



Waste problem in European Union and its influence on waste management behaviours

Audronė Minelgaitė^a, Genovaitė Liobikienė^{a,b,*}

^a Department of Environmental Sciences, Vytautas Magnus University, Vileikos st. 8, LT-44404 Kaunas, Lithuania

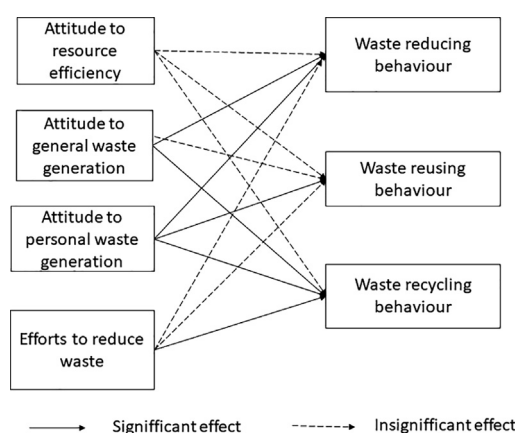
^b Lithuanian Institute of Agrarian Economics, V. Kudirkos g. 18, Vilnius 01113, Lithuania



HIGHLIGHTS

- In EU significant differences was observed in terms of municipal waste generation.
- The level of waste generation significantly depended on economic development.
- The relationship between recycling behaviour and waste generation was significant.
- Attitudes to personal waste generation influenced reducing and recycling behaviours.
- Efforts to reduce waste influenced only waste recycling behaviour

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 10 January 2019

Received in revised form 18 February 2019

Accepted 20 February 2019

Available online 22 February 2019

Editor: Huu Hao Ngo

Keywords:

Waste management

Recycling

Waste minimisation

EU

Waste policy

Attitude to waste generation

ABSTRACT

Waste generation is a critical problem globally and even in the European Union (EU). In EU countries, significant differences have been observed in terms of municipal waste generation. The level of waste generation significantly depended on economic development. The most effective tools for solving the waste problem should be the enhancement of reducing, reusing, and recycling behaviours. However, our results revealed that the level of reducing and reusing behaviours insignificantly influenced waste generation. Thus, countries seeking to minimize waste generation should also pay more attention to the promotion of sustainable consumption and production. Meanwhile, the relationship between recycling behaviour and waste generation was positive and statistically significant. Analysing the determinants of waste management behaviours, attitude to personal waste generation significantly contribute to all waste management behaviours. Meanwhile, attitudes to general waste management significantly but negatively influence waste reducing and recycling behaviours. Thus, only these respondents who understand that they personally contribute to waste problem, more perform waste management behaviours. Furthermore, the efforts to reduce waste significantly influenced only recycling behaviour while attitude to resource efficiency insignificantly determined all waste management behaviours, revealing that people in the EU have a lack of knowledge about the relationship between waste reduction and resource efficiency.

© 2019 Elsevier B.V. All rights reserved.

* Corresponding author at: Department of Environmental Sciences, Vytautas Magnus University, Vileikos st. 8, LT-44404 Kaunas, Lithuania.
E-mail address: genovaite.liobikiene@vdu.lt (G. Liobikienė).

1. Introduction

The waste problem, due to the growing global population, consumerism and the linear approach to industrialisation, has become an increasingly severe issue in the 21st century (Stoeva and Alriksson, 2017; D'Amato et al., 2016; Feo et al., 2019). As people's lives become more affluent, the amount of waste increases (Malinauskaite et al., 2017) and global solid waste generation is expected to triple by 2100 (World Bank, 2013). The reduction of waste contributes to the natural resource depletion, environmental pollution, for which treatment in recent years is paid so much attention (Zhang et al., 2017a; Huang et al., 2018; Liu et al., 2018; Zeng et al., 2016). Furthermore, globally, and even in European Union (EU) countries, landfill rates are still high; meanwhile, waste prevention and recycling rates are too low (Pietzsch et al., 2017; Samadder et al., 2017). Therefore, the efficiency and success of waste management are more important than ever.

The priorities of EU waste management policy, in ascending order is the disposal of waste, energy recovery, recycling, reuse, and waste prevention (Stoeva and Alriksson, 2017). Authors agreed that waste reducing, reusing, and recycling (3R) behaviours have been widely accepted tools of waste management (Ma et al., 2018; Pandey et al., 2018; Matsuda et al., 2018). This waste management hierarchy also plays a central role in greening the household waste sector by minimizing waste generation and in achieving a circular economy (Pandey et al., 2018; Stoeva and Alriksson, 2017; Awasthi et al., 2018; Pietzsch et al., 2017; Millward-Hopkins et al., 2018). However, EU waste policies mostly defined targets for waste reduction (reducing waste mostly by recycling) despite waste prevention (avoidance of waste) being at the top of the 'waste solution hierarchy' (Cecere et al., 2014; Wilts et al., 2013). The European Commission proposed targets to reuse and recycle municipal waste at least by 70% before 2030 (including a minimum of 5% of total municipal waste for reuse) (Malinauskaite et al., 2017). Thus, EU targets on waste prevention are very recent and waste management is in its initial stages (Pietzsch et al., 2017).

In this paper we examine the waste problem in EU. The main attention is paid to impact of waste management behaviour on waste generation. Thus, referring to Eurostat waste generation database and the Eurobarometer survey "Attitudes of Europeans towards waste management and resource efficiency" conducted in 2014, we analyse the tendencies of waste 3R behaviours in EU countries, and we reveal whether the gap between declared behaviour and real changes in waste generation exists or not. Considering that only a few of authors have analysed the determinants of all three waste management (i.e. waste 3R behaviours) behaviours (Barr et al., 2001; Barr, 2007; Tonglet et al., 2004), and also the effects of attitudes on waste generation as the problem, to the best of our knowledge, have not been analysed yet, we provide new insights into the subject.

