COMPOST PRODUCTION

IN THE FALKLAND ISLANDS

FEASIBILITY STUDY

ECOLOGICAL SCIENCES Ltd

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APPENDICES

1.0 INTRODUCTION

EcoSci was invited by the UK Falkland Islands Trust to put forward proposals as to how indigenous materials in the Falkland Islands might be used to generate organic matter with the objective of improving the soil structure both for agricultural/horticultural proposes and, in the longer term, to improve pastures for fattening stock - both sheep and cattle.

This report is based on information gathered during a visit to the Falkland Islands in late November/early December 1998 and concentrates on the feasibility of establishing a composting plant at Stanley and proposals for practical trials to assess the viability of a process using "culled" sheep to produce compost on farms.

Over recent years, Jim McAdam, as a consultant to the UK Falkland Islands Trust, aided by the Falkland Island Department of Agriculture, carried out a series of growth trials using kelp extract as a source of nutrients, trace minerals etc. Results have shown this to be beneficial but these extracts do not significantly enhance the nutrient levels of the soil and are thus not an adequate substitute for artificial fertiliser . It is technically feasible to harvest kelp both for purposes of soil improvement, when ploughed into the ground, and as a source of trace elements, but any such project would entail both serious capital investment and a substantial requirement for labour. Although unquestionably plentiful and superficially attractive as a vast and renewable resource, it is very difficult to envisage that the harvesting, and subsequent distribution of kelp would be economically viable. This is because kelp has an exceptionally low dry matter content (circa 5%) and large scale harvesting has proved to be uneconomic - even when used for the extraction of high value speciality chemicals (salts of *alginic acid*). Accordingly, any proposals would be dependant upon long term strategy, and even pilot scale trials would entail substantial investment.

2.0 OBJECTIVES

The terms of reference are as set out in Appendix A. It will be noted that this feasibility report concentrates on the composting issues (items 1 and 2) and the use of seaweed in so far as it is an important feedstock in the composting process. The more wide ranging considerations and economics relating to the harvesting of kelp (*macrocystis pyrifera)* and other native species of seaweed (items 3 and 4) have not been addressed in this report for reasons outlined above and detailed under separate cover.

This should not detract from the very real benefits that can be achieved from using cast sun/wind dried kelp (70% to 80% dry matter) as a raw material in the composting process. By this means full benefit can be derived, at a realistic cost, from the valuable trace elements which are retained in the compost in a form that can be readily assimilated by vegetation.

3.0 PROGRAMME OF MEETINGS AND VISITS

The programme of Camp visits had been pre-arranged by Jim McAdam in conjunction with Bob Reid of the Department of Agriculture. The first five days were spent based in Stanley, followed by a visit to Saunders Island and Port Howard, allowing for a final 2 days in Port Stanley for wrap-up meetings. Unfortunately, exceptionally severe winds curtailed all FIGAS flying for 3 days so the wrap-up meetings had to be abandoned and the return flight to the UK entailed an eleventh hour flight from Port Howard direct to Mount Pleasant and a kind landlady at Stanley packing our belongings! Fortunately, with the exception of Simon Hardcastle, who was on leave during the first week, it proved possible to have brief discussions with most people who are likely to be directly concerned with any composting project.

Specifically meetings were held with:-

- Bob Reid - Director, Department of Agriculture
- Andrew Coe - Senior Vet, Department of Agriculture
- Hugh Normand - Managing Director, Falkland Islands Development Corporation
- Ian Dempster - Deputy MD Falkland Islands Development Corporation
- Manfred Keenlyside - Public Works Department
- Colin Horton - Managing Director Falkland Holdings Ltd
- Colin May - Butchery
- Alec Smith - Estates Branch Mount Pleasant
- Tom Eggling - Environmental Planning
- Tim Miller - Stanley Growers
- John Lee - Manager Goose Green Farm

In addition visits were made to:-

- Eliza Cove Landfill Site
- The existing Slaughterhouse
- Provisional site for new Abattoir
- Mount Pleasant - Estates Office
- Goose Green Farm
- Kidney Island
- Saunders Island
- Port Howard
- Recording studio - interview on radio

All concerned were extremely co-operative, very supportive of the principle of recycling, and generally enthusiastic about the possible production of compost.

4.0 OVERVIEW

Composting is the aerobic digestion of organic matter and the process, together with a summary of the beneficial properties of compost, is described in general terms in Appendix B. The microbial activity in the composting process generates heat and drives off moisture with temperatures in excess of 60°C maintained for a number of weeks. The Falkland Islands climate should not be a major problem provided the process is well insulated and the volumes are of sufficient size in relation to the surface area to contain heat loss. For this reason, small scale garden composting is likely to prove difficult.

It was apparent from the outset that the whole approach to both the economics and the practical aspects of compost production would differ radically as between Port Stanley and the Camp.

The basic raw material for producing compost in the Camp would be the annual "cull" of sheep, supplemented by cast kelp and peat, in order to ensure adequate "structure" and the necessary balance in the feedstock as between carbon and nitrogen - known as the Carbon/Nitrogen (C:N) ratio.

Although a composting plant at Port Stanley could be viewed as an environmentally friendly means for disposing of domestic waste, the quantities generated by a population of 1,800 are so trivial in terms of a conventional composting plant that it would be difficult to justify on economic grounds - even after taking into account the high cost of imported compost. However, it is understood that the new abattoir is likely to go ahead but that it is unlikely to incorporate a plant for treating the offal - as was originally envisaged. Slaughterhouse waste from the abattoir could therefore represent a disposal problem but would be a superb feedstock material for composting. This would be an important factor when considering the design, location, and the economics of a composting plant in the Stanley area.

For the purposes of this report, composting at Port Stanley will thus be treated as an entirely separate issue from composting at the various stations in the Camp.

5.0 COMPOSTING PLANT - STANLEY AREA

5.1 Sources of raw material

Various sources of putrescible waste which might be made available for composting in the Stanley area are:-

- Household waste
- Garden Waste
- Slaughterhouse offal
- Cast Kelp
- Peat
- Cookhouse waste from MPA
- Sewage Sludge from MPA

5.1.1 Household waste

A study was commissioned recently by the Falkland Islands Government into waste disposal and undertaken by Sir William Halcrow and Partners (Falkland Islands Waste Disposal February 1998). The study indicated that some 800 tons of domestic waste is collected annually in Stanley by the Public Works Department. At present this is landfilled at Eliza Cove. Eliza Cove is not a "controlled" landfill site and the diversion of the putrescible element of the waste stream from Eliza Cove, or from any landfill site that may be planned, would be a distinct advantage, both from an environmental and an economic standpoint.

The waste composition analysis in the Halcrow report indicates that food and garden waste comprises 40% of the total, with paper and board amounting to a further 12%. Theoretically, it would be possible to recover this putrescible material, thus composting over 50% of the domestic waste stream, with a corresponding reduction in the disposal of waste to landfill.

In order to achieve this, it would be necessary either to introduce a source separated collection or establish a centralised sorting operation. Typically, a source separated collection would allow for kitchen waste, garden waste, paper and cardboard to be collected on alternate weeks, with the remainder of the household rubbish collected during intervening weeks. Experience of source separated collection in the UK has been, on the whole, fairly unsatisfactory. However most of these schemes in the UK relate to large centres of urban population and the few schemes that have been introduced in rural areas have been markedly more successful. It would be fair to assume that a source separated collection in Stanley should work well, given the nature of the community. A key factor would be a well organised educational programme to explain the benefits - staring with the school.

The alternative to a source separated collection would be a centralised pre-sorting site. Although perhaps 75% of the available putrescible waste stream could be recovered by pre-sorting the mixed household waste arisings from a non source separated collection (as at present), this operation is both messy and labour intensive and would also require a building - bearing in mind the wind-blow effect.

As there is no indigenous market for any of the dry recyclables (glass, metals and plastics) which would normally be recovered and help to pay for the costs of pre-sorting, a source separated collection of putrescible waste would seem to be the preferred option.

5.1.2 Garden Waste

Household garden waste is included with domestic waste in the figures quoted in the Halcrow report. However, there is an estimated further 200 tons per year of garden waste produced by Stanley Growers. At present this is used as pig food or dumped on site. This would be an excellent material for composting.

5.1.3 Slaughterhouse Offal

This would be an excellent feedstock for co-composting with other wastes. As it has a high nitrogen content there would be a requirement for similar quantities of domestic waste and/or peat. The elevated temperatures (over 60°C) maintained over a period of several weeks during the composting process would be sufficient to ensure destruction of any harmful pathogens. It was difficult to obtain any reliable forecast of the likely throughput for the projected new abattoir. The best guess would appear to be an output of some 400 tons of offal per year based on a throughput of some 30,000 carcasses. This would balance well with 200 tons of garden waste and 200 or 300 tons of organic domestic waste.

5.1.4 Cast Kelp

This would be an excellent material to co-compost with the offal and domestic waste. The kelp holdfast would add much needed physical "structure" together with beneficial trace elements. The analysis of samples of the kelp collected during the visit is shown in Appendix C.

Following an onshore gale, a tractor, fitted with a front loader, could drag kelp above the tide mark, so that it is not carried back out to sea. It could then be left to "weather" in situ for an indefinite period and could subsequently be collected for composting with a tractor and trailer. The "weathering " process has two benefits:

1. The dry matter is increased from less than 10% typically to more than 70%. Not only does this transform the economics of subsequent transport, but also the physical nature of the cast kelp is such that it would act as a bulking agent and help to provide the necessary "structure" when mixed with slaughterhouse offal.

2. The leaching action of any rainfall will reduce the salt content.

Although seemingly labour intensive, the relatively small scale requirement for this purpose, means that collecting cast sun/wind dried kelp from the shoreline adjacent to Stanley would be infinitely more cost effective than any attempt at harvesting fresh kelp. Fresh kelp, even at 8% dry matter, would require to be artificially air dried before composting and would lack the physical properties of a bulking agent. Although some cast holdfasts are tough a, they will break down with the vigorous regime of turning entailed in the composting process.

