Does an increase in the number of aged persons affect segregation of plastic packaging waste? –A case study in Kobe, Japan–

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Abstract

Aged persons tend to segregate their garbage insufficiently. This might cause significant problems for garbage collection and treatment services at the local government level in terms of the environmental burden and treatment cost. In this study, the environmental impacts of a local government's garbage collection and management system are evaluated and discussed, considering the increase in the number of aged persons in the population and the resulting change in garbage segregation behaviour. Initially, two web-based online surveys were conducted with respondents living in Kobe, Japan. The surveys included questions on whether the respondents segregated their plastic packaging waste. The results were then quantified based on differences in respondents' behaviour regarding segregation of plastic packaging waste and their age group, into rates of garbage segregation. The rate of garbage segregation tended to increase until the respondents reached 69 years of age but tended to decline once they reached 70 years. Aged persons have difficulties segregating garbage because of their declining physical strength and/or cognitive function. Based on the garbage segregation rates, a time-series and projection of future (2015 to 2060) changes in segregation behaviour was simulated by multiplying the rate of garbage segregation and the projected number of future households. The relationship between the rate of garbage segregation and CO_2 emitted from the municipal solid waste management was also evaluated.

Keywords

aging rate, garbage segregation, plastic packaging waste, future prediction, CO_2 emission.

Introduction

The aging rate, or number of people 65 or older in a total population, has been increasing in Japan. The Cabinet Office of Japan (2016) forecasts that this rate will increase to 39.9% in 2060 from 26.7% in 2015. Japan's aging rate is by far the highest in the world, and the increase in social security costs is a major concern, but there are other problems relating to an aging population. One of the services that might be affected by an increase in the aging rate is municipal solid waste (MSW) collection and treatment by local municipalities. It is expected that the elderly with disabilities might have difficulties in following the guidelines of garbage collection issued by local governments. This issue might cause in the dynamics of garbage collection and treatment services by local governments. Japanese residents participate in garbage collection and management systems by washing and segregating recyclables. However, an aging population might increase the number of residents that cannot sufficiently segregate their garbage. The aim of this study was to analyse the environmental impacts of a local government's garbage collection and management system considering an increase in the number of aged persons in the population and the resulting changes in garbage segregation behaviour.

Methods

Background on aging in Japan

According to Japan's population census, population has declined since 2015. Figure 1 shows the present and projected future population of Japan, (Japan Ministry of Internal Affairs and Communications (MIAC) 2013; National Institute of Population and Social Security Research (NIPSSR) 2012). The 2010 population is an actual value, while that for 2015 and beyond are predicted values. According to the prediction, population will continue to decline and the aging rate will continue to increase. Figure 2 shows the time-series transition of the aging rate in each prefecture. Japan consists of 47 prefectures, and darker colours indicate a higher aging rate. Almost all prefectures have high percentages of elderly, i.e. individuals aged 65 or more.

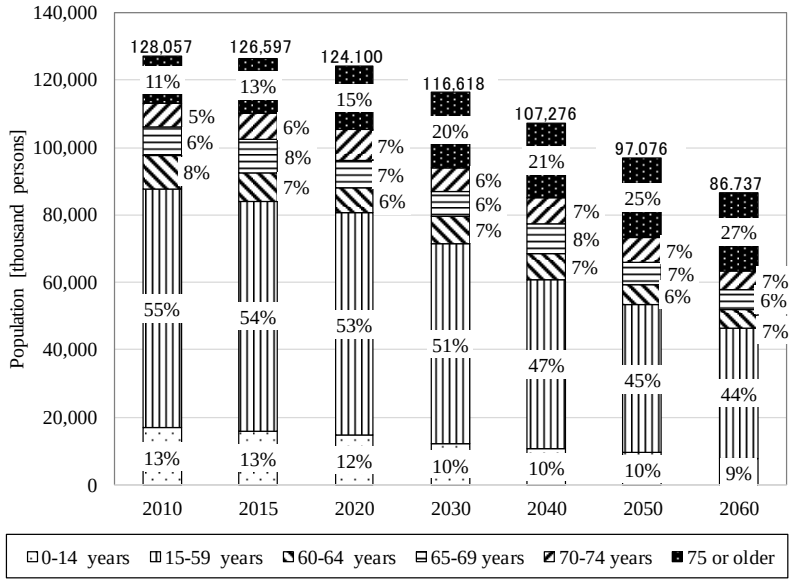

Figure 1 Actual situation and future projection of population in Japan.
Source: MIAC (2013) and NIPSSR (2012)