2. Literature review

The growth of waste generation is a serious problem. The EU countries on average produce about 482 kg per capita of waste annually. Authors have stated that to achieve the success of the actions related to waste management seeking waste growth decrease, or better the reduction of waste generation, public acceptance and behaviour are the most important (Pietzsch et al., 2017; Wan et al., 2017, 2018). Authors have analysed the gap between intention and behaviour (Stoeva and Alriksson, 2017; Ma et al., 2018) and found that intention to act (to reduce waste generation or to sort the waste) does not always translate into actual waste behaviour, suggesting limited volitional control. The gap between waste management intentions and behaviours could occur due to factors such as cultural context, lack of infrastructure, or habits (Stoeva and Alriksson, 2017). In this paper, we expand the gap theory and we reveal whether declared behaviour (as waste 3R behaviours) really contributes to changes in waste generation.

In any case, a good understanding of the factors influencing individuals' waste 3R behaviours are essential to tackling the problem of waste effectively (Cecere et al., 2014). In the literature, the majority of authors analysed the determinants only of one type of waste management behaviour (or intention) as recycling (Tonglet et al., 2004; Wang et al., 2018; Stoeva and Alriksson, 2017; Sheau-Ting et al., 2016; Zhang et al., 2017b; Conke, 2018 and etc.), reusing (Bortoleto, 2014) or prevention behaviour (Bortoleto et al., 2012). Meanwhile, other authors (as D'Amato et al., 2016; Ebreo and Vining, 2001) analysed the determinants and the relationship between recycling and reduction behaviours. Mosler et al. (2008) analysed the determinants of recycling, composting, and reusing behaviour. Only a few of authors analysed the determinants of all three waste management (i.e., waste 3R behaviours) behaviours (Barr et al., 2001; Barr, 2007; Tonglet et al., 2004). Therefore, there is still a lack of research that encompass the determinants of all three waste management behaviours, particularly in the EU.

Authors analysing the determinants of different waste management behaviours, particularly recycling behaviour, typically referred to external determinants as systems for the collection (Conke, 2018), institutional preferences (Cecere et al., 2014; D'Amato et al., 2016), the conditions concerning how easy or difficult performance of the waste management behaviour is (Bortoleto et al., 2012; Ma et al., 2018; Stoeva and Alriksson, 2017; Zhang et al., 2017b), destination from bins (Conke, 2018; Sheau-Ting et al., 2016), and social factors (Bortoleto et al., 2012; Ma et al., 2018; Stoeva and Alriksson, 2017; Tonglet et al., 2004). In terms of internal factors, authors explored the different aspects of attitudes. Some of them analysed the attitudes to recycling (Tonglet et al., 2004; Ma et al., 2018; Zhang et al., 2017b; Bortoleto et al., 2012), which reveals the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour (Wang et al., 2018). Other authors examined the environmental attitude, awareness, environmental values, environmental concern, or awareness towards the environmental problems (Barr et al., 2001; Ebreo and Vining, 2001; Stoeva and Alriksson, 2017; D'Amato et al., 2016). These variables reveal the general attitude to the environment and how people generally care about the environment and its problems. Meanwhile, only a few authors explored the concerns about the consequences of waste (Barr et al., 2001; Adam et al.,

Table 1
Items of waste management behaviours.

| Constructs | Items |
|---------------------------|---|
| Waste reducing behaviour | I avoid food waste and other types of waste by buying exactly what I need, I avoid buying 'over packaged goods'. I have made an effort to stop receiving unwanted mail, I undertake home composting, I use rechargeable batteries, I drink tap water to avoid packaging waste, I donate/sell items for reuse, I make an effort to get broken appliances repaired before buying new. |
| Waste reusing behaviour | I purchase second-hand products as textiles (e.g., clothing, bedding, curtains,). electronic equipment (e.g., TV, computer), furniture (couch, table, chairs, etc.), household electrical appliances (e.g., oven, dishwasher), books, CDs, DVDs, video games, none of these products, remanufactured product. |
| Waste recycling behaviour | I sort the following types of waste: paper/cardboard/beverage cartons, plastic bottles or other plastic materials, metal cans, glass, kitchen waste, garden waste, household hazardous waste (e.g., paint, chemicals, batteries), electrical and electronic waste, others. |

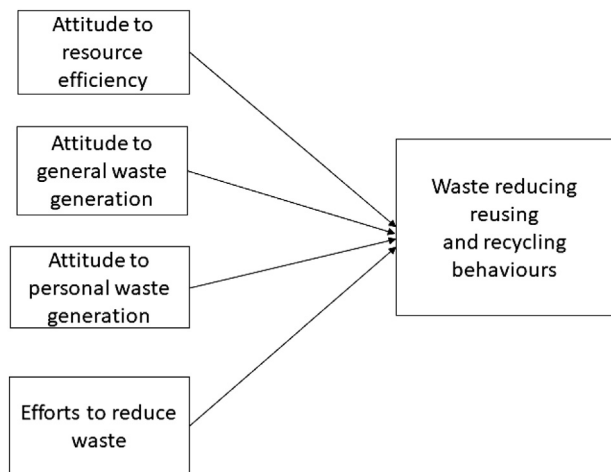


Fig. 1. Scheme of proposed model.

2015; Zhang et al., 2017b) and the awareness of waste recycling consequences (Wan et al., 2017; Tonglet et al., 2004). However, the effects of attitudes on waste generation as the problem, to the best of our knowledge, have not been analysed yet. Therefore, in this paper, we analyse the impact of attitudes to general and personal waste generation on waste 3R behaviours. The attitude to general waste management reveals the perception of waste as a serious problem, and personal waste generation should reveal the level of understanding of responsibility.

Referring to the Norm Activation theory proposed by Schwartz (1977), norm activation begins with an individual's awareness of conceivably detrimental consequences and his or her assumption of responsibility for not behaving in environmentally friendly mode (Stern et al., 1999). Therefore, pro-environmental behaviour is essential to be aware of environmental problems, in this case the increasing waste generation. Raising awareness is seen as a primary tool changing human behaviour particularly in circumstances where particular environmental problems emerge. Conke (2018) declared that one of the categories of

barriers to general pro-environmental behaviour is acceptance that the problem exists and is relevant.

