Environment Protection Engineering

Vol. 43 2017 No. 3

DOI: 10.5277/epe170320

IWONA PASIECZNIK[1], KAMIL BANASZKIEWICZ[1], ŁUKASZ SYSKA[2]

LOCAL COMMUNITY E-WASTE AWARENESS AND BEHAVIOR. POLISH CASE STUDY

e-Waste awareness and behavior of local Polish community has been examined. Specifically, the issue of selective waste electrical and electronic equipment (WEEE) collection has been explored. The main objectives of the research was to evaluate an attitude of the individuals towards e-waste treatment and to recognize the causes of low efficiency of the current WEEE management. The research was conducted among the inhabitants of a small town in Poland. Collected data may be useful while preparing household WEEE management systems. Over 52% of respondents, each was a representative of one household, conducted selective electrical and electronic equipment waste collection. Unfortunately, 12% (mostly young people aged 16–25, 9%) admitted that they threw e-waste mixed with general municipal waste. Another 12% (aged 18–25) claimed that they had never disposed of WEEE. Nowadays, the technology is developing very fast and small electronic devices are frequently exchanged, so the above mentioned statement is unlikely to be true. The research survey confirmed that further costs should be borne on educational activities which will raise people's awareness concerning WEEE threats and motivate them to collect e-waste selectively. The improvement of the management system – increasing the number of e-waste drop off points, is necessary as well.

1. INTRODUCTION

A characteristic feature of electronic and electrical equipment (EEE) is the variety of products and materials they are made of; e-waste contains various fractions of materials like: plastics (e.g., polyethylene (PE), high/low density polyethylene (HDPE/LDPE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), high impact polystyrene (HIPS), acrylonitrile butadiene styrene (ABS), poly-

[1]Wrocław University of Science and Technology, Faculty of Environmental Engineering, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland, corresponding author I. Pasiecznik, e-mail address: iwona.pasiecznik@pwr.edu.pl

[2]Graduate from the Wrocław University of Science and Technology, Faculty of Environmental Engineering.

butylene terephthalate (PBT)) [1] or valuable metals (e.g., gold, silver, palladium, platinum, aluminum, copper, iron). Reported toxic substances in e-waste include: lead, mercury, chromium, arsenic, cadmium, hexavalent chromium, ozone depleting substances (ODS), brominated flame retardant (BFR) or polychlorinated biphenyls [2–4].

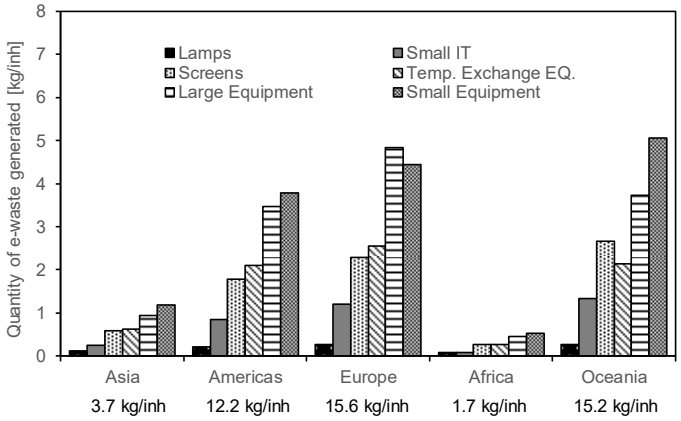

Fig. 1. WEEE generation per category, content and per inhabitant in 2014 (based on [5])

e-Waste is currently considered to be one of the fastest growing waste streams in the EU, with an annual growth rate of 3–5%. It is estimated that the total volume of WEEE generated globally in 2014 was approximately 42 million t (Fig. 1). Around 12 million t of e-waste was generated in Europe (including Russia), whereas 9.5 million t (18.7 kg per inhabitant, kg/inh) was generated in the 28 Member States of the European Union (Fig. 2) [5].

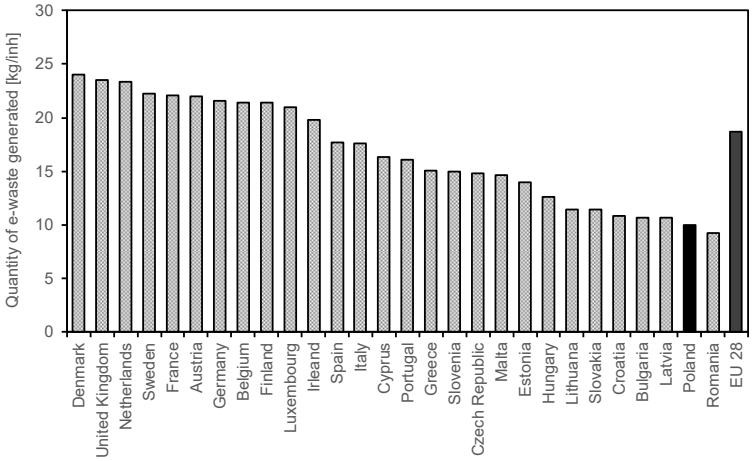

Fig. 2. e-Waste generated per country and per inhabitant in 2014 (based on [5])

Unfortunately, only 35–40% of the annually generated e-waste is collected by officially take-back systems in the 28 EU Member States [5, 6]. E-waste is also disposed of with mixed residual waste (the waste bin), where it is treated together with other municipal waste. In total, 7–8% of generated e-waste (around 1–2 kg/inh) end up in waste bins in the EU-28 [5, 6].