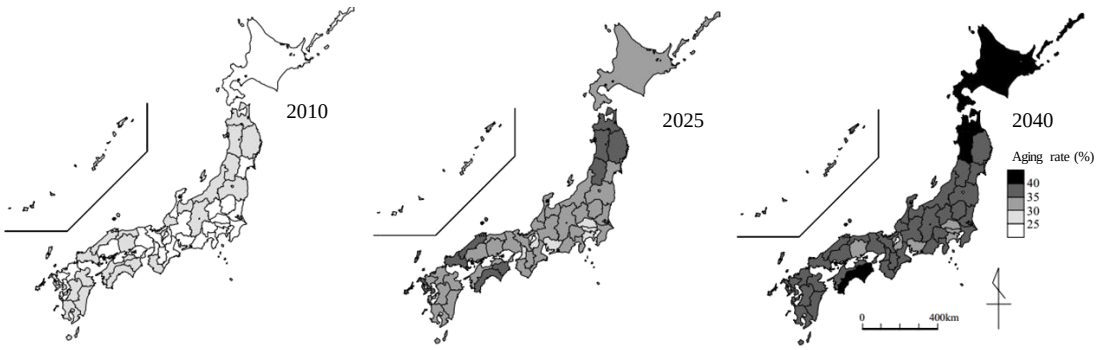

Figure 2 Time-series transition of aging rate in Japan.
Source: NIPSSR (2012) (modified by author)

One of the reasons for the rapid increase in the aging rate is the extension of average life expectancy. Japan's average life expectancy is 80.50 years for males and 86.63 years for females (Cabinet Office of Japan, 2016). However, aged person have a wide variety of personal features. For example, although there is a distinct trend for intrinsic capacity to decline with age, there are some exceptional individuals aged 80 or older who maintain their intrinsic capacity at significantly higher levels than the mean observed in young adults (World Health Organization (WHO), 2015). On the other hand, Suzuki (2012) suggested that the probability of survival starts declining at 75 years or more. Other studies indicate that the degree of autonomy starts declining at 70 (Kaiduka, 2015), and that the pace of walking of

people aged 75 or older is slower than that of people aged between 65 and 74 years (Suzuki, 2012). Suzuki (2012) also noted that aged persons who walk at a great speed are able to maintain their health and manage daily chores without help from others. Based on these studies, the borderline of the age at which people can maintain their health is approximately 75 years.

A decline in mobility caused by loss of muscle strength has several effects on the daily life of the elderly. Miyamae (2010) stated that there is a positive correlation between the number of aged persons in a municipality and the volume of garbage that violates the local segregation rules. In Japan, such garbage is not collected by the local municipality (Figure 3). In addition, although many developed countries, including Japan, obligate their citizens to finely segregate garbage, some elderly citizens find this cumbersome and physically challenging. A survey by the Graduate School of Human Development and Environment, Kobe University (2015) revealed that approximately 6.3% of the respondents aged 60 years or more stated that they have difficulty with garbage disposal and segregation. Figure 4 shows the rate of respondents able and unable to segregate the garbage. According to the figure, the rate of respondents who are unable to segregate the garbage dramatically increases after 75 years of age.

Figure 3 Municipal garbage collection station.
Note: The garbage bag in the lower right was not collected because it violated the local municipality's segregation rules.

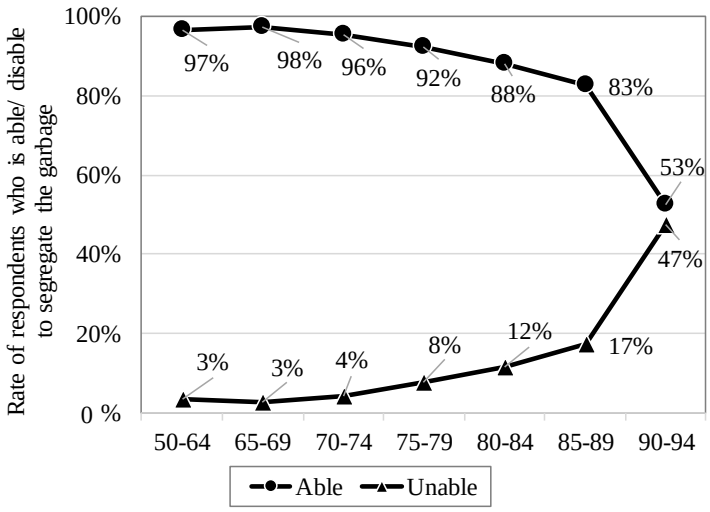

Figure 4 Rate of respondents that is able/ unable to segregate garbage.
Source: Graduate School of Human Development and Environment, Kobe University (2015)

Case study area

Figure 5 shows the location of the case study area. Kobe, Japan, has a population of approximately 1.54 million (2015); it is the sixth highest population in the country. The ageing rate in this city is 26.6%, slightly higher than the general ageing rate of Japan (26.0%) (Cabinet Office of Japan (2016), Hyogo Prefecture (2015)).