Moreover, in this paper, we also analyse the effects of attitude on waste reduction consequence as resource efficiency, and the efforts to reduce the waste on waste management behaviours. As Williams and Taylor (2004) declared, the public needs to be educated to think of waste as a resource rather than as goods that just need to be thrown away. Lehman and Geller (2005) also pointed out that knowing the consequences of some behaviour affects its repetition and continuance, especially in pro-environmental behaviour.

Therefore, the main aim of this paper is to reveal the degree of waste problem in EU countries and to show how waste management behaviours contribute to solution of waste problem, and reveal how the perception of waste problem influences waste management behaviours.

3. Methodology

In order to reveal the waste problem in EU countries, the cross-country correlation between municipal waste generation (expressed in kg per person), growth rate (in the period of 2006–2016), and initial (in 2006) municipal waste generation level was analysed. Moreover, analysing the effect of economic development on municipal waste generation the gross domestic product (GDP) per capita in purchasing power parity (constant 2011 international \$) was used. To evaluate these relationships, the Spearman correlation coefficient was applied. The study covers all the EU countries. Only Luxemburg was excluded, where the GDP level is 3 times higher comparing with the EU average.

Furthermore, in this study, we separately analysed waste management (waste 3R behaviours) behaviours. Referring to the Eurobarometer survey “Attitudes of Europeans towards waste management and resource efficiency” conducted in 2014, we evaluated the tendencies and main determinants of these behaviours. This survey was carried out by the TNS Political & Social network in all EU countries between the third and seventh of December 2013. The respondents from different social and demographic groups were interviewed via telephone. The detailed interview methods and confidence intervals are presented in the report of European Commission (EC, 2014). The waste 3R behaviours were estimated by summing the dichotomous

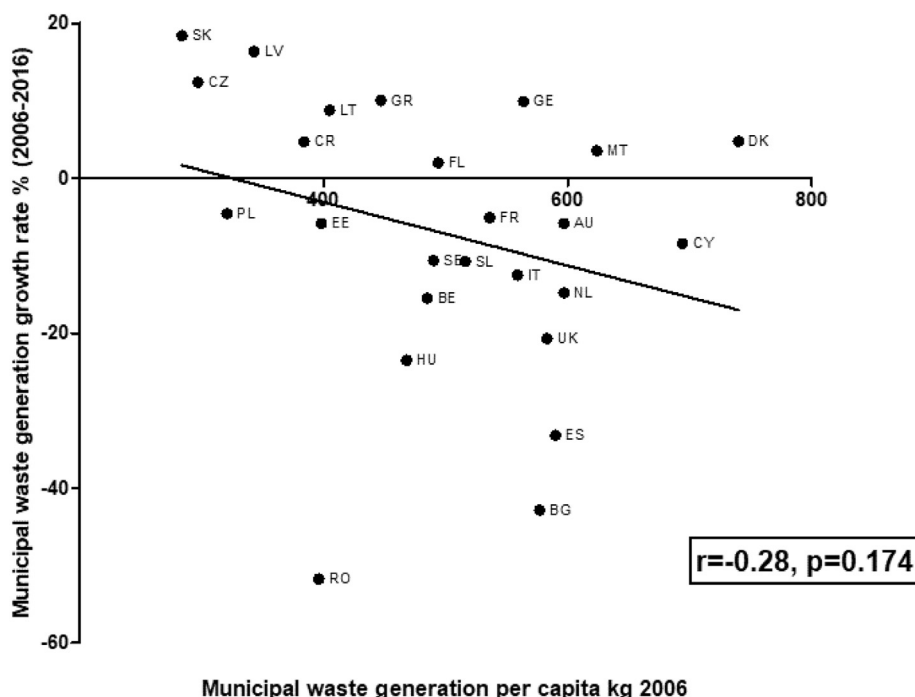


Fig. 2. Cross-country relationship between municipal waste generation in 2006 and growth rate during the period of (2006–2016).

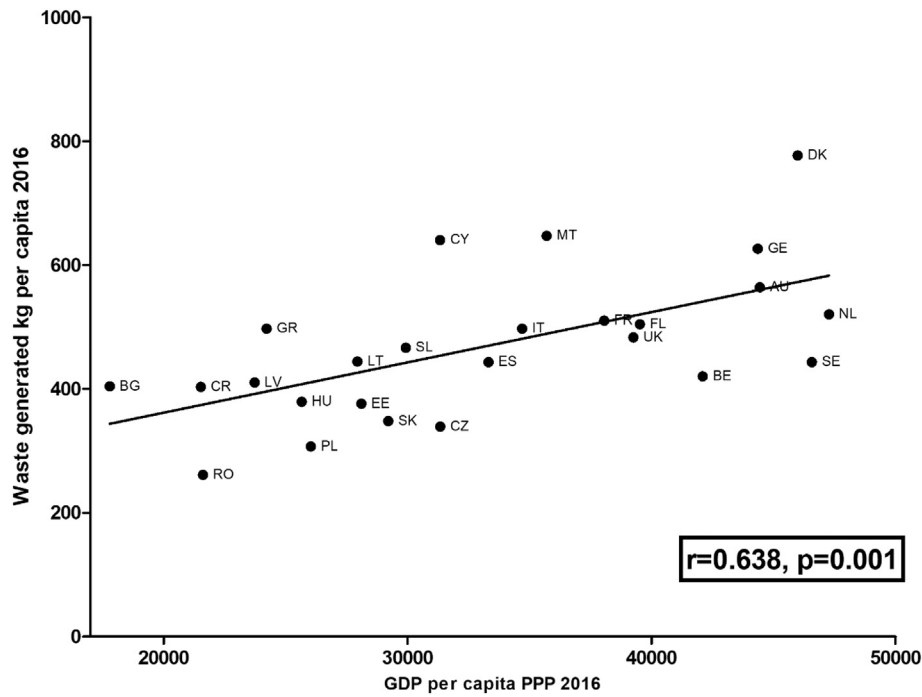


Fig. 3. Cross-country relationship between municipal waste generation and GDP in 2016.

items presented in Table 1. The gap between declared waste 3R behaviours and real waste generation were evaluated analysing the correlation between these variables.

