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RECYCLING POTENTIALS OF SOLID WASTE IN ASIA THROUGH ORGANISED SCAVENGING

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ABSTRACT

The increasing quantity of solid wastes is a serious environmental problem not only in developed countries but also in the developing countries in Asia. Until recently disposal was the only technical and economical option that could be taken in the management of these wastes. The technology for resource recovery and recycling was not considered because of its economic impracticality (risks involved) and its low quality for use as raw material in production. However, the time has come when recycling needs to be considered as a strong alternative against disposal for the following reasons: (i) present waste management techniques are not adequate to prevent serious environmental pollution, (ii) there is a need to conserve scarce and expensive resources. Furthermore, in most developing countries, the possibility of integrating organised and hygienic scavenging for resource recovery and recycling has been completely neglected. The objective of this paper is to first provide a cursory review of the types of the solid waste in the countries in Asia and then to provide technical options that look appropriate for these countries. Finally, an outline and examination of key criteria to determine the viability of recovery alternatives and the socio-economic viability of the several recycling options have been pointed out.

INTRODUCTION

The Asia-Pacific region contains just over half the world's population and although it comprises only 20% of global economic activity, it promises to be one of the most dynamic regions in the world. One of the most pressing problems afflicting its people is the lack of proper sanitation and waste disposal programs. Thus, it is not unusual for Westerners to be apalled at the sight of groups of scavengers, from the young to the elderly, living in dump sites even in the region's capital cities of Manila, Bangkok, Calcutta, Jakarta and the like. However, in most developing countries in the region the possibility of integrating organised scavenging in the overall solid waste management has been completely neglected. Recycling of several constituents in the solid waste disposal sites has been an ongoing activity and scavengers have taken it up as a profession, but the socio-economic and epidemiological considerations have been completely forgotten by the authorities responsible for solid waste management in the large cities in Asia.

THE ASIAN SCENARIO

Typical differences which occur in composition of municipal wstes are shown in Table 1[1,2,3]. Wastes generated in general tend to be of low calorific value, high in organic putrescibles content and moisture and are subject to seasonal variations.

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Table 1. Comparative municipal solid waste analysis (wt.%) [1,2,3].

	Composition										
	Metal	Glass, Ceramics	Vegetable, Putrescible	Paper	Textiles	Plastic, Rubber	Miscellaneous Combustible	Miscellaneous Incombustible	Inert <10 mm	Others	Density kg/m³
ASIA											
Petaling Jaya	6.6	4.5	55.0	20.1	-	7.8	4.7	-	-	1.3	-
Kuala Lumpur	6.4	2.5	63.7	11.7	-	7.0	7.8	-	-	0.9	-
Bangkok	1.0	1.0	44.0	24.6	3.0	7.0	-	3.5	4.8	-	250
Hong Kong	2.17	9.72	9.42	32.46	9.58	6.24	4.94	-	14.09	10.47	-
Jakarta	2	2	60	2	-	2	7	-	-	25	-
Bangalor	0.1	0.2	75.2	1.5	3.1	0.9	0.2	6.9	12.0	-	570
Seoul	0.4	0.15	-	4	-	1.8	0.6	78.0	-	13.7	-
Taiwan	1.1	2.8	24.6	7.5	3.7	2.3	-	56.0	-	0.8	-
Singapore	3.0	1.3	4.6	43.1	9.3	6.1	3.9	-	6.4	22.3	175
Japan	5.9	15.0	11.7	38.5	4.1	11.9	3.8	-	9.1	-	-
MIDDLE EAST											
Accra	2.6	0.7	87.1	5.7	1.2	1.3	-	-	-	1.4	-
Istanbul	1.43	0.65	60.8	10.15	3.22	3.05	-	16.16 (ash)	-	6.35	-
Tripoli	10.15	3.05	52.17	21.42	4.21	3.90	2.50	-	-	2.60	-
Port Said	3.0	1.3	36.9	24.0	2.2	3.4	9.3	9.6	10.0	0.3 (bones)	-
U.S.A.	8.5	12.0	13.0	51.0	3.0	4.0	3.0 (wood)	-	5.5 (dirt)	-	-
EUROPE											
U.K.	9	9	28	37	3	3	1	1	9	-	150
Sweden	5-8	6-8	30-38	32-36	2	6-7	-	-	-	8-9	-
EEC	2-9	4-17	10-40	19-40	1-10	2-6	-	-	-	10-15	-

