_equipment_28EEE.29_put_on_the_market_and_WEEE_collected_by_country)

³ Source:

https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Waste_statistics_electrical_and_electronic_equipment#Electrical_and_electronic_equipment_28EEE.29_put_on_the_market_and_WEEE_collected_by_country

equipment and photovoltaic panels; Lighting equipment; Electrical and electronic tools (with the exception of large-scale stationary industrial tools); Toys, leisure and sports equipment; Medical devices (with the exception of all implanted and infected products); Monitoring and control instruments; Automatic dispensers. In addition to 10 categories, the mentioned EE equipment is also classified according to an additional 6 categories, namely: Temperature exchange equipment; Lamps; Large equipment (any external dimension more than 50 cm) including, but not limited to certain household appliances (This category does not include equipment included in categories 1 to 3); Small equipment (no external dimension more than 50 cm) including, but not limited to certain household appliances (This category does not include equipment included in categories 1 to 3 and 6) and Small IT and telecommunication equipment (no external dimension more than 50 cm). Also in the Federation of Bosnia and Herzegovina, EE-equipment is identically classified according to [2]. In particular, TV and mobile phones are also found in the mentioned categories of EE equipment. Also, it is known that TV and mobile phones and other EE-devices belong to the group of electrical and electronic devices that are considered sources of electric, magnetic and electromagnetic fields [1]. In general, the use of this EE equipment (TV and mobile phones) can have a potentially positive (information, easier communication, availability, rest, etc.) and negative impact (human health, behavior, etc.) on people.

TV AND MOBILE PHONES AND THEIR POTENTIAL INFLUENCE ON PEOPLE

Television (TV) is a global phenomenon that is available to almost every household. The first television program was broadcast in 1928 in the USA. In every household, the TV took a central place, mainly in the living room. In addition to gathering the young and old population, they are also a source of entertainment for the whole family. In most developed countries, watching TV is a very popular (in)activity among children, adolescents and the elderly. It is considered that the time spent sitting and watching television in the elderly, i.e. sedentary behavior is associated with the occurrence of cardiovascular diseases and the frequency of occurrence of type 2 diabetes and obesity [3].

Also, there are studies that indicate the influence of TV on the occurrence of depression and anxiety in children and adolescents [4], as well as the influence

on their behavior, physical activity, poorer eyesight [5].

At the beginning of its application, the mobile phone was used for business purposes and not for general social conversation [6]. However, it quickly found widespread use among people, and it is assumed that about two-thirds of the world's population uses mobile phones. According to [7] in 2021, the number of mobile users worldwide stood at 7.1 billion, with forecasts suggesting this is likely to rise to 7.26 billion by 2022. In 2025, the number of mobile users worldwide is projected to reach 7.49 billion. According to data [8], in BH in 2021 the number of mobile phone users is 3 728 775 and the number of TV program distribution users is 885 620

Due to their widespread use, mobile phones have raised concerns about risks to human health [9] and deserve the attention of both the health and public health communities. Each person should fully use the potential of the cell phone as a tool, but take care that it is not used excessively for entertainment or the environment because it causes addiction [10], as well as the presence of depression [11]. According to [12] mobile screen use ≥ 8 hours/24 hours as well as mobile phone use at least 30 minutes before bedtime is associated with sleep quality. In addition to the occurrence of violence through mobile phones [13], mobile phones affect the daily social life of young people, communication and interaction [14].

EE-WASTE MANAGEMENT

In the EU, according to [1], it is stated that waste electrical and electronic equipment (WEEE) is also one of the target areas that should be regulated in terms of the application of the principles of prevention, recovery and safe disposal of waste.

The mentioned directive complements the general EU legislation on waste management, such as Directive 2008/98/EC on waste, and also refers to general waste management procedures. Earlier parts of waste management (responsibility for waste management; principles of self-sufficiency and proximity; monitoring of hazardous waste; prohibition of mixing hazardous waste; labeling of hazardous waste; hazardous waste generated in households; waste oils; bio-waste) are supplemented with the following parts: Product design, Separate collection, Disposal and transport of collected WEEE, Collection rate, Proper treatment, Permits, Shipments of WEEE, Recovery targets, Financing in respect of WEEE from private households and from users other than private households, Information for users, Adaptation to scientific and technical progress, Penalties, Inspection and monitoring etc.