Meanwhile, in order to evaluate the determinants of waste 3R behaviours the linear regression model was applied. The model was estimated using ordinary least square regression. This method was used because it helps to evaluate the determinants that influence waste management behaviours the most and directly. We analysed the direct effects of attitudes to resource efficiency (The usage of resource more effectively is important for me (1 = very important to 4 = not important at all)), attitude to general (as a whole is generating too much waste 1 = totally agree to 4 = totally disagree)) and personal waste generation (my household is generating too much waste (1 = totally agree to 4 = totally disagree)), and efforts to reduce waste using these behaviours (I make efforts to reduce the amount of household waste I generate (1 = totally agree to 4 = totally disagree)) (Fig. 1). The analysis focuses on the panel EU data, rather than on regions and municipalities. Thus, we evaluated the means of analysed determinants and waste management behaviours in separate EU countries, and the values of means were included in the regression analysis. Additionally, by evaluating the values of standardized residuals we checked the outliers. Normality of residuals was measured by applying Shapiro-Wilk test. Variance inflation factor (VIF) statistics was applied in order to check multicollinearity. These diagnostics did not reveal any problems with the suitability of the models. The unstandardized regression coefficients (B) and t values showed which factors determine waste management behaviour directly and which have the greatest influence.

4. Results and discussion

4.1. Waste generation in EU

In the EU, significant differences were observed in terms of municipal waste generation. As we see in Fig. 2, in 2006 in Denmark and Cyprus, waste generation was the most significant. Meanwhile, in Slovakia, Czech Republic, Poland, and Latvia, people wasted 2–2.5 times less comparing with the “leaders”.

The changes in waste generation were unequal as well. During the period of 2006–2016 in countries where the waste generation was the lowest, the highest growth of waste generation was observed. However, the relationship between waste generation level in the 2006 and the growth rate was insignificant. The increase of waste was observed in Croatia, Lithuania, Greece, Finland, Germany, Malta, and Denmark, and from the environmental perspective it was evaluated very negatively because countries did not achieve the reduction of waste. Meanwhile, in the last 10 years, the most significant reductions of waste generation were observed in Romania, Bulgaria, and Spain. These countries

Table 2

The means of waste management behaviours in EU countries.

| Country | Waste reducing behaviour | Waste reusing behaviour | Waste recycling behaviour |
|-------------------|--------------------------|-------------------------|---------------------------|
| AU-Austria | 5.7065 | 2.4056 | 7.2927 |
| BE-Belgium | 5.2362 | 2.4360 | 7.2990 |
| BG-Bulgaria | 4.4520 | 2.0380 | 4.0340 |
| CY-Cyprus | 4.2860 | 1.7285 | 4.2475 |
| CZ-Check Republic | 5.3006 | 2.3100 | 6.3430 |
| GE-Germany | 5.4465 | 2.6150 | 7.3100 |
| DK-Denmark | 5.1455 | 2.6329 | 6.3869 |
| EE-Estonia | 4.2656 | 2.2270 | 5.8210 |
| ES-Spain | 5.2364 | 3.1888 | 6.2887 |
| FL-Finland | 5.5253 | 2.8020 | 6.7353 |
| FR-France | 5.0171 | 2.8008 | 6.7012 |
| UK-United Kingdom | 5.8611 | 3.0149 | 6.7577 |
| GR-Greece | 4.7675 | 2.2730 | 5.4450 |
| HR-Croatia | 4.0313 | 1.8647 | 5.0796 |
| HU-Hungary | 4.1575 | 2.3819 | 5.4347 |
| IE-Ireland | 5.3926 | 2.1390 | 6.9960 |
| IT-Italy | 4.7808 | 2.2208 | 6.3017 |
| LT-Lithuania | 4.2359 | 2.5000 | 4.8260 |
| LV-Latvia | 4.7190 | 2.3127 | 4.6274 |
| MT-Malta | 3.8547 | 1.1240 | 5.3380 |
| NL-Netherlands | 4.9256 | 2.5928 | 6.3134 |
| PL-Poland | 4.8173 | 2.4605 | 6.3427 |
| PT-Portugal | 5.6373 | 2.9870 | 6.2914 |
| RO-Romania | 3.5741 | 1.5034 | 3.0302 |
| SE-Sweden | 5.3225 | 2.7660 | 7.1430 |
| SL-Slovenia | 4.3278 | 2.0929 | 6.6471 |
| SK-Slovakia | 5.1469 | 1.9920 | 6.1406 |

successfully implemented waste policy and reduced waste almost two times.

In 2016, Denmark remained the “leader” of waste generation. In Cyprus, Malta, and Germany the amount of waste generation was one of the highest as well and reached more than 600 kg per capita. Romania, Poland, Czech Republic, and Slovakia were the EU countries where the waste generation was the lowest. The amount of waste produced did not reach 400 kg per capita. Furthermore, the results reveal the level of waste generation depended significantly on economic development (Fig. 3).

This result confirms the findings of other authors that the rising standard of living means the growth of consumption and increase in the generation of waste (Malinauskaitė et al., 2017; Beigl et al., 2008).

4.2. Waste management behaviours

Analysing the tendencies of waste management behaviours, the highest level of waste reducing behaviour was observed in the United Kingdom, Austria, and Portugal (Table 2). In these countries, the majority of respondents declared they made an effort to stop receiving unwanted mail or to get broken appliances repaired before buying new, donating, or selling items for reuse and avoiding food waste and other types of waste by buying exactly what they needed, and avoiding

buying ‘over-packaged’ goods (EC, 2014). Meanwhile, in Romania and Malta, respondents stated they rarely reduced waste (Table 2 and Fig. 4A). Only one-third of respondents declared they drank tap water to avoid packaging waste, undertook home composting, and made an effort to stop receiving unwanted mail (EC, 2014).

