Urban solid waste management in Bandung: towards an integrated resource recovery system

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I. INTRODUCTION

THIS PAPER DESCRIBES the action-research which was undertaken in Bandung and other cities in Indonesia in developing new ways of working with scavenging communities in integrated resource recovery modules. Each module would take up around 1,000 square metres and produce compost from organic wastes while also recovering glass, paper, metal cans and other recyclable items. Such a module could serve between 25,000 and 30,000 inhabitants. These modules can be developed incrementally so that a growing network of them comes to serve an increasing proportion of the population of a major city such as Bandung. These modules also have many cost and social advantages over the more conventional, centralized solid waste management systems. Section II describes how the concept of this module was first developed, in collaboration with a group of scavengers. Section III describes recent changes in the Bandung Municipal Cleansing Enterprise while Sections IV, V and VI consider how to develop the network of Integrated Resource Recovery modules.

City administrators and planners know well that the management of solid wastes is an increasingly difficult problem. As a city grows, so too do the distances between the city areas where the wastes are generated and the dumping sites and this is reflected in increasing costs. In addition, new dumping sites are harder and more expensive to obtain. The costs of waste management increase; in most instances, the subsidy needed to maintain an effective service is beyond the financial capacity of local governments.

In Indonesia, as in other Third World countries, two waste management systems exist side by side. One is what might be called the "formal system" which is managed by the local government and based on the concept of collection-transport-dumping of waste. As the volume of waste increases, to too do environmental health concerns and the need for environmental protection. This is why more sophisticated methods and technologies for collection-transportation-dumping are being continuously developed and introduced;

these may include large, centrally located waste processing plants for waste separation which allow the sorting of wastes and thus the separation of those parts of the waste which can be recycled.

The use of containers at the household and neighbourhood level, mechanized equipment such as compactors and bailers, special dump-trucks and bulldozers, and sanitary landfill are becoming more common in the larger cities. All these make waste management more efficient and hygienic, but they also increase costs and makes the service more expensive. Recently, the private sector has been encouraged to participate in the collection, transportation and dumping of waste, acting as a contractor for municipal government. It is a strategy which helps to reduce the physical burden of waste management, but it does not reduce the cost. Initiatives to use waste for energy generation through recycling and incineration are now also being introduced. But their effectiveness and economic viability is still not proven. The use of large and expensive composting plants in two of Indonesia's larger cities, Medan and Surabaya has not been successful and the one in the largest metropolitan centre, Jakarta has never been installed.

The "formal system" of solid waste management has an "informal" counterpart - scavengers who draw out of the waste stream those wastes with a resale value, such as plastic, paper, glass, tin cans and bones. Most of this material is sold to industries which recycle waste materials. This activity is quite pervasive, using around five to ten per cent of urban waste. Scavengers may collect wastes direct from the household or separate saleable wastes from household and neighbourhood dumps, transfer depots and final dumping sites. Usually, the scavengers do not tidy up after sorting through the wastes (in final dumping sites, this does not matter). Thus, they are regarded as a nuisance by the communities and by local government. This negative image of scavengers is reinforced by the fact that among them there are petty thieves, who may steal from houses and factories they visit. This negative image is more dominant in the minds of local government officials than their potential as a user of waste. Official policy usually classifies them as vagabonds who have to be evicted and put in "social rehabilitation centres".

However, at the end of 1988, official policy changed when the Indonesian president declared scavengers to be a "self-reliant army", who do not ask for government assistance to create job opportunities. Furthermore, they contribute to the use of wastes and earn their living from doing so. As such, they should be given the necessary support to do their job. With this statement, it became politically more acceptable to develop the potential of the scavenging system into an alternative approach to conventional waste management.

The two approaches to waste management - the formal and the informal - represent two different views of waste. One considers urban waste as a health and environmental hazard, and believes that every step should be taken to protect the environment against it. The second approach considers urban waste as an economic resource from which marketable products can be derived. As such, it achieves several objectives at the same time: lessening the volume of waste that needs to be dumped; reducing the need for financing and subsidizing waste management; and creating job and income opportunities.

