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A CASE STUDY ON SUCCESSFUL MUNICIPAL SOLID WASTE MANAGEMENT IN INDUSTRIALIZED COUNTRIES BY THE EXAMPLE OF KARLSRUHE CITY, GERMANY

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ABSTRACT
Solid wastes constitute a growing problem and have gained increased political awareness over recent years. The amount of solid waste generated in the world is steadily increasing and every government in this world is currently focusing on methods to approach the challenge. This paper is to present a case study on municipal solid waste management in the city of Karlsruhe in Germany and its practice as lessons learnt. This is because country like Germany is recognized one of the greatest examples in the world to deal with such issue. In order to solve the solid waste management problems in the World, this study is recommended that clear goals and timeframes need to be established, duties and responsibilities of national and local governments and industry clarified and funding needs to be allocated in order to produce an effective waste management framework in developing and developed countries in the world.
Keywords:
Managing, Municipal solid waste; Karlsruhe city; Germany

1. INTRODUCTION

The appropriateness of the hard approach to Urban Solid Waste Management (USWM) in developing countries has been an important concern for scholars and policy-makers. Gotoh (1989) observed that USWM should not be viewed from a narrow perspective of collection and disposal, but should instead be seen as a part of issues arising out of rapid urbanization. Expressing a similar view-point, Furedy (1990) stated that USMW is basically a socio-cultural problem, which would limit the effectiveness of a techno-managerial approach. Furedy (1992) also observed that solid waste planning in developing countries does not focus on the concept of “resource recognition”, i.e. treating waste as an unused resource. In reality, the problem is acute in developing countries, where economic growth as well as urbanization is more rapid. Effective management of municipal waste is required, but local authorities in many countries are constrained by limited finances and inadequate services (Omran and Read, 2008; van Beukering et al., 1999, Omran and Gavrilescu, 2008). The decisions in the area of municipal solid waste management are not only very capital intensive, but also difficult from the environmental and social points of view. There is a need to develop, master and implement a simple, but reliable tool that will help the decision makers in the analysis process (Omran and Read, 2008; Schiopu et al., 2007). Local governments are usually authorized to have responsibility for providing solid waste management services, and most local government laws give them exclusive ownership over waste once it has been placed outside a home or establishment for collection. As cities grow

economically, business activity and consumption patterns drive up solid waste quantities. At the same time, increased traffic congestion adversely affects the productivity of the solid waste fleet. As urbanization continues to advance, the management of solid waste is becoming a major public health and environmental concern in urban areas of many developing countries. Large municipalities and metropolitan regions are encouraged to undertake city-wide strategic planning to design and implement integrated solid waste systems that are responsive to dynamic demographic and industrial growth. Strategic planning needs to start with the formulation of long-term goals based on the local urban needs, followed by a medium- and short-term action plan to meet the goals (http://web.worldbank.org/). Many different actors have experimented with various technological options to find viable alternatives for appropriate collection and disposal of waste (Schiopu *et al.,* 2007). Solid waste management is a complex task which depends as much upon organization and cooperation between households, communities, private enterprises and government as it does upon recycling and disposal. Stakeholders in SWM are many and varied. The aim of this study is to present an overview of solid waste management as case study on successful municipal solid waste management in Karlsruhe city (Germany).

2. LITERATURE REVIEW ON MSWM

In Municipal Solid Waste Management (MSWM) of developing countries typical problem areas can be identified. These can be described as (Zurbrugg, 2003): 1) inadequate service coverage and operational inefficiencies of services, 2) limited utilization of recycling activities, 3) inadequate landfill disposal, and 4) inadequate management of hazardous and healthcare waste. The need to understand community participation and community-based environmental management initiatives have been addressed by researchers and concerned institutions for the several years now (Richardson, 2003, Omran et al., 2006, Omran & Gavrilescu, 2008).

