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Waste reduction and recycling initiatives in Japanese cities: Lessons from Yokohama and Kamakura

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Abstract

Waste reduction and recycling at the city level will acquire greater significance in the near future due to rising global volumes of waste. This paper seeks to identify policy-relevant drivers for successful promotion of waste reduction and recycling. Factors influencing the success of waste reduction and recycling campaigns are identified. Two case study cities in Japan which depict the successful use of the 3Rs (reduce, reuse and recycle) at the municipal level are presented. In these cases, the existence of incinerators, which are generally considered as disincentives for recycling, was not functioning as a disincentive but rather as an incentive for waste reduction. Owing to the high cost of incineration facilities, the movement to close incinerators has become a strong incentive for waste reduction and recycling in these two cities. The study suggests that careful consideration is necessary when making decisions concerning high-cost waste treatment facilities with high installation, maintenance and renewal outlays. In addition, intensive source separation and other municipal recycling initiatives have a high potential for producing positive results.

Keywords

Recycling, reduction, waste management, incineration, waste prevention, Japan, Yokohama, Kamakura

Introduction

The goals of municipal solid waste management in Japan in the 1970s and 1980s were to raise levels of sanitation, decrease the final amount of waste for disposal, which had ballooned as a corollary to the economic 'bubble', through incineration and recycling (MOEJ, 2006) and address the lack of landfill sites. However, the multitude of small incinerators used until the 1990s released massive amounts of dioxins into the atmosphere, which precipitated a health dilemma (90% was incinerator-generated in 1997; MOEJ, 2000). This led to the introduction of more advanced, larger-scale facilities (MOEJ, 2007) which also incurred higher costs to build and renovate; hence municipalities started to adopt an approach of waste reduction via recycling in coordination with other localities.

Japan adopted the 3Rs (reduce, reuse and recycle) to promote environmentally sound waste management and resource efficiency in the mid-1990s. Under the framework law of waste management and recycling: Japan's Basic Law for Establishing Sound Material Cycle Society, the 3R principle was positioned as a basic principle of Japan's waste management and recycling policy. It inaugurated a policy programme entitled 'Sound Material–Cycle Society' to facilitate recycling and waste reduction at national and local levels ('Basic Law for Establishing Sound Material Cycle Society'; 2000). Under this policy, which includes product-specific recycling mechanisms, the national government sets directions and priorities which local government translates into tangible actions, such as collection of recyclables, consensus building for correct sorting, and dissemination of information on recycling policies ('The 1st Fundamental Plan for Establishing Sound Material Cycle Society'; 2003). As mentioned above, local governments in the 1990s were under pressure to further reduce the volumes of waste for final treatment sites. In response, Tokyo Metropolitan Government introduced volume charges for business waste collection in 1996 (MOEJ, 1997) and Nagoya city, wishing to avoid controversy over the use of its wetlands, initiated sorted collections of recyclables and reductions in the volume of waste for final treatment in 1999 (Nagoya City, 2013).

Drawing on Japan's success in waste management and recycling, this paper aims to reveal insight into planning at the city level by studying the 3R activities undertaken in two cities, Yokohama and Kamakura, which were chosen as best exemplifying efforts in waste reduction and recycling in Japan. Every year, recycling rates of municipal solid waste of all municipalities in

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Japan are ranked into three levels, based on population size – small, medium and large (under 100 000; 100 000–500 000; over 500 000). In Japan, the rate of recycling is calculated as shown in Equation (1) here (MOEJ, 2013):

$$Rate\ of\ recycling(\%) = \left[\begin{matrix}(DRR + IRR + CRR)/\\(WT \ + CRR)\end{matrix}\right]*100 \quad (1)$$

where *DRR* is the amount of recyclable resources going directly to recycling businesses without going through intermediate treatment; *IRR* is the amount of resources recovered after intermediate treatment of recyclable resources, bulky wastes and others; *CRR* is the amount of recyclable resources collected by communities; and *WT* is the amount of waste treatment. This is equivalent to [amount of incineration+ amount of final treatment + *DRR* + *IRR*] (MOEJ, 2013).