Inappropriate collection and storage of e-waste can be hazardous to environment and human health. Highly developed countries introduced legislation concerning WEEE management, while in developing countries dominates informal recycling or backyard recycling which has a negative impact on the environment and public health [7]. Despite the ban on electronic and electric waste export from the European Union countries, the e-waste is still shipped to developing countries as an equipment that can be reused [5, 6, 8]. This is encouraged by low employment costs (WEEE treatment) and non-effective environmental legislation. Actually, e-waste is landfilled or recovered [9]. Waste treatment methods performed at such places are primitive and they cause releasing toxic substances to the environment [10]. What is more, employees are not protected sufficiently so they are in danger of a negative chemical substances exposure [11]. It applies to unrestricted burning of waste which aims at metal recovery in particular. Burning results in emission of organic fractions EEE polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDFs), dioxin-like polychlorinated biphenyl (DL-PCBs) [3, 11].

The issue of WEEE toxicity was documented by many researchers and not only does concern developing countries. The threat of being exposed to chemical substances emission is also crucial for employees who work in e-waste plants and introduce systems of safety and hygiene management in the workplace. For example, Julander et al. [4] while analyzing the exposure biomarkers, noticed higher concentration of cadmium, chromium, mercury, indium and lead recycling workers' blood, urine and/or plasma (in reference to white collar workers) of three WEEE plants performing in Sweden.

Furthermore, Feldt et al. [12] conducted research concerning the threat of PAHs absorption among workers and people living in the area of Agbogbloshie (Accra, Ghana), called the world's largest e-waste dump. They analyzed body fluids (urine) of a group of people. Together with urine, the organism releases toxins, products of detoxification, medicines and their metabolites. So the urine analysis might be the source of information about toxins absorbed by the organism. Researchers noticed higher concentration of PAHs among employees exposed to emission from WEEE treatment. In addition, above mentioned people, more frequently complained about symptoms like: cough, chest pains and dizziness. Research results suggest direct influence of PAHs exposure [12].

Poland's EU accession required the obligation to adjust national legislation to European community standards. In accordance with the Directive 2002/96/EC on waste electrical and electronic equipment, member states committed to collect minimal rate of 4 kg on average per inhabitant per year (from 2006). The minimum yearly WEEE collection target has been in force for Poland since 2008. New directive on waste electronic

and electrical equipment with the transposition deadline of February 14, 2014 [13] came into effect on August 13, 2012. However, in Poland the legislation changes included in the directive 2012/19/EC have been passed by the Polish Parliament only on September 11, 2015 [14].

The crucial change is the new classification of electronic and electrical equipment. WEEE has been divided into six instead of ten specific categories: temperature exchange equipment, screens, monitors and other equipment containing screens having a surface >100 cm^2, lamps, small IT and telecommunication equipment (no external dimension more >50 cm), other small equipment (no external dimension >50 cm), other large equipment (with any external dimension >50 cm) [13,,14]. The new classification helps monitoring and collecting waste.

The 2012/19/EC Directive obliges distributors and retailers or all retail outlets with an EEE sales area of 400 m^2 or more, to take-back any small item (no dimension >25 cm) of WEEE at no charge to the consumer and without any obligation to buy anything new.

Furthermore, stricter targets for collection of waste have been introduced. The directive mentioned above requires reaching the level of 45% of collected waste since January 1st, 2016. Poland, among other countries, needs to reach over 40% (since August 14, 2016) [13]. The amount of gathered waste is calculated on the basis of the total weigh of WEEE collected and the average weight of EEE placed on the market in the three preceding years (in that member state). The minimum collection rate at least 4 kg per inhabitant per year of WEEE from private households was in force until December 31, 2015.

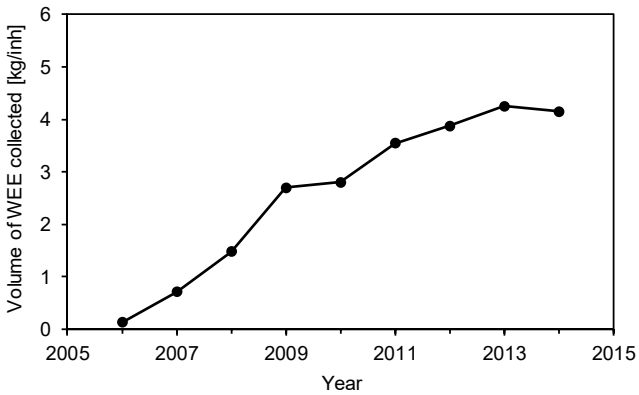

Fig. 3. Collection rates of WEEE from households in Poland from 2006 until 2014 (4 kg/(inh·year)) (based on [15])

Since 2006 in Poland Chief Inspectorate of Environmental Protection (CIEP) has been conducting a register of plants which introduce, collect, treat and deal with the

recovery of e-waste. Those companies submit reports concerning the volume of introduced, collected and recovered and recycled electronic and electrical equipment. On the basis of the reports the Chief Inspectorate of Environmental Protection (CIEP) reports about the WEEE management system functioning. The first report was published in 2007 [15]. Despite the ongoing WEEE management system development or informational and educational campaigns, the target of 4 kg per inhabitant per year was only reached in 2013 (Fig. 3). According to data from 2013, in Poland, 4.25 kg of WEEE were collected from households and the total WEEE collected reached 35.32% [15]. Undoubtedly, a disadvantage of the report above mentioned, published in 2014, (authors admitted that) was not covering 7000 reports and another 1200 which were wrongly prepared.