In the Federation of BH, with the aim of achieving the elements of a circular economy, there is a legal act that regulates the way of managing EE-waste, which include the operation of the entire management system for this type of waste and also the label (Figure 1). For the establishment of a waste management system created from EE-products, the procedure and rules for placing EE-products on the market have been defined. The following activities are defined in the EE-waste management system: collection, processing/recycling, export, temporary storage and other activities of waste management of EE-products and their parts [2]. The following participate in the EE-waste management system (chapter I-general provisions): Federal Ministry of Environment and Tourism; operators of waste electrical and electronic equipment (WEEE) management systems; importers, producers, distributors, traders of EE-equipment; owners of EE-waste; companies dealing with transport and/or temporary storage, processing, recycling and export of waste; utility companies, Fund for environmental protection FBiH; Information system (available on the web: www.otpadfbih.ba) and competent inspection bodies for market and environmental supervision [2]. In [2] there are other chapters related to: Informing and raising awareness of end users about WEEE management; Obligations of the final user; Free collection of WEEE from the household to the final user and other entities; Objectives of collection and collection of WEEE and temporary storage; Obligations of producers, importers and distributors; System operator and Transitional and final provisions.



Figure 1. A sign indicated for the mandatory special collection of waste equipment [2]

In addition to [2], there are other legal acts that touch on the topic/problem of EE-waste, such as: Law on collection, production and trade of secondary raw materials and waste materials (Official Gazette F BH, No. 35/98, 109/12), Guideline on categories of waste with lists (Official Gazette F BH, No. 9/05), Regulation on criteria for calculation and method of payment of fees for products that become packaging

and EE-waste after use (Official Gazette F BH, No. 104/22) and others. However, in practice, unfortunately, one of the leading problems in the management of EE-waste is that complete recycling and repurposing is still not carried out within the borders of our country, and that this type of waste often ends up in the environment together with municipal waste.

WASTE MANAGEMENT IN THE CITIES OF BIHAĆ AND KLJUČ

Bihać and Ključ are located in the northwestern part of Bosnia and Herzegovina within the Federation of Bosnia and Herzegovina and are part of the US Canton. The area of the city of Bihać occupies an area of about 900 km², it is composed of 35 local communities with a total number of households of 20 650⁴. The municipality of Ključ is smaller with an area of about 358km² and has 10 local communities with a total number of households of 5 249, and the city part of Ključ itself has 5 409⁵. The total population as of 30 June 2022 for Bihać (municipality code 10049) is 54 921 and for Ključ (municipality code 11509) is 15 315 [15]. Also according to [15], the average number of employees in Bihać is 13 512, Ključ is 1 513, while the average net salary for Bihać is about 1 195 KM, and for Ključ about 904 KM.

In the city of Bihać, the company that manages waste (municipal and part of EE-waste) in the territory of the city of Bihać is the Public Utility Company (JKP) „Komrad“. This company contains a recycling yard that receives and temporarily stores discarded EE-devices, i.e. EE-waste. In the city of Ključ, the company authorized to manage municipal and partly EE-waste in the area of the city and municipality of Ključ is PUK „Rad“.

Both companies provide services of collection, removal and depositing of municipal waste. However, both of these companies are obliged to act in accordance with the current legislation that also refers to the management of EE-waste, ie that part of EE-waste brought to them by the owners (owners) of EE-waste. The amount and composition of collected EE-waste depends on the interest of citizens to take such waste to the receiving station of the utility company for temporary storage.

⁴ Source: <https://www.bihac.org/mjesne-zajednice>
ISSN 1840-0426 (P); ISSN 2232-7588 (E)

⁵ Source: <https://opcina-kljuc.ba/kljuc/#>
<https://hrcak.srce.hr/ojs/index.php/technologicaacta> * <http://tf.untz.ba/technologica-acta>

MATERIAL AND METHODS

Two scientific methods were used in this research: the survey method (conducted on the basis of a survey questionnaire⁶) and the comparison method.