We chose Yokohama and Kamakura, in the 'large' and 'medium' categories, respectively, and excluded the 'small' town category under 100 000 as their characteristics are too disparate. Yokohama, Japan's second largest city in terms of population, became active in recycling and waste reduction in the mid-2000s and was placed second or third in recycling rate in the 'large' category from 2005–2008 (third place in 2005 with a recycling rate of 24.6%, second place in 2006 with 26.0%, third place in 2007 with 26.7%, third place in 2008 with 26.7%, fifth place in 2009 with 26.7%, sixth place in 2010 with 26%, and sixth place in 2011 with 25.6%) (MOEJ, 2011, 2012, 2013). Although Yokohama's rank in recycling rate dropped from third place in 2005 to sixth place in 2010 and 2011, this is mainly due to the increase in recycling rates in other cities. Kamakura consecutively achieved first place in recycling rate in the 'medium' category from 2004 to2008 (second place in 2009, 2010, 2011 with a 47.6% recycling rate in 2011), and was thus considered to have been one of the most active cities in waste reduction and recycling since the early 1990s (MOEJ, 2011, 2012, 2013). Both cities are close to Tokyo but vary greatly in population size and recycling rate: 3.69 million and 24–27%, respectively for Yokohama, 0.174 million and 45–50% for Kamakura (2012, both cities). Although the higher recycling rate in Kamakura may suggest that recycling initiatives are more effective in smaller cities than in mega cities such as Yokohama, this study will discuss against this point.

This paper seeks to identify policy-relevant drivers for successful promotion of waste reduction and recycling. The following section discusses and identifies major factors influencing waste reduction and recycling initiatives at the city level based on the related literature. As used herein, the term 'waste reduction' is understood as measure, which aims to reduce the amount of waste going to landfill or incineration. The cases of Yokohama and Kamakura are then examined in terms of the incentives behind the waste reduction and recycling campaigns and how these campaigns have contributed to waste reduction. Finally, lessons are drawn from these cases in terms of their applicability to waste reduction and recycling promotion at the city level.

Factors influencing waste recycling and reduction activities at the municipal level

In spite of the Japan's recent reputation in the 3R activities, many analyses on factors influencing municipal initiatives for waste recycling and reduction are based on case studies of the UK (Abbott et al., 2011; Evison and Read, 2001; Martin et al., 2006; McDonald and Oates, 2003; Timlett and Williams, 2009a, 2009b; Wilson and Williams, 2007), the US (Callan and Thomas, 1997; Sidique et al., 2010; Taylor, 2000; Vining et al., 1992), Mediterranean cities (Jorgensen and Jakobsen, 1994), Portugal (Vincente and Reis, 2008) and developing countries such as India, Thailand and Tanzania (Agarwal et al., 2005; Suttibak and Nitivattananon, 2008; Uiterkamp, 2011).

One of the drivers for waste recycling and reduction in the context of Japan is 'shortage of final treatment sites' because of the high population density of the country. For example, the case study of Boston and Yokohama by Contreras et al. (2010) demonstrated that limitation to solid waste management capacity driven by policy in Boston and by increased population in Yokohama played an important role for improved solid waste management. Extension of landfill sites is a concern of local governments as seen in the case of Tokyo Metropolitan Government referred to in the introduction of this paper. Usui and Chikasada (2012) also consider that sole ownership of landfill sites by municipalities (in contrast to co-ownership or non-existence of landfill sites) aids source separation and collection and extends landfill life.

The relationship between institutional and technical infrastructure and recycling activities also has an interesting aspect. In the case of Japan, incineration as a major treatment technology and promotion of recycling and reduction may have some mutual influence. On this point, Usui and Chikasada (2012) compared the influence of existence of incinerators, landfill sites and increasing labour price resulting from source separation and collection in 3000 municipalities in Japan, and concluded that the existence of incinerators or waste energy recovery facilities might lead to a collection of solely high-calorific-value waste such as paper and plastics, thus not benefiting source separation and collection of waste, a line of thinking that is echoed often (The Guardian, 2013).

In addition to the technology choice, intuitional aspects (policy and responsibility of waste management) have an important influence on waste management (Hotta, 2013). In particular, national or state policy functions as a 'backstop' for local recycling efforts (Jorgensen and Jakobsen, 1994; Ong et al., 2010; Taylor, 2000). In Japan, as in many other countries, national policy plays a crucial role in municipal efforts in recycling (for the UK, Wilson and Williams (2007); for nine Mediterranean cities, Jorgensen and Jakobsen (1994)) for the impact of EU's landfills directive to national efforts for recycling in EU, EEA (2009). The significance of institutional infrastructure and public consensus in the US has also been covered; factor analysis of 8937 municipalities by Kinnaman (2005) concluded that state regulations and local community preferences or demands for recycling are the two major stimuli.