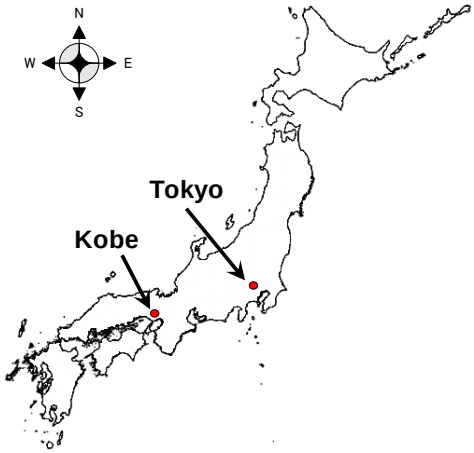

Figure 5 Location of case study area

Questionnaire survey

Initially, we conducted two web-based online surveys with qualified respondents living in Kobe. We gathered demographic information including gender, number of people in the household, and annual income. We then asked respondents if they segregated their plastic packaging waste[1] (we call this 'frequency of segregation'). We classified plastic packaging waste into six categories (see Table 1) based on those outlined by the Japan Ministry of Environment (MOE, 2015). The main reason for selecting plastic packaging waste, as this is a fraction of MSW, is the ease of identifying these recyclable materials based on their labelling. The majority of Japanese municipalities require residents to segregate their garbage as per the 'Containers and Packaging Recycling Law' of 1997. Although plastic packaging is labelled, their multiplicity (e.g., food packs, containers, and bottles) makes source segregation complex. Moreover, the necessity of washing packaging materials before disposal discourages some inhabitants from adequately segregating these recyclables for recycling. This study aims to improve our understanding of household garbage segregation behaviour.

The first survey was conducted in the period November 16–24, 2015; 1,304 people aged 20–69 years old responded. The second survey was conducted in June 14–17, 2016; 413 people aged 70 years old or more responded. In this survey, respondents with 20 to 69 years answered themselves. And persons aged 70 years or older who lives with respondents answered the question. This is why we deemed that respondents with 70 years or older are active persons that can not only operate a personal computer but also segregate garbage. Further survey is needed on persons who were 70 years or older and were not familiar with the use of the personal computer.

[1]Question: Do you segregate these plastic packaging waste as recyclables?
Answer: always segregate (5 points, 100%), almost segregate (4 points, 75%), sometimes segregate (3 points, 50%), rarely segregate (2 points, 25%), not segregate (1 point, 0%).

Table 1. Categories of plastic packaging waste.

	Ratio of composition
(1) Cups, food containers and packs Ex. Cups (puddings, yoghurts, ice cream and so on), food containers (boxed lunches, tofu, margarine and so on) and packs (eggs, vegetables, hams, sausages, retort foods and so on)	34%
(2) Packaging of product (excluding aluminum component) Ex. Exterior film (snacks, noodles and so on), bags (clothes, glossaries and so on) and plastic bottle labels	27%
(3) Plastic bottles (excluding polyethylene terephthalate) Ex. Bottles (cooking oil, sauce, dressing, detergent, bleach, shampoo, cosmetics and so on)	17%
(4) Plastic bags	9%
(5) Aluminum foil compound Ex. Chocolates, gum, ice cream, soap, detergents, shampoo and so on	8%
(6) Packaging of delivery agents Ex. Food wrap (fresh foods, boxed lunches and so on) and packaging (bread, snacks, vegetables and so on)	5%

Source: MOE (2015)

Quantification of rate of garbage segregation

We quantified the differences in plastic packaging waste segregation behaviour, considering the inhabitants' age group, based on the results of the two surveys. The rate of garbage segregation was calculated by multiplying the frequency of segregation with the ratio of composition (Table 1).