Similarly in 2012, over 8000 reports were not submitted and another 2500 needed correction. A verification in the second half of 2013 enabled to state that if the WEEE collectors had submitted statutory required reports on time, the volume of WEEE collected from household would reach 4.34 not 3.88 per inhabitant per year [15].

The basis of effective WEEE management besides enforced legislation is people's awareness concerning the influence of substances contained in e-waste on human health. The introduction of compulsory selective e-waste collection and establishing drop off points is not sufficient to meet the European Union directives. A lack of proper education causes e-waste to be thrown away with other municipal solid waste (MSW), scrap yards or informal recycling/disposal points. The confirmation of the above mentioned statement is that Poland reached the target of 4 kg of WEEE per inhabitant per year not until 2013 (4 years later than it had been declared).

2. RESEARCH OBJECTIVE AND AREA

The objective of the research was to analyze the social behavior concerning the WEEE within the context of the current selective collection system. The investigated group were inhabitants of Lwówek Śląski (51°06′39.1″N 15°35′08.8″E), a small town (surface area of 17 km^2) located in Lower Silesia, 55 km from Zgorzelec (Polish-German border) and 42 km from border-crossing in Czerniawa Zdrój (Polish-the Czech border). According to the Data Bank of Central Statistical Office, in 2013 Lwówek Śląski had 9271 inhabitants. Its main source of income is tourism. An average monthly available income (the sum of current household income from different sources decreased by prepayments on personal income tax social security and health insurance premiums) was 1367 PLN per person in a household [16].

According to Act on WEEE [14], the EEE users duty is to return WEEE to collection facilities. The inhabitants may dispose WEEE for free: (i) in a service point when fixing the device is not possible or it is unprofitable (service point may refuse to take equipment that may be hazardous to health or life of people who collect e-waste),

(ii) may leave used equipment when they buy a new one of the same kind, (iii) may give it away during "one-day e-waste collection events" organized by town/commune, collection and treatment facilities (iv) may leave it at retail shops with sales areas relating to EEE of at least 400 m^2, in e-waste drop off points including recycling centers or scrap yards, registered in Chief Inspectorate of Environmental Protection, with a permission to collect e-waste. Not registered facility performing illegally might receive a 10 000–50 000 PLN fine [14].

In accordance with Article 3 (2) as amended in June 2011 act on maintaining the cleanliness and order in communes, communes take over the obligation of creating points of selective municipal waste collection (recycling center). Inhabitants may leave there free of charge recyclable waste and other waste which cannot be thrown to municipal solid waste or recycling bins. Consistently with the act mentioned above [17], inhabitants should have an easy access to the recycling centers. The guidelines prepared for the Ministry of the Environment suggest that there should be at least one recycling center for 80–100 thousand inhabitants. 3 or 4 of smaller communes might be serviced by one recycling center. It means that some communes (especially in the countryside) may not have their own selective collection drop off points. It is hard to say that in such situation, the inhabitants have an easy access to drop off points. On the other hand, if a recycling center may service a commune up to 100 000 inhabitants for most of them it will mean that they have to cover a distance of a few kilometers. For example, in September 2014 in Wrocław with a population of over 630 000 there were only two recycling centers.

In Lwówek Śląski, WEEE drop off point (51°06′35.4″N 15°34′51.0″E) was established by the commune in September 2011. It was opened on Thursdays only from 10 a.m. till 2 p.m. and it did not take incomplete facilities, e.g. broken TVs, refrigerators without compressors, cases, etc. After analyzing the performance of the point, it could be easily concluded that giving away e-waste meant taking a day off at work. The changes were introduced in January 2014 when the Municipal Department of Waste Management in Lwówek Śląski established a recycling center instead of WEEE drop off point. The center was open Tuesday–Friday, and on the first and third Saturday of each month a few hours per day, not in the afternoon. The recycling center accepted only complete equipment together with power supplying cables [18]. Additionally, the Municipal Department of Waste Management offered extra paid transport of waste to the recycling center. The price list is given in Table 1.

In reference to inhabitants' earnings, the cost of service was quite high. For example, the cost of transport of a refrigerator from a town household was about 120 PLN, it was 4–22% of a budget of an inhabitant excluding costs of living like: food, accommodation fees, health, communication, relax and education.

During the research conducted in Poland, the 4.25 kg on average per inhabitant per year of WEEE were collected. According to the Register of Entrepreneurs and the WEEE Recovery Organisation, there were five plants which collected WEEE in

Lwówek Śląski in 2013 (Fig. 4). The main receiver was the Municipal Department of Waste Management operating own Recycling Center where the inhabitants may leave freely unlimited amount of e-waste from households (Fig. 4, point a). Additionally, in November 2013 and 2012 the inhabitants could give away their e-waste during an event organised by the Municipal Office.