Public awareness, namely consensus building is the key to successful recycling schemes (Evison and Read, 2001; Vincente and Reis, 2008; Wilson, 2007). In an analysis of non-participation in 8000 households in Sheffield, UK, McDonald and Oates (2003) concluded that publicity, clear information and promotion of recycling schemes as well as a tolerant attitude of local government to foster the goodwill of the public are all important for successful recycling schemes. Reams and Ray (1993) show that direct, personal contact by local government promotes public participation. Vining et al. (1992) also discuss the usefulness of a voluntary recycling scheme to reduce waste by promoting environmental concern and consciousness in the community. Naturally, however, actual services and support must already be in place (Martin et al., 2006; Vining et al., 1992).

Thus, the main findings from the above literature review for promoting recycling at the city level are:

- lack of capacity at the final treatment site promotes recycling,
- existence of incinerators or waste energy recovery facilities discourages source separation and collection of waste,
- national regulations, local community preferences and demands for recycling services are key incentives for recycling, and
- direct, personal contact by local government promotes recycling.

Case studies of Yokohama and Kamakura

The following sections summarise the results of case studies investigating the recycling initiatives in Yokohama and Kamakura in terms of background, major activities, and outcome.

Methodology

A semi-structured interview survey was conducted in August 2010 involving key officials in waste management in Yokohama and Kamakura to identify key background and features of promoting reduction and recycling initiatives in these cities. A list of interviewees is attached in the Appendix. Unlike a structured interview which utilizes a structured and pre-determined set of questions to and interviewees are all asked these standardized questions in the same manner, a semi-structured interview prepares a certain range of questions beforehand but is usually conducted in a dialogue style between interviewers and interviewees. This allows the interviewer to follow up and initiate further discussions on particular topics raised during the interview. The range of questions put to the officials covered: (1) historical background and objectives of waste minimization initiatives and whether these objectives changed over time, (2) budget size for waste reduction campaigns, (3) concrete examples of initiatives taken by cities for waste reduction, (4) inter-departmental collaboration, (5) role of stakeholders, and (6) national policy or schemes helpful for promoting waste minimization initiatives. The range of questions was sent to the officials before the interviews and the interviews were conducted in a semi-structured manner. To supplement data related to solid waste management and to confirm the argument of city officials in these two cities, reviews of reports (Kamakura City, 2013a, 2013b; Kamakura City Committee for Waste Reduction and Resource Recycling, 2013; Yokohama City, N.D.; Yokohama City, 2006, 2009, 2011; Zushi City, 2011) related to the solid waste management plans of the two cities were conducted. An interview with a city official of Yokohama was conducted on 4 August 2010. An interview with Kamakura city officials was conducted mainly on 10 August 2010 and supplemented by information obtained during an earlier interview with Kamakura city officials on 4 June 2009.

The case of a 'large' city: Yokohama

Background and objectives. In 2003 Yokohama launched a campaign coined 'G30' (G means *gomi*: rubbish) targeting a 30% reduction in waste by 2010 compared to fiscal year (FY)2001. From 2006–2008, it spent 2.7–2.8 billion Japanese yen (JPY) (27–28 million US$) on waste management (total expenditure: 4.2–4.6 billion JPY; total income: 1.2–1.5 billion JPY), which included awareness-raising and separation and collection. The main motives prompting G30 were: (1) rising population and waste volumes, (2) a dearth of disposal sites, (3) need for incinerator replacement, (4) increased environmental awareness, and (5) a proactive city mayor.

Campaign programmes. The main thrust of G30 was waste reduction via separation at source, and involved increasing the number of municipal solid waste items (mainly household combustibles) from 7 to 15, and the number of categories from 5 to 10 (Table 1) (Yokohama City, 2011). Here, categories refers to the categories for source separation and collection. The term 'items' reflects a more detailed separation of the category of containers and packaging as well as used papers (Yokohama City, 2014). These waste materials are usually discharged in sorted order at collection points for several households and collected by the municipality on different days for different categories. Citizens are expected to separate both by category for sorted collection and also considering different ways of sorting 15 items when the waste materials are delivered to the collection point. Combustible household waste, incombustibles, used batteries, and spray cans are collected on the same days twice a week. Cans, bottles, polyethylene terephthalate (PET) bottles, small metal items are collected on the other day once a week. Containers and packaging are collected on another day once a week. Old clothes and used papers are collected twice a month. Bulky waste is collected upon request.

