Solid wastes research in South Africa

R G Noble

A report by the Committee for Solid Wastes
National Programme for Environmental Sciences

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PREFACE

The National Programme for Environmental Sciences aims at identifying, evaluating and working towards solutions for environmental problems through cooperative studies drawing together interested scientists from various sectors. Apart from solid wastes, the National Programme also includes research relating to ecosystems, their structure, functioning and exploitation and disturbance by man. It includes research relating to environmental problems in inland waters, terrestrial ecosystems, the sea and lower atmosphere. It includes research designed to meet local needs as well as projects being undertaken in South Africa as contributions to the international programme of SCOPE (Scientific Committee on Problems of the Environment), the body set up in 1970 by ICSU (International Council for Scientific Unions) to act as a focus of non-governmental international scientific effort in the environmental field.

The Committee for Solid Wastes advises the National Committee for Environmental Sciences (Chairman Dr C vdM Brink, President: CSIR) on research requirements and opportunities relating to solid wastes management and disposal. This report reflects the preliminary thoughts of the Committee and identifies areas in need of further attention. Through the concerted attention of cooperating agencies, it is hoped that pollution effects arising from the disposal of solid wastes will be minimised and that it will contribute to the conservation of natural resources.

Readers are invited to study the report and to submit comments or suggestions, addressed to the National Scientific Programmes Unit of the CSIR.

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1. A description of the Savanna Ecosystem Project, Nylsvley, South Africa. December 1975. 24pp.
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INTRODUCTION

The importance of solid wastes management in environmental pollution control cannot be over-emphasised. Increased socio-economic development in South Africa has brought with it increasing volumes of urban, industrial and agricultural wastes, problems associated with the disposal of toxic and other wastes and an increasing awareness of the need to conserve raw materials likely to be in short supply in the future.

Techniques for the safe disposal of solid wastes are of course available. However, we believe that these techniques will be insufficient to meet future needs and that the necessary technology needs to be developed to utilize wastes as a resource in the future, by recovering materials and perhaps energy from wastes for re-use and by synthesizing new products from waste materials. Research is necessary in order that tomorrow's technological needs can be met in this way. Experience with research relating to the reclamation of waste water has taught us that advanced techniques, although they may be uneconomic today, can become economic in the future and that it takes considerable time to develop them to the point at which they can be implemented. For this reason, research into solid wastes technology is urgent.

The Committee for Solid Wastes came into being in order to meet a very pressing need. It aims at identifying research needs, at initiating and coordinating research and at bringing its findings to the attention of decision-makers. There is no scientific institution in South Africa whose primary task it is to undertake research into solid waste problems. Through the National Programme for Environmental Sciences, this research is being undertaken on a cooperative basis by all of the existing institutions and scientists willing to collaborate in this joint venture.

WAR ON WASTE

Before discussing what could be done with solid wastes, it is necessary to say that a great deal could in our view be done in South Africa through cooperation between the public, commerce, industry and the authorities concerned to reduce unnecessary waste. We believe that the economic benefits of this would be enormous and Bolitho (1975) has pointed out that the conservation of energy and resources is becoming as important as the prevention of pollution.

TECHNO-ECONOMIC SURVEYS

Selection of the most desirable strategy for solid wastes management in a given area is basically an economic problem, subject to such technical and institutional constraints as may apply to the specific situation. An important objective of research on solid wastes is to determine when the re-use of certain materials would be economical.

Another important objective is to minimise the social cost associated with the system of waste flows in an economy which is expected to throw light on questions of overall planning for wastes handling.

As the first step in the planning of management strategies for solid wastes handling and in planning the research which goes with them, it is necessary to have reliable data on various aspects of waste generation, collection, treatment and disposal. Specifically with respect to methods of wastes handling there is a need for both technical and economic data that can be used in economic decision models. The figures that are available are difficult to compare with one another because they have been derived in different ways, because they reflect particular situations and because they are very often influenced by external factors. For this reason, it is essential that economic and techno-economic studies should form the basis for the programme.

