Japanese Solid Waste Management (SWM):
A Case Study of Yokohama's G30 Waste Policy

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Abstract: Despite heightened awareness of sustainability issues, annual per capita waste generation continues to grow around the globe. Japan's solid waste management (SWM) policy is relevant as one of the few exceptions where levels of waste have peaked and are now in decline, mainly through the dissemination of a 3Rs (reduce, reuse and recycle) policy. The aim of this paper is to showcase the Japanese example through the case study of Yokohama`s G30 plan which targeted a 30% reduction in the volume of waste generated in 2010 compared to the 2001 benchmark. As the target was ultimately exceeded, a critical analysis is offered of the success factors that underpin the G30 policy, leading to the identification of certain challenges and opportunities. Drawing on a range of secondary sources, the paper is organized into four sections; i) transition in SWM approaches; ii) implementation of the G30 plan and; iii) analysis of G30 success factors; iv) ongoing challenges and opportunities.

Keywords: solid waste management (SWM); 3Rs (reduce, reuse and recycle) policy; Yokohama`s G30 plan; Japan

I. TRANSITION IN SWM APPROACHES

Yokohama covers an area of 437.38 km2 divided into 18 wards. The second largest city in Japan, it had a population of 3,697,006 residents and 1,606,472 households in 2012. The population grew rapidly in the post-war period (Fig.1). Together with the rapid expansion of industrial output, this necessitated a radical evolution of solid waste management (SWM) policy-making. From the 1940s, incineration overtook landfill as the dominant form of final disposal on account of certain disadvantages, such as groundwater contamination and air pollution from toxic gases and dust and above all, the extreme pressure on land prices due to the rapidly rising population.

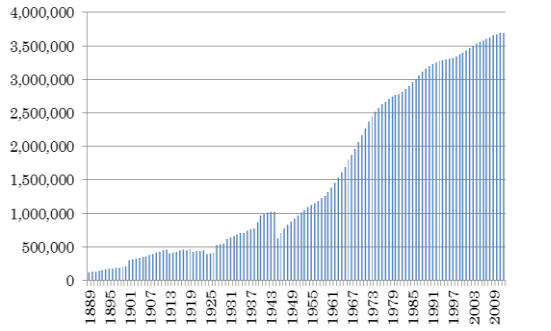

Fig.1. Yokohama's population 1889-2012 [1].

Incineration offered a quick and convenient means to greatly reduce the total volume of waste, and thereby the amount of space required for landfill. Moreover, the resulting ash could be transported and used more easily to reclaim areas of coastline. As the national economy expanded rapidly in the 1950s and 1960s, this kind of large scale environmental engineering became increasingly prevalent. One such project was the Honmoku Pier built to accommodate container ships; four jetties were constructed in a comb-like shape between 1963 and 1970, covering an area of 287.7ha [2].

However, the new waste incinerator facilities entailed high set-up costs, and had serious disadvantages in terms of air pollution, including the release of dioxins, and the production of toxic ash. By the 1960s, industrial pollution had reached chronic levels due to the breakneck speed of development, and the regulatory framework was struggling to catch up. In 1962, when one of the first environmental acts [3] was passed, the Ministry of Health and Welfare had only a small pollution control unit within the Environmental Sanitation Division. However, the increasing number of civil liabilities cases resulted in the set-up of several special divisions to deal with pollution-related matters. Growing public concern was fanned by large-scale law suits such as Minamata disease, due to methyl mercury, and Itai-itai disease, thought to be caused by cadmium [4]. The force of public opinion compelled central government to take radical steps, and a Basic Law for Pollution Control was passed in 1967. Then, after the so-called "pollution parliament sitting" in 1970, fourteen environment-related laws were passed to mitigate the impacts of industrial pollution, and a national Environment Agency established for the first time in 1971.

Although the primary target of the new environmental legislation was the industrial clusters responsible for much of the air and water-related pollution, SWM policy-making was also affected. It was thus in the 1970s that household waste began to be separated in earnest in Yokohama City, as direct disposal to landfill was phased out entirely. Initially this policy change was chiefly dictated by economic constraints and the new round of tougher regulations governing waste disposal, yet it also coincided with the growing awareness of the 3R's philosophy to Reduce, Reuse, and Recycle. Demographic drivers were again at the fore; by 1986 the population had exceeded 3 million residents, and the amount of waste generated subsequently soared to 1.2 million tons.

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This was partly due to the increase in industrial waste, with a combined total of over 1.6 million tons generated in 2000 (Fig.2).