The following measures were carried out to ensure thorough separation activities by the public.

- *Information dissemination*: Over 11 000 public meetings were held over 2 years, involving 4700 city officials and environmental activity coordinators, and on-site guidance at collection points.

Table 1. Items and categories of waste sorting of Yokohama City (New items and categories have been added since April 2005).

Conventional items and categories	Added items and categories since April 2005
Conventional 7 items: combustible household waste, cans, bottles, PET bottles, small metal items, used batteries, bulky waste	Added 8 items: plastic containers, incombustibles, spray cans, old clothes, newspapers, magazines, carton boxes, used paper
Conventional 5 categories: combustible household waste, containers and packaging, small metal items, bulky waste, used batteries	Added 5 categories: plastic containers, incombustible waste, spray cans, old clothes, used paper

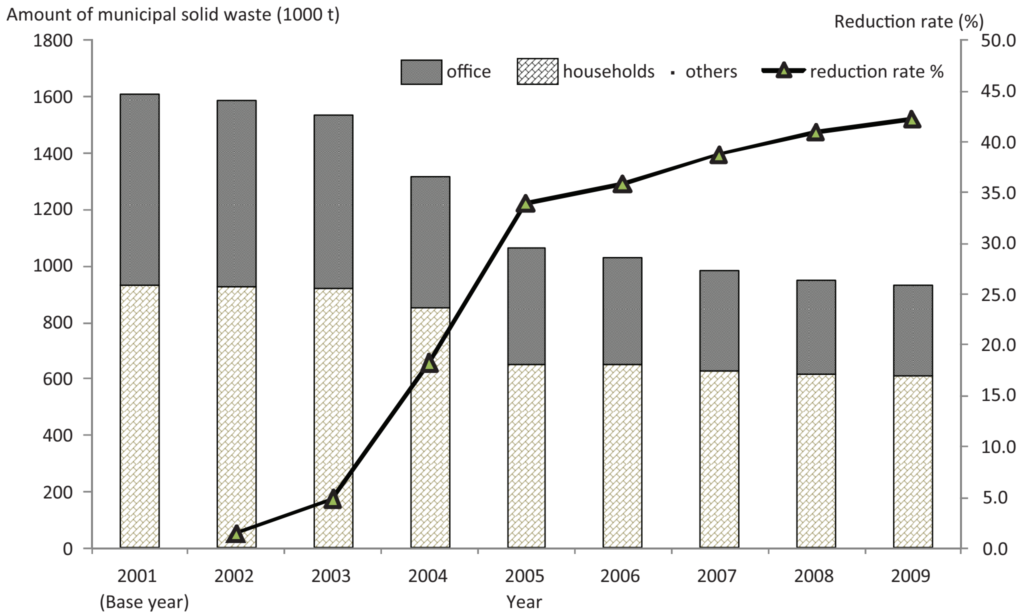

Figure 1. The reduction of final treatment amount of municipal solid waste in Yokohama [Source: Yokohama City, 2011].

- *Media strategy*: A mascot design contest was held. A celebrity campaign as ambassadors and a local rock band (Crazy Ken Band) for the G30 song were involved. TV, radio, mobile phones, internet websites and other media tools were used to promote separation activities.
- *Model projects*: At the initial stage, model projects were implemented in some communities to instruct them on how to separate their waste into further expanded classifications.
- *Non-penal fines*: In this scheme, a sticker with a warning message was attached to any incorrectly separated garbage bag and these bags were left uncollected. If no improvement was seen, the garbage bag may be opened to identify the discharger for guidance. If such guidance (subsequently a recommendation, then an order) was not followed, the authorities ultimately imposed a non-penal fine (only imposed on those who intentionally broke the guidance for separation but not to those just mistook the method of separation).
- *Recycling of school lunch leftovers for composting and pig feed*: Waste food disposers were installed at 57 elementary schools; some waste was privately recycled into pig feed.
- *Municipal waste reduction at businesses*: City officials involved major supermarkets (and shoppers) in plastic food tray, packaging and milk carton recycling, and use of eco-friendly shopping bags.