CLIMATE AND SEASONAL VARIATION

Most developing countries lie in the tropical region and are often beset by sudden climatic changes which have to be accounted for in planning solid waste management schemes. Monsoon rains cause problems of collection and disposal. Moisture content varies from below 5% during the dry season to above 65% during the wet months.

BUDGET AND FOREIGN EXCHANGE LIMITATIONS

Municipal solid waste disposal costs often exceed 20% of municipal budgets. Labour and energy absorb the major portion of the operating costs. Solid waste management is one of the most expensive services and hence must be tailored to financial capability. The acute shortage of foreign exchange is another powerful economic constraint in most countries in Asia.

PHYSICAL CHARACTERISTICS OF CITIES

The inner, usually older, areas of cities have very high population densities combined with difficult access. It is not uncommon to see urban sprawls of squatter settlements brought about by rural migration. It is usually in these areas that problems of solid waste are most acute.

SOCIAL AND RELIGIOUS CONSTRAINTS

Constraints of this kind may sometimes over-ride rational solutions. It is easier to impress the people with programs of water supply while there is little prestige in tackling disposal problems. Thus, waste disposal often has less priority than other services.

MANAGEMENT AND TECHNICAL RESOURCES

A critical factor in the efficient organisation of a labour-intensive industry is the quality of management. This involves not only good "man-management" but the deployment of a complex set of technical skills which derive from several professional disciplines. Richer countries export consultancy and management services to poorer countries. However, such aid must not take the form of imposing Western systems blindly, but should seek to encourage the development of indigenous technologies. The long-term solution lies in the establishment of training courses within these countries.

The maintenance and repair of equipment are similar throughout the world, apart from some specifications for tropical conditions. But the availability of necessary skilled labour varies widely and should be considered in deciding levels of mechanisation.

The ideal solution is, of course, that which results in maximum reduction in generation of waste by way of recovery and re-use. Approaches to the solution are as follows:

attraction of recycling in its basic form if refuse contains valuable re-usable materials;

refuse removal as a job creation programme;

valuable refuse compost or other products; and

cost-cutting through the use of appropriate technologies. The cost factor, type of waste involved and operational factors call for appropriate and simple technology, and as much human labour as possible.

The costs of solid waste management are high and rising at a time when the costs of energy and material resources are also rising. The important factors in these increases are:

scarcity of capital;

environmental and health constraints;

difficulties in attracting and retaining experienced managerial, professional skilled and support personnel;

limitations and misapplications of both traditional and advanced technology;

shortage of primary materials and manufactured products;

under-utilised labour and materials; and

single-purpose approaches rather than integrated solutions which consider all components of wastes and potential recycling products.

Concepts which are likely to remain permanently dependent on foreign expertise and spare parts should be minimised under all circumstances. These suppress private entrepreneurs and are too technically sophisticated, and are sooner or later bound to fail because of high subsidy needs.

DISPOSAL SITES FOR SCAVENGERS

All waste recovery operations rely on sanitary landfilling for ultimate disposal of waste and/or process residues. Controlled landfilling is not extensively practiced although well-maintained units may be found in some countries, e.g. in Hong Kong. There are a total of four landfill sites in operation in Hong Kong, disposing of a total of 2520 tonnes of refuse per day. However, because of land shortages, land acquisition and site clearance expenses, site preparation costs are high. Covering material can be quite expensive if obtained from borrow areas where high land and landscaping costs are required. If cover material can be obtained from adjacent site formations where surplus excavations are made, the cost for cover material can be substantially reduced. Experience has shown that, in general, the larger the capacity of the tip, the lower the maintenance cost.