A study of strategies for solid waste management on a regional basis is being undertaken by the Agricultural Economics Institute at the University of Stellenbosch and a cost-benefit study of present solid wastes management practice in the south-western Cape Province is also under way. The studies are aimed at identifying the relevant economic, physical and institutional factors and at incorporating these into a suitable framework for regional planning. The application of such a framework to the existing situation in a specific region will then be demonstrated, which will also serve to identify deficiencies with respect to available empirical data and to evaluate these through sensitivity analysis. A second and broader series of surveys also to be undertaken by the Techno-Economics Division of the CSIR will examine some broader options.

AGRICULTURAL WASTES

Very little information is available on quantities of agricultural wastes produced in South Africa. There is an urgent need for a techno-economic survey of this field to be undertaken.

Animal feed-lot wastes

The Department of Agricultural Technical Services has appointed a Standing Interdepartmental Committee to investigate existing legislation as related to the possible registration of feed-lots and to give guidance regarding feedlot requirements as related to the handling of animal feed-lot wastes. Presently the Department of Health is revising the Public Health Act (36 of 1919). A set of draft regulations have been prepared and a technical guide is being prepared.

The quantities of feed-lot wastes are expected to increase in the future and research needs in regard to these wastes remain to be identified.

Crop wastes

Bassett (1975) has pointed out that techniques are available to utilize such agricultural wastes as pineapple wastes to produce protein-containing animal and human food. He has begun a study of these fermentation techniques in order to explore the possibilities which exist in this direction. The Committee for Solid Wastes believes that fermentation for the production of protein and of special chemicals from a vast range of wastes presents exciting possibilities for the future.

Wastes of agricultural industries

Figures are also lacking on the quantities of wastes produced by food and other agricultural processing and packaging industries, as well as by the wood industry.

INDUSTRIAL WASTES

Alexander (1974) has described some general principles involved in handling solid industrial wastes (Table 1). As he points out, industrial wastes problems are best dealt with at source, where materials are commonly recovered and either recycled internally or sold as byproducts. Buchholz (1975) points out that substantial quantities of industrial solid wastes are disposed of by sanitary landfill, chemical reduction, biodegradation and incineration and Table 2 illustrates some of the categories of wastes involved.

URBAN SOLID WASTES

Sanitary landfill

Sanitary landfill is the most widely used means of disposing of urban solid wastes in South Africa, and will be the most important for some years. Estimates of the costs of sanitary landfill vary from R1,30/t (Bolitho 1975) to R3,00/t (Wolmarans 1975). These differences reflect differences in the calculation of the costs and differences in the kinds of waste and circumstances involved. It is hoped that the techno-economic study being carried out by the University of Stellenbosch will provide a formula for calculating values which can be used for comparison.

Bolitho (1974) has pointed out that landfill is not only cheap, but is also being used to create valuable recreation areas from waste land and could conceivably be used to store potentially recoverable wastes whose recovery is either not possible or not economic at present.

Possible research needs relating to landfill still require to be determined. There is a need to establish whether or not currently acceptable procedures are adequate to prevent the pollution of under-ground water. There is also the need to find out what chemical reactions might take place in landfills and possibly cause problems in the future.

The efficient operation of wastes management schemes involving landfill depend to a large extent on the efficient management of transport involved. The Johannesburg City Council has undertaken systems analysis studies to develop simple models to predict refuse generation rates from different areas and socio-economic groups and at different times (Veres 1974). These should certainly be repeated in other centres.

Problems can also arise when large quantities of any one material are introduced into landfills. In South Africa, large numbers of polythene containers and rubber tyres can cause spongy, non-degradable deposits and interfere with the normal breakdown and consolidation process (Bolitho 1975). Thus these materials, when delivered in bulk, should be kept out of landfills and either treated separately or recycled.

Incineration

A range of modern incineration equipment is currently available and incineration is a widely used means in Europe and the United States of disposing of solid wastes. However, the costs in South Africa, taking into account the heavy capital expenditure and high running costs involved, are very high indeed. Consequently, incineration only becomes a paying proposition in South Africa in special situations, to dispose of particular kinds of waste.

Energy recovery

Urban wastes contain quantities of organic matter and have a heating value of about 10 KM/kg, about two-fifths that of coal, and the recoverable energy content of South African municipal solid wastes has been estimated as 2 percent of the national energy consumption (Connor 1975). Various possibilities exist, including the production of fuels through pyrolysis and the mixture of wastes with coal for the production of power, for which Bolitho (1974), suggests a nett annual cost of R3,75/t.