Results of the initiatives. The volume of waste dropped from 1.61 to 1.06 million tonnes over the five-year period FY2001 (base year) to FY2005, thus attaining the 30% reduction goal 5 years early, despite population and gross production increases over the term (in detail: waste volume for FY2001, 1.61 million tonnes (1274 g day^{-1} capita^{-1}); for FY2003, 1.53 million tonnes (1190 g day^{-1} capita^{-1}) for FY2004, 1.32 million tonnes (1011 g day^{-1} capita^{-1}); for FY2005, 1.06 million tonnes (815 g day^{-1} capita^{-1})) (Yokohama City, 2013b). By FY2010 waste volumes had dropped by about 42% from the base year, mainly by diverting household waste into combustibles and recyclables via the re-categorization outlined above (Figure 1).

The above reduction in waste brought about by the campaign enabled the city to shut down two of its seven incinerators and put a third one on stand-by (Table 2) (Yokohama City, 2011).

This translated into annual savings of Yokohama's spending for waste management services of 600 million JPY (6 million US$), a reduction in incineration maintenance of 3 billion JPY (30 million US$) but incurred the additional cost for intensive source separation and recycling which amounted to 2.4 billion JPY (24 million US$), and a total spending of 4.1–4.6 billion JPY (41–46 million US$) (Yokohama City, 2011). The above figures also exclude significant costs linked with campaign staffing and PR materials. A further 110 billion JPY (1.1 billion US$) was

Table 2. Status of incinerators in Yokohama as of August 2013.

Incinerator	Capacity	Status
Tsuzuki	1200 t day^{-1}	Operating since 1984
Kanazawa	1200 t day^{-1}	Operating since 2001
Tsurumi	1200 t day^{-1}	Operating since 1995
Asahi	540 t day^{-1}	Operating since 1999
Hodogaya	1200 t day^{-1}	Suspended as of 2010
Kounan	900 t day^{-1}	Opened in 1974 Closed in 2006
Sakae	1500 t day^{-1}	Opened in 1976 Closed in 2005

saved for non-renewal of old incinerators by taking two incinerators out of service.

The amount of waste generated dropped to 950 000 tonnes in FY2008, and in 2009 CO_2 emissions from the waste sector had dropped to 396 000 tons; a reduction of 213 000 from the 609 000 tons in the year 2000 (calculated from incinerated waste volumes; Yokohama City (2013a)). In terms of greenhouse gas (GHG) source, 78.3% resulted from municipal solid waste incineration and 21.7% came from industrial solid waste incineration in 2009 (Yokohama City, 2012). An additional climate benefit from the life-cycle perspective is the reduction in virgin production of materials.

The case of a 'medium-sized' city: Kamakura

Background and objectives. Kamakura as a city is highly environment-conscious (according to a public survey in 2012, 88.5% consider themselves 'active in environmental protection'). A campaign named 'Garbage Dieting' was started in 1990 aimed at fine classification of waste for collection under the banner of 'No more incineration, no more landfills'. With the 'Declaration of a state of emergency to halve waste generation' issued in 1996, city-wide efforts were accelerated to achieve more thorough separation and recycling of waste. Kamakura stopped landfilling as a final treatment and started molten slag treatment from 2000, thus necessitating minimization of final treatment volumes.

Furthermore, after dioxin problems from small incinerators was recognized by the public in late 1990s, the central government made a direction for municipalities to renew or integrate old incineration facilities into more advanced, larger-scale facilities (Zushi City webpage, 2011). Because of the relatively small size of the city and population it was suggested that the high cost of renewal of incineration facilities should be shared with other cities and plans to integrate incineration facilities with four neighbouring cities and towns (Zushi, Yokosuka, Miura and Hayama) was under negotiation from 1998. Integration of solid waste management facilities among five neighbouring cities was scraped in 2005 and negotiations for integration were continued among two groups (between Zushi and Kamakura, and between Yokosuka, Miura and Hayama). Zushi and Kamakura then agreed a memorandum to discuss the integration of solid waste management facilities in 2006, but Zushi withdrew in 2008 (Zushi City webpage, 2011). This led to the scraping of the original plan for integration of incineration facilities among neighbouring cities. In 2010, Kamakura and Zushi agreed a new memorandum to continue negotiation but the negotiation was not progressed. Thus Kamakura decided to extend the use of old facilities and promote further waste reduction via recycling in the meantime and this is cited as one of the reasons behind the city's renewed waste reduction and recycling efforts during 2008–2010.

Specific measures. The measures taken by Kamakura city since 1990 and renewed effort in the late 2000s are outlined below.