A review of existing literature reveals that a great number of studies on SWM have been undertaken, even prior to 1970 (van Beukering et al., 1999). Earlier studies show that the prime consideration management of the public officials was the quick waste removal and destruction (Melosi, 2005). During the 1970s the debate shifted to issues of waste utilization, focusing on the technical and economic issues surrounding the allocation and utilization of available resources. Also, the existing state-of-the-art of resource recovery for managing municipal waste was examined (Bever, 1976; von Heidenstam, 1977). The early studies reveal that recycling in the past was mostly industrial and based on financial considerations to reduce production cost, unlike the current emphasis on recycling as a way of reducing waste in the environment and preserve dwindling resources (Cointreau et al., 1984; Diwekar, 2005). During time, systems approaches have also been attempted at by authors dealing with one or few aspects of MSWM (Imam et al., 2008; Omran and Read, 2008; Zurbrugg, 2003; van Beukering et al., 1999). Tsiliyannis (1999) discussed the main environmental problems related to MSWM and in particular those concerning pollutant releases. The analysis was based on the solid waste composition of Athens, Greece, and the facilities were assumed to meet EU Directives and to include the proper disposal of residues. It was found that landfilling with energy recovery produces slightly higher air pollution and greenhouse gas releases, mainly owing to the emission of uncollected biogas. Chang and Wang (1997) proposed a fuzzy goal programming approach for optimal planning of SWM systems, in which they consider four objectives: economic costs, noise control, air pollution, and traffic congestion limitations. Another possible approach is based on life-cycle assessment, which is a tool can provide the data needed for choosing the best combination from an environmental standpoint (Finnveden, 1996).

However, life-cycle assessment does not predict actual impact; assess risk, safety or whether a threshold may be exceeded by choosing an option (Bagchi, 2004). With regards to the development of a solid waste management system, Zia and Devadas (2007) attempted to introduce a SWM system in Kanpur City and by analyzing the major problems pertaining to SWM faced in the City. Because some of Indian cities are often characterized by poorly rendered services including waste management, the most ignored of all basic

services on account of various reasons. They have observed that the existing solid waste management system in the city is found to be highly inefficient. Consequently, Jin et al. (2006) presented an overview on the current solid waste management practices and situation in Macao during the last decade. However, they drew conclusions that due to Macao's geographic area and high cost of land, landfilling has the lowest priority for waste disposal and solid waste incineration has been given a top priority over the other waste disposal methods although it is much more expensive. One of their suggestions was that for an effective and efficient solid waste management in Macao, waste minimization needs to be implemented strictly in order to reduce the amount of solid waste. The establishment of new regulations for more effective and efficient integrated solid waste management system is also necessary. The regulations should indicate the appropriate authority to define and implement waste management regulations (Jin et al., 2006). Elsewhere, Turan *et al.,* (2008) presented an overview on of solid waste management in Turkey. However, they drew conclusions that MSW management is a major problem facing municipalities. The annual generation increases in proportion to the rise in the population and urbanization, and issues related to disposal have become challenging as more land is needed for the ultimate disposal of solid waste. They commented that open dumps can be detrimental to the urban environment. In spite of efforts to change open dumps into sanitary landfills and to build new modern recycling and composting facilities, Turkey still has over 2000 dumps because of insufficient financing. Turan et al., (2008) stated that composting is an excellent method of recycling bridgeable waste. However, many composting plants have failed because not enough attention was given to the quality of the product and to marketing activities. To conclude, determining methods of final disposal requires an understanding of the make-up of the MSW stream. A MSW decision support system based on integrated solid waste management should be developed for cities in Turkey (Turan et al., 2008). A recent study conducted by Hazra & Goel (2008) has presented an overview on of current solid waste management practices in Kolkata, India and suggested solution to some of the problems. They argued that the collection process is deficient in terms of manpower and vehicle availability. Bin capacity provided is adequate but locations were found to be inappropriate, thus contributing to the inefficiency. Further, Hazra & Goel (2008) proved that there is no treatment is provided to the waste and waste is dumped on land after collecting it. However, in order to improve these problems, authors provided some solutions for these problems. For instance, to improve collection and transportation at Kolkata city, public-private partnerships can be successful solution, with private agencies providing waste collection service at lower cost and grater efficiency (Hazra & Goel, 2008). Another study conducted in Sir Lanka by Vidanaarachchi et al. (2006) described the problems, issues and challenges of solid waste faced in the country's Southern Providence. However, they revealed that only 24% of the households have regular access to waste collection and that in rural areas it was less than 2%. Substantial number of household in areas without waste collection expects local authorities to collect their waste. Vidanaarachchi et al. (2006) showed that most sites in the province are under capacity to handle any increased demand on waste collecting. However, they suggested that urgent and immediate improvements of the waste disposal sites are necessary to meet the current demand for sustainable waste collection. This study was carried out using two approaches. Firstly a review study based on published and unpublished information gathered by the authors and other scientists. Secondly, informal interview was conducted with the representative director, Department Leader City Cleaning, Stadt Karlsruhe from municipal council of Karlsrhe city.