Table 1

Price list of the transportation to the recycling center [18][a]

Region	Time	Heavy goods vehicle up to 3.5 t	Heavy goods vehicle over 3.5 t
Town area	up to 1 hour	60 PLN/rate of exchange	100 PLN/rate of exchange
	over 1 hour	surcharge 30 PLN/commenced hour	surcharge 50 PLN/commenced hour
Outside town area	up to 1 hour	40 PLN plus 2.5 PLN/km starting from leaving the center	70 PLN plus 3.0 PLN/km starting from leaving the center
	over 1 hour	surcharge 30 PLN per commenced hour	surcharge 50 PLN per commenced hour

[a]The price does not include loading and unloading as well as VAT tax (23%).

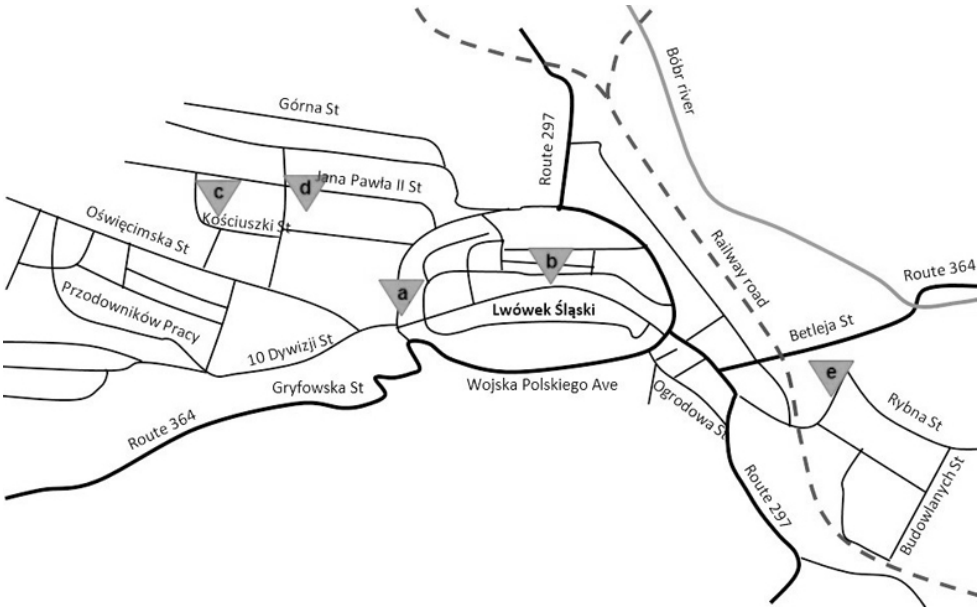

Fig. 4. The location of WEEE collection points in Lwówek Śląski for WEEE falling under categories: a) 1–7, b) 1–3 and 5, c) 1–4 and 6–8, d) 3 and 4, e) 1–10, of the Annex IA of Directive 2002/96/EU

3. INTERVIEW SURVEYSH

3.1. METHODOLOGY

The research was conducted between October and November 2013. The survey form consisted of 10 questions concerning: (i) characteristics of respondents (age, occupation, number of people in a household), (ii) ways of dealing with WEEE, and (iii) evaluation of the current e-waste management system.

The issues concerning harmfulness of e-waste and their proper treatment are a novelty in Poland. The first act of law was an Act on WEEE passed in 2005. Therefore in this study, the target research group were pupils and students who should have had fresh knowledge about threats connected with WEEE. Additionally, in rural areas or small towns in Poland, multigenerational families are frequent (two, three generations living together in one household). In such cases, the young who grew up in the world of new technologies should be the ones who share information and shape the attitudes of older people.

In the research, 122 respondents took part. They were inhabitants of Lwówek Śląski (assuming: 95% confidence level, 9% confidence interval, and 50% picking a choice), each of them represented one household. The interviewees were 1.3% of the town's population, it was much over the average in reference to waste management research literature data [7, 19]. From a few research survey techniques: (i) direct interview of an interviewer and interviewee, (ii) telephone conversation, (iii) online survey supervised by a computer system, direct contact with a respondent was chosen, conducted usually in public places. Each of the interviewees filled in the form independently and then gave it to the interviewer. In the case of a telephone conversation or an online survey, there was a probability of low response rate or false respondents answers. It especially concerned questions (important for the authors) about characteristics of respondents for example age.

3.2. RESULTS AND DISCUSSION OF THE SURVEY

The analysis of characteristics of respondents has shown that most of the interviewees (about 60%) were young people aged 16–25. Women more willingly answered the questions, they were 63% of the group. Except pupils (46%) and students (14%) (target group), also people with stable work or entrepreneurs (about 38% of respondents) took part. In the group mentioned, people aged 36–55 with secondary or higher education prevailed (Fig. 5). The retired and pensioners constituted only 2%, so they could not be considered as a representative group.

The majority of interviewees (33%) represented 4 person households, 18% – 3 and 5 persons households and 14% – 2 and 6 person households. High proportion of 5 and 6 persons households confirmed the presence of the numerous and multigenerational

families. Gathered data shows that the research covered over 5% of households from the area of Lwówek Śląski.