5.1.5 Peat

This will need to be at least part dry in order to add "structure". The analysis of a typical sample is shown in Appendix C. As with cast kelp, there would be a cost entailed with this material - possibly in the region of £5 per air dried ton. The preferred balance of feedstock would be determined by practical trials, but a reasonable guess at this stage would probably be approximately equal proportions of, respectively, domestic waste, slaughterhouse waste, cast kelp and semi-dry peat. However it is unlikely that the exact balance will prove to be critical and could be dictated to some extent by the economics and availability.

5.1.6 Cookhouse Waste - MPA

In discussions with the Estates Department of MPA, it became clear that it would be a relatively simple matter to arrange a separate collection of cookhouse waste and, for that matter, possibly paper waste. Although the costs of transport of this waste material from MPA to Stanley would not be trivial, there would be corresponding savings in the cost of landfill at MPA. Depending on the size of the garrison, this could be a potential source of a further 400 tons per year of putrescible waste.

5.1.7 Sewage Sludge

At present the sewage sludge from Stanley is discharged untreated into the harbour. It appears that there are no immediate plans for a treatment plant at Port Stanley but there does exist a sewage treatment plant at MPA. In theory, sewage sludge cake (25% dry matter) would be an excellent material for co-composting and, from EcoSci's experience with co-composting trials in the UK, this would add to the nutrient value of the compost. There was, however, insufficient time to investigate this matter further during my visit to MPA, so its inclusion should be treated as a possible added bonus rather than a core factor in evaluating the viability of a composting plant.

5.2 Location of Stanley Composting Plant

The new abattoir and its location is likely to prove a key factor in deciding the location of a composting plant. The proposed location for the slaughterhouse is to be just off the road to MPA overlooking Port Harriet on the Stanley side (photograph - Appendix F). There are good reasons for locating a composting plant adjacent to the abattoir as this would minimise the transport cost of a major element of the waste stream and allow for shared infrastructure and overheads. It also has the advantage that there is an ample supply of peat nearby which could be harvested mechanically. The availability and proximity of cast kelp would require further investigation but it is unlikely that this would prove to be a key factor in deciding the location of the plant.

5.3 Design of Stanley Composting Plant

When space is not a major consideration, the most cost effective method of composting is the traditional method of turned windrows. These are elongated piles and are usually some 3 metres at the base and 2 metres high. They are built on open level ground and turned approximately once every 2 weeks over a 12 week period. However, this method is not recommended for composting domestic waste and sewage sludge as consistent high temperatures cannot always be maintained at the surface of the windrows and therefore pathogen kill cannot be assured. More importantly, the prevailing winds in the Falkland Islands would create unacceptable wind-blow of extraneous material and maintaining the correct moisture level could prove difficult. Some form of "contained" composting system would therefore be required.

There are numerous variations on the theme of "contained" systems that are currently available. In order to maintain the oxygen level required for aerobic conditions these rely either on forced aeration or mechanical turning. Bearing in mind the nature of the feedstock and the lack of any conventional "bulking agent" such as wood chips , a system based on mechanical turning would be more suited to prevailing conditions. There are numerous proprietary systems based on both mechanical turning and forced aeration or a combination of the two . The choice of system should be dictated by considerations of simplicity, reliability and economics.

Examples of systems based on forced aeration and mechanical turning are shown in Appendix D and Appendix E. The Plus-Grow system (Appendix E) is a simple low cost system which is manufactured in the UK and would certainly be worthy of consideration. Forced aeration has lower capital costs but higher running costs; however, such systems perform better at ambient temperatures that are higher than those prevailing in the Falkland Islands and, accordingly these systems are unlikely to prove satisfactory.

5.4 Costings

5.4.1 Assumptions

For the purposes of this exercise it is assumed that:-

1. The plant will be based on the "Plus-Grow" design scaled down for an input of some 1,600 tons per year of mixed waste material, yielding some 800 tons per year of compost.

2. Waste material will comprise :-

400 tons of source separated domestic waste (kitchen waste and paper)
400 tons of slaughterhouse offal
400 tons of air dried peat
300 tons of air dried cast kelp
100 tons of green waste from Stanley Growers

3. Ideally the plant would be operated 5 days per week for 50 weeks per year (i.e. not at weekends or on Public Holidays) but, bearing in mind the seasonal nature of some elements of the feedstock, the most cost effective mode of operation will require further examination.

4. Paper and cardboard would require shredding prior to composting.

5. A simple bag ripping device followed by a 50 mm rotary screen will be used for the source separated domestic waste. Any overtails from the screen should be less than 15% of input material and would be sent for incineration or landfill. The composting system would be a single bay Plus-Grow enclosed in an agricultural type building. This relies on mechanical turning to maintain aerobic conditions.

6. Two operators should be more than sufficient to operate the plant but, in order to provide cover for sickness and holidays, a third operator is assumed for costing purposes.

7. The slaughterhouse offal and the domestic waste are assumed to be delivered at "nil cost" in view of the fact that there would otherwise be a disposal cost to landfill.

8. Semi-dried peat, mechanically harvested, would be delivered in bulk from a nearby peat bed at an assumed cost of £5 per ton.

9. The cost of air dried cast kelp (collection and transport) has been estimated at £10 per ton.

5.1.2 Capital Costs

A single bay Plus-Grow has a capacity of approximately 2,500 tons of input material per year and, erected in the UK, would cost approximately £200,000 inclusive of site preparation and building. In addition to the Plus-Grow system the "front end" treatment would include a bag ripper, paper shredder and rotary screen. In the UK this plant would cost in the region of £80,000 but, with a throughput of around 10 tons per week, would be running well within it's design capacity.

Assuming an additional 50% for transport of machinery and most materials to Port Stanley and for the additional cost associated with construction in the Falkland Islands, the total capital cost for such a plant is likely to be in the region of £450,000.

In addition a teleloader and trailer would also be required at an assumed capital cost of £35,000.

5.1.3 Operating Costs

The figures shown below are really only "guesstimates" to enable some conclusions to be drawn as to whether or not the concept is worth pursuing at some later stage. Clearly, before embarking on a project of this nature, a proper feasibility study should be undertaken to compare the merits of different systems and to verify and update the assumptions that have been made in this report.

Some further assumptions have been made as follows:

1. The buildings and structures have been depreciated over 20 years and the plant and machinery over 10 years.

2. An allowance equivalent to 15% per year of capital cost of plant and machinery has been made to cover repairs and maintenance.

£/year		**DESCRIPTION**
23,000		Repairs & maintenance - plant and machinery (15% of £150,000)
5,000		Repairs and maintenance of building (5% of £100,000)
500		Fuel for mechanical turner
36,000		Labour (3 operators @ £12,000 p.a.)
5,500		Fuel, Repairs & Maintenance for telehandler
5,000		Cast kelp and peat
70,000	**75,000**	**Sub total - direct operating costs**
15,000		Write-off of capital costs of plant (£150,000 over 10 years)
15,000		Write-off of capital costs (civils and building)
7,000		Write off of tractor, trailer and telehandler (£35,000 over 5 years)
37,000	**37,000**	**Sub total - depreciation**
	112,000	**TOTAL COST**

With an estimated output of 800 tons compost per year, a ton of compost would cost, theoretically, £140. However, it is likely that the labour costs for collection of kelp and peat could be offset by savings made in the diversion from landfill of both the slaughterhouse waste and the domestic waste.

Although compost produced in this manner may represent an expensive means of acquiring soil nutrients when compared with imported artificial fertiliser, it is difficult to place a value on the long term benefits gained through adding much needed organic matter and trace elements to the soil.

6.0 COMPOSTING - THE CAMP

6.1 Sources of Waste Material

As mentioned in the overview, the Camp represents a totally different proposition to Stanley. Firstly, the domestic waste generated by even the larger settlements is minimal in composting terms. A settlement of 20 inhabitants would generate perhaps 1 ton of organic waste per year. Even assuming similar quantities of peat and cast kelp as amendment materials, the volume would not be sufficient to maintain the necessary high temperatures to ensure proper aerobic conditions. The only possibility would be some form of home composting system which would produce an inferior type of soil conditioner under anaerobic conditions.

6.1.1 Sheep Cull

The key to composting on the Camp is the annual cull of sheep at each settlement. At present the carcasses resulting from the cull are either thrown over cliffs and washed out to sea or they are heaped together in some suitable location at a respectable distance down wind from the settlement. However, within a matter of a few weeks the birds scavenge the flesh and entrails - leaving only the skull and bones. Photographs of a pile of part decomposed and fully decomposed sheep carcasses at Goose Green and at Port Howard are shown in Appendix F.

In theory these carcasses would be a suitable feedstock for compost production. However:-

1. The nitrogen content is too high and hence a source of added carbon would be required to ensure an adequate balance for aerobic composting.

2. It is likely that the carcasses would require to be physically broken down into smaller pieces in order to make possible the effective mixing with the amendment materials (peat and cast seaweed).

3. Until such time as the composting process is underway with the associated elevated temperatures, the carcasses will remain attractive to birds and will thus require to be protected from scavenging.

6.1.2 Amendment Materials

As will be the case with the slaughterhouse waste at Stanley, the only materials that are available in abundance, and would thus be economically viable, are peat and cast kelp.

It is difficult to be specific over the balance of the 3 feedstock materials - carcasses, cast kelp and peat. All will vary in consistency and dry matter, depending upon the prevailing conditions. The optimum balance can only be ascertained by a series of practical trials and, as a start point, a blend of approximately equal proportions by weight is recommended.

6.2 Design of Composting System

Although both poultry and pig carcasses have been composted, there are no records of trials relating specifically to sheep. It will be seen from the trials with pig carcasses (Appendix G) that the flesh was composted successfully but that the bones remained more or less intact. However, trials at the University of Maryland have shown that cow carcasses can be composted successfully without dismembering. For this reason it is suggested that two trials should be carried out in parallel. One with complete carcasses and the other with dismembered carcasses. It is understood that there is a prototype machine suitable for dismembering carcasses which is at present on Saunders Island and there are various machines commercially available if trials suggest that some form of crude breakdown of the carcass prior to composting is beneficial.