In terms of waste reusing behaviour, the respondents in some countries (i.e., Malta and Romania) purchased second-hand and remanufactured goods the least. It could be related to fact that in these countries respondents do not trust in the quality of products, and they are more willingness to buy new products. Meanwhile, in Spain, the United Kingdom, and Portugal, the level of waste reusing behaviour was the highest (Table 2 and Fig. 4B). More than half of respondents in these countries declared they buy second-hand products such as books, CD, DVD, furniture, and electronic equipment (EC, 2014). In order to promote the waste reusing behaviour in EU it is important to enhance the quality and the duration of the goods. Particularly it is important for electronic goods, because e-waste is the most increasing and the treatment is most problematic (Awasthi et al., 2018; Fiore et al., 2019)

The level of recycling behaviour was the highest in Germany, Austria, and Belgium. In these countries, the majority of respondents (99–90%) stated they sort paper, plastic, glass, and electronic waste (EC, 2014). Meanwhile, in Romania, Cyprus, and Bulgaria, the recycling

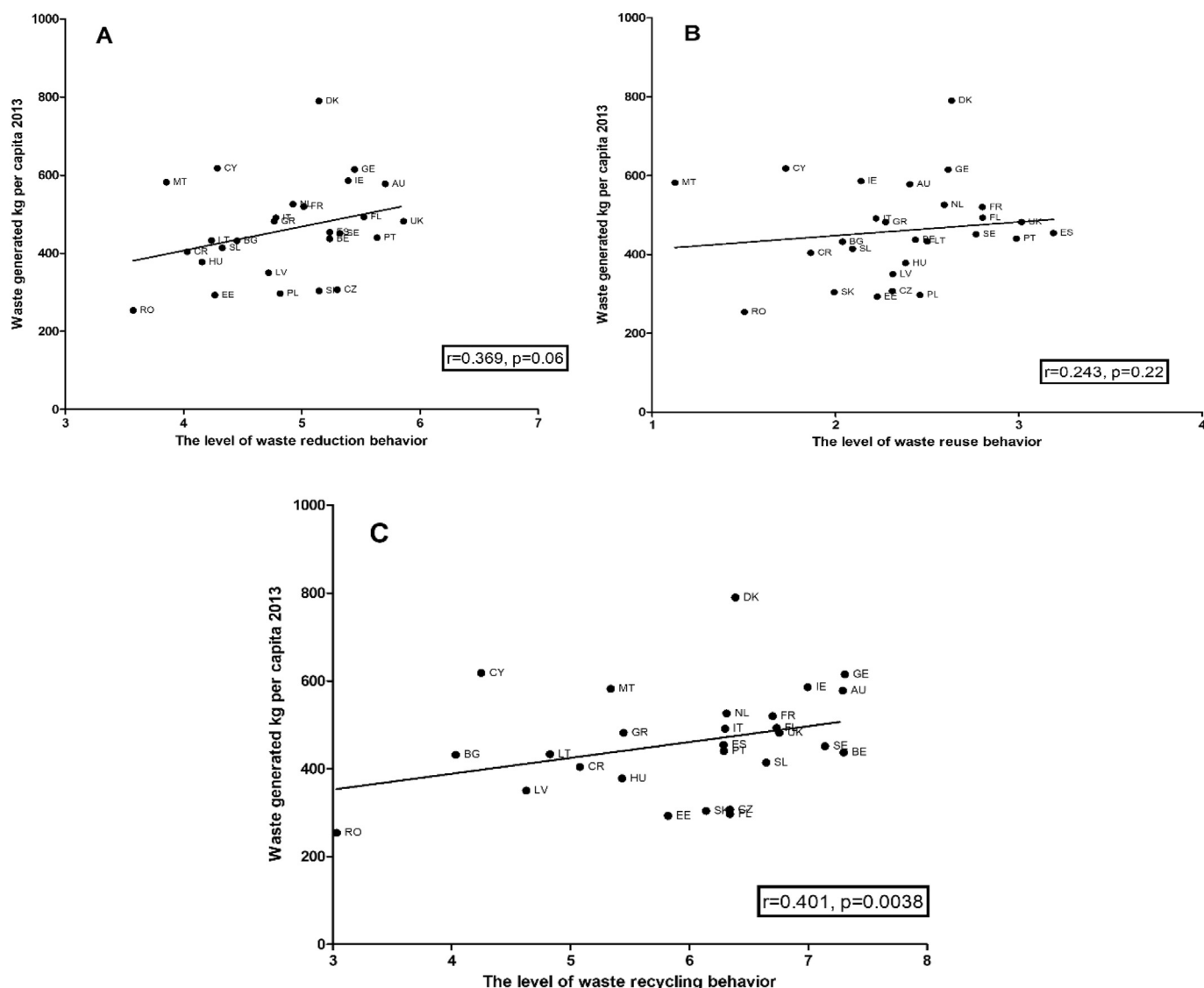


Fig. 4. Cross-country relationship between municipal waste generation and A) waste reducing behaviour, B) waste reusing behaviour, and C) waste recycling behaviour.

Table 3
Regression results of waste reducing behaviour.

| | Unstandardized Coefficients | | Standardized coefficients | t | Sig. |
|---------------------------------------|-----------------------------|------------|---------------------------|--------|-------|
| | B | Std. error | Beta | | |
| Intercept | 10,235 | 2868 | | 3569 | 0,002 |
| Attitude to resource efficiency | −0,257 | 1178 | −0,055 | −0,218 | 0,829 |
| Attitude to general waste generation | 2555 | 1151 | 0,680 | 2220 | 0,037 |
| Attitude to personal waste generation | −2158 | 0,915 | −0,548 | −2359 | 0,028 |
| Efforts for waste minimisation | −2212 | 1570 | −0,341 | −1409 | 0,173 |

R² = 0.242.

level was the lowest (Table 2 and Fig. 4C), and in these countries, only half of the respondents declared they sort the main waste components (i.e., paper, plastic, and glass) (EC, 2014).