In Kelang Valley, Malaysia, sites used for landfilling are mainly old tin mining areas. Solid waste is dumped and a bulldozer operates full-time levelling and compacting the deposited refuse. Salvaging is always carried out unofficially before solid waste is covered by mining sand daily.

Most of the tips in the Philippines are located near running water and thus pose environmental and health hazards. After dumping the collected waste from the trucks, scavengers sort out the garbage, picking up cans, cartons, boxes and paper which are sold for recycling.

Since most Asian countries favour sanitary landfill as the most cost-effective option at present, scavenging at these disposal sites is a common practice. Although the best place to collect the valuable materials from the solid wastes is at the point of generation and the worst is at the disposal site when the wastes are mixed up, yet scavenging at the disposal sites is still attractive as may be seen in many cities in Asia.

TECHNICAL OPTIONS FOR RESOURCE RECOVERY AND RECYCLING

General technological options for resource recovery and recycling exist, some of which are:

SEPARATION OR INITIAL RECOVERY

Known as the "front end system", separation or initial recovery can be done at the source manually or through physical and mechanical means. But for it to be a success in urban areas, dedication, interest, careful planning and administration and cooperation from the citizens are required. Residents have to be educated which ultimately means a change in their daily habits. Source separation is not a "technical option" in the truest sense, but it greatly facilitates the use of subsequent conversion processes which require sophisticated technology[2].

CONVERSION PROCESS OR FURTHER TREATMENT

Incineration (with energy recovery), composting, pyrolysis, single cell protein (SCP) production and anaerobic digestions are some of the methods used for further treatment of the waste.

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INCINERATION

In many developing countries, the calorific value of refuse is so low that a fuel supplement may be necessary as part of the incineration process. Most Indian wastes are unable to sustain their own combustion. The high moisture content of the Philippines' wastes also makes them unsuitable for incineration without the addition of auxiliary fuel or pre-treatment by sorting to remove the combustible material. All these additional steps would result in higher incineration costs.

There are a few countries like Korea who are considering incineration with heat recovery on a long-term basis. In Taiwan, Republic of China, the use of central incinerators is preferred as an efficient and sanitary method, but this requires large capital investments and operational costs. The mixed refuse of low heat value is removed first from a salvage or open dump by use of separate collectors, leaving only the combustible material.

There are three existing incineration plants in Hong Kong, each comprising four units, each unit having a maximum capacity of 10.5 tonnes per hour. The variable moisture content of the waste posed problems. To incinerate the waste to an acceptable degree, the basic design was modified. Furthermore, there are difficulties in public acceptance of incineration as a disposal process due to high capital and recurrent operating costs. In Jakarta, Indonesia, incineration was regarded as not appropriate as about 30% of the volume of waste is in the form of dust, hard matter or metal and other materials.

Incineration was found to be the most cost-effective method in Singapore. Incineration cannot be applied to most urban wastes in Asia because of the high organic and putrificable fraction, high ash and non-combustibles, high moisture content and rather low calorific values.

COMPOSTING

There are several arguments which speak in favour of composting as a resource recovery option particularly suitable for developing countries, and these could be: (i) simple technology; (ii) process is readily adaptable to local conditions; (iii) only a small amount of residue is left to be disposed of; (iv) compost sells well; (v) compost has a low toxic substance burden; (vi) composting meets requirements concerning hygiene; and (vii) refuse composition is appropriate for composting.

There are at least five pre-conditions which are necessary for the successful operation of composting projects in developing countries. These are: (i) suitability of waste, (ii) a market for the product near the compost source, (iii) support from government authorities, particularly those responsible for agriculture, (iv) price of the product which is applicable to most farmers, (v) net disposal cost (plant costs less income from sales) which can be sustained by the local authority.

Marketing of the compost products has been a problem and furthermore composting cannot recover certain valuable materials. Wood, rubber, textiles, metals and plastics are either impossible or very difficult to compost.