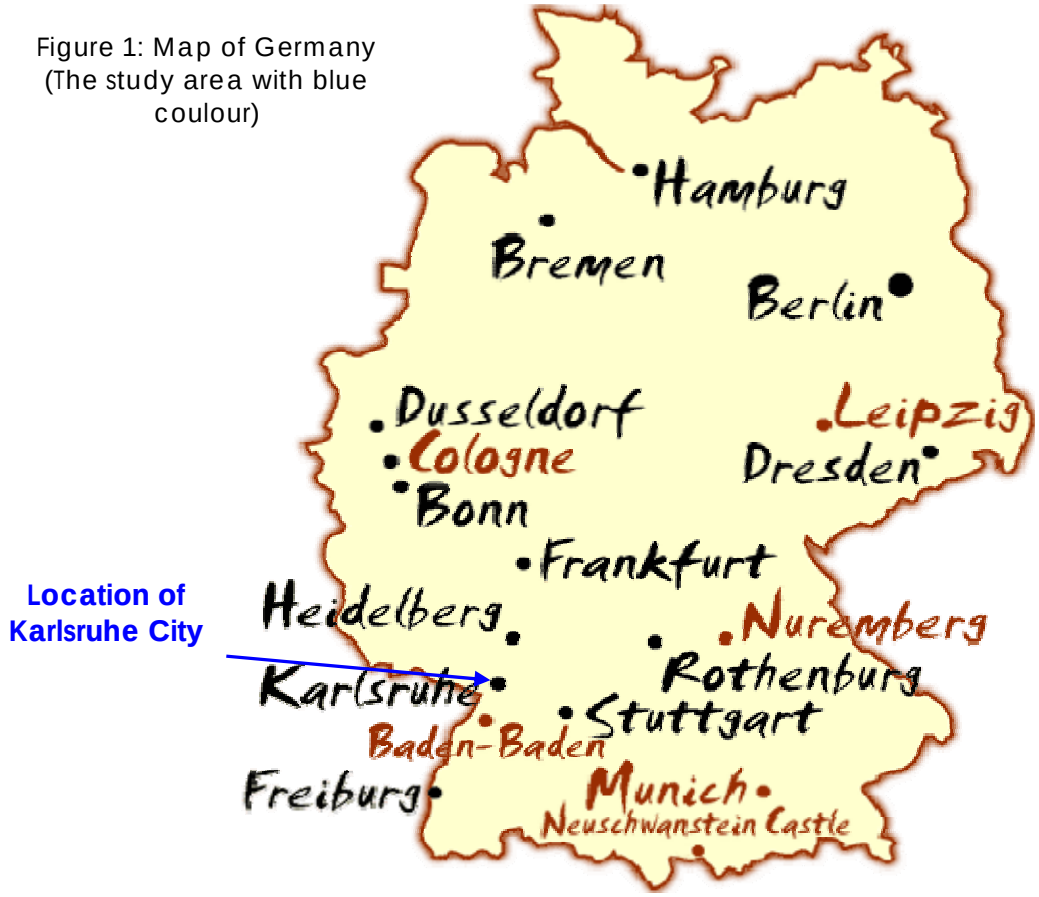
3. DESCRIPTION OF KARLSRUHE CITY (GERMANY)

Karlsruhe, the former capital of the German state Baden[1], is a city in the South-West of Germany near the French border (see Figure 1). The city has more than 300.000 inhabitants. Karlsruhe is the location of the two highest Federal German courts, the Federal Law Court, "Bundesgerichtshof" (BGH), and the Federal Constitutional Court, the "Bundesverfassungs-