In richer nations in Europe and North America, higher wages force the introduction of "back-end technologies" to sort waste, which are costly and capital intensive (although more sorting is now being done at source by promoting participatory methods). These do not help

reduce transportation costs since the waste in its entirety still has to be collected and taken to the recycling plant. In the Third World, by contrast, there are thousands of self-employed people who live from sorting waste; this is part of their survival strategy.[1] However, any alternative approach to conventional waste management has to deal with the utilization of organic waste which constitutes around 70-80 per cent of the total waste. The most efficient solution would be the introduction of waste processing (including organic waste) as near to its source as possible to reduce the cost of transportation and dumping. This might be in the form of composting and/or incineration.

The problem is how to develop an alternative waste management system which remove wastes economically, with low investment costs, which is socially and politically acceptable and which is sustainable because it finances its own operation. Subsequent sections describe the evolution of an alternative waste management system in Bandung, using what is sometimes called the Integrated Resource Recovery System.[2]

II. RESEARCH AND DEVELOPMENT IN INTEGRATED RESOURCE RECOVERY

IN 1980, THE Centre for Environmental Studies at the Bandung Institute of Technology undertook a study of the urban informal sector in co-operation with the Institute for Social Studies in the Netherlands and this included a focus on scavengers. After the completion of this study in 1982, the project grew into participatory action research with a group of 35 families who were illegally occupying a piece of land in the centre of Bandung. Co-operation with the municipal government was sought; the municipal government wanted to organize this group (which was to be moved from this site to make way for the construction of a parking lot), possibly as a productive community. As the research developed, local scavengers became actively involved. A strategy was adopted by which a professional fieldworker acted as a participant observer to report to the research board on the kind of actions that might secure the participation of the scavengers. The fieldworker, a sociologist, lived for three months with the scavengers. Surprisingly, the first result of such contact was a mass wedding of seven couples who were already living as husband and wife, but who could not get married because they did not have an identity card. Another 29 couples were to get married during the lifetime of the project. This broke the barriers between researchers and the scavenger group who up to that point had distrusted outsiders. The second step was to set up an evening school for the group's children, and this school became a rallying point for the women. This programme was supported by a local non government organization. The third action involved the development of activities around the mosque, supported by the Da'wah Institute of the Islamic University of Bandung. These included sermons which became very popular, and attracted not only local scavengers but also other members of the neighbourhood. The mosque also became a centre for resolving local conflicts and for organizing common action. The final step in the project was to establish a savings and loans association, aptly named the "recycling co-op". Thus, within three months, a group of scavenger families who had been trying to survive

1. Editors' note: see for instance the example of Smokey Mountain in Manila describes in a paper by Jimenez, Rosario D. and Sister Aida Velaquez (1989), "Metropolitan Manila: a framework for its sustained development", *Environment and Urbanization* Vol. 1. No. 1. pp. 51-58; 20,000 or more people who live next to this, Manila's main solid waste dump and most make a living as scavengers.

2. Cointreau, Sandra et. al. (1989), *Integrated Resource Recovery, Recycling from Municipal Refuse: A State of the Art Review and Annotated Bibliography*, World Bank Technical Paper No. 30, Washington DC.

Box 1: Project activities with the scavengers

Over a three year period, the work included:

- **intensified sorting of waste and sale of recovered material (including paper, plastic, glass and metal cans);**
- **introduction of aerobic composting of organic waste with the end product both sold and used for intensive urban farming by the community;**
- **introduction of seed farming, using seeds collected from wastes. This was initiated by a request for mango seed from an NGO for a re-greening programme; 200,000 seeds were collected within two weeks and sold for Rp 850,000 (US$ 464).[3] This motivated the scavengers to organize a seed farm - a three-month old seedling of various fruit plants may bring up to Rp 300. At one time a stock of 6,000 seedlings was sold. Towards the end of the project, demand for pineapple seedlings for East Indonesia increased. Forty-three thousand seedlings were supplied by the co-op at Rp 30 per three-month old seedling;**
- **rabbit-raising was initiated by the community. Fourteen rabbits were given as a loan, and 28 rabbits were returned as repayment within one year; in all about 200 rabbits were raised during the project;**
- **improvement of all the shelters took place incrementally, so that after two years the settlement began to look like an ordinary *kampung*;[4]**
- **the co-operative was able to save Rp 200,000 in the first year. By the end of the project, savings totalled Rp 2,000,000 (US$1,093).**
- **a unit to purchase and then make available goods for daily needs such as rice, sugar and oil was established under the co-op;**
- **health care, child and mother care were introduced in co-operation with the Municipal Health Department;**
- **the Municipal Co-op Office helped in training and auditing the co-op;**
- **a double-pit public toilet was built by the community themselves as a field test by the United Nations Development Programme.**

3. 1 US$ = Rp 1,830.