Pyrolysis

Pyrolysis involves the breakdown of wastes at high temperatures in the absence of oxygen to produce CH_4, CO, H_2 and a variety of liquid fuels, tars and oils. It is expensive but made economic by the sale of its products and could be considered for a number of applications in South Africa, notably for the recovery of fuels and other products from scrap rubber and plastics (Bolitho 1975). The technology is largely available and could be applied directly.

Composting

The composting of urban refuse is only practised on a large scale in South Africa in the south-western Cape, where there is both a shortage of landfill sites within easy reach and a demand for compost to improve poor sandy agricultural soils in the close vicinity of the source of compost. The estimated costs of composting by different local authorities in the western Cape differ tremendously. The lowest estimate given is R4,75/t estimated in 1971 in Worcester. This compost is sold at R6,10/t which, if one assumes that 33 percent of the material received is sold, will mean a nett sales income of about R2,00/t waste received (Wolmarans 1975).

Estimates of composting costs in other centres have generally been higher and some have exceeded R30,00/t (Tworeck 1975). The cost structures of these operations should obviously be examined in some detail. Wolmarans has suggested that they could be reduced considerably if the methods were rationalized. Calculated in terms of nitrogen, phosphorus and sawdust equivalent, the Department of Agricultural Technical Services has estimated the agricultural value of compost to be R3,15/t (M C F du Plessis private communication). This may be taken as the minimal value of compost for agricultural use.

The work of the National Institute for Water Research Cape Regional Laboratory has been concentrated upon the production of stabilized and hygienically safe compost, free of pathogens and parasite ova and free of toxic compounds, from the various mechanical composting methods in use in the western Cape (Tworeck 1975). These processes can all yield acceptable and safe compost, especially if the mechanical process is followed by 5 weeks maturation in windrows. The feasibility of enriching compost with sewage sludge has also been investigated.

External recovery of materials by sorting at source

Table 3 shows that the resale value of materials found in urban refuse is greatly reduced when these are contaminated by other refuse. Bolitho suggests that the total mass of urban refuse generated annually in South Africa (2,5 x 10^6t) would have a total "uncontaminated value" of R30,5 million, or 0,16 percent of the Gross National Product, that only a very small proportion of all refuse could be recovered in practice. In his view, the recovery of these materials at source is normally only feasible at points where the wastes are reasonably concentrated, as in factories.

Sorting of urban refuse

The Johannesburg City Council has for some time sorted 2 800 t of refuse a month by hand from a moving belt at its Norwood sorting station. Bolitho (1974) estimates the cost of the operation to be R5,00/t and the real resale value of the material reclaimed to be R1,70/t. The total cost therefore compares highly unfavourably with sanitary landfill, taking into account practical scale of operation, and requirements of the Factories, Building Works and Machinery Act.

Wolmarans (1975) undertook a short-term but fairly detailed study of a similar belt hand sorting scheme at Verwoerdburg. He concluded that the total cost of this operation amounted to R2,50/t and suggested that improvements to the sorting efficiency of the Norwood transfer station could have been streamlined in such a way as to increase the yield of reclaimed material.

Mr Wolmarans' observation would suggest that 'front end' sorting could be made economically competitive in spite of the low value and restricted outlets of the contaminated materials recovered. Bolitho (private communication) expressed the view that the simple, non-capital intensive system used at Verwoerdburg is suitable only for small communities and the aggregate yield of recovered materials would be correspondingly low.

There are, of course, also several mechanical sorting methods available in other countries.

Biochemical processes

Mention was made earlier of Bassett's work on the fermentation of agricultural wastes to produce protein and other useful products. The fermentation of urban refuse is also an attractive theoretical prospect, although it would require a great deal of research if it were ever to be pursued.

PAPER WASTE

Paper waste makes up the largest portion of urban refuse and merits separate consideration. White (1975) estimates that about 275 000 t of paper waste is currently being recovered annually in South Africa. This represents 24 percent of the total percentage of all paper consumed as compared with 19 percent in 1969. Of this, some 60 000 t is used for paper making and the remainder is used for moulded paper maché products and filler.