For purposes of the trial it is suggested that two pits should be constructed for each trial - each approximately 2m wide, 3m long and 2m deep. Ideally these should be on a slope with a shallow gradient so that a field drain can be incorporated at the bottom of each pit to drain off any excess moisture. It will probably be necessary to line the walls of the pit with whatever material is available (? corrugated sheeting) in order to maintain the structure during mechanical turning.

6.3 Conduct of Trial

The whole/dismembered sheep carcasses should be interspersed with layers of kelp and partially air dried peat sods.

1. The mixture should be left untouched for approximately 1 month and then should be turned at intervals of approximately 2 weeks using a tractor fitted with a back actor.

2. Primary aerobic composting is likely to take at least 12 weeks, but this may well depend upon the prevailing conditions. It is quite possible that the process could take up to 6 months depending upon the time taken to achieve elevated temperatures at the start.

3. Success or failure of the trial will become apparent within a few weeks as aerobic composting generates temperatures of at least 50°C.

4. It can be assumed that the composting process is complete when temperatures fall below 25°C.

5. At this point the contents of the pit should be dug out and left in a pile in order to mature for a minimum of a further 6 weeks.

6. The frequency of turning the contents of the pit during the composting process is a matter of trial and error - the object being to achieve and maintain the highest temperature.

7. Placing some form of cover over the pit may well be desirable for aesthetic purposes, but the design of any cover will need to take account of both the strength of the wind and considerations of how it is best handled. Once the composting process has started, it is unlikely that the material will prove attractive to birds. If the pit is dug into the side of a slope, it is important that there is some form of drainage on the uphill side to ensure that surface water does not run into the pits.

8. The composting process is likely to be accelerated during the initial stages if small amounts of compost are added from the most recent previous batch - preferably when the material is still at an elevated temperature. It is suggested that the trials are carried out at Port Howard in view of the enthusiasm for the project expressed by Robin Lee coupled with the other successful trials that have been carried out over the years in conjunction with UK F I T. Clearly there will be a cost associated with such trials - both in terms of materials for constructing the pit and, more significantly, the labour entailed with the trials. This will encompass gathering supplies of cast kelp and peat sods in addition to the work entailed with the trial itself.

It will be necessary to record temperatures at least once per week during the trials and collect samples for analysis at the end of both the primary composting stage when the material is removed from the pit and at the end of maturation - when the temperature in the maturation pile falls below 25 °C.

6.4 Costings for Trial

It is extremely difficult to produce any accurate estimate of costings for a full scale project at this stage. Much will depend upon the outcome of the trials. It would seem that £2,500 for each of the initial trials should be sufficient to cover the costs associated with the trial. The critical factor being, of course, whether suitable labour can be spared to undertake the work. Once sufficient quantities of peat and cast kelp have been accumulated, the trial itself will only entail approximately 1 half day each week (approximately 2 tons of cast kelp and 2 tons of air dried peat together with some 80 carcasses will be required for each trial). In the case of a full scale operation, the availability and proximity of cast kelp will vary from station to station. The going rate for peat, when cut mechanically, is somewhere in the region of £3 per cubic yard or wet ton. This could equate to perhaps £6 per ton when partially air dried.

The overriding factor is likely to prove to be the degree to which the resulting compost can be shown to improve both the quality and the yield of pasture - particularly when raising beef cattle. An application rate of 10 tons per acre would be a good start point for comparative growth trials. To put this into perspective, 80 sheep carcasses together with matching quantities of peat and cast kelp should generate approximately 3 tons of finished compost.

The question of scale will have to be addressed. As mentioned earlier in this report, heat loss will be a significant factor in the prevailing climate. The larger the composting pit, the greater the ratio of volume to surface area and, hence, the lower the heat loss. It is recognised that some farms will have a relatively small cull but the trial should indicate whether heat loss is a serious problem and hence whether a smaller pit might be possible.

7.0 CONCLUSIONS

The economics and practical aspects of composting in the Falkland Islands fall in to two entirely separate categories as between Stanley and the Camp.

Stanley

1. The issue central to the economic viability of composting in Stanley will be the availability of abattoir waste when the projected new abattoir is completed.

2. Subject to a "twin-bin" household collection of domestic waste with efficient separation of putresicble matter, slaughterhouse waste and garden material could be co-composted with domestic waste.

3. Peat and cast kelp are readily available and would be suitable sources of raw material for co-composting in order to achieve a balanced feedstock.

4. Due to the intensity of the prevailing winds, some form of "contained" composting system will be required.

5. A contained system, such as the "Plus-Grow", which relies on mechanical turning to maintain aerobic conditions, is likely to prove to be both cost effective and the most versatile for this combination of raw material.

6. A plant to produce some 800 tons of compost per year would utilise the raw materials readily available and would cost in the region of £450,000 when constructed at Stanley.

7. Compost would cost in the region of £140 per ton, after allowing for depreciation, but would have a nutrient value similar to artificial fertilisers, together with significant added beneficial properties through improving the organic content of the soil.

8. The most suitable location for a composting plant in the Stanley area is likely to be in the vicinity of the projected new abattoir. The technology for a "contained" composting process is well proven so pilot scale trials should not prove necessary. However, it would be prudent to undertake some trials to establish the feasibility and costs of collecting cast kelp.

The Camp

1. The key to composting at the various settlements in the camp will be to use the annual cull of sheep as a principal raw material.

2. As with the plant at Stanley, air dried peat and cast kelp would require to be co-composted in order to achieve the required balance of feedstock.

3. As there is no published information relating to the composting of sheep carcasses, pilot scale trials will be essential to establish optimum proportions of feedstock materials, frequency of aeration, and whether or not carcasses require to be dismembered prior to composting.

4. The most suitable location for these pilot scale trials would seem to be Port Howard or, possibly, Goose Green.

5. Theoretically, a settlement with an annual cull of 4,000 sheep, could be capable of producing between 120 and 150 tons of compost per year - sufficient for treating some 5 or 6 acres of pasture annually. However, in practice, much will depend both upon the economics of a full scale operation and the availability of suitable labour.

6. Provided that labour is available, the same technology is applicable to small farms (500 sheep culled per year) but the quantities of compost produced (15 tons) would really be more suited to growing vegetables than as having any significant effect on pastures - at a recommended application of 25 tons per acre.

8.0 RECOMMENDATIONS

1. A contained composting system, based on mechanical agitation, would be the preferred choice for Stanley.

2. As this technology is well proven, a pilot scale trial should not be necessary. Indeed it would be difficult and uneconomic to scale down any conventional "contained" system to this extent.

3. The plant would be small by UK standards and the deciding factors would be availability of slaughterhouse waste from the new abattoir and the feasibility of a source separated collection of organic household waste in Stanley.

4. Pilot scale trials should be sanctioned for a suitable settlement in the Camp to ascertain the feasibility, optimum process conditions and economics for composting carcasses from the annual cull of sheep.

5. Port Howard would appear to be the most suitable location for these trials.

6. Two composting trials should be arranged in parallel at the same time for purposes of comparison - one with whole carcasses and the other with dismembered carcasses.

7. The compost produced in each trial (approximately 3 tons) should be sufficient for application to a defined area of pasture in order to assess the benefits.

8. A contribution of £2,500 towards the costs of each composting trial should prove sufficient to cover most of the direct costs. A more accurate estimate of total costs would depend upon a review of resources available locally.

Appendix A TERMS OF REFERENCE

The terms of reference were stated as follows:

1. To report on the feasibility of composting municipal and other waste products in the Stanley area (including sewage and abattoir waste)

2. The options available, potential for and likely mechanisms of small scale on-farm composting involving products such as cull sheep carcasses, kelp, peat and harvested vegetation.

3. The costings and feasibility study of harvesting kelp at a range of scales from on - farm processing for local use to producing potential export product.

4. A full consideration and feasibility of all other potential uses for all varieties of seaweed harvested or collectable on the Islands including such uses as seaweed mineral meal for livestock, liquid seaweed production, human consumption, etc.

Composting: Renaissance of an age-old technology

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Appendix B

Andrew C. Groenhof

Ecological Sciences Ltd, Exeter

Composting plays a crucial role in the management of organic wastes. In addition to reducing the volume of waste destined for landfill, composting creates a product which combines the benefits of nutrient value with the ability to suppress commercially important plant diseases, all in an environmentally friendly way.

Composting has been practised for many thousands of years and for a number of different purposes. For centuries the Chinese co-composted faecal matter with vegetable and animal wastes to create a product for maintaining soil fertility. Composting was used extensively in the production of saltpetre for the gunpowder industry during the English Civil War. Nowadays, composting is synonymous with agricultural/horticultural practices, such as the processing of manures on farms and green/vegetable wastes in gardens and/or parks, to create a useful, humified product for reviving over-exploited soils.

More recently, however, compost technology has gained a respectable reputation as a low cost means of processing various domestic and industrial organic waste streams. This interest has been bolstered by the introduction of the Government's White Paper 'Making Waste Work' (Anon, 1995), which describes a hierarchical waste strategy of reduction, re-use and recycling of waste. It is obvious that composting could satisfy either one or all three of these objectives, by transforming organic waste materials (eg those derived from industries such as sewage and poultry farms, paper mills and abattoirs, and domestic waste from houses and gardens) into useful products that could be applied back to the land and thereby elicit a number of beneficial effects. Further endorsement of composting came from the Government proposal that at least 1 million tonnes of organic household waste per annum should be composted by the year 2001 (Anon, 1995).

The process

Composting is a relatively simple technology and is defined as the controlled biological oxidation of organic matter to produce a stable and humified product:

$$\text{Organic matter} + O_2 \rightarrow \text{stabilised product} + CO_2 + H_2O$$

The process of aerobic biodegradation is actually very complex and is a balance between the levels of organic waste, microorganisms, oxygen and moisture content. These parameters need to be carefully controlled if the process is to proceed satisfactorily.

An ideal feedstock with a carbon to nitrogen ratio of 30:1 is required for effective microbial activity, thus preventing unnecessary recycling of carbon and excessive loss of nitrogen. This can be achieved by careful selection and mixing of feedstock materials such as straw (high in carbon) and manure (rich in nitrogen) to create the ideal starting mixture.

