SURABAYA INDONESIA: OPTIONS IN SOLID WASTE MANAGEMENT

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1. INTRODUCTION

The Government of Indonesia requested assistance from the United States Trade and Development Program (TDP) regarding improvements to the solid waste management system of the City of Surabaya. TDP retained the author to prepare a Preliminary Feasibility Study which will enable TDP to make an informed decision on the desirability of funding further engineering work leading to solid waste projects.

Surabaya is the major industrial city of the Province of East Java, Indonesia. It is also the second largest city in Indonesia with a current population of 2.8 million, which is expected to increase to about 3.5 million by the year 2000.

As in many other large cities, the collection and disposal of solid waste has become a critical problem in Surabaya. The current solid waste management system cannot keep pace with the current rate of solid waste generation and will be completely overwhelmed in the near future if significant improvements are not implemented soon.

2. METHOD OF APPROACH

The Preliminary Feasibility Study was conducted in Indonesia during the period August 28 through September 4, 1986. The following procedure was followed:

2.1 Data collection

The primary means of data collection was by interview and site visits. Five Temporary Collection Areas and all of the Final Disposal Sites were visited. Existing solid waste records and reports were reviewed. The U.S. Consulate assisted by translating the Province Solid Waste laws. Translation assistance was also provided by Mr. H. Poeryanto of the Provincial Planning Board.

2.2 Photography

A detailed photographic record was collected by both 35 mm still photography and VHS video. The video tapes shot in-country have been edited into a 20 minute tape. Videotaping of interviews provided error-free transcription which was used in the preparation of this report. The edited tape was also provided to TDP and the City of Surabaya as a supplement to the main report.

2.3 Sorting Study

A field sorting study was performed at one of the Temporary Collection Areas. The study involved manual sorting of the waste into potentially recyclable materials (i.e. glass, paper, metals, etc.) and weighing each component.

3. EXISTING SOLID WASTE MANAGEMENT SYSTEM

3.1 Waste Generation

Current waste production in Surabaya is approximately 5600 cubic meters per day. This is expected to increase to 8500 cubic meters per day by 1992. The projected increase in waste production is caused by both an expected population increase and an increase in waste generation per capita (Reference 1).

Of the current total, approximately 2000 cubic meters per day are not collected (Reference 2). These wastes are either burned or illegally dumped in the streets and into rivers and canals.

3.2 City Solid Waste Management Organization

The city has a total staff of over 1300 workers involved in the solid waste managemnet system. These workers operate hand pushed collection carts, collection trucks, street sweeper trucks, transfer vehicles, and manage the Temporary Collection Areas and Final Disposal Sites. In addition to city workers, a substantial portion of the wastes (2500 cubic meters per day) are transported by private contractors.

3.3 Collection

Solid Waste is collected in the city by both trucks and hand carts. In many parts of the city, hand carts are the most feasible method for collection on the narrow streets.

3.4 Transfer and Transport

After collection, the wastes are taken to one of 20 Temporary Collection Areas, or TCA's, located troughout the city. At these sites, waste is loaded into either steel containers which are later picked up by special container trucks, or reloaded into dump trucks. Several types of TCA's exist:

3.4.1 Off-street yard -The Bukit Barisan TCA is typical of this type. Waste is collected in a walled, concrete floored area away form the street. Wastes are reloaded by hand with pitch forks and baskets into dump trucks for transport to the Final Disposal Site. This process takes up to an hour, greatly reducing the productivity of the truck crew.

3.4.2 On-street container area -At the Penghela Street TCA, waste is loaded into 10 cubic meter containers for truck transport to the Final Disposal Site. Waste is hand loaded and packed into the containers. The containers are parked on the shoulder of a busy street. Heavy traffic is a hindrance to operation of the area and a significant hazard to city workers.

3.4.3 Off-street container area -At the Pirngadi Street TCA, wastes are unloaded from hand carts into 10 cubic meter containers. The loading area is fenced off from the street. This removes the loading activity from the street and improves the cleanliness of the area.