Paper pulp accounts for possibly 26 percent of softwood timber production in South Africa and is predicted by the Department of Forestry to be a resource which will be in very short supply both in South Africa and elsewhere within this decade. It can therefore be expected that the price of raw pulp will increase and that the recycling of waste paper on a larger scale than at present will be highly desirable.

White points out that the prices of waste paper range from R15/t to R90/t depending on the grades, the quality of the pulp it will yield and the supply volume of that grade. The picture is therefore dominated by market conditions. So much so, in fact, that large-scale efforts in the U K and elsewhere to recycle waste paper have been thwarted by such factors as price instability and the need to store quantities of waste paper in order to cover fluctuations in supply and ensure a steady supply in terms of both quantity and quality (Bolitho 1975).

Bolitho estimates that it costs about R2,00/t of urban refuse to arrange for the separate collection of paper presorted at source. Assuming an average price of R16/t of waste paper he estimates the revenue from the sale of waste paper at R1,06/t of total refuse.

Wolmarans, in a separate pilot study of waste paper collection in Kempton Park and Verwoerdburg, has shown that the cost of the collecting and hence the profitability of the undertaking is greatly influenced by the degree to which households and businesses cooperate. As is shown in Figures 1 and 2, 50 - 70 percent of households cooperated in his pilot studies during the first month, when the level of publicity was high, but the percentage dropped to 10 - 30 percent when the publicity stopped.

The Johannesburg City Council is currently conducting an extensive study of waste paper collection in its northern suburbs and will be in a position within the coming year to throw a great deal more light on this problem.

There is uncertainty at this stage as to what further research into paper waste might be desirable. In our view, waste paper recycling could be substantially increased through public and official cooperation and steps should be taken by the authorities concerned on the one hand to guarantee stable prices for paper waste and on the other hand to facilitate outlets for products made from waste paper.

PLASTIC WASTES

Nurse and Symington (1975) have examined current trends in South Africa and elsewhere in regard to plastics production and the supply of raw materials. They conclude that plastics do not pose a waste disposal problem now and are not likely to do so in the near future. No particular action needs to be taken in regard to disposal of plastics. Recycling is practiced in South Africa to some extent, especially within the industry, and will presumably increase as raw materials costs increase.

Hall (1975) says that virtually all types of plastic material in common use are recyclable into one or other useful form. In most instances, recycling is technically feasible and dictated simply by economics and by the availability of plastics for recycling.

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Table 1. Preliminary guidelines for the disposal of solid wastes to dumps (Alexander 1974)

Problem Solid and semi solid wastes are produced

Objective To dispose of wastes in an economically and ecologically acceptable manner

PRINCIPLES	TECHNIQUES
1) Avoid Waste Disposal	1) Classify into avoidable, saleable and re-useable
2) Avoid Hazards	1) Classify and segregate Physical (solids, liquids, sludges, slurries): Hazardous (explosive, flammable, oxidising poisonous, infectious, corrosive, radioactive); Nuisance (purrescible, dusty, loose papers, plastic, insect breeding, colour, taste and odour producing substances); Non-Hazardous (Materials not included in above classification)
	2) Check analyses, toxicity (individual chemicals to be checked against values quoted in the literature). Decide if dumping is acceptable or if other means of disposal is required.
	3) Check compatability with other wastes and handle separately if necessary.
	4) Consider physical, chemical and biological interrelationships.
	5) Process wastes to render safe if necessary before dumping, i e move toxic component.
	6) Issue clearance certificate - stipulating composition and pre-treatment.
	7) Record where hazardous waste is dumped.
	8) Fence site adequately, to avoid intrusion of unauthorised persons, put on warning notices, lock gates.

(Table 1 continued)

PRINCIPLES		TECHNIQUES
3) Avoid Fumes, Wind blown materials, fires smoke infestation by vermin	1)	By providing suitable cover - inert material.
	2)	Segregation of oxidising materials, inflammable materials, hot ash, etc.
	3)	Consolidation of dump - spraying if required.
	4)	Regular inspection and control.
	5)	By providing services (telephone fire-fighting).
4) Avoid pollution of water courses/ground water	1)	Site dump away from water course.
	2)	Compact ground before dumping wate in minimise percolation.
	3)	Seal site to reduce percolation to acceptable limits - clay, plastic, other material.
	4)	Interleave bad wastes with impervious layers.
	5)	Segregate wastes - provide collection bins, receptacles and demarcated areas for wastes of various catagories.
	6)	Make use of absorptive properties of other wastes.
	7)	Treat to reduce leaching, e g mix ash, cement and metal hydroxide sludges encapsulation).
	8)	Check natural flows in and out of dumping site, and deviate where practicable.
	9)	Check nature of strata, faults, stability of ground, leaching rates, consolidation characteristics, depth of water table, distance of site from water course and boreholes.
	10)	Check chemical characteristics and toxicity of wastes - ascertain quantities and likely effect on ground water or stream.