[1] Before Stuttgart became capital of Baden-Württemberg in 1953

sgericht" (BverfG). Furthermore, Karlsruhe is the residence of the district administrator, the government presidency of Northern Baden. The eldest technological university of Germany is located in Karlsruhe: the physicist Heinrich Herz and the engineer Robert Bosch as well as the chemician Fritz Haber have teached at this university. Karlsruhe with the research center Karlsruhe and different Frauenhofer Institutes (Fraunhofer-Institut f. System- und Innovationsforschung ISI, Fraunhofer Institut für Informations- und Datenverarbeitung IITB, Fraunhofer-Institut für Chemische Technologie ICT) is best known as the centre of a upcoming technology region. In the sector of culture, the Handel-Festival and an elitary university, offering equally humanities and social sciences as well as natural sciences and engineering, is to be mentioned.

Figure 1: Map of Germany (The study area with blue coulour)



3. MUNICIPAL SOLID WASTE (MSW) IN KARLSRUHE CITY

3.1. Waste Management in Karlsruhe: Stakeholders

Different public and private actors are involved into the solid waste management in Karlsruhe who share the responsibility for waste disposal, transportation and recycling. The office for waste management Karlsruhe ("Regiebetrieb" = regie firm) is responsible for waste disposal, street cleaning and the municipal haulage park. Merely in some outskirts, a private disposer has been put in charge of the waste disposal. After the pickup and transportation of the different waste types, which is performed by the municipal office for waste management, the different waste types are separated and treated/ recycled by different public and private enterprises which can be shown in more detail below in the next sections.

3.2. Waste collection of different waste types

Mainly three different waste types are gathered in Karlsruhe city in different waste bins which are located in front of the residents' home: residual waste (refer to Table 1), reusable materials (including packages marked with the green dot) and biowaste. The waste bins (which have to be ordered by the residents from the waste office) are grey and differ only

from each other by the colour of the top. The top of the residual waste bin is grey, the top of the recyclable waste bin is red and the one of the biowaste bin is green. There is no combined collection of residual waste and recyclable waste. Karlsruhe has introduced the system of the assorted reusable waste bin: dry and wet wastes do not mix. Consequently, there is a higher exploitation rate. An intermediate storage is not required. The following table provides an overview about the bins for the disposal of different waste types:

Table 1: Waste bins for residual waste, recyclable waste and bio-waste

Disposal	Residual waste Bin	Recyclable Waste Bin	Bio-waste
Waste type	Old clothes (not wearable), empty folders, ash, baking paper, lead glass, broken eyeglasses, carbon bands , sanitary napkin, slides, floppy disks, vapor exhaust filter, bicycle saddle, furs, spyglasses, films , fireproof glass, lighters out of use, desiccated markers, photos, empty pens, doormats, hosepipe, coated gift wrap paper, dishes, light bulbs, plaster figures, rubber materials, gloves, suspenders, inline skater, soft dirt, cassettes (music/video), ceramics (not sanitary ceramics), candle residues, candle wax, adhesive tape, adhesive labels, carbon paper, blue paper, used refills for a ballpoint pen, artificial leather, stuffed animals, leather residues, linoleum residues, air mattresses, rags, solvent-free crayons, natural fungus, nylon pantyhoses, object lens, paper tissues, paper napkins, band-aids, brushes, chinaware, dolls, floor clothes, erasers, razor blades, test tubes, raincoat no wearable, roller skates,carbon black, records, discarded shoes, used napkinst, skate board, mirrors, syringes (packed in a way which prevents injuries), vaccum cleaner bags, tampons, hangings residues, flashlight (without any batteries), carpet residues, thermal paper, thermos flask, mineral litter for animals, audiotape, clay pots, watches without batteries, dressing material, highly polluted packages, video cassettes, hot water bag from rubber, cotton batting, cotton buds, wicker basket, swaddling clothes, butts, sparkplugs	Used paper, aluminium, antennas, baking dishes, plate, lead, sinkers, blister packages, boilers, shelves, envelopes, brochures, books, electric irons, CDs*, tins, buckets, disposable plates, electric cables, foils, hair blower, cameras, gift wrap papers, beverage cans**, packages with the green dot, domestic foils, wood (small parts), yoghurt cup (empty), yoghurt cup lids, canister, paper board container, catalogs, plastic toys, cans, crone corks, plastic packages, plastic bottles, copper pipes , margarine tub, brass bowls, metals, cartons of milk, fruit packages, tissues, paper sacks with plastic inlet, paper packages, cardboard, plastic bags, posters, radio, melting pot, juice bags, screwtop, particle boards, scavenger bottle, steel pans and pots , polystyrene (small parts in a plastics bag), pots, pans, carrier bags, tubes without noxious materials, vaccum packages, combination packages, closures, tool parts, magazines***, newspapers***	Balkony plants, banana peels, biolitterbags from paper, flower soil, bread, egg shells, finger nails, fish offals, sarco-waste, residues from vegetable peeling, hairs, excelsior, jute, coffee grounds, cheese residues, bones, diseased aeriel parts, aliment residues, fruit residues, orange peels, untreated saw dust, seeds, cut flowers, tartare/boiled leftovers, except from soups and sauces, tea bags, animal litter (if compostable), potted plants, fould food without packaging, sausage residues, lemon peels