Analysing the relationship between declared waste management behaviours and real waste generation, we found that waste reducing and reusing behaviours positively, however insignificantly, influence waste generation (Fig. 4A and B). Therefore, we reveal the gap between declared behaviours and real waste generation. Despite that the level of reducing and reusing behaviours are high, waste generation is high as well. Such a result could be related to the fact that the consumption level of goods is so high that reducing and reusing behaviours did not offset and did not contribute to the reduction of the amount of waste generation. Thus, current recovery performance is yet insufficient to contain the annual increase of generated waste (Tao et al., 2017) even if advanced recovery technologies are adopted. The option of waste reducing and reusing behaviour may even induce an increase in waste production by mitigating the guilt associated with wasteful consumption (Cecere et al., 2014). The interesting tendencies were observed in Romania, where the reducing and reusing behaviours are the lowest, but the amount of waste generation is the lowest as well. We assume that it could depend on low consumption level in this country.

Analysing the relationship between recycling behaviour and waste generation, we found a positive and statistically significant influence (Fig. 4C). The results revealed that in the countries where the waste generation is high the level of recycling is high as well. It can be related to the idea that people trying to mitigate the guilt of the increase in waste generation, sort the waste and so contribute to solving waste problems. Another section will analyse this assumption in depth.

4.3. The determinants of waste management behaviours

Analysing the determinants of waste management behaviours in the EU, we found different determinants of these behaviours and we confirmed the other authors' findings that these behaviours are different and are likely to be driven by different motivations (Ebreo and Vining, 2001; Barr et al., 2001; Barr, 2007; Tonglet et al., 2004). Our results revealed that the attitude to general waste generation significantly and influenced waste reducing and recycling behaviours (Tables 3, 5). Therefore, more respondents are concerned about generating too much waste, less they perform reducing and recycling behaviours. These results contradict to the Zhang et al. (2017b) findings which revealed that municipal solid waste is a serious environmental problem

and has significant and positive relationships to waste separation behaviour. In EU countries, despite that respondents understand that as a whole is generating too much waste, but they do not try to reduce waste generation. Struk (2017) declared that this “out of sight, out of mind” culture might often result in having very little awareness of how much waste is actually produced among the local population. Thus, people should more take responsibility of waste generation and reduce waste primarily in their private life.

Furthermore, our results reveal that the efforts to reduce waste significantly influenced only waste recycling behaviour (Table 5). More respondents agree that they make efforts to reduce the amount of household waste, more waste categories they recycle. This result reveals that waste reducing and reusing behaviours could be attributed to habits, when no efforts is needed to perform behaviour and these behaviours are carried out automatically without deliberate thinking due to repeated use. Meanwhile for recycling behaviour we need to make efforts. Thus, in order to promote the waste management behaviours, this aspect should be considered.

Only one of the analysed factors (i.e., the attitude to personal waste generation) significantly influenced all waste management behaviours (Tables 3–5). More people declared they generated too much waste, more they performed waste 3R behaviours. These results suggest that the attitude to personal waste generation is related to responsibility and people who understand that they personally contribute to waste generation, they try to reduce the amount of household waste which they generate. Furthermore, our results reveal the attitude to resource efficiency insignificantly influence all waste management behaviours (Tables 3–5). Therefore, this gap could occur due to the lack of understanding and knowledge about the relationship between waste reduction and resource efficiency.

4.4. Policy implications and future directions

The highest waste generation levels were observed in the most economically developed EU countries. Therefore, by implementing waste management policy, waste reduction programmes should keep in mind the general objectives of breaking the link between economic growth and waste generation, and moving towards a zero waste economy. The promotion of waste 3R behaviours are one of the main tools seeking waste reduction. Thus, in the EU countries waste reducing behaviour should be promoted by raising the awareness that waste problems are serious and all individuals could contribute to the reduction of

Table 4
Regression results of waste reusing behaviour.

| | Unstandardized Coefficients | | Standardized coefficients | t | Sig. |
|---------------------------------------|-----------------------------|------------|---------------------------|-------|-------|
| | B | Std. error | Beta | | |
| Intercept | 3642 | 2044 | | 1782 | 0,089 |
| Attitude to resource efficiency | 1549 | 0,840 | 0,437 | 1845 | 0,079 |
| Attitude to general waste generation | 0,196 | 0,820 | 0,069 | 0,239 | 0,813 |
| Attitude to personal waste generation | −1435 | 0,652 | −0,479 | −2201 | 0,039 |
| Efforts for waste minimisation | 0,141 | 1119 | 0,029 | 0,126 | 0,901 |

R² = 0.335.

Table 5
Regression results of waste recycling behaviour.

| | Unstandardized coefficients | | Standardized coefficients | t | Sig. |
|---------------------------------------|-----------------------------|------------|---------------------------|-------|-------|
| | B | Std. Error | | | |
| Intercept | 20,233 | 3493 | | 5792 | 0,000 |
| Attitude to resource efficiency | 0,260 | 1453 | 0,037 | 0,179 | 0,860 |
| Attitude to general waste generation | 5310 | 1396 | 0,933 | 3804 | 0,001 |
| Attitude to personal waste generation | −4518 | 1107 | −0,754 | −4082 | 0,001 |
| Efforts to reduce waste | −7319 | 2000 | −0,728 | −3659 | 0,001 |

R² = 0.3.

waste at home. To promote waste reusing behaviour in the EU, it is essential to enhance the quality and the duration of the goods. In terms of recycling behaviour, according to respondents' suggestions about what could convince people to separate waste, more and better waste recycling facilities and reassurance that these wastes are effectively recycled are the most useful tools to promote recycling behaviour (EC, 2014). The future research should more elaborately analyse the factors which could enhance the levels of waste management behaviour.

Analysing the waste management behaviours impact on waste reduction, our results showed a gap between declared behaviour and waste reduction. Therefore, our results reveal that in the EU the decrease of consumption level is important to solving the problems of waste generation. Thus, the successful implementation of sustainable consumption and production policy is necessary for waste policy. The future research should analyse how the consumption level and pro-environmental behaviour influence waste generation and how implementation of sustainable consumption policy could contribute to waste reduction.