Results and discussions

Garbage segregation behaviour of each age group

Figure 6 shows the rate of garbage segregation by age group. The average rate of garbage segregation of households was 61.4% overall; multiple-family households had a higher rate than did single-family households (the averages were 63.8% and 57.5% respectively). The rate of garbage segregation tended to increase up to 69 years of age; however, it tended to decline after 70 years of age. This suggests that older persons cannot segregate the garbage because of a decline in their physical strength and/or cognitive function.

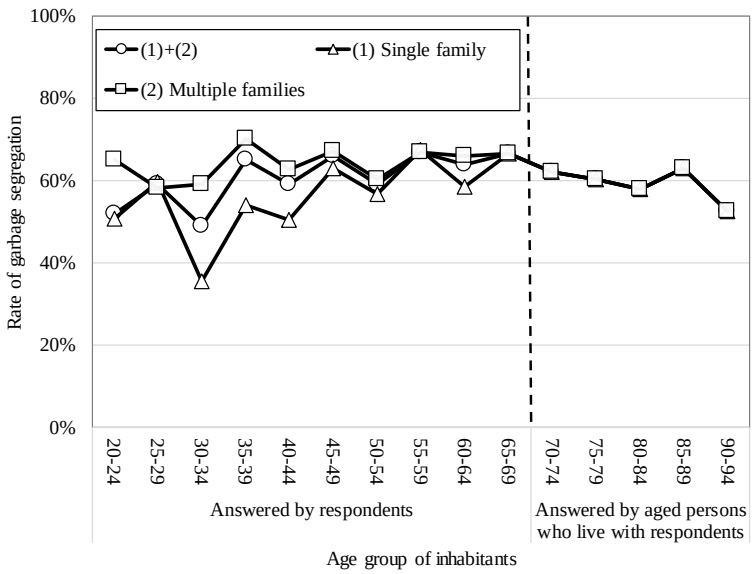

Figure 6. Rate of garbage segregation by age group.

Future projection of garbage segregation behaviour and environmental impacts

We then simulated a time series and projected changes in segregation behaviour from 2015 to 2060, by multiplying the rate of plastic packaging waste of the population and a projection of the number of future households (NIPSSR, 2012 and 2014). Figure 7 shows the projection of the rate of garbage segregation from 2015 to 2060. The ratio of the population that was 80 years or older was 10% in 2015. This ratio will increase to 27% by 2060. According to this projection, the rate of garbage segregation will change slowly. The rate of garbage segregation in Kobe would change from 61.3% in 2015 to 60.7% in 2060, indicating a slight decline. However, the number of responses from persons aged 70 years or more was quite low compared to those from persons aged 20 to 69 years. Thus, additional surveys targeting persons who are 70 years or older are necessary.

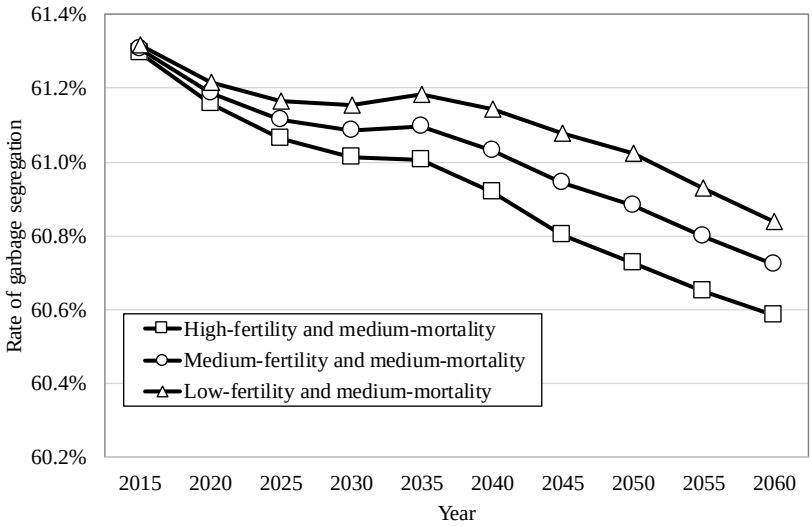

Figure 7. Future projection of rate of garbage segregation.
Source: NIPSSR (2013)

We also evaluated the relationship between household garbage segregation and CO_2 emissions from incineration and material recovery processes. We focused on garbage segregation behaviour and CO_2 emissions to reveal how each age group affects the CO_2 emissions of the MSW management system. Figure 8 shows the relationship between the rate of garbage segregation and CO_2 emissions. A lower rate of segregation resulted in higher CO_2 emissions, and a higher rate of segregation resulted in lower CO_2 emissions. Based on this, the tipping point for the rate of segregation when the CO_2 emissions derived from incineration and from material recovery turned back was 74%. The rate of segregation of respondents aged 30–34 was 49.0%, which was the lowest among all the age groups. The CO_2 emissions derived from incineration were significant. In contrast, the highest rate of segregation was 67.0%, for respondents aged 55–59. In this case, the CO_2 emissions derived from incineration is reverse proportion to those derived from material recovery. This result indicates the importance of moving all generations closer to the 67.0% with a higher rate of segregation. We must carry out further surveys to clarify the garbage segregation behaviour of aged persons, as well as the related environmental impacts and treatment costs.