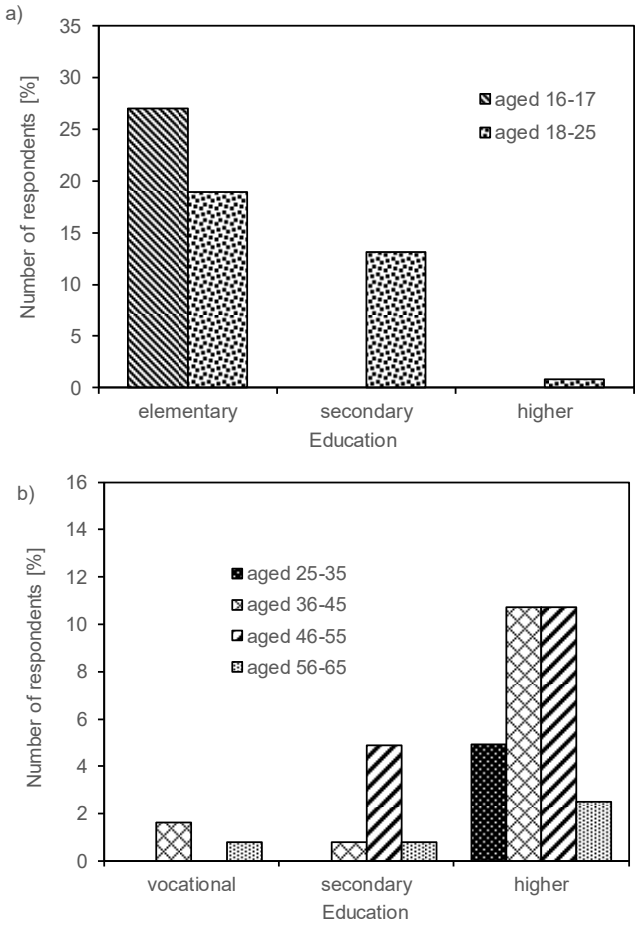

Fig. 5. Age and education of the respondents:
a) pupils and students, b) people with stable work or entrepreneurs

The main objective of the research was to gather information about the ways of dealing with WEEE performed by the inhabitants. In addition, hazardous e-waste also contains many valuable materials (such as iron, copper, aluminum and plastics) and precious metals (like gold, silver, platinum and palladium) that can be recycled. Iron and steel constitute about 48% of the e-waste, followed by plastics (21%), non-ferrous metals (13%) (Fig. 6) [20, 21]. From the resource perspective, e-waste is a potential "urban mine" that could provide a great amount of secondary resources [5]. According

to a literature survey [21], cell phones, calculators, and printed circuit board scraps contain a large number of precious metals. The precious metals make up more than 70% of their value. It is important to notice that 84.3% of residents were aware of the valuable materials embedded in electronic products. Unfortunately, despite their knowledge about WEEE, the official collection rates through formal take-back systems are quite low (Figs. 2, 3).

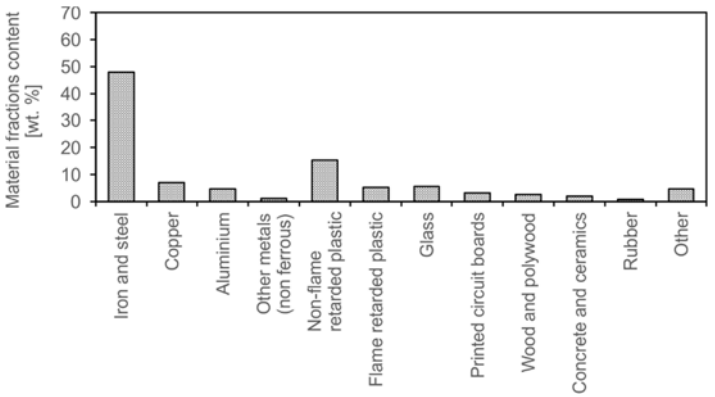

Fig. 6. Composition of e-waste (based on [20])

About 30% of respondents stated that they take WEEE (mostly damaged equipment) to the recycling center which should be organized by the commune accordingly with the Act on Cleanliness [17]. Unfortunately, as much as 43% of people who declared such a behavior were not able to indicate the recycling center location.

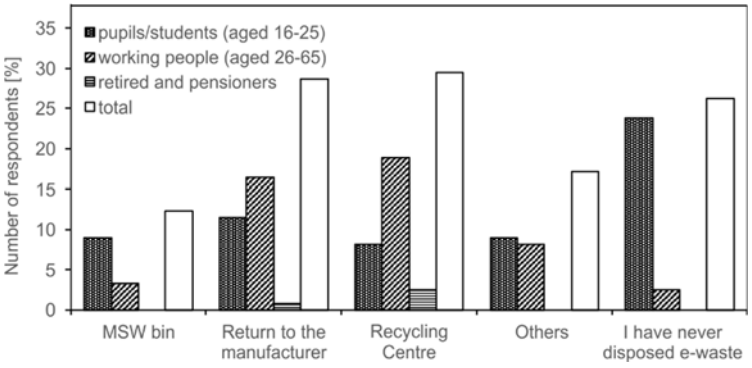

Fig. 7. Methods of disposal of household WEEE

The lack of proper education results in people's ignorance why they should segregate e-waste. The obligatory ban of putting WEEE into municipal solid waste or disposal in random places [14] might be fined even 5000 PLN. 12% of interviewees (over

18–6%) admitted that they throw away WEEE to mixed municipal waste containers or leave in MSW the drop off points (mostly large household appliances, Fig. 7). Partly, it may be the result of high costs of transport to the recycling center (in the case of large and heavy EEE).