Taking into account the results of how attitudes to resource efficiency, general waste generation, personal waste generation and efforts to reduce waste influence waste management behaviours, we found that not all impacts were positive and significant. Thus, in this cases, waste management campaigns should expand the consequences of waste management behaviours and highlight that waste 3R behaviours contribute to the reduction of waste generation, and enhance resource efficiency. The education about the increasing amount of global waste generation that it is related to personal behaviour is essential in seeking to promote the waste management behaviours as well. Therefore, it is imperative to raise greater awareness about personal responsibility, that if people understand they generate too much waste, it could be a motivation to reduce waste in the household. Furthermore, the communication on how to minimize the wastes and on why to do that it is the essential tool for seeking waste reduction. The future research should take the particular attention to the efficiency of environmental information and education seeking to enhance waste management behaviours.

5. Conclusions

The growth of waste generation, high landfill rate, and low rate of waste minimisation require the efficient waste management than ever. The EU countries on average produce about 482 kg per capita of waste annually. However, a significant difference was observed in terms of municipal waste generation. The "leader" of waste generation is Denmark, where the respondents generated about 777 kg per capita waste annually. In Cyprus, Malta, and Germany the amount of waste generation was one of the highest as well and reached more than 600 kg per capita. Meanwhile, in Romania, Poland, Czech Republic, and Slovakia the amount of waste was almost two times lower than in the EU countries mentioned. Furthermore, the level of waste generation significantly depended on economic development. Therefore, the richer the country, the more waste is generated.

However, the changes in waste generation were not related to the amount of waste in the initial year (2006). During the period of 2006–2016, the growth of waste generation was observed not only in

countries where the waste generation was the lowest, but also in Croatia, Lithuania, Greece, Finland, Germany, Malta, and Denmark, where the level of waste was rather high. Meanwhile, in the last 10 years, the most significant reduction of waste generation was observed in Romania, Bulgaria, and Spain. These countries successfully implemented waste policy and reduced waste almost two times.

Waste 3R behaviours have been widely accepted tools of waste management solving the waste problem. However, our results revealed that the level of reducing and reusing behaviours influenced waste generation insignificantly. Therefore, the performance of these behaviours did not offset the waste generation, and countries seeking to reduce waste generation should also pay more attention to the promotion of sustainable consumption and production. Meanwhile, the relationship between recycling behaviour and waste generation was positive and statistically significant. Therefore, in the countries where the waste generation was high, the level of recycling was high as well.

Analysing the determinants of waste management behaviours, results reveal that waste management behaviours are different, and are likely to be driven by different motivations. The attitude to consequences of waste management insignificantly influenced all waste management behaviours behaviour. Attitude to general waste generation significantly but negatively contributed to reducing and recycling behaviours. Meanwhile, attitude towards personal waste generation significantly but positively influenced all waste management behaviours. Thus, the level of responsibility is important for the promotion of waste management behaviours. Furthermore, the declared efforts to reduce waste significantly influenced only waste recycling behaviour and reveals that waste reducing and reusing behaviours could be attributed to habits. Thus, in order to promote the waste management behaviours, this aspect should be considered.

References

- Adam, S.U., Shamsudin, M.N., Sidique, S.F., Rahim, K.A., Radam, A., 2015. Solid waste pollution concern in economic value assessment: is it uni-dimensional or multi-dimensional? *Resour. Conserv. Recycl.* 104, 49–60.
- Awasthi, A.K., Cucchiella, F., D'Adamo, I., Li, J., Rosa, P., Terzi, S., Wei, S., Zeng, X., 2018. Modelling the correlations of e-waste quantity with economic increase. *Sci. Total Environ.* 613–614, 46–53.
- Barr, S., 2007. Factors influencing environmental attitudes and behaviors: a U.K. case study of household waste management. *Environ. Behav.* 39 (4), 435–473.
- Barr, S., Gilg, A.W., Ford, N.J., 2001. A conceptual framework for understanding and analysing attitudes towards household-waste management. *Environ. Plan. A* 33 (11), 2025–2048.
- Beigl, P., Lebersorger, S., Salhofer, S., 2008. Modelling municipal solid waste generation: a review. *Waste Manag.* 28, 200–214.
- Bortolotto, A.P., 2014. *Waste Prevention Policy and Behaviour: New Approaches to Reducing Waste Generation and its Environmental Impacts*. Routledge, New York.
- Bortolotto, P.A., Kurisu, K.H., Hanaki, K., 2012. Model development for household waste prevention behaviour. *Waste Manag.* 32, 2195–2207.
- Cecere, G., Mancinelli, S., Mazzanti, M., 2014. Waste prevention and social preferences: the role of intrinsic and extrinsic motivations. *Ecol. Econ.* 107, 163–176.
- Conke, L.S., 2018. Barriers to waste recycling development: evidence from Brazil. *Resources, Conservation & Recycling* 134, 129–135.
- D'Amato, A., Mancinelli, S., Zoli, M., 2016. Complementarity vs substitutability in waste management behaviors. *Ecol. Econ.* 123, 84–94.
- Ebreo, A., Vining, J., 2001. How similar are recycling and waste reduction? Future orientation and reasons for reducing waste as predictors of self-reported behaviour. *Environ. Behav.* 33 (3), 424–448.