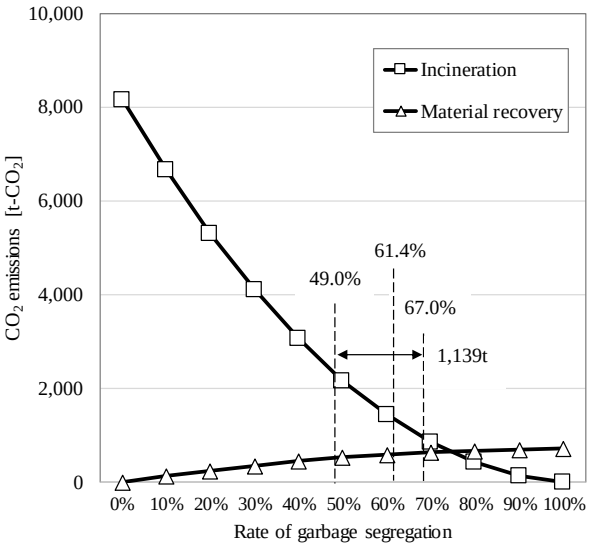

Figure 8. Relationship between rate of garbage segregation and CO_2 emissions.

Conclusions

This study investigated garbage segregation behaviour considering the age groups. We also studied the current and projected rates of garbage segregation, and the relationship between garbage segregation behaviour and CO_2 emissions as the environmental impact. Figure 9 shows different scenarios for how changes in garbage separation could affect the MSW management system. At present, many persons under 74 years of age do not experience difficulty with garbage segregation; however, they might experience such difficulty as they age further. This might increase the amount of plastic packaging waste that violates a local municipality's segregation rules. The number of combustibles might also increase because garbage segregation is reduced. This may lead to an increase in the amount of garbage that is incinerated and a decrease in recyclables (Figure 9, Scenario A). Such a scenario would lead to an increase in environmental impact in terms of CO_2 emissions and treatment costs as a whole in the MSW management system, as compared to Scenario B.

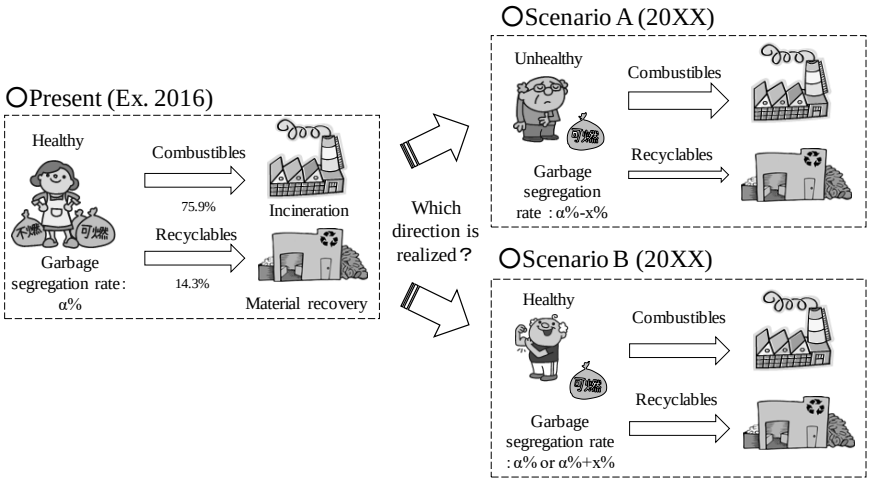

Figure 9. Scenarios for future MSW management

Scenario A above is assumed to be the worst, and as such, might not realistic. However, the WHO (2015) indicates that the societal response to population aging will require a transformation of health systems that moves away from disease-based curative models and towards the provision of older-person-centred and integrated care. This is similar to the

situation in MSW management; precautionary measures to prevent or minimize the issues that might arise with an increase in the number of aged persons should be discussed, beginning with a preliminary analysis of various possible future scenarios.

Acknowledgement

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