Fig. 8. WEEE thrown to the MSW bin, around 1000 m from the recycling center, Wrocław, Poland (taken by Kamil Banaszkiewicz, 30.10.2014)

Fig. 9. TV left on the municipal solid waste collection site, around 650 m from the recycling center, Wrocław, Poland (taken by Kamil Banaszkiewicz, 17.10.2014)

Figures 8 and 9 show e-waste left by the inhabitants of Wrocław (Lower Silesia) in places prepared for collection of municipal solid (MSW), only few hundred meters from the recycling center. It is frequent that left e-waste is dismounted and valuable elements go to the scrap yard (also in this case of disassembling WEEE there is a fine of 10 000–500 000 PLN [14]). The improvement in e-waste management by inhabitants

has been noticed. In research conducted in 2011 in Oborniki Śląskie area (a town of similar size as analyzed Lwówek Śląski, also located in Lower Silesia), 26% of respondents admitted that they throw away small e-waste into mixed waste containers [22]. Gathered data was similar to data reported by researchers in Malaysia [7] where 30% of interviewees – inhabitants of Kuala Lumpur admitted to throwing e-waste to the waste containers. In EU, 0.7 million t per year of mainly small appliances end up in the waste bin. This fraction is mainly comprised of small equipment such as mobile phones, lamps, electrical toothbrushes, toys, etc. [5, 6]. In 2010–2011, the top countries with the highest e-waste disposal in mixed residual waste were Great Britain (6.33 kg/inh), Estonia (3.76 kg/inh), and the Czech Republic (2.32 kg/inh) [5].

Due to enforced legislation, whenever you buy a new appliance, the seller is bound to receive WEEE of the same type, (one to one). 28% of respondents stated that they behave in this way. It is important to notice that for 65% of this group it is the only way of WEEE management. It is not known what the 18% of respondents (65% of the analyzed group) do with e-waste (if they do not buy a new device of the same type and therefore cannot leave the old one in the shop). The respondents from Oborniki Śląskie (Poland) [22], Thaizhou (China) [23] or Kuala Lumpur (Malaysia) [7] frequently indicated that the broken or obsolete appliances are stored at homes/warehouses (garages/basements, etc.)

The respondents (about 17%) who ticked "other ways of WEEE treatment" were asked to complete their answer. Over 7% of interviewees (about 43% of the group) admitted that they also give away WEEE during e-waste collection events called also mobile collection. In the area of Lwówek Śląski, the inhabitants could deposit their e-waste twice in September of 2012 and 2013. The mobile collection point was located in the town center near the Town Hall. This type of collection should be developed and done repeatedly for example 3–4 times a year in the area of particular town districts or housing estates. Collection done regularly by recycling facilities should decrease the amount of e-waste in mixed MSW. Among other answers concerning WEEE treatment (9.8% of respondents) respondents mentioned: (i) giving away WEEE to scrap yards, (ii) giving away WEEE to the poor or (iii) selling WEEE. Only by disposing e-waste at a registered by the Chief Inspectorate of Environmental Protection scrap yards which have permission for collecting waste we can be sure that the waste will be managed and treated properly. Otherwise, the waste will probably be recycled informally.

By giving EEE to the poor (if the appliances still work) we lengthen the equipment's life-cycle but we are not sure if the appliances are re-used or recycled improperly (dismantling the valuable parts and leaving the rest) (Figs. 9–11). Unfortunately, due to a range of social and economic factors, the informal sector continues to play a major role in the collection and recycling of e-waste (especially in developing countries) [5, 7, 23, 24]. Furthermore, informal sector often leads to detrimental effects on the environment and human health. Additionally, many precious metals are wasted during informal recycling [25].

Fig. 10. TVs left on the municipal solid waste collection site, around 300 m from the recycling center, Wrocław, Poland (taken by Kamil Banaszkiewicz, 20.10.2014)

Fig. 11. Refrigerator left on the municipal solid waste collection site, around 300 m from the recycling center Wrocław, Poland (taken by Kamil Banaszkiewicz, 20.10.2014)

Another vital information is that 26% of respondents claimed that they had never given away WEEE. The most of the group were respondents aged 18–26 (47%) and 16–17 (43%). It is unlikely in the age of technology that a person over 18 had never had any e-waste. Furthermore, younger consumers, more often update their EEE products, e.g., due to their desire to update and obtain new software, not due to breakage of the machine [7]. As a result, it is decreasing lifespan of all consumer electronic and electric equipment (e.g., the average lifespan of computer is estimated to be 2 to 3 years, in the case of mobile phones it is from 1 to 2 years) [7]. Choosing this answer is probably dictated by the fear of revealing the truth about ways of WEEE treatment (for example

storing and throwing them away into mixed waste containers). It is highly alarming as the young should be the ultimate source of knowledge for the older generations and be aware of threats concerning inappropriate WEEE treatment.