PYROLYSIS

The results of pyrolysis developmental work abroad demonstrate that the process is self-sufficient and regenerative. The gas obtained is sufficient for heating the retort, the by-product tar-oil can be used as a substitute for furnace oil and the coke can be used as domestic fuel. Sunavala[4] recommends investigation of pyrolysis on a pilot or semi-commercial scale in the Indian cities of Calcutta, Delhi, Bombay and Madras. Basing his calculations on an estimated 2000 tonnes day^{-1} refuse input and combusting the gas to self-sustain the reaction, 600 to 700 tonnes day^{-1} of coke, 70,000 to 90,000 l day^{-1} of oil, 30 tonnes day^{-1} of glass and 30 tonnes day^{-1} of metals could be obtained.

SCP PRODUCTION

Urban solid wastes that are rich in organics and cellulose can be utilised for SCP production in which a "controlled fermentation process where selective use of aerobic thermophilic organisms are used for the formation of protein from cellulose and lignin wastes".

Collection from Disposal Sites of Municipalities

This is practiced to a high degree in developing countries and beggars and scavengers perform efficiently as soon as collectors empty their loads at the disposal sites. Sometimes whole families of scavengers support themselves living on these dump sites and little of value is thrown away.

Scavenging is also highly organised at major dump sites in Manila. The system in effect is self-contained through the action of middlemen and subsequent interaction with buyers of secondary materials. Although this provides a method of resource recovery, the scavenger, who is at the heart of the system, must work under deplorable and hazardous conditions.

In Bangkok, salvage of materials by garbage collectors and other workers is performed during the collection stage. The volume of retrieved materials is equal to about 5 bamboo baskets; paper and vinyl bags or the like are retrieved. The salvaged materials are purchased by junk dealers at prices given in Table 3. Monthly earnings from this source amount to an average of 2,000 Baht per worker (US$1 = 22.9 Baht).

Table 3. The price of picking materials sold to the manufacturer

Type of waste	Selling price (Baht kg^{-1})*	
	By middleman to manufacturer wholesaler	By scavengers to middleman
Mixed paper	0.7 - 1.25	0.5 - 0.7
Black & white paper	2.0 - 2.5	1.0 - 1.2
Card paper	2.0 - 3.0	1.0 - 4.0
Newspaper	1.5	0.5 - 1.0
Soft unwashed plastic	1.5 - 3.0	1.5 - 3.0
Soft washed plastic	8.0 - 11.0	6.0 - 11.0
Hard plastic	4.0 - 7.0	2.5 - 4.0
Glass	0.5 - 0.7	0.4 - 0.6
Rubber	5	0.8 - 4.0
Bone	1.2	0.4 - 1.0
Iron (thin)	0.9	0.4 - 0.7
Iron (thick)	1.0 - 1.5	1.0
Aluminium	20	15.0
Copper	25 - 28	15 - 25

NB: * US$1 = 22.9 Baht

Salvaging operations are largely uncoordinated; scavengers are allowed to operate at all stages of collection, storage and waste disposal. While some capital-intensive, high-technology solutions alleviate the human costs of scavenging, these ignore the potential for efficient waste recovery and hence, the source of employment and resource base for a variety of small enterprises. Existing scavenging practices provide employment for new arrivals and household incomes ranging from base survival in exploitative entrepreneurial recovery. Sorting and marketing of recyclable materials is ordinarily in the informal sector and small enterprises return them to the formal sector.

Organised Scavenging

The potential of developing organised scavenging in Asia should be emphasised. In the Philippines, a prototype solid waste project called "Resource Recovery" has been launched. This is aimed at demonstrating a more systematic way of recycling starting from education

ANAEROBIC DIGESTION

About 70% methane, 30% carbon dioxide, traces of oxygen and hydrogen sulfide are the end products of anaerobic digestion thus forming a valuable fuel gas. However, the constant requirement of carbon to nitrogen ratio 30:1 canot usually be met in Asia due to the changing nature of the urban wastes.

SCAVENGING AND RECYCLING

Recycling in developing countries is highly labour-intensive. This is possible only because the rapid rate of population growth in the urban sector, combined with the slow growth of the economy has led to a high level of unemployment and hence, low wages. Under these conditions, hand-picking of refuse becomes a viable economic proposition. Crude dumping is almost universal in these countries and often supports a large army of scavengers who extract valuable materials. It is paradoxical that the poorest countries are in this way achieving a high level of recycling despite the small proportion of saleable matter in the waste.