3.4.4 Off-street market area -The Keputran TCA is a typical market area. It services both residential and commercial customers. At this area, wastes have overflowed the collection area and spilled over into the street. This poses a hazard to both city workers and the general public. Again, the hand loading of trucks reduces productivity.

3.4.5 On-street "emergency" area -At the Pandigiling Emergency TCA, a section of city street has been set aside as a Temporary Collection Area. This causes health and safety problems because the waste connot be isolated from the general public and interferes with the flow of traffic. The area has been used as an Emergency TCA since 1978. Fortunately it is not typical of the other 19 TCA's in the City.

3.5 Problems with Uncollected Waste

Surabaya is criss-crossed by rivers and drainage canals. In some areas of the City these canals have been used for the illegal disposal of wastes. These solid wastes float downstream until they lodge on an obstruction and form banks. Besides being unsightly, these waste deposits reduce the carrying capacity of the canals and rivers and cause flooding during the rainy season. The City is aware of these problems and has a dredging program to keep the canals clear. A law has been passed outlawing dumping into the canals. Violators are subject to a heavy fine.

A related problem exists in regards to the accumulation of wastes in the drainage ditches. In most cases this is caused by street litter. In some cases, the filling of drainage ditches is caused by wind-blown wastes from a TCA, as sometimes occurs at the Penghela Street TCA. The clogged ditches allow the collection of standing water and the subsequent breeding of mosquitoes.

3.6 Final Disposal Sites

After the wastes have been consolidated at the Temporary Collection Areas, they are transported to Final Disposal Sites. Solid wastes are spread on the ground at these sites and compacted with tractors. There are two city owned sites currently operational and one private site. A new site is being developed by the City at Asemrowo. It is typical of conditions in Surabaya in that the site has high groundwater and is already heavily encroached by housing areas

At the nearby Asemrowo private landfill site, fires are common, causing hazardous conditions for workers and generating unhealthy air emissions. Scavenging of recyclable materials at the landfill is a common, but potentially dangerous practice. As in the new Asemrowo city landfill site, this site is surrounded by housing areas.

The main Final Disposal Site for Surabaya is the Keputih Disposal Site. Over fifty transfer trucks a day deposit wastes at the site. Operations are conducted from 7 AM to midnight. Wastes are already over 5 meters deep. Scavenging is conducted at the site by local residents, often at great hazard since visibility is hampered by the piles of waste and the truck and tractor operations. During the rainy season the site is only accessible to heavy duty trucks and crawler tractors.

The site is operated as an open dump. Wastes are uncovered during the operational lifetime of the site. While this makes the wastes available for scavenging, it allows the breeding of disease vectors such as flies and mosquitoes, causes significant air pollution from the emissions of methane and other naturally generated gases, and allows the penetration of rainwater into the landfill. Water percolating through the solid waste causes the formation of leachate, a highly concentrated liquid waste. Leachate can enter the groundwater, contaminating local wells.

3.7 Recycling

Recycling is an integral part of Indonesian life, A prior solid waste study in 1976 (Reference 2) found that up to 25 percent of the waste generated in the test households was recycled before it left the home. This type of recycling, source separation, is the best because it produces the cleanest material.

Additional recycling is also occuring at the Temporary Collection Areas. Typical recycled materials include: plastics, cardboard, tin cans, glass, and mixed paper.

A third type of recycling is taking place at the Final Disposal Sites. Known as scavenging, this is probably the least productive recycling since so much has already been removed from the waste sttream. Nevertheless, scavenging provides a meager living for a considerable older men and women are involved. Due to the operation of tractors and trucks at the disposal sites, scavenging is very hazardous.

3.8 Solid Waste Composition

Prior studies in Surabaya (Reference 3) and other cities in Indonesia (Reference 4) have shown that the solid waste stream is predominantly organic material, 94 and 67 percent respectively. A 353 kilogram sample sorted during this study at the Pandegiling Street TCA confirmed these findings. Over 95 percent of the sample was found to be organic and food wastes. By comparison data from the United States (Reference 5), shows less than 28 percent of the solid waste is organic.