II. IMPLEMENTATION OF THE G30 PLAN

In order to decouple the amount of waste generated from the growing population, the need for a long-term SWM strategy was clear, and after scoping in 2002, Yokohama's G30 policy was implemented in January 2003. The plan aimed for a 30% reduction (*genryō* in Japanese) of the volume of generated waste (*gomi*) by 2010 compared to the baseline of fiscal year 2001. The crux of policy realization would be a paradigm shift in thinking among three main stakeholders; identified as citizens, industries and the local government. The shift would emphasize a sustainable lifestyle by urging citizens and businesses alike to separate almost all of their own waste at source. In order to achieve this, the 3Rs philosophy was absorbed and advocated on an unprecedented scale. The G30 strategy included "hard" and "soft" components, and the policy was backed up with environmental education as well as concrete steps including increasingly rigorous separation rules, quality checks and sanctions. Finally, technological know-how would maximize the gains in waste reductions by a mixture of disposal facilities and innovative civil engineering.

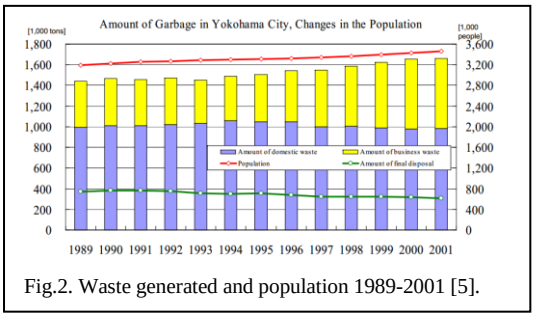

Fig.2. Waste generated and population 1989-2001 [5].

The first stage of the G30 revolved around stepped-up separation rules. The number of separation categories increased from five to ten as new categories such as paper waste – which in turn contained four sub-categories – were added (Table 1), bringing the total of sub-categories up to 15. Quality checks were also increased, with the purchase of transparent rubbish bags now made mandatory. Bags also had to be labelled with a thick felt-tip pen, which promoted accountability by making it easy to spot waste that had not been properly separated. This in turn facilitated the setting of sanctions, achieved via a two-pronged strategy. On the one hand, municipal waste trucks became increasingly selective about improperly separated waste. In 2009, for example, about 10,900 items per day were rejected [6]. Meanwhile, a system of "Garbage Guardians" was also set-up to employ local volunteers to check for offending bags. These guardians were empowered to leave reminder notes for reluctant citizens, or even deliver the trash bags back to the owner's doorstep. Sanctions were also put in place for repeat offenders, with one young couple ultimately evicted from their apartment because they consistently refused to follow the trash separation guidelines [7].

TABLE.1. INCREASING NUMBER OF CATEGORIES FOR SEPARATION

Existing 5 categories			New 5 categories		
1	combustible waste		6	plastic packaging	
2	containers	cans	7	aerosols	
		glass bottles	8	paper	newspaper
		PET bottles			magazines
3	small metal items				cartons
4	used dry-cell batteries				cardboard
5	bulky waste		9	used cloth	
			10	non-combustible waste	

Although extreme, stiff sanctions such as these ultimately helped assure the success of the G30 plan; the volume of generated waste dropped from 1.6 million tons of waste in 2001 to 0.9 million tons in 2009, a reduction of 42% which easily surpassed the initial objective of 30%. Higher levels of reused materials, and increased volumes of recycled goods would seem to account for this notable reduction, which was achieved despite continued population growth (Fig.3). The upshot of the G30 policy was thus a 58% reduction in the amount of waste being transported to landfill from 310,000 tons in 2001 to 130,000 tons in 2009 (Fig.4). This in turn allowed local government to close incineration plants, thereby saving money and reducing the emission of greenhouse gases.

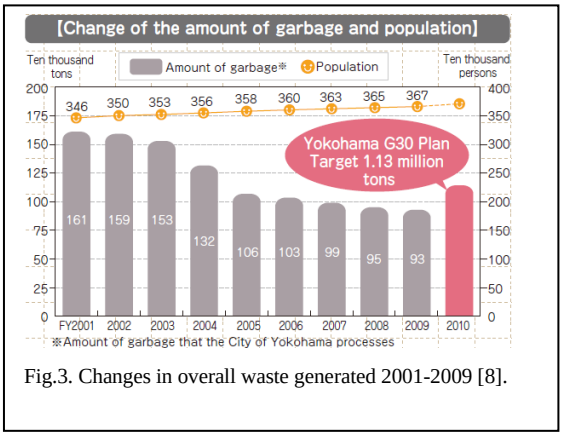

Fig.3. Changes in overall waste generated 2001-2009 [8].

III. ANALYSIS OF G30 SUCCESS FACTORS

As well as the stiffer sanctions mentioned above, the success of Yokohama's G30 project can be attributed to improvements in two critical areas; environmental education and SWM technology. This next section will next address the two factors in turn to offer insights from both hard and soft policy-making.