The grim realities of child labour and public health hazards must not be overlooked. As the whole family is usually employed in scavenging, even the very young and the elderly are exposed to a wide variety of pollution effects, obnoxious odours and most specially disease vectors which may seriously endanger the health of all workers who come in direct contact with the waste.

COMMON RECYCLING METHODS

The common methods of achieving recycling are:

Household or internal waste sorting

Some materials in collected refuse are noticeably low as they are already sorted out at the household level, used and/or sold. Cinders, coal, coconut shells are extracted for fuel, metal cans for domestic vessels and vegetable wastes for animal feed. Others, e.g. paper (for repulping), tin cans (for resmelting), glass (for re-use, remelting or abrasives manufacture) and plastics (for re-use or inferior grade production), are sold to small merchants who operate collection and sorting depots or to collectors who wander in the streets. Table 2 shows economic incentives typically provided to encourage recycling in the People's Republic of China[5].

Table 2. Recycling incentives in the People's Republic of China[5]

	Purchase price per tonne	Selling price per tonne
Mixed paper	100 DM	160 DM
Newspaper	420 DM	660 DM
Plastic (good)	650 DM	880 DM
Plastic (poor)	300 DM	
Steel/iron	120 DM	140 DM
Tin	700 DM	
Copper	1,700 DM	
Bronze	4,000 DM	
Glass	60 DM	
Cotton	160 DM	
Bones		250 DM
Rubber (tyres)	960 DM	1,200 DM

NB: where gaps are left in the table, no enquiries were made. DM=Deutch Marks

at the household level to training and fielding of "ecology aides" or Eco-Aides to the identification of end-buyers. The establishment of such a working system will provide a more decent means of living for scavengers and minimise their exposure to filthy conditions.

The project plan is to hire as many of those currently engaged in scavenging as Eco-Aides. They will make the rounds of households and be authorised to buy at predetermined prices those recyclable materials which have been previously sorted by the household into wet organic or dry re-usable items. The materials will be redeemed at redemption centres at about 20-25% more than what they paid for them, and where the materials can later be sold to junk dealers. As high as 70% of the garbage in Metro Manila may be recycled, 20% consisting of "wet garbage" can be digested for methane production, 10% for composting and the rest to be landfilled.

In refuse disposal sites in Bangkok groups of 12-30 scavengers demarcate the site radially into sectors by means of wooden logs and separate the valuable materials into baskets. The disposal trucks come to the centre of the plot and dump the solid waste. This form of scavenging is so profitable that the leader of a group even gives cash or liquor to the driver so that he does the favour of dumping the waste more often into his zone. All materials collected are sold to middlemen who visit the site.

Most of the people work for 8 h a day and make an average of ฿80 per day per person. Some of the scavengers are high school graduates who claim to make ฿100-200 a day. The standard of living of some of the scavengers visited is unbelievable as they own a television, fan and a refrigerator which is excellent by Asian living standards.

If emphasis is put on a better working standard at the site, vector control measures to prevent diseases, and basic amenities, the scavengers would be a happier group of people. Furthermore, if the system is controlled to avoid middlemen cheating these hard workers, organised scavenging would be a very prosperous livelihood for many, an economic gain for the city and an achievement in the field of solid waste management.

A recent study made at Bangkok on the health conditions of the scavengers revealed the following facts:

1. Generally speaking scavengers had poor health.

2. Colds were very common as they were exposed to the sun and rain for a long duration

3. The prevalence of muscle and tendon disease was very high, particularly muscle ligaments affecting the back.

4. Skin disease was very common and very difficult to cure.

5. Hand and foot injuries were very common.

6. Depression and "moody" feelings crept in among the scavengers due to the long, continuous working hours.

The trader who buys from the scavengers and sells to the wholesaler is known as the middleman who further sells it to the manufacturer. In Bangkok the roles of the trader and wholesaler are very similar.