4. A *kampung* is a traditional settlement or neighbourhood; most developed from villages.

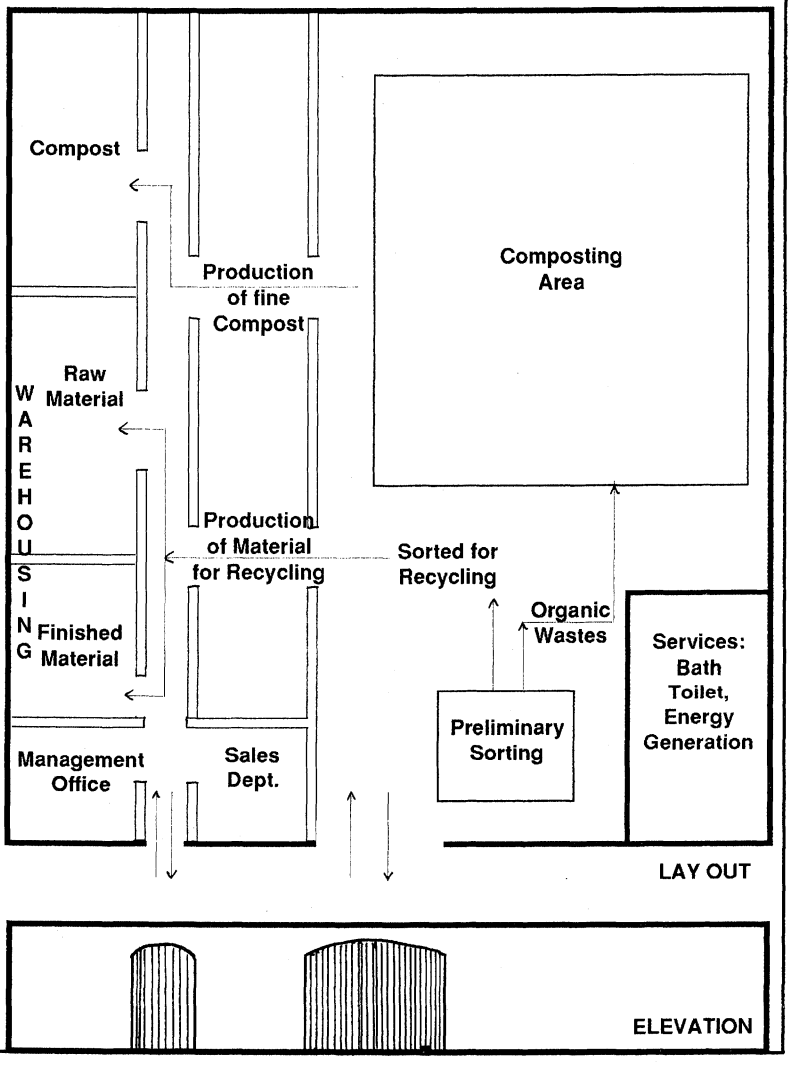
individually in a hostile environment had transformed themselves into a dynamic and creative community. At the end of the research in 1986, when the site was taken over for the construction of a parking lot (as part of the expansion of a nearby sports and recreational complex), the community had grown to 88 families. Box 1 summarizes the activities undertaken over a three year period.

The research showed that with careful social preparation, a productive community can be established. This experience became the basis for developing the concept of the Integrated Resource Recovery module as the building block of a dispersed system of waste processing. Such a dispersed system could be developed incrementally, as market opportunities permitted. Each module requires very little investment but can be economically viable. For promotion purposes, the module came to be called the Garbage Industrial Estate. Performance and technical specifications have been developed from the

research in Bandung and from experiments carried out in the Jakarta Zoo, experimental work in Jakarta and the experience with the Bandung Municipal Cleansing Enterprise (see section III).