The microbiology of composting involves a succession of bacteria, actinomycetes and fungi, dictated in part by the availability of specific nutrients within the composting material (ie carbohydrates and proteins at the beginning, followed by more complex molecules such as lignin towards the end of the process). This microbial consortium is also governed by temperature, with the early (mesophilic) stages involving mainly bacteria and fungi. The subsequent (thermophilic) phase is characterised by actinomycetes plus bacteria, and the final curing stage (again mesophilic) may involve the appearance of higher fungi. Thus, a distinct pattern of events can be recognised during the composting process (Figure 1), referred to respectively as phase I and maturation (curing).

Throughout the composting process, it is essential that oxygen is in plentiful supply (~ 15%), first to ensure that optimum aerobic microbial activity is sustained, and secondly to prevent the process from becoming anaerobic and consequently producing unpleasant odours. One way of achieving this is to regularly turn the compost heaps. This can be done by a tractor with a front-end bucket or, if being carried out on a large scale, turning the elongated heaps (windrows) using a purpose-built windrow turning machine (Figure 2). The frequency of turning is governed by the temperature of the composting heap, and usually takes place when the heap approaches 60°C. Turning is therefore carried out frequently during phase I (about once or twice per week), but only occasionally during maturation. Other, less mechanised methods of composting also exist, including forced aerated static piles. This involves placing feedstock materials onto a perforated base, through which air can be either blown or sucked. These types of system have been particularly successful in the on-farm composting of wastes such as straw and manures/sludges (Bujang and Lopez-Real, 1993).

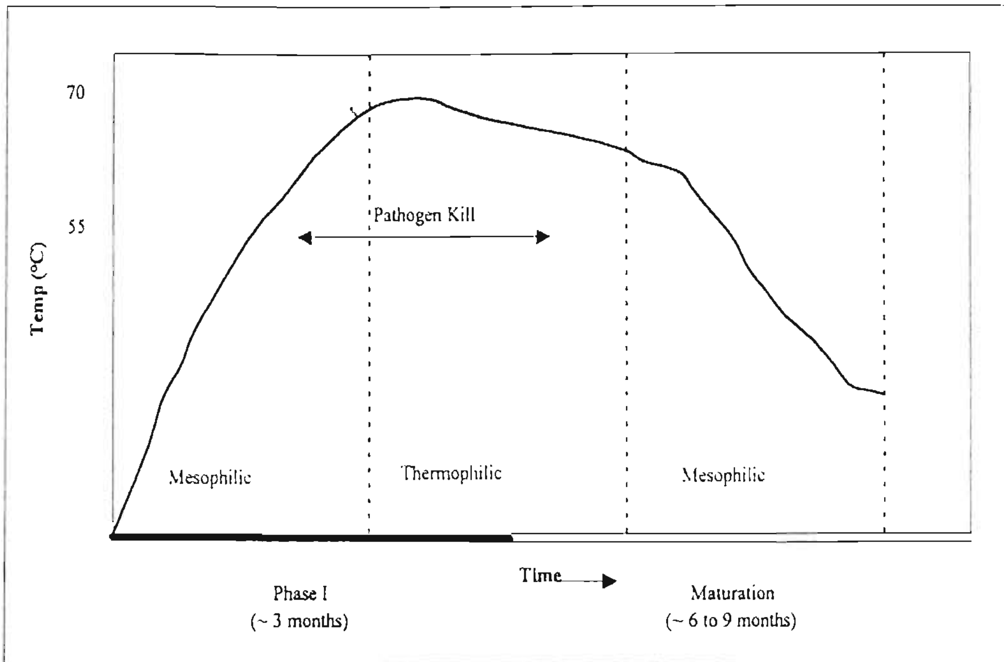

Figure 1. Typical temperature profile of a compost heap with its associated phases of microbial activity.

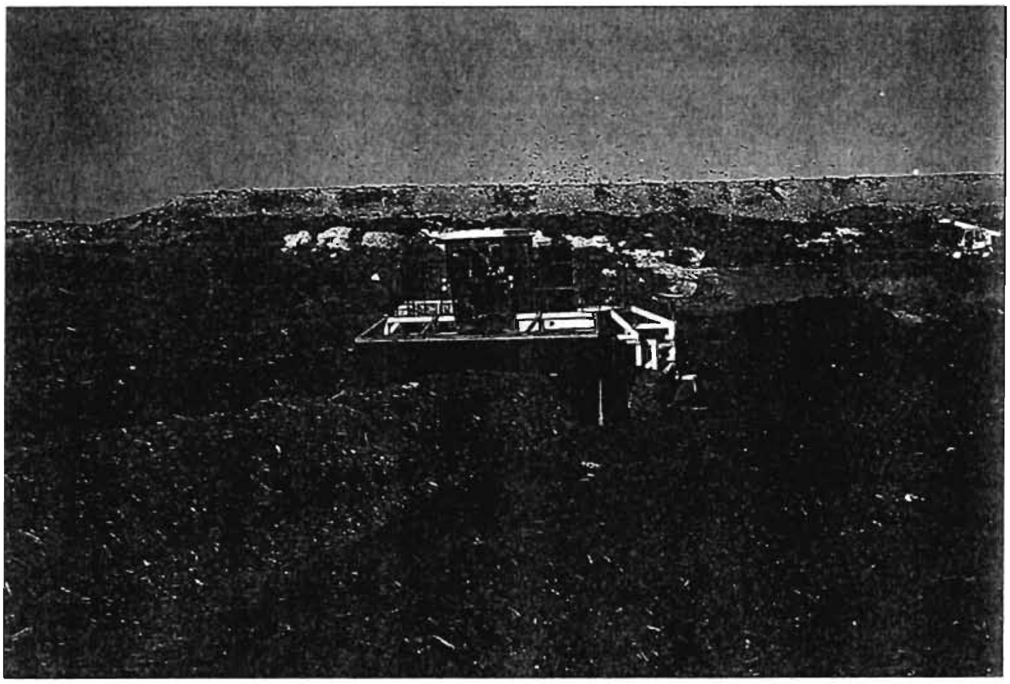

Figure 2. Windrow turner in operation at a greenwaste composting facility.

Moisture is also an essential component of the composting process, and needs to be carefully regulated. Too much moisture in the material will displace the oxygen within the interstitial spaces, leading to anaerobiosis. This, in turn, will prevent any significant rises in temperature, due to microbial activity, and the compost heap will 'die'. Optimum composting conditions can be achieved and maintained using a moisture content of 55%. However, when composting is complete and the material is ready to be bagged, this figure should ideally be 40%.

The composting process, from start to finish, takes approximately 9 to 12 months. This comprises the initial thermophilic stage (phase I), lasting for a period of approximately 3 months, followed by the maturation phase, lasting between 6 and 9 months. During this time, the feedstock material(s) will have lost about 50% of their volume (mainly as CO_2) and become mineralised and humified. In addition, the high temperatures achieved during the process (usually in the region of 60–70°C) will have killed any weed seeds and pathogens associated with the feedstock materials (Figure 1). The humification of the organic matter and the sanitisation of the material are the major benefits of composting.

In summary, composting deals with organic waste that would otherwise be destined for landfill by reducing its volume, thus saving landfill space, sanitising the material, and creating compost for use in agriculture and/or horticulture. It is worth noting that the production of this type of material could replace some or all of the peat currently used in horticulture, thereby helping to conserve a valuable resource.

To date, composting in the UK has not been widely used as a waste management option. However, this will need to be addressed soon, particularly in view of proposed changes in legislation. For example, sewage sludge disposal at sea is to be banned in 1999, so a suitable alternative will have to be found.

Applications

Agronomy

Studies have been carried out on forage maize (*Zea mays* var. Cyrano), grown as an experimental plant, in randomised field plots incorporating treatments of co-composted sewage sludge with Municipal Solid Waste (MSW) applied at a rate of 50t ha^{-1}. The results of these trials showed significant increases in germination and early establishment of plants, compared to control treatments (Parkinson *et al.*, 1993). Furthermore, the compost plots gave total plant yields 75% greater than those of the controls (with no soil amendments whatsoever), and a 50% increase compared to plots in which only inorganic fertiliser had been applied. Accompanying results of total grain yield reflected a similar trend, with compost treatments producing 40% more than those containing inorganic fertiliser only.

The use of recycled organic matter for improving soil properties is well documented (McConnell *et al.*, 1993), and its use in the production of agronomic, horticultural and silvicultural crops has been identified as the largest market for this type of material. The product consistently contains more than 50% organic matter and therefore increases the humic content of soils, with associated increases in soil water holding capacity. Soil properties such as pH and CEC (cation exchange capacity) are also increased, leading, respectively, to decreased heavy metal bioavailability within the soil, and providing greater availability of nutrients to plants. Compost is also a valuable source of slow release nitrogen and will reduce the risk of nutrient leaching into ground waters.

Disease suppression

Another application of compost produced from recycled organic matter is its role in plant disease control. Initial work in the US has provided evidence that using waste-derived composts eliminates a number of commercially important crop diseases, such as *Phytophthora* and *Rhizoctonia*, rots of soybeans and black-eye beans, respectively (Logsdon, 1993; Hoitink and Fahy, 1986). Damping off and root rot diseases are a major economic problem in the UK and many other European countries, and many commercial crops are susceptible to plant pathogens such as *Pythium* and *Rhizoctonia* (beet crops), *Gaeumannomyces*, *Fusarium* spp. and *Pseudocercosporella* (cereals), *Fusarium* spp. (bulb crops), and *Pythium*, *Phytophthora* and *Fusarium* (glasshouse crops). Currently, these pathogens are suppressed by the application of biological control and chemical fungicides or integrated methods, which are less effective in perennial crops and in situations where diseases become established later in the development of the crop(s).