- European Commission, 2014. Attitudes of Europeans towards waste management and resource efficiency. Report. Flash Eurobarometer 388, 153.
- Feo, G., Ferrara, C., Iannone, V., Parente, P., 2019. Improving the efficacy of municipal solid waste collection with a communicative approach based on easily understandable indicators. *Sci. Total Environ.* 651, 2380–2390.
- Fiore, S., Ibanescu, D., Teodosiu, C., Ronco, A., 2019. Improving waste electric and electronic equipment management at full-scale by using material flow analysis and life cycle assessment. *Sci. Total Environ.* 659, 928–939.
- Huang, Q., Zhao, J., Liu, M., Chen, J., Zhu, X., Wu, T., Tian, J., Wen, Y., Zhang, X., Wei, Y., 2018. Preparation of polyethylene polyamine@tannic acid encapsulated MgAl-layered double hydroxide for the efficient removal of copper (II) ions from aqueous solution. *J. Taiwan Inst. Chem. Eng.* 82, 92–101.
- Lehman, P., Geller, E., 2005. Behavior analysis and environmental protection: accomplishments and potential for more. *Behav. Soc. Issues* 13 (1), 13–32.
- Liu, Y., Huang, H., Gan, D., Guo, L., Liu, M., Chen, J., Deng, F., Zhou, N., Zhang, X., Wei, Y., 2018. A facile strategy for preparation of magnetic graphene oxide composites and their potential for environmental adsorption. *Ceram. Int.* 44 (15), 18571–18577.
- Ma, J., Hipel, K.W., Hanson, M.L., Cai, X., Liu, Y., 2018. An analysis of influencing factors on municipal solid waste source-separated collection behavior in Guilin, China by using the theory of planned behavior. *Sustain. Cities Soc.* 37, 336–343. <https://doi.org/10.1016/j.scs.2017.11.037>.
- Malinauskaitė, J., Jouhara, H., Czajczynska, D., Stanchev, P., Katsou, E., Rostkowski, P., Thorne, R.J., Colón, J., Ponsá, S., Al-Mansour, S., Anguilano, L., Krzyżynska, R., López, I.C., Vlasopoulos, A., Spencer, N., 2017. Municipal solid waste management and waste-to-energy in the context of a circular economy and energy recycling in Europe. *Energy* 141, 2013–2044.
- Matsuda, T., Hirai, Y., Asari, M., Yano, J., Miura, T., Ii, R., Sakai, S., 2018. Monitoring environmental burden reduction from household waste prevention. *Waste Manag.* 71, 2–9.
- Millward-Hopkins, J., Busch, J., Purnell, P., Zwirner, O., Velis, C.A., Brown, A., Iacovidou, E., 2018. Fully integrated modelling for sustainability assessment of resource recovery from waste. *Sci. Total Environ.* 612, 613–624.
- Mosler, H.J., Tamas, A., Tobias, R., Rodriguez, T.C., Miranda, O.G., 2008. Deriving interventions on the basis of factors influencing behavioral intentions for waste recycling, composting, and reuse in Cuba. *Environ. Behav.* 40 (4), 522–544.
- Pandey, R.U., Surjan, A., Kapshe, M., 2018. Exploring linkages between sustainable consumption and prevailing green practices in reuse and recycling of household waste: case of Bhopal city in India. *J. Clean. Prod.* 173, 49–59.
- Pietzsch, N., Ribeiro, J.D.L., Medeiros, J.F., 2017. Benefits, challenges and critical factors of success for zero waste: a systematic literature review. *Waste Manag.* 67, 324–353.
- Samadder, S.R., Prabhakar, R., Khan, D., Kishan, D., Chauhan, M.S., 2017. Analysis of the contaminants released from municipal solid waste landfill site: a case study. *Sci. Total Environ.* 580, 593–601.
- Schwartz, S.H., 1977. Normative influences on altruism. In: Leonard, B. (Ed.), *Advances in Experimental Social Psychology*. Academic Press, pp. 221–279.
- Sheau-Ting, L., Sin-Yee, T., Weng-Wai, C., 2016. Preferred attributes of waste separation behaviour: an empirical study. *Procedia Eng.* 145, 738–745.
- Stern, P.C., Dietz, T., Abel, T., Guagnano, G.A., Kalof, L., 1999. A value-belief-norm theory of support for social movements: the case of environmentalism. *Hum. Ecol. Rev.* 6 (2), 81–97.
- Stoeva, K., Alriksson, S., 2017. Influence of recycling programmes on waste separation behaviour. *Waste Manag.* 68, 732–741.
- Struk, M., 2017. Distance and incentives matter: the separation of recyclable municipal waste. *Resour. Conserv. Recycl.* 122, 155–162.
- Tao, H., He, P., Zhang, Y., Sun, W., 2017. Performance evaluation of circulating fluidized bed incineration of municipal solid waste by multivariate outlier detection in China. *Front. Environ. Sci. Eng.* 11, 4.
- Tonglet, M., Phillips, P.S., Bates, M.P., 2004. Determining the drivers for household environmental behaviour: waste minimisation compared to recycling. *Resour. Conserv. Recycl.* 42, 27–48.
- Wan, C., Shen, G.Q., Choi, S., 2017. A review on political factors influencing public support for urban environmental policy. *Environ. Sci. Pol.* 75, 70–80.
- Wan, C., Shen, G.Q., Choi, S., 2018. Differential public support for waste management policy: the case of Hong Kong. *J. Clean. Prod.* 175, 477–488.
- Wang, Z., Guo, D., Wang, X., Zhang, B., Wang, B., 2018. How does information publicity influence residents' behaviour intentions around e-waste recycling? *Resour. Conserv. Recycl.* 133, 1–9.
- Williams, I.D., Taylor, C., 2004. Maximising household waste recycling at civic amenity sites in Lancashire, England. *Waste Manag.* 24 (9), 861–874. <https://doi.org/10.1016/j.wasman.2004.02.002>.
- Wilts, H., Dehoust, G., Jepsen, D., Knappe, F., 2013. Eco-innovations for waste prevention – best practices, drivers and barriers. *Sci. Total Environ.* 461–462, 823–829.
- World Bank, 2013. Global Waste on Pace to Triple by 2100. October 30, 2013. <http://www.worldbank.org/en/news/feature/2013/10/30/global-waste-on-pace-to-triple>.
- Zeng, G., Liu, X., Liu, M., Huang, Q., Xu, D., Wan, Q., Huang, H., Deng, F., Zhang, X., Wei, Y., 2016. Facile preparation of carbon nanotubes based carboxymethyl chitosan nanocomposites through combination of mussel inspired chemistry and Michael addition reaction: characterization and improved Cu²⁺ removal capability. *J. Taiwan Inst. Chem. Eng.* 68, 446–454.
- Zhang, X., Huang, Q., Deng, F., Huang, H., Wan, Q., Liu, M., Wei, Y., 2017a. Mussel-inspired fabrication of functional materials and their environmental applications: progress and prospects. *Appl. Mater. Today* 7, 222–238.
- Zhang, H., Liu, J., Wen, Z., Chen, Y.-X., 2017b. College students' municipal solid waste source separation behavior and its influential factors: a case study in Beijing, China. *J. Clean. Prod.* 164, 444–454. <https://doi.org/10.1016/j.jclepro.2017.06.224>.