Low-cost waste processing technologies have been developed in co-operation with the Development Technology Centre. These consist of:
(i) first generation of aerobic composting technology with stacks of 1.5 x 2.0 x 2.5 cubic metres, manually formed and turned over for aeration and fermentation; cost of production of raw compost Rp 25-35/kg;
(ii) second generation composting technology with holed bamboo pipes to get water and air into the composting stacks, no turning over necessary. Production cost about Rp 25-30/kg;
(iii) third generation composting technology (still being developed) using a ferris wheel or carousel to minimize the need for land. Target cost Rp 10/kg;
(iv) multipurpose plastic and compost chopping equipment to produce plastic and compost grains; for plastic to increase value from Rp

Figure 1: Preliminary design for an Integrated Resource Recovery Module Not to scale



Box 2: Performance and design specifications for an Integrated Resource Recovery Module

The figures here are still tentative since the experiments were conducted under conditions which were not fully controllable. In addition, they would also be influenced by local conditions, and the development of the organization and management system and the technology and market conditions.

Capacity	**- 24 cubic metres raw waste a day (14.4 tons)**	
Land area needed	**- 1,080 square metres**	
Employment	**- 22-23 persons (including those employed in transport, sorting, composting, chopping and processing of inorganic wastes**	
Initial investment	**- land (variable, depends on location)**	
Production cost of raw compost	**- equipment Rp 2.5-3.5 million (US$1,367 - 1,913)**	
	Labour (8 persons)	**Rp 720,000/month**
	Gas, oil, maintenance, depreciation	**Rp 240,000/month**
	TOTAL	**Rp 960,000/month**

(NB labour costs exclude variable costs such as land, transport, contributions to community)

Total initial output would be some 3.6 tons of raw compost a day (or 108 tons per month plus other recyclable items (the amount depending on the structure of the waste)

In financial terms, this is equivalent to
108,000 kg at Rp 20 per kg = Rp 2,160,000 (raw compost)
70,000 kg at Rp 75 per kg = Rp 5,250,000 (fine compost)
plus the income from selling the other recyclable items.

The final investment would depend on how much input-output was desired but for a module serving between 25,000 and 30,000 people, the investment would range between Rp 40-60 million, depending on the degree of mechanisation.

100-150/kg to Rp 750-900/kg, and for compost from Rp 25-35/kg to Rp 125-300/kg, or even Rp 500/kg;
(v) plastic cleaning equipment for soiled plastic film to make it saleable at Rp 50/kg, or to be further extruded into granular form;
(vi) pulp, paper and cardboard-making equipment from soiled waste paper; used only for technical testing.

Figure 1 presents a preliminary design of an Integrated Resource Recovery Module while Box 2 presents a summary of the performance and design specifications, based on field experiments with composting and waste recovery. Such a module is conceived of as an economically viable enterprise owned jointly by a local scavenging cooperative, the local community and the Bandung municipal cleansing department and operated by the scavengers.

III. THE BANDUNG MUNICIPAL CLEANSING ENTERPRISE

THE MUNICIPALITY OF Bandung is one of the cities which was given high priority in the national urban development programme; Bandung is the second largest city in Indonesia and estimates suggest that its current population exceeds two million inhabitants.

The Bandung Urban Development Project was established in 1979, and one of the project components is urban waste management. In 1985, the Bandung Municipal Cleansing Enterprise was established, growing out of an existing city cleaning service. The aim of setting up the service as a public enterprise is to give it more autonomy in managing its own affairs, to run the enterprise as a business with its own revenues and, possibly, to make loans with the permission of the local government.

The experience in running the enterprise has been quite positive. Revenues have increased from Rp 67.5 million in 1984 (as the City Cleaning Department) to Rp 1,183.0 million in 1989. This may increase sharply in the near future when payments for waste collection are integrated with payments for electricity. There is a significant differential in the charges made between functions and the income bracket, so there is an internal cross subsidy between rich and poor areas. The volume of solid waste to be handled has increased very considerably after the municipal boundaries were expanded in 1989 to include an additional 8,600 hectares and 360,000 people.