- *Information dissemination*: Under the motto 'Anytime, anywhere, again and again', public meetings disseminated separation at source. City officials manned waste collection stations to address problems, answer questions and raise public awareness. The Waste Reduction Promotion Committee, comprised of community representatives, was also mobilized to raise public awareness.
- *Subsidies*: Under the city's 3R Promotion Project Subsidy Programme, a subsidy was granted to shops and youth clubs cooperating in waste reduction, volume reduction and recycling.
- *Education of business enterprises*: The municipal waste produced by the office sector has been inspected by local government for appropriate separation and verified for non-inclusion of waste materials from sources other than the office. An annual seminar was organized to educate office building operators.
- *Subsidies for purchases of kitchen waste disposers*: The city subsidized purchases of electric drier-type kitchen waste disposers and supported outdoor composting baskets and buckets; 14.6% of households in the city now have such disposers – a rate that is significantly higher than other cities.
- *Composting of school lunch leftovers*: Kitchen waste from schools was composted for sustainable recycling, benefiting from economies of scale, ease of handling and consistent quality.

Results and remaining challenges. The campaign for source separation was a success and achieved a high recycling rate but still faces waste volume challenges and related management costs.

Kamakura was ranked first among all 'medium-sized' cities in terms of municipal waste recycling rate (47.8%) in FY2009 – a value that is much higher than the average rate of 20.3% (FY2009).

The initial success of the waste reduction campaign enabled the Imaizumi incineration plant to be closed (Table 3), and the city concurrently announced plans to halve the annual incineration volume to 35 000 tonnes. However, failure to achieve this target (Figure 2) meant restarting the Imaizumi incinerator for 10 years. Along with the failure of negotiation to integrate incineration facilities with neighbouring cities, Kamakura city is under pressure to renew the effort for waste reduction.

As expanded separation had been launched nearly 20 years previously, the public exhibited signs of apathy, which led the city having to reiterate the visible benefits of precise waste separation, namely reduced public costs. Despite this, waste reduction measures were still lacking, so the city considered introducing a bio-gas generator for co-processing of wastewater sludge and organic waste but shelved the plan due to high costs. It is now considering expanding organic waste composting as well as a volume-based waste fee charge and kerbside collection.

Four factors and two cases

What lessons can we draw from the above two cases about the factors influencing waste reduction and recycling initiatives?

(1) Lack of capacity at final treatment sites promotes recycling

In both cases, lack of final landfill sites motivates reliance on incineration as well as recycling to reduce the volume of waste materials going to final treatment. After dioxin problems from small-scale incinerators were widely recognized by the public in the later 1990s, central government demanded local government should renovate or integrate old incineration facilities into more advanced facilities. In the case of small cities such as Kamakura or other neighbouring cities such as Zushi, negotiation for integration of facilities among several cities was underway but faced political difficulty in reaching agreements, which prompted the local government to purposely obviate the need for another one, through increased waste separation.

Table 3. Status of incinerators in Kamakura City as of August 2013.

Incinerator	Capacity	Status
Nagoe	150 t day^{-1}	Operating since 1981
Imaizumi	75 t day^{-1}	Operating since 1973 (suspended in 2002; reopened in 2005)

(2) Existence of incinerators or waste energy recovery facilities act as a disincentive for source separation and collection of waste material

This hypothesis does not hold for Yokohama or Kamakura. The presence of incineration facilities and plans to reduce costs for incinerator renewal and operation was a strong motivation behind the waste reduction and recycling campaign.

(3) National regulations, local community preferences and demands for recycling services are key incentives for recycling

Both cities are implementing their waste reduction and recycling activities based on their basic plan for general waste management (Kamakura City, 2013b; Yokohama City, 2006). These basic plans were developed along national guidelines for development of basic plan for general waste management. As central government put the concept of Sound Material Cycle Society and the 3Rs as a basis of Japan's waste management and recycling policy in 2000, these local plans were developed along these concepts. Influence of national policy and regulations can also be observed for pressure for these cities to renovate old incinerators due to change in policy for incinerators by central government after dioxin problems in the late 1990s. On the other hand, citizens of both cities have relatively high awareness in issues related to recycling. According to the survey by Yokohama city on citizens satisfaction to city services, waste management services, recycling and separation activities have been awarded either first place or second place from 1993 to 1998 and from 2001 to 2012 (Yokohama City, 2013c). Also, during the interview, Kamakura city officials (Appendix) confirmed that the recycling cause is