Firstly, one of the preeminent challenges faced by G30 policy-makers was how to provide several kinds of education in order to change the mindset and behaviour of citizens, and promote greater adhesion to the 3Rs philosophy. To this end, civic outreach has taken various forms (Table 2).

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TABLE.2. VARIETY OF PUBLIC OUTREACH CONDUCTED FY2004-05

Separation guidance sessions	11,000 times
Explanations at collection points	3,300 times
Campaigns at train station	600 times

As shown, the core of the G30 information dissemination programs were the in-depth explanations about waste separation procedure provided to local neighbourhood associations at 11,000 guidance sessions. However, the city has also reached out directly to residents via early morning campaigns conducted at collection points and in front of train stations. Moreover, educational trips are frequently made to junior high and primary schools (and even to nurseries) in order to gain the understanding and support of younger generations in the struggle to reduce waste. Municipal incineration plant facilities are also open to the public, with free tours available on request. Consumer-friendly mascots such as Mio have also been created to personify these efforts to explain and promote the 3Rs philosophy in a user-friendly manner. In this way, municipal SWM authorities have sought to gradually raise the environmental awareness of citizens and companies and solicit their cooperation in the separation and recycling that are an essential part of the G30 policy to tackle waste disposal in a systematic way. These environmental education campaigns are underpinned by advanced SWM technology, as will be explained in the next section.

Yokohama city is divided into 18 wards, with each having an office to administer waste collection. The city also owns three transportation offices, although forwarding services are now outsourced to private contractors. The single landfill site is located at Minami Honmoku Pier, an area of reclaimed coastline where construction of a deepwater container port has been underway since 1990.

Yokohama city also has four incineration plants, although two of the plants are now closed while another one has temporarily suspended operations due to the reduced volumes of waste. In light of this current situation, Tsurumi Plant – home to Yokohama's single operating incinerator – can thus be said to be the hub of current SWM operations. It started operating in 1995 and is located in coastal Tsurumi ward in north-east Yokohama bordering Kawasaki. Prior to arriving at the plant, the various types of waste are separated at source to reduce the overall volume. Collection points are also allocated different time slots to efficiently gather combustible and non-combustible waste, cans, bottles and so forth. Recyclable materials such as PET and glass bottles are collected to reuse, or recycled by the plant's partner firms. Only after the separated waste has been thoroughly checked is the combustible portion then forwarded for incineration at the Tsurumi plant, which consists of a furnace, stack and other facilities. On reaching the plant, the truck is weighed, and the volume of waste automatically calculated and recorded. Next it is deposited into the refuse pit, from where it is fed into a charging hopper by one of the refuse cranes (Fig.10). An automatic combustion device controls the quality of refuse being fed into the stoker and the waste eventually reaches the furnace. The plant's modern incinerator unit allows fully continuous combustion at 850-950 degrees centigrade, minimizing the release of dioxins and furans which are among the most serious environmental impacts associated with incineration, and tend to be produced when oxygen combines with chlorine in low-temperature burns. At Tsurumi, the central control room regulates emissions, keeping pollution within closely monitored thresholds that are significantly stricter than the minimum standards required by national law (Table 3).

Other steps are also taken to mitigate environmental impacts. For example, a dry type integrated dust collector (bag filter) is used to remove the dust from flue gas. Trucks are also thoroughly washed before leaving the plant as a hygienic precaution. Moreover, the suitable moistening of bottom ash prevents untimely leakage during loading. The bottom ash itself is then recycled at a separate facility, finally becoming roadbed material which is used in landfill sites, mainly for the creation of reclaimed land such as Minami Honmoku Pier.

From the perspective of a business model, the Tsurumi case study offers certain other competitive advantages. Disposal capacity at the plant is currently estimated at 1200 tons of garbage per day, and the annual budget is 51.8 billion JPY. However, this is partially offset by the production of some 14,000 megawatts of electricity per day from the excess heat generated during the incineration process – the equivalent energy demand for 28,000 homes. Many operational procedures are also mechanized which further reduces running costs, while ensuring pristine hygienic conditions. The Tsurumi plant is also the centrepiece of a cluster of low-emission facilities. Non-combustible, bulky garbage is crushed at the nearby Tsurumi Resource Management Centre, where citizens are required to pay a handling fee for this oversize waste. This provides an additional revenue stream from the crushing of large items like furniture and off-cuts such as waste wood, glass, iron and etc. Meanwhile the Tsurumi plant also provides recreation facilities to support the healthy lifestyle of local residents. Next door is a sports centre in use since July 1996, whose swimming pool, public bath, and green house are all powered by residual heat from the plant. Aside from the economic return, the availability of such facilities creates a sense of familiarity between local residents and the waste disposal plant, and could encourage them to recycle large-scale rubbish such as furniture which would otherwise go to waste.