* Alternatively, computer trade; ** Alternatively, restoration in distraint; *** better: waste paper collection
Source: Self-compiled, based on "Abfall-ABC", Office for Waste Management, March 2007 KR

Beyond these waste bins, there are also some other containers or disposal facilities for particular waste types. There are some special waste containers, e.g. glass waste containers for bottle glass and glass containers as well as battery collecting containers, which are located at most glass waste container sites[2]. Furthermore, there are textile waste containers for old clothes, shoes and textiles, green waste containers for grass and green waste which can, alternatively, also be self-composted or be carried to the compost site, and the leaves bag action for foliage. Additionally, there is the bulky waste pickup for furniture (e.g. tables, chairs, couches), bedsteads, stoves, suitcases, bureaus, refrigerators, mattresses, standard lamps, and washing machines (Table 2). Alternatively, these items can be taken to a recyclable materials counter. Wrecked cars have to be taken to an authorized recycling

[2] Alternatively, trade or to noxious substances counters

plant. Furthermore, there are some sites to which certain waste types, e.g. certain recyclable materials on the one hand and dangerous substances on the other hand are to be delivered as shown in the table below:

Table 2: Disposal/ recycling centres for special Waste Types

Disposal Sites	Recycling centres*	Noxious waste counters
Waste Types	Used tires, asbestos, bedsteads**, boilers, electric iron, computers, couches**, electrical equipment, electronics crap, windows, sheet glass, tubes (TVs), flagging, floor covering, glass (flat glass), heraclit plates, hearth**, wood (larger parts), coffee machine, suitcases**, bureau**, corks***, ice boxes**, mattresses**, metals (larger parts), oil filters, lawn-mowers, mirror glass****, floor-lamps**, hi-fi system, chairs**, tables**, toasters, doors, washbasins*****,washing machine**, breezeblocks, bricks	Paint remover, drain pipe cleaner, accumulators, used oil ******, oven cleaner, batteries, mordant, chemicals, disinfactants, fertilizers, energy saving lamps, defroster, softening agent, rust removers, developer, colors, photochemicals, oil for deep-frying, antifreezer, glass cleaner, grill cleaner, herbicides, wood preservative, impregnating, insectizides, lime remover, adhesives, cosmetics, varnish, bases, phosphor tubes, dissolvers, drugs, furniture polish, carpet moths preservatives, nitro diluter, oils, oil tanks, oil binders, agents, pipe cleaner, rust converter, sanitary cleaner, cooking fat residues, spirit, turpentine diluter, thermometer, weed killer, benzine, toilet cleaner tablets

* Recycling centre Nordbeckenstr. 1, recycling centre Maybachstr.10b, and recycling centre Grünwettersbach

** Alternatively: Bulky waste pickup; *** Alternatively: environmental centre Kronenstr.9;

****Alternatively: Residual waste; ***** rubble from a building site recycling plant;

****** Alternatively, trade or to noxious substances counters

Source: *Self-compiled, based on "Abfall-ABC", Office for Waste Management, March 2007 KR*

3.3. WASTE DISPOSAL (WASTE PICKUP), WASTE TRANSPORT, AND RECYCLING

3.3.1 Waste Disposal (pick up)

The waste disposal (waste pick up) is implemented by the office for waste management Karlsruhe as regie firm. After the waste pick up, implemented by the office for waste management Karlsruhe as municipal service provider, the different waste types are transported to different destinations (Rapp, 2008).