Table 3 shows the selling price by scavengers to middlemen to manufacturers. A chunk of the profit is made by the middleman from the scavengers. Table 3 has to be seen with caution as it is very difficult to get a picture of the exact nature of the trade at the wholesaler level. They are very secretive about divulging any information regarding the trade. Overall reaction from the wholesalers was that their profits were large. The wholesaler has an establishment including a shop, a godown, 4-5 labourers (paid a daily wage of 60-70 Baht). Besides the overheads, he can still make a profit which shows that by establishing an organised scavenging system, the scavengers could benefit more by cutting out the middleman.

The average waste collected daily per person is shown in Table 4. The waste value collected per day per person is about 80 Baht. This is the average earning a person makes at the dumping site not including the waste that was sorted at the source.

Thus it can be emphasised once again that developing a decent system for scavengers should be given a priority.

Table 4. Various types of waste and the daily quantity collected

Types of Waste	Average kg of waste collected daily per person
Paper (hard)	1.9
Paper (soft)	5.0
Plastic (hard)	5.02
Plastic (soft)	14.91
Glass	39.51
Leather/rubber	1.17
Iron (thin)	4.65
Iron (thick)	4.24
Bones	5.69

It can be seen from Tables 5 and 6 that scavenging is a profitable profession for industries that recycle the products:

Table 5. Estimated cost/benefit value of paper production at a paper mill in Thailand (in Baht)

Raw Material	Cost of raw material	Other expenditure	Total cost of production	Value of finished product	Benefit: cost ratio
100% wood pulp	5,640	1,642	7,280	11,500	1.57
17.5% wood pulp 82.5% waste paper	2,440	1,642	4,080	87,000	2.13
100% waste paper	1,880	1,642	3,520	6,900	1.96

Table 6. The estimated benefit/cost value of plastic production at a Plastics factory in Thailand (in Baht)

Raw Material	Cost of raw material	Other expenditure	Total cost of production	Value of finished product	Benefit: cost ratio
Pure pelletised plastic	864,000	175,750	1,045,750	849,000	0.81
All waste plastic	327,000	212,500	539,500	849,000	1.57
Pure plastic and waste	459,000	212,500	671,500	849,000	1.26

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The benefit:cost ratio carried out in a paper mill (Table 5) indicated that the most economical way for paper production was the use of the combination of wood pulp and waste paper. Although the ratio of paper production from 100% waste paper is more than 100% wood pulp, the price is low for the low quality toilet tissue. To use the wood pulp as the only raw material in the manufacture they ahd to afford a very high price for the raw material.

The manufacturer of a plastics factory (Table 6) uses pure and waste plastic in combination. Although using pure waste achieves more profit, it is not easily marketable.

In a glass factory (Table 7) the benefit:cost ratio of the two options are almost the same. The manufacturer operates with the second option because of higher benefit:cost ratio. Mixing the cullet with raw material needs a lower melting temperature which reduces the cost of maintenance. Another important reason is the availability of cullet in the country. The rejected product can also be recycled in the factory.

Table 7. The estimated benefit:cost value of glass production at a glass factory in Thailand (in Baht)

Raw Material	Cost of raw material	Other expenditure	Total cost of production	Value of finished product	Benefit: cost ratio
Virgin raw material	16,087,500	55,072,875	71,160,375	108,000,000	1.50
75% raw material + 25% cullet	14,505,000	51,350,000	65,850,000	108,000,000	1.64

CONCLUSIONS

Recycling of materials is as much a part of the existing solid waste system in developing countries. Although scavenging is considered an unorganised operation which can occur at all stages of the system, resource recovery schemes must recognise this and strive to incorporate it in the set-up. Large-scale scavenging not only provides income for a small informal sector but also reduces the need for highly mechanised recovery systems. Controlling specific scavenging points in the system may be difficult but a programme by the municipality to organise scavengers into a recognised group and permit scavenging activities only at the dump sites or processing centres may be a solution. Furthermore, several welfare facilities, if provided at the site or outside, would make scavenging a major component of the overall solid waste management programme.

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