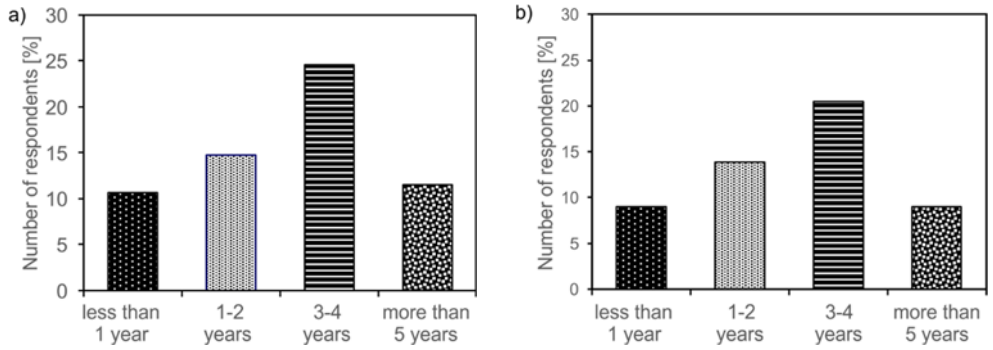

Fig. 12. Time of selective WEEE collection performed by respondents
a) 100% of answers, b) excluding the answers of respondents who were not able to give location of the recycling center and it was the only way of WEEE treatment they had mentioned

The research showed that over 65% of respondents gathered WEEE in a selective way (Fig. 12). Some respondents who admitted that they deposit all their WEEE to the recycling center could not indicate its location. Therefore, it was not possible to assume that 100% of answers were true. Figure 12 shows the time of conducting the selective WEEE collection by the respondents (excluding the ones who admitted that they put some WEEE into mixed waste): (a) 100% answers, (b) excluding the answers of respondents who were not able to give location of the recycling center and it was the only way of WEEE treatment they had mentioned. Most of people who segregated waste (over 52%) performed a selective collection less than 4 years (34.4%; including 23% less than 2 years). The commune established the drop off point in November 2011, that is 2 years before the research.

Over 47% of interviewees claimed that there are not enough WEEE drop off points (Fig. 4). A partial solution to the problem is launch of the collection at retail shops with sales areas relating to EEE of at least 400 m^2, or in their immediate proximity of very small WEEE (no external dimension more than 25 cm) [13, 14]. Only 25.4% of respondents stated that e-waste collection system is well-organized; 42.6% of a group had no opinion about it.

4. CONCLUSIONS

• Conducting social research may be difficult because of: (i) the risk of low response rate or (ii) the risk of giving untrue information. Answering the interviewer directly increases the amount of received answers but on the other hand it may stress the

respondent. Some of the interviewees (probably because of the lack of knowledge or being aware they deal with e-waste incorrectly) gave contradictory, excluding answers. For instance a group of respondents claimed that they had never disposed of WEEE before and performs a selective WEEE collection for a few years at the same time.

- Even though legislation on WEEE has been enforced, the model of WEEE from the households management is non-effective. Low awareness of the society regarding the e-waste threats causes people throw them away into the mixed waste containers (12% of respondents). The issue mostly applies to the youth who were the target research group. Many people aged 18–25 (12% of respondents) claimed that they had never disposed of e-waste before. It seems impossible in the age of fast IT development. It can be presumed that the respondents were unwilling to share true information regarding their WEEE management (for example: storing). The research confirmed that some expenditures for informational and educational campaigns (targeted at elementary and secondary students especially) are necessary to raise public awareness and motivate people to perform selective WEEE collection. Additionally, each household should get a leaflet covering the information about; harmfulness of WEEE, proper ways of WEEE treatment and the locations of the drop off points or dates of mobile collection events.
- It is common that appliances left at municipal waste drop off points are dismantled and valuable parts are removed. The removal is done roughly and it causes contamination. For example, while disassembling refrigerators' compressors there is an emission of ozone-depleting substances. Parts get to informal sector yards not registered by the Chief Inspectorate of Environmental Protection, without legal permission to collect e-waste. Legislation introduced fines for illegal collection or WEEE treatment so it is important for Chief Inspectorate of Environmental Protection to intensify inspections to eliminate informal sector.
- Over 47% of respondents stated that there are not enough WEEE drop off points. Too few e-waste drop off points makes inhabitants travel long distances. Inhabitants' low income restricts the possibility to use the service of transport of WEEE to the recycling center offered by the commune. Above mentioned situation may easily discourage inhabitants from selective waste collection. The solution might be opening in the area of Lwówek Śląski mobile collection points which would gather not only e-waste but all hazardous waste from the households (regularly from the particular parts of the town). 7% of interviewees claimed that they give away WEEE during one-day e-waste collection events. Repeated collection from the particular parts of the town done for example 3–4 times a year should decrease the amount of WEEE in the stream of municipal waste.
- Data gathered during the research might be very useful while planning selective household waste collection (different groups of waste) system. Taking into consideration the inhabitants opinions should engage them into individual e-waste collection and applying enforced by law minimum collection rate of WEEE from private households.

REFERENCES

[1] FREEGARD K., TAN G., MORTON R., COGGINS C., FORES D., ALGER M., CRACKNELL P., MAEURER A., STUDDS P., FREER E., HUSIMAN J., *Develop a process to separate brominated flame retardants from WEEE polymers*, Final Report, 2006. Available from: www.wrap.org.uk (accessed 9.10.2014).

[2] KIDDEE P., NAIDU R., WONG M.H., *Electronic Waste Manage. approaches. An overview*, Waste Manage., 2013, 33 (5), 1237.