The survey was conducted in the period from April 2022 to April 2023. The research convenience sample consisted of 200 households from the area of two cities. Respondents from different households from Bihać (100 households) and Ključ (100 households) participated in the research. The survey questionnaire consisted of a selected tabular review of EE-devices in which respondents entered numerical data on how many of them the household owns. For Bihać, households were surveyed from the area of 7 local communities in the narrower part of the city, namely: Centar, Bakšaiš, Harmani, Hatinac, Luke, Ozimice I and II. From the area of Ključ, households were surveyed from the area of the largest local community of Ključ, which in fact includes the area of the city.

The main objectives of the research within this work were to determine the annual amount of total potential EE-waste in the area of two cities and to estimate the annual amount of potential EE-waste per inhabitant for Bihać and Ključ. For the realization of the set goals, the following research tasks were defined: quantitative representation of EE-equipment; percentage representation (most and least represented) EE-devices per household; average age of EE-devices; total weight of EE-equipment as potential waste.

RESULTS AND DISCUSSION

The results of the research in relation to the surveyed households (a total of 200) in the cities of Bihać and Ključ are presented tabularly (Table 1 – 2) and graphically (Figure 2 – 3).

Table 1. Amount of EE-waste (kg) in the city of Bihać

Device name	1	2	3	4	5
TV	142	16	2272	7	324.6
Washing machine	100	70	7000	5	1400
Clothes dryer	39	50	1950	5	390
Fridge	107	90	9630	5	1926
Computer	56	13	728	4	182
Clothes iron	102	2	204	6	34
Hair straightener	50	0.3	15	4	3.8
Mobile phone	267	0.2	53.4	3	17.8
Tablet	46	0.3	13.8	4	3.5
Laptop	93	2	186	4	46.5
Bluetooth speaker	36	0.5	18	3	6
Vacuum cleaner	116	10	1160	6	193.3
Boiler	112	20	2240	10	240
Electric stove	110	60	6600	9	733.3
Microwave oven	59	15	885	7	126.4
Dishwasher	66	50	3300	5	660
Heater	58	15	870	6	145
Air conditioning	36	40	1440	3	480
Electric kettle	96	0.4	38.4	4	9.6
Shaving machine	47	0.2	9.4	5	1.9
Printer	40	6	240	5	48
Σ	1778	460.9	38853	5.2	6971.7

1–Quantitative representation of devices in Bihać (pcs); 2–Average device weight (kg); 3–Total weight of the device (kg); 4–Average age (years); 5–Annual amount of waste (kg)

⁶ The survey questionnaire in this paper was specially designed for this type of research

Table 2. Amount of EE-waste (kg) in the city of Ključ

Device name	1	2	3	4	5
TV	167	16	2 672	8	334
Washing machine	103	70	7 210	5	1442
Clothes dryer	33	50	1 650	5	330
Fridge	124	90	11160	10	1116
Computer	64	13	832	4	208
Clothes iron	106	2	212	7	30.3
Hair straightener	71	0.3	21.3	4	5.3
Mobile phone	263	0.2	52.6	2	26.3
Tablet	57	0.3	17.1	4	4.3
Laptop	52	2	104	3.5	29.7
Bluetooth speaker	44	0.5	22	3	7.3
Vacuum cleaner	109	10	1090	5	218
Boiler	107	20	2140	10	214
Electric stove	104	60	6240	9	693.3
Microwave oven	64	15	960	7	137.1
Dishwasher	53	50	2650	5	530
Heater	43	15	645	6	107.5
Air conditioning	35	40	1400	3	466.7
Electric kettle	91	0.4	36,4	4	9.1
Shaving machine	50	0.2	10	5	2
Printer	32	6	192	6	32
Σ	1772	460.9	39316.4	5,5	5942.9

1–Quantitative representation of devices in Bihać (pcs); 2–Average device weight (kg); 3–Total weight of the device (kg); 4–Average age (years); 5–Annual amount of waste (kg)

The results of the research showed that the quantitative representation of EE-devices for Bihać and Ključ was approximately the same and in the middle it was 1 775 pieces. The average age of EE devices was 5.35 years. The total weight of EE-equipment for Bihać was slightly lower i.e. by 463.4 kg compared to Ključ, while the annual amount of waste for Bihać was higher by 1 028.8 kg compared to Ključ.