To date, a number of soil-borne plant diseases have been successfully suppressed under glasshouse conditions, using greenwaste-based composts (ie material that has been collected from public and/or domestic parks and gardens, for composting). For example, disease levels of several foot-rots, including take-all *(Gaeumannomyces graminis)* have been reduced by up to 80%, as have root-rot of peas, *Phoma medicaginis* (60%), red-core of strawberries, *Phytophthora fragariae* (70%) and white-rot of onions, *Sclerotium cepivorum* (90%), whilst symptoms of clubroot *(Plasmodiophora brassicae)* were negligible (see Pitt *et al.*, 1996). No single compost is effective against all pathogens (Table 1), but they do all support excellent seed germination and plant growth. The suppressive efficacy of compost has been extended to the plant pathogenic bacterium *Ralstonia solanacearum*, the cause of brown rot of potatoes.

Work is currently underway to transfer these apparent benefits from glasshouse conditions to the field (Tilston *et al.*, in press). It is postulated that the disease suppressive effects of organic waste composts may be due to a number of factors: direct parasitism, competition for resources, or the production of some anti-fungal compound(s). These may occur either singly or in combination. In some cases (eg clubroot and black scurf), the effect may even be chemical since autoclaved composts also elicit a suppressive response (Figures 3 & 4).

Current investigations are continuing on the use of compost leachates in suppressing foliar plant diseases. For example, preliminary work, both in the US and UK, has shown some success in the suppression of diseases such as rusts/smuts and powdery/downy mildews, using leachate derived from composts.

The ability both to demonstrate and quantify the beneficial effects of composts and/or leachates against a number of soil-borne and foliar plant diseases is providing a valuable outlet for products that have hitherto been regarded as waste. Furthermore, the development of such technology is in accord with current UK objectives to

Table 1 Suppression of soil-borne fungal diseases using waste-derived composts

Disease	*Very mature greenwaste*	*Mature greenwaste*	*Paperwaste plus greenwaste*
Foot-rot of cereals *(Cochliobolus sativus)*	27.7%	28.5%	NS
Brown foot-rot of cereals *(Fusarium culmorum)*	62.3%	86.5%	37.0%
Take all of cereals *(Gaeumannomyces graminis* var. *tritici)*	46.5%	80.6%	65.7%
Blight of peas *(Phoma medicaginis* var. *pinodella)*	N.S.	66.3%	61.3%
Redcore of strawberries *(Phytophthora fragariae* var. *fragariae)*	69.7%	42.0%	NS
Clubroot of brassicas *(Plasmodiophora brassicae)*	Variable	NS	100%
White-rot of onions *(Sclerotium cepivorum)*	75.1%	89.6%	68.8%

NS: non significant.
Adapted from Pitt *et al.*, 1996.

minimise the current over-use of pesticides and chemical sprays in agriculture and horticulture.

Bioremediation

Composts, by virtue of their rich microflora/fauna, provide an ideal medium for aiding the biodegradation of various organic and industrial wastes (Epstein and Alpert, 1978). For example, there is now a wealth of evidence to show the effective breakdown of hydrocarbon oils by soil microorganisms (mainly *Pseudomonas* spp.), which can be further enhanced by the addition of a suitable nutrient source (eg compost). Hazardous wastes such as TNT, and other munitions wastes, can be converted into innocuous compounds through composting, as can polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and residues of pesticides such as DDT (see Barr and Aust, 1994). In these cases biodegradation can be facilitated by the activities of lignin peroxidases (LiP) and manganese-dependent peroxidases (MnP) associated with the white rot fungus *Phanerochaete chrysosporium*. The unique nonspecific mechanisms that this fungus employs for the degradation of lignin could thus be equally as effective at degrading a range of pollutants. It may therefore be feasible to inoculate isolates of this fungus or other specific microorganisms into compost heaps to facilitate the bioremediation of anthropogenic organic contaminants.

Although composting has been around for a great many years, it is the environmental issues such as peat extraction and the need to recycle waste that have brought this technology back into the scientific limelight. Recent interesting advances in the uses of composting technology are providing evidence for its commercial application in waste reduction and bioremediation.

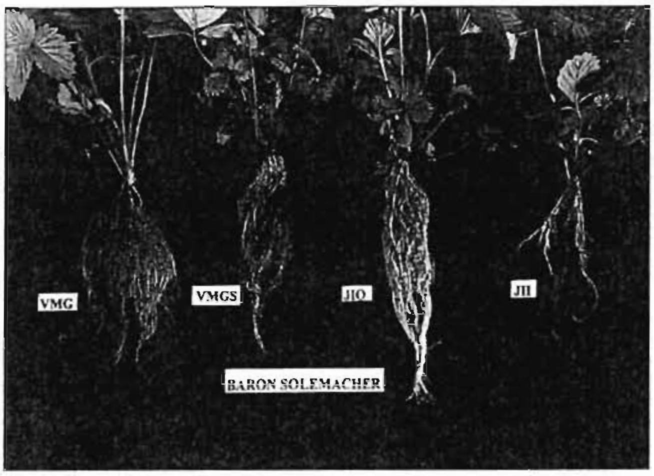

Figure 3. Strawberry plants (Fragariae vesca) *grown in various native and sterilised composts inoculated with redcore pathogen* (Phytophthora fragariae *var* fragariae). *VMG = very mature greenwaste; VMGS = very mature greenwaste, sterilised; JIO = John Innes, not inoculated with pathogen; JII = John Innes, inoculated with pathogen.*

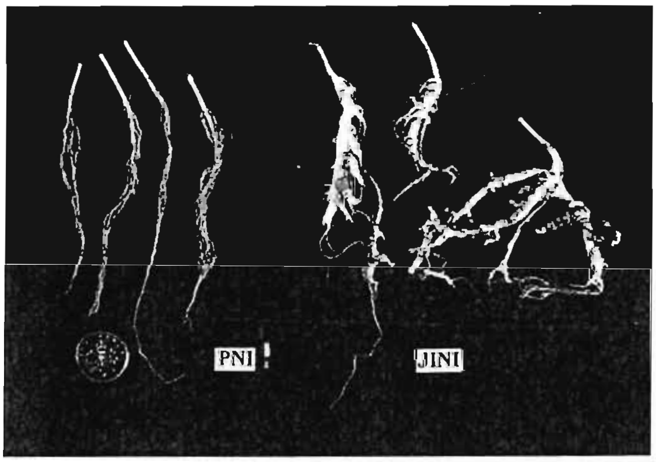

Figure 4. Roots of rape (Brassica napus) *after plants have been grown in composts inoculated with clubroot* (Plasmodiophora brassicae). *PNI = native paperwaste compost, inoculated; JINI = native John Innes compost, inoculated.*

Acknowledgements

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APPENDIX C

ANALYSIS OF SAMPLES OF KELP AND PEAT

(EX FALKLAND ISLANDS)

	Moisture Content %	Kjelahl Nitrogen %	Available Carbon %	C:N Ratio
Peat - Air dried	17.6	1.79	49.39	27.59
Seaweed A - Wet cast	55.81	1.98	40.28	20.33
Seaweed B - Dry cast (Leaf and Stem)	31.87	4.8	35.45	7.38
Seaweed C - Dry cast (Holdfast)	18.78	3.79	45.13	11.92

NB.

1. "Kjelahl" Nitrogen is a measure of "Total Nitrogen".

2. "Available Carbon" is determined by "ashing" in a muffle furnace and dividing the % loss by 1.8 (a recognised conversion). "Available Carbon" is a measure of the carbon actually available for uptake by plants.

3. The Holdfast would appear to be a good source of carbon and its chemical properties are excellent as a "bulking agent".

4. Wet kelp has a relatively high salt content and is covered with a slimy gum type substance.

Appendix D

EcoSci

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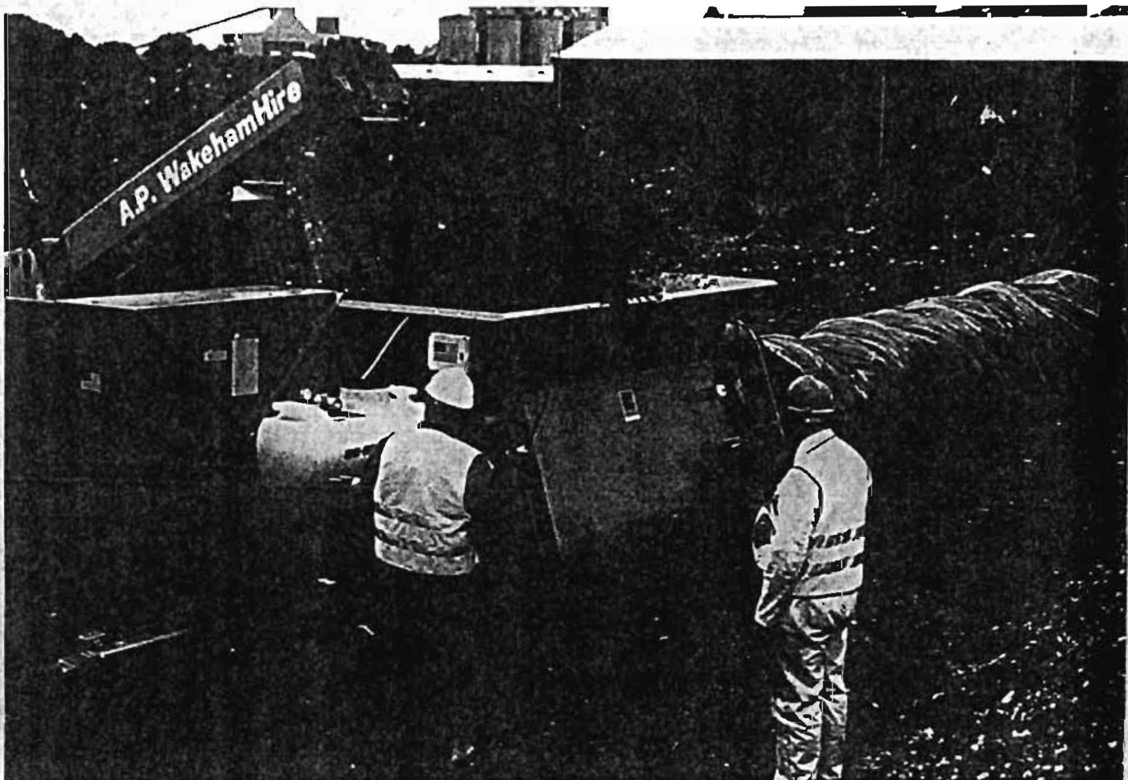
INTRODUCING THE MINI-POD COMPOSTER



- **WHAT DOES THE MACHINE DO?**

The system has been specifically designed to process organic wastes by way of contained, controlled, forced aeration composting. The machine works by "stuffing" the material to be composted into a large polythene bag called an Eco-Pod, whilst simultaneously inserting aeration pipes. These are subsequently linked to fans with aeration cycles timed to optimise conditions for aerobic composting.