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TABLE.3. VARIETY OF PUBLIC OUTREACH CONDUCTED FY2004-05

Pollutant	Relevant law	Legal threshold	Tsurumi threshold
Dust	National Clean Air Act	0.08g/m3N	0.02g/m3N
Hydrogen chloride	National Clean Air Act	430ppm	15ppm
Sulfur oxides	National Clean Air Act	325ppm	20ppm
Nitrogen oxides	Municipal Bylaw	56ppm	50ppm

IV. CHALLENGES AND OPPORTUNITIES.

Yokohama`s G30 policy has been widely acclaimed as a successful example of environmental policy-making implemented by local government. The volume of generated waste dropped from 1.6 million tons of waste in 2001 to 0.9 million tons in 2009, a reduction of 42% which surpassed the initial objective of 30%. Moreover, that reduction was achieved despite continued population growth, thereby symbolizing the kind of decoupling needed on a broader scale to tackle not only SWM but also other environmental issues such as climate change. Nevertheless, a critical analysis of the G30 success factors has identified certain challenges and opportunities that will now be discussed. Firstly, of the numerous challenges faced by the Yokohama G30 policy, two are more general and two are site-specific. Among the former, the key issues are longevity and transferability, while the latter site-specific issues include organic waste and certification; these four issues will now be tackled in turn.

The first issue is one of longevity, in other words how to maintain the support and cooperation of the three key stakeholders identified earlier as citizens, industries and the local government. This is a universal problem exacerbated by the overlapping nature of SWM, yet the short-term nature of environmental education campaigns is of great importance because they were found to be a linchpin of the G30's success. In this respect, more research is needed to see if the various means of public outreach conducted in FY2004-05 are expected to be repeated anytime in the near future.

The next topic is transferability, because not all of the G30 lessons learned are relevant for other municipalities. On the one hand, the increasingly rigorous separation rules, quality checks and sanctions seen in the Yokohama case have been echoed and even emulated by other sites such as Kamikatsu in Tokushima Prefecture, where a Zero-waste policy has been implemented since 2003. On the other hand, the numerous disadvantages of incineration including high-set up and monitoring costs means that lessons from Yokohama are not necessarily transferrable to other less well-off municipalities. The lack of transferability is symptomatic of a larger challenge, with discrepancies in SWM regulation at the local government level inadvertently leading to illegal dumping of industrial waste across prefectural boundaries [9].

The third challenge is organic waste such as kitchen slops and left-over food, which is not currently separated but merely burnt along with other combustibles. The collection and utilization of organic waste would pose a range of problems, including logistical, health-related and cultural issues. Nonetheless, the fact that organic waste is currently being ignored is a costly and inefficient anomaly, wasting a potential source of biomass while demonstrating inconsistency with the long-term target of zero emissions. This is an important oversight, because organic waste often represents the biggest fraction of municipal waste; for example in Europe organic waste alone accounts for between 30 and 50% of the total [10].

The fourth and final challenge is related to certification, either in the form of an external audit from domestic institutions or from an international ISO-certified watchdog. A waste audit is normally defined as a systematic evaluation of the amount and types of waste being generated by an organisation, and is usually conducted at the level of individual organisations. Yet there should also be clear evidence of which watchdog is responsible for monitoring local government institutions such as the Tsurumi Plant to maintain that high levels are indeed being maintained. This point is especially important as Japan has over 1300 incinerators that account for around 80% of total waste disposal.

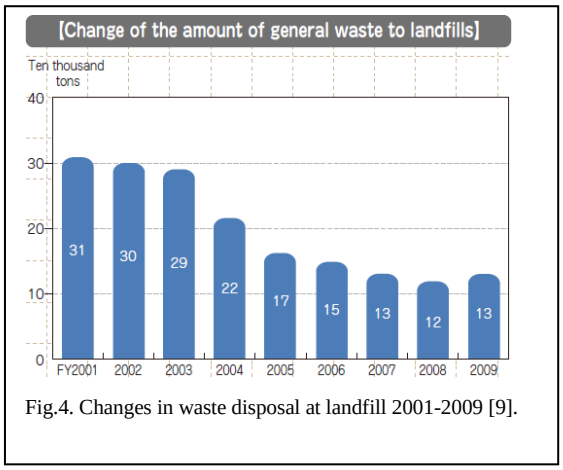

Fig.4. Changes in waste disposal at landfill 2001-2009 [9].

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