Considering the research period, the estimated annual amount of waste was calculated according to the official population census from 2013 and 2023. The estimated annual amount of potential EE-waste per inhabitant for the city of Bihać (6 971 kg/56 261 inhabitants⁷) was 0.12 kg/inhabitant, while for the city of Ključ (5 942 kg/4 898 inhabitants⁸) it was 1.21 kg/inhabitant, which means that for the municipality Ključ (5 942 kg/16 744 inhabitants⁹) was 0.35 kg/inhabitant.

However, according to the official population census from 2023¹⁰, the estimated annual amount of

potential EE waste as of June 30, 2022. for the city of Bihać (6 971 kg/54 921 inhabitants) is about 0.13 kg/inhabitant, for the city of Ključ (5 942 kg/5 409 inhabitants) 1.09 kg/inhabitant and for the municipality of Ključ (5 942 kg/15 315 inhabitants) about 0.39 kg/inhabitant.

From the point of view of the percentage representation (Figure 2 – 3) of EE-devices by households in the surveyed cities, they showed that the most represented was in Bihać: mobile phone (267%), TV (142%) and vacuum cleaner (112%), and in Ključ were mobile phone (263%), TV (167%) and refrigerator (124%). Of the three EE-devices with the lowest percentage representation for the city of Bihać were: bluetooth speaker (36%), air conditioner (36%) and clothes dryer (39%). For the city of Ključ, the three least represented EE devices are: printer (32%), clothes dryer (33%) and heater (43%).

Based on the high prevalence of TVs (approximately two TVs per household) and mobile phones (about 2-3 mobile phones per household), it

⁷ Source: According to the official population census for the city of Bihać from 2013

⁸ Source: According to the official population census for Ključ – a populated place from 2013

⁹ Source: According to the official population census for the municipality of Ključ from 2013

¹⁰ Source: Federal Statistical Office (2023). Una-Sana Canton in numbers, Sarajevo 2023

can be determined that their use has a potential impact and risk on both the physical and mental health of people.

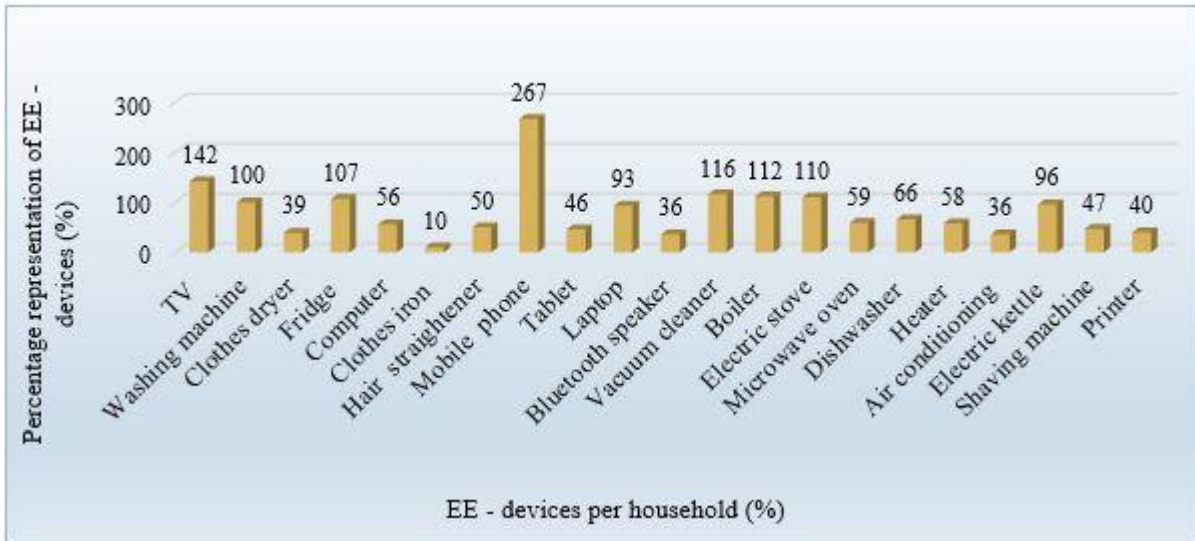


Figure 2. Percentage representation of EE-devices in Bihac (%)