[3] FRAZZOLI C., ORISAKWE O.E., DRAGONE R., MANTOVANI A., *Diagnostic health risk assessment of electronic waste on the general population in developing countries' scenarios*, Environ. Impact Assess. Rev., 2010, 30 (6), 388.

[4] JULANDER A., LUNDGRENA L., SKAREA L., GRANDÉRA M., PALMA B., VAHTERA M., LIDÉNA C., *Formal recycling of e-waste leads to increased exposure to toxic metals: An occupational exposure study from Sweden*, Environ. Int., 2014, 73, 243.

[5] BALDÉ C.P., WANG F., KUEHR R., HUISMAN J., *The global e-waste monitor 2014*, United Nations University, IAS-SCYCLE, Bonn, Germany, 2015.

[6] HUISMAN J., BOTEZATU I., HERRERAS L., LIDDANE M., HINTSA J., LUDA DI CORTEMIGLIA V., LEROY P., VERMEERSCH E., MOHANTY S., VAN DEN BRINK S., GHENCIU B., DIMITROVA D., NASH E., SHRYANE T., WIETING M., KEHOE J., BALDÉ C.P., MAGALINI F., ZANASI A., RUINI F., BONZIO A., *Countering WEEE Illegal Trade (CWIT). Summary Report, Market Assessment, Legal Analysis, Crime Analysis and Recommendations Roadmap*, Lyon, France, 2015.

[7] AFROZ R., MASUD M.M., AKHTAR R., DUASA J., *Survey and analysis of public knowledge, awareness and willingness to pay in Kuala Lumpur, Malaysia. A case study on household WEEE management*, J. Cleaner Prod., 2013, 52, 185.

[8] ROBINSON B.H., *e-Waste. An assessment of global production and environmental impacts*, Sci. Total Environ., 2009, 408, 183.

[9] HIRSCH A., *Ghana accuses UK recycling firm Environcom of illegal fridge imports*, The Guardian, 4 November 2013. Available from: http://www.theguardian.com/world/2013/nov/04/ghana-uk-environcom-illegal-fridge-imports (accessed: 9.10.2014).

[10] STHIANNOPKAO S., WONG M.H., *Handling e-waste in developed and developing countries. Initiatives, practices, and consequences*, Sci. Total Environ., 2013, 463–464, 1147.

[11] WITTSIEPE J., FOBIL J.N., TILL H., BURCHARD G.D., WILHELM M., FELDT T., *Levels of polychlorinated dibenzo-p-dioxins, dibenzofurans (PCDD/Fs) and biphenyls (PCBs) in blood of informal e-waste recycling workers from Agbogbloshie, Ghana, and controls*, Environ. Inte., 2015, 79, 65.

[12] FELDT T., FOBIL J.N., WITTSIEPE J., WILHELM M., TILL H., ZOUFALY A., BURCHARD G., GÖEN T., *High levels of PAH-metabolites in urine of e-waste recycling workers from Agbogbloshie, Ghana*, Sci. Total Environ., 2014, 466–467, 369.

[13] Official Journal the European Union, Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE).

[14] J. Laws of the Republic of Poland, Act as of 11 September 2015 on WEEE J. Laws 2015, position 1688 (in Polish).

[15] Chief Inspectorate of Environmental Protection (CIEP), *Waste Electrical and Electronic Equipment Management System Functioning Report, 2007–2015* (in Polish).

[16] Central Statistical Office (CSO), *Household budget survey in 2012*, Warsaw 2013.

[17] Journal of Laws of the Republic of Poland: Parliament Speaker's notice as of 13 September 2013 concerning consolidated text of Act on cleanliness., J. Laws, 2013, position 1399 (in Polish).

[18] Public Information Bulletin (PIB), *Lwówek Śląski commune and town: Selective Municipal Waste drop off point in Lwówek Śląski – regulations*, 2013. Available from: http://www.bip.lwowekslaski.pl/wiadomosci/1/wiadomosc/219345 (accessed: 19.10.14) (in Polish).

[19] DE FEO G., DE GISI S., *Public opinion and awareness towards MSW and separate collection program mes. A sociological procedure for selecting areas and citizens with low level of knowledge*, Waste Manage., 2010, 30, 958.
[20] HUISMAN J., MAGALANI F., KUEHR R., MAURER C., *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE). Final Report*, United Nation University, Bonn, Germany, 2007.
[21] CUI J., ZHANG L., *Metallurgical recovery of metals from electronic waste. A review*, J. Hazard. Mater., 2008, 158, 228.
[22] BANASZKIEWICZ K., PASIECZNIK I., RACZ P., *Evaluation of effectiveness of municipal solid waste collection*, [in:] T. Traczewska (Ed.), *Interdisciplinary issues in engineering and environmental protection*, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2013, 23–33 (in Polish).
[23] CHI X., WANG M.Y.L., REUTER M.A., *E-waste collection channels and household recycling behaviors in Taizhou of China*, J. Cleaner Prod., 2014, 80, 87.
[24] LI J., ZENG X., CHEN M., OGUNSEITAN O.A., STEVELS A., *Control-Alt-Delete: rebooting solutions for the e-waste problem*, Environ. Sci. Technol., 2015, 49 (12), 7095.
[25] GU Y., WU Y., XU M., MY X., ZUO T., *Waste electrical and electronic equipment (WEEE) recycling for a sustainable resource supply in the electronics industry in China*, J. Cleaner Production, 2016, 127, 331.