4. SOLID WASTE MANAGEMENT OPTIONS

The current status of solid waste management in Surabaya, Indonesia has been reviewed by means of site visits, interviews, and a review of available translated documents. It is this author's opinion that significant improvements can be made in the solid waste management system in the areas of transfer and transport, final disposal, volume reduction, and energy recovery.

Although these options are site specific to Surabaya, similiar conditions exist at other cities in emerging midnight. Wastes are already over 5 meters deep. Scavenging is conducted at the site by local residents, often at great hazard since visibility is hampered by the piles of waste and the truck and tractor operations. During the rainy season the site is only accessible to heavy duty trucks and crawler tractors.

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Although these options are site specific to Surabaya, similiar conditions exist at other cities in emerging nations. The options do not represent radically new technology, but rather appropriate technology which can be easily adapted to Surabaya.

4.1 Transfer and Transport

The City Cleaning Section has over 1300 workers. Reference 1 indicates that the City cannot afford to add more wokers to the payroll. It is therefore important to optimize the performance of the existing workers. Total mechanization of the operation is neither desirable nor affordable. Hand collection of wastes is the only feasible method in many parts of the city. However, there may be sections of the city where mini-trucks or scooters could be used. A careful evaluation of collection routes should be performed to evaluate this concept.

A major bottleneck in the existing system is the manual loading of transfer trucks at the Temporary Collection Sites. Some of the areas are large enough that small front end loaders could be utilized with no modifications to the existing area (i.e. the Bukit Barisan TCA). At other areas redesign is necessary to speed up loading. For example the sites which use containers are not suitable for loading by mechanical means. However a ramp system could be devised by which the hand carts would be unloaded from a platform above the containers, eliminating the time consuming unloading and reloading process.

The feasibility of using waste compaction in the transfer trucks should be investigated as a possible method of decreasing costs. The weight carrying capacity of the streets and highways enroute to the Final Disposal Sites should also be considered.

The optimization of the collection and transfer process should free up workers who can be reassigned to duties which still require manual labor. This should allow service to expand into areas not currently served.

4.2 Final Disposal

The current practice of open dumping of solid wastes should be curtailed for several reasons:

a. It causes significant air pollution from the emission of methane and other hydrocarbons which are natural decomposition products of organic wastes. Open fires, such as observed at the Asemrowo private disposal site are an additional air pollution hazard.
b. Because of poor compaction, the present practice is wasteful of land.
c. The exposed waste provides a haven for mosquitoes, rats and other disease vectors.
d. The percolation of rainwater through the uncovered waste leads to the formation of leachate, an extremely concentrated wastewater which can contaminate local groundwater.

The technology of choice is the sanitary landfill. Briefly, an sanitary landfill differs from the current practice in that the waste is not just piled on the ground, but rather placed in thin layers, compacted, and covered with a thin layer of earth every day. This has many benefits including the isolation of the waste from rats and other vermin, control of rainwater infiltration, and control of methane leakage to the atmosphere. A properly designed sanitary landfill can be reclaimed for parks or other public uses after filling. It is also possible to drill wells and recover the methane gas for beneficial use. The ramp and area methods of landfilling would be most appropriate for Surabaya because of the flat terrain.

4.3 Incineration

Reference 1, the Draft Five-Year Solid Waste Plan for Surabaya, recommended the use of incineration for volume reduction. In the opinion of the author incineration is not economically feasible because of the extremely high organic content of Surabaya's waste which has high moisture and low energy contents.

Wastes sampled on September 2, 1986 by the author and in 1984 (Reference 1) had calculated moisture contents of 62.3 and 58.3 percent respectively. Energy content calculations for the same two samples were 2,621 BTU/lb (6,096 kJ/kg) and 2,846 BTU/lb (6,619 kJ/kg) respectively (as discarded basis). A solid waste study in Bandung, a city in West Java, found 66.5 percent organic matter in the waste, with a measured moisture content of 83.5 percent for the combined waste (Reference 4). The study concluded that the waste was not suitable for incineration. By comparison, typical solid waste in the United States has an average moisture content of only 20 to 30 percent and an as discarded energy content of over 4,500 BTU/lb (10,467 kK/kg), Reference 5.