This is not to say that the problem of waste management has been solved. At this stage, the capacity of the enterprise to collect and dump waste is still limited to 4,400 cubic metres/day, or 66 per cent of all waste produced. This means that if all waste has to be collected, at least 34 per cent of the income has to come from subsidies. There is also a growing concern about the high rate of depreciation of expensive equipment through higher than anticipated corrosion. This may also increase the need for subsidies.

It was with this background that the composting method was introduced, developed in co-operation with the Centre for Environmental Studies, the Development Technology Centre and the Centre for Horticultural Research, Ministry of Agriculture at Leuwigajah (one of the municipal dump sites). The objectives of composting organic waste are to prolong the life of the dump site, to decrease leakage, and to have some income from the sale of compost. The method used is a manual method, developed as the first generation of composting technology. The composting time is approximately 46 days, and production of one ton of compost (or 13.1 cubic metres wet garbage equivalent) takes 13.3 person-days. The investment in equipment is minimal, in total approximately Rp 2.5 million for the initial operation, excluding a truck but including compost chopping equipment. The final costs of production are Rp 35/kg for raw compost and Rp 75/kg for fine compost. There is a noticeable absence of bad odour due to fermentation, which instead becomes sweetish.

At present, ten scavengers are engaged in compost production with a monthly output of approximately 16 tons. Waste for composting is exclusively from markets in the area serviced by the Leuwigajah dump site. At present, the sale of compost is still limited to municipal agencies such as the parks and road department. However, there are other potential markets which are not yet developed.

The Bandung Municipal Cleansing Enterprise has had difficulties

Box 3: Scavenging in Bandung

In any one district, or *kecamatan*, there are on average 1 to 14 *lapaks* (leaders of scavenger communities). Each *lapak* usually employs around 11 to 60 scavengers, with the total number of scavengers in Bandung estimated at about 2,000 to 3,000. Their level of education varies, with 53 per cent having reached primary school level, 25 per cent secondary school level, and 22 per cent high school level; these figures include drop-outs. The daily income of a *lapak* is between Rp 5,000 and Rp 500,000, that for a scavenger between Rp 1,000 and Rp 5,000. The total investment for waste collection in Bandung (recorded) is Rp 408.5 million. The table below shows the volume and type of waste collected for recycling, and where it is sold.

Type	% or number	Value (Rp)	Recycled into
Paper	38.9%	70-100/kg	Paper, card-
Metals	22.0%	40-300/kg	board, kitchen
Bottles	20.6%	75/piece	utensil, various
Textiles	12.0%	200/kg	glassware,
Drums (steel)	100/month	150-800/kg	hoes, caps for
Drums (plas-	100/month	5,000/piece	bottles, cat-
tic)	26,000/	1,500/piece	tlefeed, shoes,
Sacks	month	125/kg or	soles, etc.
Tyres	90/month	500-850/piece	

in recruiting garbage staff because it can only offer low wages of Rp 54,000/month. An incentive system was introduced to attract more people in the form of collecting waste for the recycling market, such as paper, plastics and tin cans, ordinarily collected by scavengers. This becomes additional income for staff who, on average, earn an extra Rp 1,000-3,000 a day from scavenging. They sell their collected waste to the existing network of intermediaries.

Alongside this system of scavenging, "professional scavengers" are given permits to work on municipal dump sites, subject to certain regulations. For instance, they are given only 30 minutes to sort through the waste after the truck arrives at the dump site to prevent a conflict with the operation of the bulldozer. At present, between 70 and 300 scavengers work on each dump site. Monitoring reveals that approximately 10 per cent of the waste is recovered for recycling.

As can be seen, some of the most important elements for an Integrated Resource Recovery system are already outlined: composting of organic waste, collecting of recyclable waste and marketing of their products. However, composting is still done on a very limited scale and, being centrally organized on a final dump site, does not contribute to decreased transportation costs. This is also true with the collection of recyclable waste. A more effective system is much needed in view of the growth in the volume of waste, future needs for financing conventional waste management systems, the difficulties in obtaining new dump sites and increasing competition to get subsidies.