- **WHAT ARE ECO-PODS?**

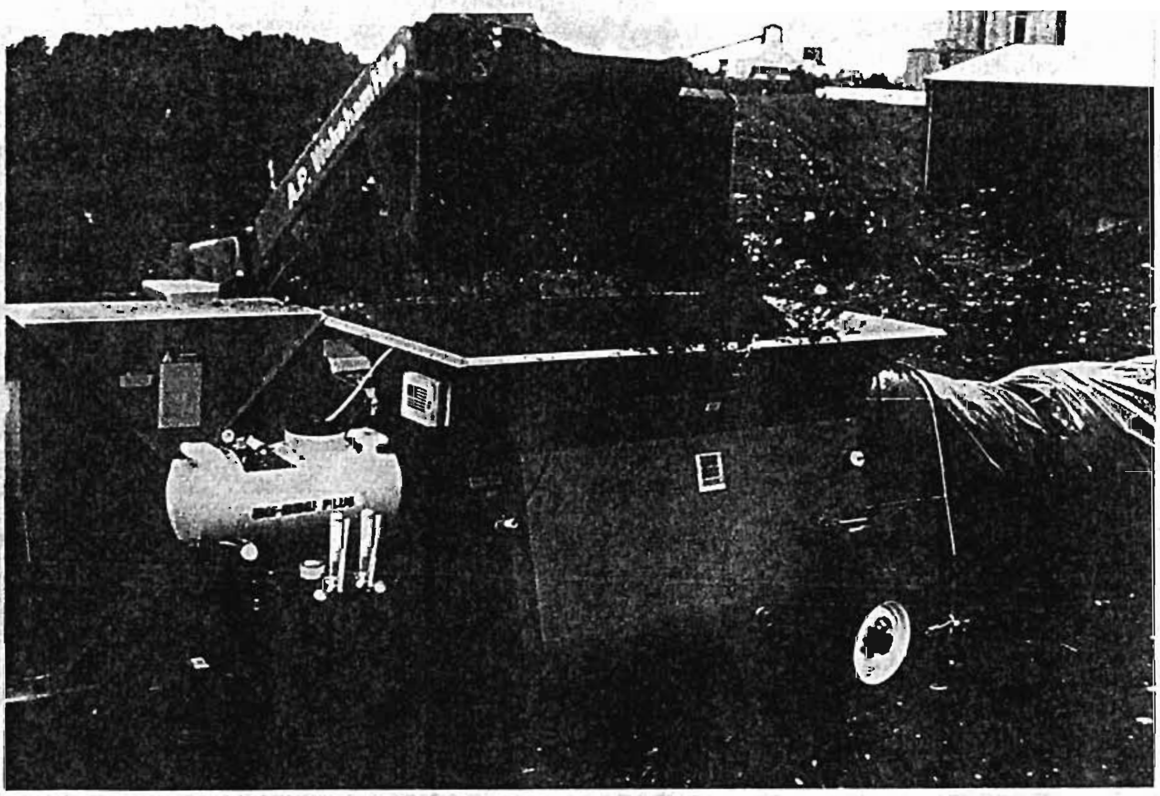
They are 60m long green plastic bags, 1.5m in diameter, each holding around 75 tonnes of material. Vents are placed along the length of the Pod to allow excess moisture and CO_2 to escape, and they provide easy access for measuring temperatures which reach up to 70°C, effectively sanitising the material. Essentially, Pod-composting offers a low-cost flexible contained system as an alternative to expensive "fixed" in-vessel composting systems.

• WHY ARE THEY NECESSARY?

For waste streams which may include putrescible municipal waste (food waste etc.). The Environment Agency is likely to insist on total containment of material whilst composting. Main concerns are about windblown material, leachates, odours and vermin attraction, particularly if there is residential housing nearby. In certain situations, the use of Eco-Pods relieves the operator of the necessity to carry out such exhaustive site preparation or installation of expensive technology.

• WHAT WASTE TYPES ARE SUITABLE?

Most organic biodegradable wastes are suitable feedstocks. Depending on the nature (particularly moisture and density) of the waste to be Podded, it may be necessary to add a "bulking material" - i.e. shredded green waste or straw.



• HOW DOES THIS PROCESS DIFFER FROM NORMAL WINDROW COMPOSTING?

Being a contained system, aeration can be controlled, and thus Eco-Pods are far less sensitive to extremes of weather than in the case of open-air windrows.

• HOW MUCH WILL A MINI-POD HOLD?

Approximately 75 tonnes. Compaction may be varied to suit the bulk density of the materials being treated.

• HOW LONG DOES THE PROCESS TAKE?

Typically, twelve weeks in the bag, followed by one month curing (maturation) in a static pile outdoors, after removal from the Pod, dependant on feedstock quality. At this point the material should be stabilised, sanitised and free of odour.

WHAT ARE THE ADVANTAGES OF USING THE POD SYSTEM OVER OTHER FORMS OF CONTAINED TECHNOLOGY?

- **Simplicity and flexibility**

- **Low-cost plant**
  Minimal capital investment - ideal for short-term contracts.

- **Minimal maintenance**
  Relatively 'low-tech', thus less to go wrong.

- **Low labour requirements**
  The machine is simple and self-powered when Podding.
  Remote control is standard.

- **No need for extensive site preparation costs**
  (buildings, concrete etc.) - only a level surface is required.
  May be moved around site as needed.

- **Mobility**
  The machine may be transported to different sites (easily towed), or shared on a rota basis by different parties / local authorities.

• HOW MUCH DOES THE SYSTEM COST?

The Podding machine costs approx. £40,000. Aeration fans with timers also need to be purchased. For multiple-Pod operations, an automatic diverter valve system will enable up to four Pods to be run cyclically (at any one time) by one fan with valve assembly. Using this apparatus also minimises fan housing and wiring arrangements. Aeration assembly will be good on an ongoing basis, usually with minimal maintenance, and would cost in the region of £3,000 for a four-Pod assembly (1,200 tonnes composting p/a). For a 10,000 tonne p/a operation, fan assembly would cost around £10,000 including installation.

• WHAT IS THE THROUGHPUT OF THE MACHINE?

This will depend on the type of material, collection and storage arrangements, and the number of operating sites etc. Typically, a single machine is capable of filling 4 Pods (300 tonnes) per day, and could thus be used on multiple sites.

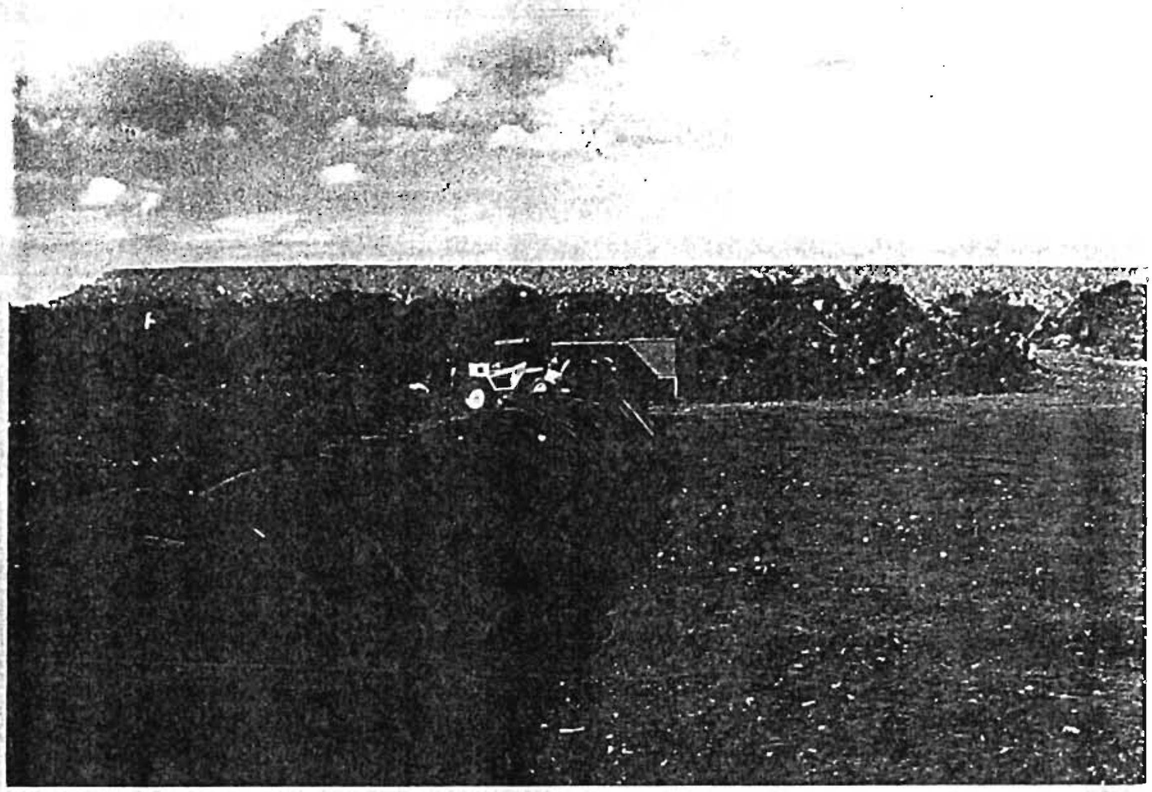
• WHAT ARE THE SPACE REQUIREMENTS FOR MINI-PODS?

0.8m^2 per tonne surface area per year (1.0m^2 allowing for maturation). e.g. a 10,000 tonne per annum operation would require 1 ha (2.5 acres) Podding area.

• WHAT ARE THE OPERATING COSTS?