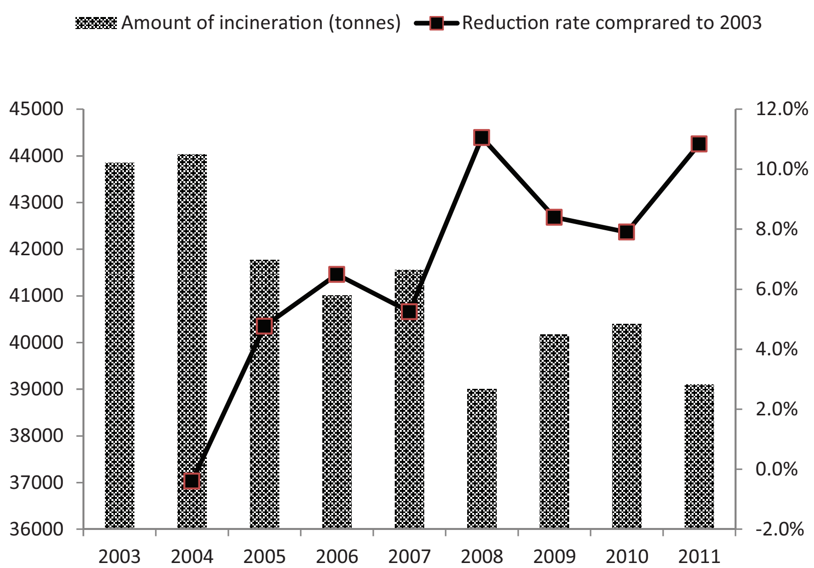

Figure 2. The reduction of amount of incineration of municipal solid waste in Kamakura [Source: Kamakura City, 2013b].

assisted by the city's high general environmental awareness and tourists' attraction as 'old capital town', meaning the cityscape is well maintained.

(4) Importance of direct, personal contact by local government to promote public participation in recycling

In both cases, city officials emphasized the importance of direct communication and through explanation of necessity of source separation to citizens. Both officials emphasized the importance of involving 'all' communities or 'all' schools, for example. This implies that, for a successful waste reduction and recycling campaign, 'public awareness' campaign for source separation is not enough but efforts and facilitation for 'consensus building' by city officials for voluntary participation of citizens to waste reduction and recycling campaign is a key.

Discussion

Of the four factors influencing waste reduction and recycling at the city level identified through the literature review, three factors were supported by the cases of Kamakura and Yokohama: (1) lack of capacity in final treatment site promotes recycling, (2) national regulations, local community preferences and demands for recycling services are key incentives for recycling, and (3) importance of direct, personal contact by local government to promote citizen participation in recycling.

In both cases, the lack of capacity in final treatment or need to renew old incinerators was a key incentive for waste reduction and recycling – a factor mirrored in other cities in Japan such as Tokyo and Nagoya – which helped establish a sound material cycle society over the 1990s and 2000s. Development of national legislation to promote recycling as well as stricter regulations for incineration facilities also aided in the promotion of waste reduction and recycling. The public awareness campaign for source separation, which involved face-to-face meetings between city officials and the public, as well as inclusion in school curricula, was the key to raising and maintaining high recycling rates, and confirms the efficacy of direct communication in recycling activities (Reams and Ray, 1993).

On the other hand, in one aspect, the case studies revealed that the 'existence of incinerators or waste energy recovery facilities' has interesting implications for the promotion of waste reduction and recycling policy. It is often believed that existence of incinerators would become disincentive for source separation and recycling (BBC, 2013; The Guardian, 2013). A comparative study of 3000 municipalities in Japan (Usui and Chikadsada, 2012) also concluded that the existence of incinerators or waste energy recovery facilities might not benefit source separation and collection of waste. On the contrary, the two cases presented in this study do not support this claim.

Waste reduction meant that certain high-end incineration facilities could be closed down and costs for upgrades reduced. As in the case of Yokohama, the high cost of maintenance and operation of high-end incineration facilities was reduced. However, for smaller municipalities with fewer facilities, as in Kamakura, closing down facilities and cutting costs posed the challenge of achieving radical reductions in waste generation due to the increased costs of more advanced separation.

Major cities and municipalities generally have a number of large, expensive treatment facilities. If source separation and other waste reduction measures succeed in cutting waste by 30–40% (Yokohama original waste reduction target was 30% and it achieved 42% waste reduction in FY 2010 compared to the base year), local government could close facilities such as incineration plants, leading to savings in waste management costs and prolonged life-spans of existing final disposal sites, thus yielding significant cost reductions in major cities.