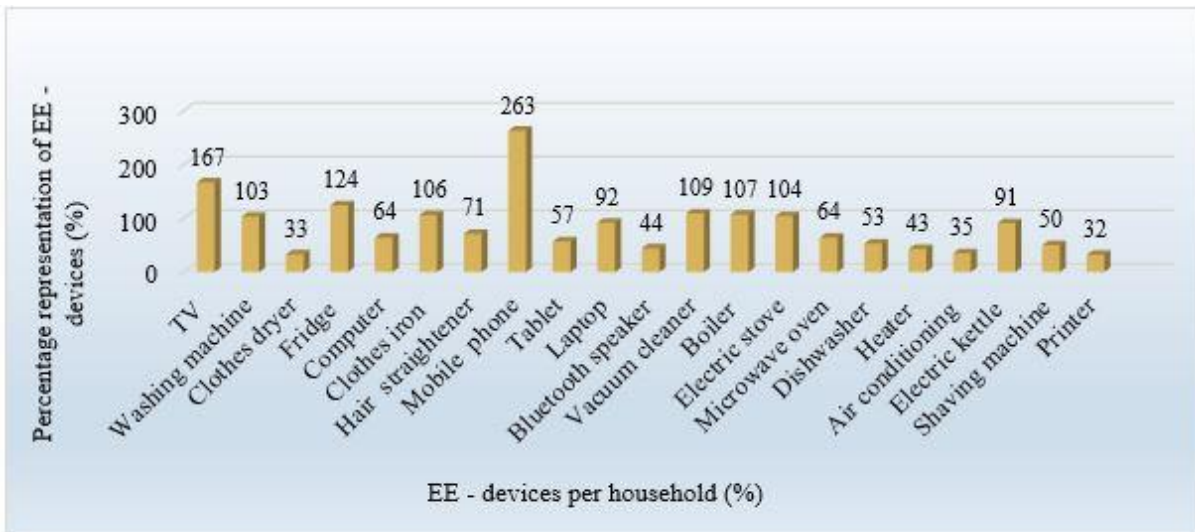


Figure 3. Percentage representation of EE-devices in Ključ (%)

CONCLUSIONS

The quantitative representation of EE-equipment in the middle was 1 775 pieces, including 1 778 pieces for Bihac and 1 772 pieces for Ključ.

In terms of percentage, the most represented EE-devices for Bihac and Ključ were mobile phones (Bihac: 267%; Ključ: 263%) and TV (Bihac: 142%; Ključ: 167%). The least represented EE-devices for Bihac were the bluetooth speaker (36%), air conditioner (36%) and clothes dryer (39%), and for Ključ they were printer (32%), clothes dryer (33%) and heater (43%).

The average age of EE devices was 5.35 years, i.e. 5.2 years for Bihac and 5.5 years for Ključ.

The total weight of EE-equipment as potential waste for Bihac was 38 853 kg, and for Ključ: 39316.4 kg.

The total amount of potential EE-waste in the area of the two cities was 12914.6 kg, for Bihac it was 6971.7 kg, and for Ključ 5942.9 kg.

The calculated values of the amount of potential EE-waste according to the official population census from 2013 and 2023 for the city of Bihac and for the city of Ključ did not vary much.

The values mostly ranged for the city of Bihać from 0.12 to 0.13 kg/inhabitant and for the city of Ključ from 1.09 to 1.21 kg/inhabitant (municipality of Ključ from 0.35 to 0.39 kg/inhabitant).

The management of EE-waste is handled by municipal companies of the cities of Bihać and Ključ. Unfortunately, the EE-waste management system has not yet fully taken off.

Due to the high prevalence of TV and mobile phones, there is a potential impact and risk on human health (mental and physical).

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