Pods and aeration pipes cannot be re-used in practice. These are 'consumables' and the cost equates to approx. £6.00 per tonne input material. Vents and Pod sealing strips are supplied along with the bags. Electricity consumed during aeration will add around £1.00 per tonne composted over twelve weeks in a Pod, making elementary operating costs for Podding £7.00 per tonne.

The *total* operating costs will vary considerably depending on the nature of the input material and the pre-treatment required (shredding, mixing etc.) and the specification required for the end-product.



• HOW DO COSTS COMPARE WITH OTHER SYSTEMS?

Given adequate space and suitable site membrane / liner to satisfy the Environment Agency, open-air windrow turning is usually the least expensive option. However, mini-pods do not require an impermeable base due to their inherent containment. The additional operating costs (consumables) may therefore be offset by lower costs for site preparation.

For many types of putrescible waste (domestic & commercial food waste etc.) regulations require some form of contained system. Typically the capital cost of tunnel systems or forced aeration boxes (roll on/off design) will be at least ten times greater than Eco-Pods. Accordingly, when other systems are compared with Eco-Pods, the potential savings in operating costs will be more than offset by higher depreciation costs.

• WHAT ARE THE MACHINE'S DIMENSIONS?

1.57m (15 ft.) long, and 2.13m (7 ft.) wide. This is the same in transport or when fully operational. The weight is 3.5 tonnes.

Appendix E

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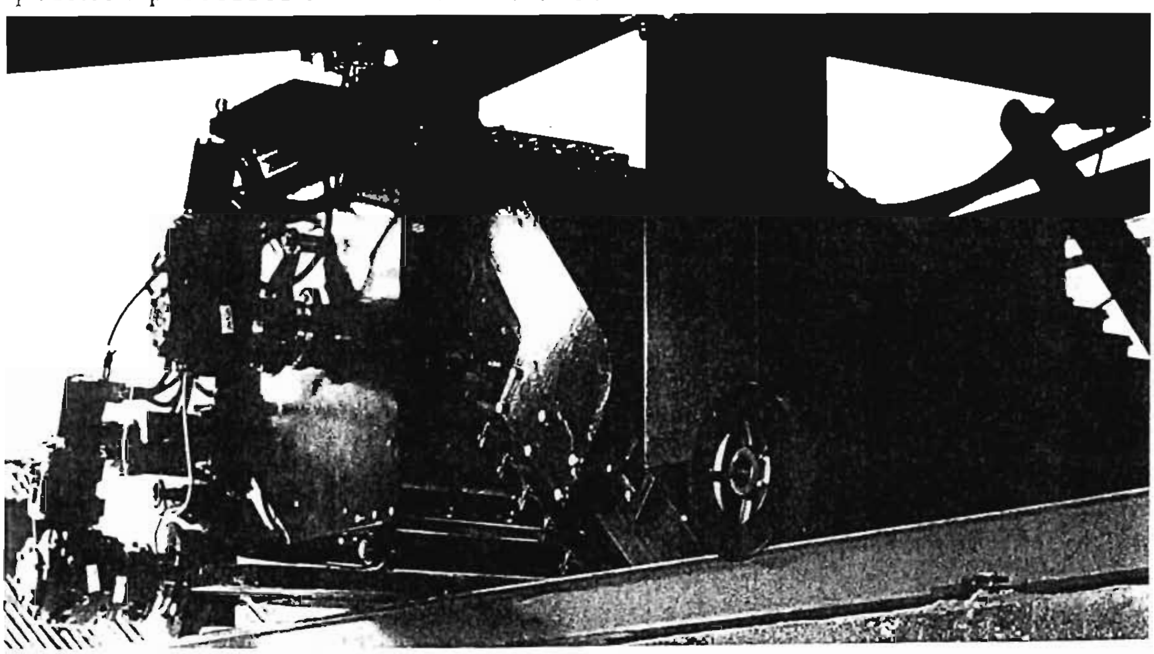
Composting made easy with the

THE PLUS GROW COMPOSTING SYSTEM

• WHAT IS IT AND HOW DOES IT WORK?

The Plus Grow Bay Composting system is a versatile in-vessel composting system designed to treat a wide range of organic wastes. The system comprises a robust diesel powered, hydraulically driven machine which moves along rails situated on the top of concrete bays. The machine incorporates a moving grid conveyor, which 'eats' into the waste, lifting it into a shredder/mixer, and then discharges the composting material from its rear, moving it progressively down the bay. This efficient aeration speeds up natural decomposition processes and minimises odour emissions.



• WHAT WASTE STREAMS CAN BE COMPOSTED IN A PLUS GROW?

The system will handle most compostable organic wastes, including domestic putrescibles, commercial and industrial food wastes, agricultural wastes, spent mushroom compost, sewage sludge, paper pulp/sludge, animal manures etc. Different waste streams may be blended to optimise the process. Should some daily feedstock variances occur at the input stage, the vigorous mechanical agitation of the turner/shredder will amalgamate the feedstock as it progresses down the bay.

• CAN DIFFERENT WASTE STREAMS BE TREATED IN INDIVIDUAL BAYS?

Yes. Each reinforced concrete bay is separate from the others and treatment can be tailored to suit different types of feedstocks (e.g. wetter putrescible waste streams may require more regular turning than green waste). Once the turning machine has completed a pass along the length of a bay, it is transferred onto the rails of the next bay requiring turning by means of a cross-bay transporter.

WHAT ARE THE ADVANTAGES OF THE PLUS GROW BAY COMPOSTER?

1. **Exceptionally low capital outlay for contained system**
2. **Low operating costs**
3. **Rapid primary composting time - approx. 1 month**
4. **Minimal space requirement**
5. **Flexibility of operation - each bay can be treated separately to suit feedstock variations**
6. **Hydraulic drives facilitate overload protection to prevent damage to machinery**
7. **Consistent high temperatures generated by homogeneous mix of materials and thorough agitation / aeration within well insulated, contained environment**
8. **Modular construction offers flexibility to extend capacity**

• IS PRE-TREATMENT OF WASTE NECESSARY?

This will depend largely on the nature of the material to be composted. Whilst green waste generally requires shredding prior to composting, some forms of municipal waste may require screening to separate non-compostable contaminants.

• WHAT IS THE THROUGHPUT OF THE SYSTEM AND HOW LONG DOES THE PROCESS TAKE?

The bays in which the machine operates are each 70 m long, 2.75 m wide and 2.5m deep. Fresh waste is delivered in at one end of a bay, and as it is processed, it is moved along by the turner by 5 m every second day. A complete pass down each bay takes approx. two hours, and this process is automated.

The normal turnaround cycle from waste to compost is thus 28 working days. Each bay will therefore accept and discharge 34.4m^3 (5m x 2.75m x 2.5m) every second day. If one assumes a density of input material of 0.6 tonnes per m^3, each bay will accept and discharge approx. 10 tonnes of waste per day.

As the system is modular, additional bays can be added if required, although a six bay system is considered optimum for a single turner (this arrangement could process circa 15,000 tonnes per annum).

• HOW MUCH DOES THE SYSTEM COST?

Typically, a six-bay system capable of handling circa 15,000 tonnes per annum will cost in the region of £420,000, including civils. The level of site preparation necessary and local facilities available (weighbridge etc.) will affect total project costs accordingly. Equally, certain planning conditions may affect the design and cost of the building.

- **WILL THE PROCESS SATISFY THE ENVIRONMENT AGENCY (EA)?**

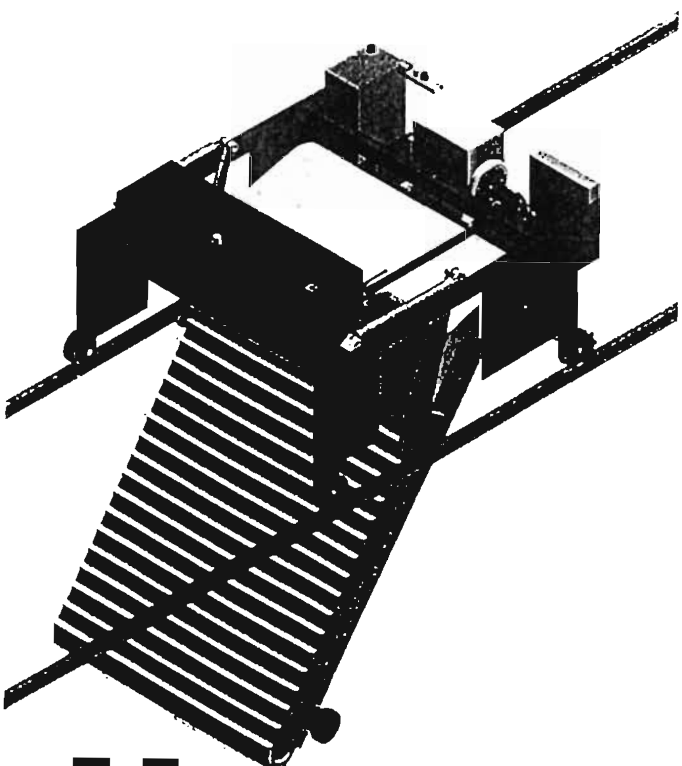
All the major potential pollutants to the environment, such as leachate and odour can be addressed with the Plus Grow system.

When EC standards become enforceable in the UK, it seems likely that most centralised licensed composting facilities dealing with food wastes or commercial / industrial organic wastes will be required to be contained, or take place in a 'controlled' environment.

Composting of most organic waste is normally relatively odour-free. Where difficult or malodorous wastes are to be treated, an odour control system may be necessary, particularly if the facility is situated within an urban environment. Odours can be reduced by mist sprays, or the building can be placed under negative pressure and process air exhausted through a biofilter.

Leachate is managed through containment and subsequent recirculation in each bay.

PLUS GROW BAY COMPOSTER



PLUS GROW ENVIRONMENTAL LIMITED

- **WILL FURTHER TREATMENT OR MATURATION BE REQUIRED AT THE END OF THE PROCESS?**

This would largely depend on the intended disposal route. If stabilising the waste for use as landfill cover or reinstatement purposes, maturation should not prove necessary. If, however, the product is to be used in agriculture or horticulture, curing for a further period in a maturation pile, would be advisable prior to screening to the required specification.