		11)	Construct booms to minimise erosion - ensure dump consolidated and stable.
		12)	Contain surface run off if necessary - by bund walls.
		13)	Provide cut off drains for storm water and impervious "capping" over leachable wastes.
		14)	Monitor seepage and boreholes around the site.
5)	Avoid "eyesores" and complaints	1)	Formal approval of dumping site by Government Department or local authority.
		2)	Cover dump, landscape, plant grass, plant trees to screen.
		3)	Regulate height of dump.
		4)	Avoid nuisance - minimise exposed area.
		5)	Site away from residential area.
		6)	Avoid deposition of material on public highways.
		7)	Regular inspection and control.
		8)	Operate dump on limited area each day/week/month and cover frequently as dumping proceeds.
6)	Minimise cost	1)	Distance of site from source of waste.
		2)	Suitability of contours.
		3)	Suitable access.
		4)	Availability of cover material.
		5)	Cost of reducing percolation to acceptable limits - criteria required.
		6)	Consider present and possible future uses of the land, e g playing fields, etc.
		7)	By providing correct equipment.

Table 2. Industrial solid waste disposal producers (Buchholz 1975)

Waste	Adverse Effects	Disposal
OILS & GREASES from refineries, workshops, vehicle washing, engineering works, tanneries, wool washing, etc.	Blocked sewers & equipment, scum, anaerobic conditions, smells, flies.	Sanitary landfill Incineration Biodegradation (organics)
INSECTICIDES, PESTICIDES from chemical food & textile factories	Toxic to bacterial & aquatic life, ineffective sewage treatment	Incineration Chemical reduction
HEAVY METALS from pickling & planting	-do-	Chemical reduction Sanitary landfill
CYANIDE from metal finishing, plating, coking refineries	-do-	-do-
CHEMICALS from chemical, pharmeceutical dyes, solvents, textile, pulping, coking operations	Unpleasant taste & odours, toxic to aquatic life	Chemical reduction Sanitary landfill Biodegradation (organics) Incineration (organics)
ACIDS (mineral & organic) from pickling, chemicals, food operations	Corrosion and toxic	Chemical reduction Sanitary landfill Biodegradation (organics)
ALKALIS from finishing plating, textile, pulping, acetylene, tanning	Toxic to fish, brack conditions	Chemical reduction Sanitary landfill
NITROGEN, PHOSPHORUS, from fertilisers, detergents	Growth of aquatic organisms	Sanitary landfill
CARBOHYDRATES from fruit, vegetable canning, sugar milling	-do-	-do- Biodegradation
DETERGENTS from textiles, metal finishing	Foaming	Sanitary landfill
PATHOGENS, etc, from hospitals, abattoirs	Disease	Incineration Sanitary landfill Biodegradation
PHENOLICS	Toxic	Incineration Biodegradation

Table 3. Approximate resale value of a ton of refuse (after Bolitho 1975)

Item	Proportion of mass (t)	Value contaminated		Value uncontaminated	
		Price/t	Total	Price/t	Total
Paper, board, rags	± 0,33t	± R9/t	R3,00	R18/t	R6,00
Ash, cinders	± 0,22t	-	-	-	-
Organic matter	± 0,15t	-	-	-	-
Grass	± 0,08t	R7/t	R0,56	R10/t	R0,80
Ferrous metal	± 0,08t	R10/t	R0,80	R20/t	R1,60
Other metal	± 0,002t	R200/t	R0,40	R400/t	R0,80
Plastics	± 0,05t	R15/t	R0,75	R60/t	R3,00
Other	+0,09t	-	-	-	-
	1t		R5,50/t		R12,20/t

Using similar figures, Wolmarans (1975) estimates the "value uncontaminated" at R14,05/t.