3.3.2 Waste Transport

The biowaste is carried to a municipal fermentation plant, operated by Karlsruhe for composting. Recycable waste is loaded on conventional garbage trucks and delivered to the sorting plant Karlsruhe Rheinhafen Alba, a private waste disposer (Rapp, 2008). The transport of the residual waste, which is carried to the waste heating plant[3] (garbage incineration plant) in Mannheim (MVV), is implemented by means of an interchangeable container system: the residual waste stays in the same container from the waste collection until the delivery to the waste heating plant. At the container terminal of the railroad in Karlsruhe the containers are entrained from the group age vehicles to rail wagons for the haulage to Mannheim. A portal crane in the waste heating plant discharges the containers to a shuttle vehicle which carries the containers for offloading to the waste bunker. After emptying, the containers are returned by railway to Karlsruhe, are put on the car frames and the pick up process starts again (Rapp, 2008).

3.3.3 Waste Separation and Recycling

The biowaste is processed into compost and screen residues in the municipal fermentation plant. A part of the compost is placed at the disposal of Karlsruhe's residents free of charge as manure for the garden, another part is used for the production of premium soil, once another part is used in agriculture. The screen residues are partially usable for composting, partially they can be used for energy production by incineration (Rapp, 2008). The recyclable waste which is carried to the private waste sorting plant Alba, a partner of the office of waste management Karlsruhe, is applying different kinds of segregation technologies for different recyclates. There is a handy separation for some materials, e.g. for

[3] Partially operated privately, partially by authorities

wood, and there are different kinds of separation techniques by machines for the different sorts of reusable materials. There are, for example, screening segregations for the separation of mineral materials on the one hand and small parts on the other hand (coarse fractioning and fine fractioning). Metals are separated by a magnet separators whereas non-ferrous metals as, for example, Aluminium, are separated by an eddy-current separator (Rapp, 2008). There are different NIR-machines applied for the separation of different sorts of paper and plastic waste, which are able to identify the tetra packages among the paper and plastic waste by means of a spectrometer. This high-tech system which is applied since about four years at Alba works as follows: The waste parts run on an assembly line and pass below a camera which is able to detect the tetra packages by a spectrometer (graphic scanning system). At the end, the tetra packages are blown out by an air pressure jet (Rapp, 2008). Once the waste separation of the recyclable waste is finished, the waste is pressed in large bales, loaded on trucks and transported to different private recycling enterprises: The paper waste is delivered to paper mills, the plastics to plastic processing factories, the metal to metal recycling plants, the wood to wood recycling enterprises and the biomass is delivered to the public energy provider EnBW (Rapp, 2008). The treatment of the residual waste is done in the private-public heating plant in Mannheim (MVV), an energy producing plant, which is partially producing energy by the incineration of residual waste (Rapp, 2008).

4. CONCLUSION

Without doubt, untreated solid wastes frequently contain components that have the potential to cause infectious diseases. The level of this potential remains largely not assessed, but more current treatment process can either totally or consistently eliminates such risks (Hamer, 2003). The waste management situation in Germany is constrained in various ways that differ from region to region. Once cannot, speak of an emergency. Management of domestic and bulky waste is largely assured. More serious problems arise in the management of commercial wastes; these will persist for some time. To ease the situation, greater efforts need to be made to segregate wastes at source, to sort them, and in particular, to complete, expand and newly establish treatment and recovery facilities. Until such facilities are completed, wastes will need to be sought abroad. One thing, however, is certain: There is no turning back. Acting in unison, those responsible in the federal and local authorities, in the municipal and private-sector waste management industry and in the industry federations will be able to master the difficult waste management situation in Germany.

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