Although it is possible to incinerate almost anything including sewage sludges at 90 percent moisture content, to do so requires the input of additional energy to evaporate the moisture. Typically this energy is in the form of natural gas or fuel oil. The cost of this additional energy was not included in the estimates of Reference 1.

4.4 Composting

The high moisture, high organic content of Surabaya's wastes make them ideal for biological treatment. Two types of treatment are possible: aerobic treatment (composting), and anaerobic treatment (landfill gas recovery). The latter process will be discussed as an energy recovery option.

Composting of Surabaya's solid wastes has already been performed on a commercial scale by a private firm under City franchise. The firm failed about two years ago because it could not market the compost at a profit. The firm used a relatively capital intensive European composting system, the Dano process, which was not cost competitive in the Indonesian market. Twenty thousand tons of the compost have been stockpiled and are still being sold, but production has ceased.

A less costly form of composting, the aerated pile method, has been developed by the U.S. Department of Agriculture Research Laboratory, Beltsville, Maryland. The process involves building piles of waste over a grid work of perforated plastic pipes. Air is drawn through the waste by a small blower connected to the pipes. After composting is completed, the pipes and blower can be reused.

The process is used in the United States for the composting of sewage sludge. The liquid sludge is mixed with wood chips before composting. The high moisture, high organic content solid waste of Surabaya would be ideal for this method. Any sales of compost which may result should be regarded as cost offsets and not profit. Unsold compost can be used to reclaim closed sanitary landfills and for other City landscaping and park projects.

4.5 Landfill Gas Recovery

Solid wastes are naturally decomposed by anaerobic bacteria in the wastes. These bacteria convert organic waste into carbon dioxide gas and methane gas, about a 50 percent mixture of each. This process occurs quite slowly, taking up to 20 years. In contrast, the aerobic composting process is quite fast, taking place over a period of days.

The mixture of methane and carbon dioxide is known as landfill gas. Left uncontrolled, it is a serious pollution and safety hazard. The carbon dioxide gas is heavier than air and highly soluble in water. It lowers the pH of water making it acidic. Methane is lighter than air and insoluble in water. It migrates through the soil or waste along cracks and fissures. Methane is highly flammable and even explosive in certain mixtures with air (5 to 15 percent).

Current open dumping practice in Surabaya allows the landfill gas to escape into the atmosphere or migrate through the soil, possibly entering adjacent houses which completely surround all the existing Final Disposal Sites. Landfill gas also escapes through the top of the open dump into the atmosphere. This is both a safety and environmental problem and a waste of a valuable resource.

About 10 years ago, increasing natural gas prices made it economic to recover landfill gas. The recovered gas can be used in boilers, engines, and gas turbines. For example Los Angeles County, California generates 2.8 megawatts of electricity, enough for 5,600 homes (Reference 6). Landfill gas is recovered at over 70 other sites in the United States (Reference 7).

Most of the landfill gas systems in the United States have been developed under royalty contracts by private developers. The landfill owner receives a royalty (typically 13 to 20 percent) of gross revenues. In return the developer builds and operates the system at no cost to the landfill owner.

Some landfill gas projects have been developed and operated by landfill owners themselves. In this case the owner receives all of the income but must pay the capital and operating costs.

A feasibility study should be done to estimate the potential for gas recovery if sanitary landfills are adapted in Surabaya. The study should also identify potential landfill gas developers interested in Surabaya. It may be possible to offset much of the sanitary landfill costs by a suitable contract with a landfill gas developer. The potential for a landfill gas system owned and operated by the City of Surabaya should also be explored.

5. CONCLUSIONS

A solid waste survey was conducted in the city of Surabaya, Indonesia under the sponsorship of the U.S. Trade and Development Program. The present solid waste management system was found to be overloaded. The following improvements were recommended:

a. The transfer and transport of solid waste should be improved to make more efficient use of existing man power by partial mechanization.
b. The existing open dumps should be converted to sanitary landfills.
c. Composting should be re-evaluated as a volume reduction method.
d. Landfill gas recovery should be investigated a means of controlled gas migration and generating revenues.

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