Conversely, small- and medium-sized cities generally have only a few incinerators which cannot be closed down unless waste generation is reduced by around 50% (Kamakura's waste reduction target is to halve the waste generation and it achieved 47.8% recycling rate but could not close down one of two incinerators as originally planned) and so no substantial cost reductions can be realized.

Thus, the lessons from the case studies have identified the implications of the relationship between the existence of incineration plants and source separation. Megacities, which have several incinerators, are able to shut down some with successful recycling schemes, realize savings in waste management costs and extended lifespans of final disposal sites. However, small- and medium-sized cities with only a few or no incinerators or final landfill sites obtain only a small cost benefit even with high recycling rates. Thus, in terms of waste reduction and recycling promotion as a strategy to reduce the solid waste management burden of municipalities, the higher recycling rate in Kamakura does not mean that its campaign has achieved more policy effect in reduction of waste management burden than in Yokohama, which has a lower recycling rate.

The case of Kamakura, which abandoned its proposed biogas generation facility for co-processing of wastewater sludge and municipal organic waste, also points to the limitation of dependence on technical solutions – there is no single silver bullet to solve the waste problem. The city is currently considering wider utilization of composting at the household level as well as a volume-based fee charge, and door-to-door collection.

We thus return to our original enquiry as to what can be learned from solid waste management planning at the city level in these two case studies. First, waste reduction through promotion of source separation and a low-waste lifestyle must be prioritized. Careful choice of high-cost waste treatment facilities, which incur high installation, maintenance and renewal costs, is also important. Indeed, a recent waste management study covering 20 cities around the world (Wilson et al., 2012) suggests that use of 'better' and 'more advanced technology' such as 'sophisticated waste-to-energy technology' is unlikely to overcome the waste management challenge, particularly where weak governance is involved.

Similarly, based on case studies of Vienna, Damascus and Dhaka, Brunner and Fellner (2007) conclude that some low GDP countries cannot afford to introduce expensive pre-treatment technologies. Therefore, except for large cities or for targeting certain hazardous waste materials, the introduction of large-scale incinerators would appear inappropriate; the better option being to maximize existing recycling practices and minimize waste generation at the outset.

Further, intensive source separation and other municipal recycling initiatives have a high potential for positive results—reduced waste generation, increased public awareness and extended final disposal site lifespan. Increasing public awareness is the key for household participation in recycling and successful implementation of waste management policies, and in two cases in this paper, public awareness campaigns that involved local government played a key role. Intensive source separation and other municipal recycling initiatives can be achieved through comprehensive awareness-raising campaigns similar to those carried out in these two cities, provided the benefits are appropriately weighted against the additional administrative and other costs (Bohm et al., 2010).

Conclusions

On the factors influencing waste reduction and recycling, this paper attempted to draw lessons of 3R initiatives at the city level in Japan. The study confirmed that shortage in capacity of final treatment, support from national regulations and public participation, and direct communication from city officials to the public are key drivers for successful waste reduction and recycling activities.

However, the existence of incinerators acting as a disincentive for recycling was not, due to the nuanced relationship between incineration and recycling activities. Because of the high cost in renovation of incineration facilities or high cost in installation and maintenance for more advanced facilities, the movement to close old incinerators has become a strong incentive for waste reduction and recycling in these two case study cities. This paper also showed that the higher recycling rate in Kamakura did not mean its waste reduction and recycling campaign was more effective than that in Yokohama.

In brief, the study confirmed that the first priority should be the promotion of waste reduction through source separation, and also advocates careful consideration over decisions concerning high-cost waste treatment facilities with high installation, maintenance, and renewal outlays. In addition, intensive source separation and other municipal recycling initiatives have a high potential for producing positive results.

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The authors declare that there is no conflict of interest.

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Appendix

List of interviewees

Yokohama City

- Interview on 4 August 2010: Chief, Resource and Waste Policy Division, Resources and Waste Recycling Bureau.
- Additional phone interview on 21 February 2014: Officer in charge of source separation and recycling, Resources and Waste Recycling Bureau.

Kamakura City

- Interview on 10 August 2010: Director, Resource Recycling Division, Environmental Bureau, and a member of Resource Recycling Division, Environmental Bureau.
- Interview on 4 June 2009: Deputy Director, Environmental Conservation Division, Chief in charge of resource recycling, Resource Recycling Division, and a member of Environmental Policy Division.