IV. TOWARDS IMPLEMENTATION

IN VIEW OF the continuous increase in Bandung's population, and consequently of its waste, a strategy for dispersing the production of compost so it is nearer to the source of waste makes more sense. There are, however, several constraints in implementing such a strategy. First, land may be difficult to acquire, especially in the centre of the city. Second, many people may reject the idea of living close to a waste processing plant. Third, the idea of legitimizing scavengers to operate in the city proper is still unacceptable in certain quarters. However, all these constraints can be overcome. Land can be obtained in central area *kampungs* near river banks. In Jakarta, one of the experimental modules has been located on a river bank. People tend to reject waste processing in their midst because it is associated with bad odour and unsightly appearance. Experience has shown that this is not true, the odour is better than the usual smell in *kampungs* and the appearance can be made architecturally elegant. Scavengers are able to operate in the centre of the city as, in the Integrated Resource Recovery modules, they become ordinary industrial workers.

From the techno-economic point of view, the Integrated Resource Recovery module can be incrementally introduced.[5] The module can replace the function of existing transfer depots or be established to serve even smaller areas, so that an area of about 1,000 square metres may suffice to accommodate a compost processing plant and the sorting of recyclable wastes - as illustrated in Figure 1. These modules can be introduced two to five at a time, and be expanded in number after new markets have been secured. In this way, the whole of waste management, or most of it, can be transformed within ten to 15 years, depending on the establishment of new markets.

The establishment of new markets requires a national system of incentives for market development such as: tax incentives for industry using waste materials; import restrictions on raw and waste materials; and annual government purchases of compost for various programmes (for instance for the reforestation programme, for the improvement of critical lands and to improve neglected plantations) with subsidies for transport. For composting, a sustained research and development programme is essential, especially aimed at developing technologies which can produce cheaper compost (less than Rp 10/kg) and which need less land for compost production.

5. By inserting the modules step by step, two to five units annually, into existing transfer depots or replacing containers of ten cubic metres. To be done as the opportunity arises, financed if possible through ordinary bank loans. The decentralized system of production and management would need an association of modular enterprises at city level for research and development, training, marketing and consulting services to members.

V. THE BANDUNG BERHIBER CONNECTION

THE BANDUNG MUNICIPAL government's goal is "Bandung BERHIBER" *(bersih, hijau, berbunga* or clean, green and flowering). The effort to improve waste management stems from this. But Bandung BERHIBER can become a synergetic process, if interdependency between its components can be fostered.

One of the components is the greening programme which has become part of application procedure for building permits. Anyone asking for a building permit has to show that their plans include the planting of trees and shrubs, even in high density areas. This helps stimulate another potential market for compost.

Another component is the introduction of rainwater intrusion wells. These are also required for the granting of building permits and

these aim to increase the absorptive capacity of individual plots, lessening the need for surface water drainage during heavy rains and increasing water retention capacity. The greening programme is designed to support this. But the total result is that the city can incrementally become cleaner, greener and more flowering - a process which is already underway.

VI. SOME CONCLUDING NOTES

BANDUNG HAS NOT yet an Integrated Resource Recovery system in the true sense. But it has introduced activities which may evolve into such a system for a significant part of its urban waste management. For this purpose, it can count on support from research centres within the city.

Much is still to be done, but Bandung is on its way to creating a waste management system which incrementally introduces Integrated Resource Recovery modules, with composting forming the backbone of the activity. It is a concept that avoids the mistakes of the past where centralized plants are capital intensive, necessitating bulk production and therefore bulk marketing. The proposed decentralized system is highly adaptive to market fluctuations since it relies on manual labour who have a side income from collecting recyclable waste. Even a decrease in the production of compost can be more easily sustained by workers through a shift to collecting more recyclable waste. However, this requires that the transportation of waste should also be flexibly organized, something which is not hard to do.

In conclusion, the introduction of a self-financing Integrated Resource Recovery modules within the larger context of Bandung BERHIBER basically aims at implementing the concept of sustainable development. This is especially true if the modules set aside savings to be used for financing environmental improvements in the *kampungs* by the communities themselves as co-owners of the investment. The problem in introducing the system is more one of perception than technical. But once the idea has been accepted, its tremendous potential as an approach for sustained environmental improvement becomes apparent.