• **WHAT TYPE OF BUILDING AND SITE PREPARATION IS NECESSARY?**

The system would be housed in a purpose-built clear span construction, or could be placed into an existing building if suitable. Space requirements are minimal - for example a building for a 15,000 tonne p/a operation would occupy less than $2{,}000m^2$. The building would normally be required to be 80m long but details of the design can be tailored to site requirements.

• **HOW MANY OPERATORS ARE REQUIRED?**

A full-scale 6 bay plant could, in theory be operated by one person. Routine tasks would include loading of waste into bays at the front-end and removal of finished compost from their rear. Because the machine runs automatically in each individual bay, the only other routine operator requirement is cross-bay transporter transfer of the machine to new bays every two hours (this takes a few minutes). However, pre-treatment, such as shredding/mixing of input material, and post-compost screening operations will require additional labour.

• **WHAT MANUFACTURER SUPPORT IS AVAILABLE?**

Plus Grow Environmental Ltd. would be responsible for commissioning the system, operator training and technical support. If required, EcoSci can provide analytical services, advice over pre- and post-treatment equipment and general support with respect to technical aspects of composting and quality management.

• **WHAT ARE THE OPERATING COSTS?**

Direct operating costs (labour, fuel, repairs and maintenance) for the process are likely to be in the region of £6/tonne of input material.

• **IS THERE ANY LIMIT ON THE OPERATING CAPACITY?**

Being a modular system, it can be expanded as required, but for practical purposes, a single Plus Grow turner can operate a maximum of six bays (approx. 15,000 tonnes p/a). One can assume that increasing the plant capacity will entail a corresponding increase in capital costs with only marginal savings in operating costs through economies of scale.

APPENDIX F

POSSIBLE SITE FOR STANLEY COMPOSTING PLANT - PORT HARRIET

TYPICAL CAST OF DRIED KELP

'THE CULL' - GOOSE GREEN

SHEEP CARCASSES

AFTER A FEW DAYS

AFTER A FEW WEEKS

Appendix G.

Poultry carcase compost for application in the UK

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Composting of poultry carcases is viewed in the USA as economically viable and as an environmentally-friendly option for disposal (Donald and Blake, 1996). The aim of this study was to determine whether the technology could be used in the UK climate to produce a hygienic material for use as an organic fertiliser on arable land. Product testing was required because composts can often be detrimental to seed germination and early plant growth (Keeling *et al.*, 1994). This is particularly likely in composts with a high electrical conductivity.

Laying hen carcases (125) were composted in a wooden bin (1·5 × 1·5 × 1·5 m), using the United States Department of Agriculture method for composting poultry carcases (USDA, 1994). The procedure involved creation of sandwiched layers of carcases between layers of manure and straw. This ensured a satisfactory moisture content and C:N ratio during composting. The experiment was conducted in late autumn and early winter (1996), though the weather was unusually mild for the season and may not be considered representative of the British climate.

The phytotoxicity and fertiliser value of the compost was assessed in perennial ryegrass (*Lolium perenne*) and spring wheat (*Triticum aestivum* L. Cv Avans) in glasshouse trials. Experiments were carried out by mixing soils (either sandy or clay loam) with the compost at up to 300 t/ha (eq) in 20 × 14 × 5 cm trays. Seeds were sown at typical field rates, then treatments were replicated in a single randomised block. Fourteen hours of daylight and a minimum temperature of 5°C was maintained. Germination rates and dry weights of shoots were determined at various times after sowing.

The composting process was aerobic and took 8 weeks (over the months of October, November and December). It effectively decomposed the carcases to leave only leg and breast bones. During this period, ambient temperature ranged from − 1° to 17·5°C. The highest temperature attained at the centre of the container was 71°C, after 8 d of composting. At 15 cm from the exterior the highest temperature was 56°C after 3 d of composting. At the end of composting, the interior temperature had dropped to 45°C.

The temperatures attained were sufficient for the effective control of pathogens (60° to 71°C), even though the composter was exposed to low ambient temperatures. *Salmonella* was fully heat-inactivated (as evaluated by *in vitro* agar culture methods), indicating that many poultry-associated bacterial pathogens would also have been inactivated. A typical analysis of the compost was: Moisture content 28%; pH 8·3; Electrical conductivity ~ 2·2 mS; N total 2·32%, available 0·5%; total C 51·6%; K 1789 ppm; Cu 55 ppm; Zn 227 ppm. The electrical conductivity and total N content were therefore high compared with many other waste-derived composts, while Cu and Zn were at acceptable concentrations for soil application.

Glasshouse trials with *Lolium perenne* indicated that the compost released available nitrogen for good plant growth at an application rate of 50 t/ha. There was no difference in growth between treatments at 21 d but yields after 59 d in soils supplemented with poultry carcase compost were higher in both sandy loam and clay loam, (Table), though there was no interaction between soil type and compost content. The compost therefore acted as a slow-release N fertiliser in common with other relatively unstable composts (Keeling *et al.*, 1995). There was little evidence of phytotoxicity below 100 t/ha, as judged by germination trials in *Triticum aestivum*.

It is concluded that the USDA method of composting poultry carcases is applicable in the UK and the product may be used safely on grass and wheat at up to 50 t/ha (according to N requirement), though the seasonal contribution of the compost to nitrate leaching over all application rates needs to be evaluated.

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Table. *Yields (g per tray dry weight) of perennial ryegrass after 59 d in soils (sandy and clay loams) supplemented with poultry carcase compost. (SEM values: soil means = 0·131, application rate means = 0·160, treatment means = 0·226)*

	Compost application rate (t/ha)			
	0	10	50	Mean
Sandy loam	3·91	5·05	7·15	5·37
Clay loam	3·09	3·71	5·94	4·25
Mean	3·50	4·38	6·54	

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Appendix G.

COMPOSTING NON-AVIAN SPECIES

Fish, swine (Murphy, 1992f) and calf mortalities have all been satisfactorily disposed of in two-stage or mini poultry composting systems at the University of Maryland. When broiler litter is available, with straw and water, it appears almost any animal carcass of up to at least 300 lbs. may be treated in essentially the same manner as broiler or turkey mortality. Mini composters are useful systems for disposal of fish and fish offal from the Universities' tilapia aquaculture project, and have been successfully employed for the disposal of pig mortality and placentas from the Universities' research sows. Large animals (calves and market swine) are disposed of in a two-stage composter, as represented in Figure 5. Swine of up to 300 Lbs. are placed on their backs, on a layer of wet straw, and their thoracic and abdominal cavities are opened, their viscera opened, and their large muscle masses dissected. They are then covered with dry broiler litter, or a mixture of recycled compost and litter, and are reduced in two 5-10 day cycles of thermophilic composting. Temperatures, tissue reduction and odor control resemble poultry composting, and bones are the only residues which persist beyond the second stage of the process.

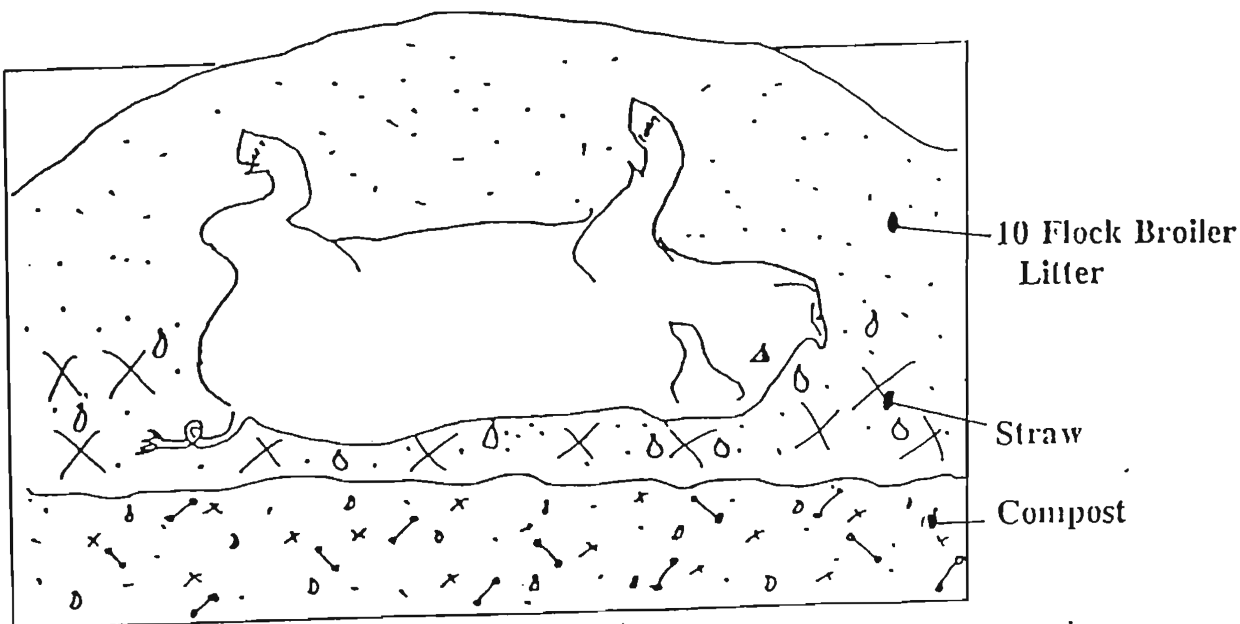

Figure 5. Schematic Cross-Section of a 2-Stage Composter Processing a Market Hog.

SUMARY

Thermophilic, aerobic composting is proving to be an effective, flexible and economical means of disposing of a variety of mortality problems. Applied research conducted at the University of Maryland within the past two years has demonstrated that windrowing is an effective method of dealing with catastrophic and even whole-population mortalities. Mini composting puts an effective and simple (small scale) composting system within the reach of virtually every poultry and swine producer. In-house composting is revolutionary, but continues to succeed in the research environment, and may have particular applications in industry. The general methods of composting poultry mortality translate effectively to other species including fish, swine and (small) cattle. Further research is needed to develop large-animal systems, to improve the efficiency of the general poultry composting system, and to develop a non-fecal waste, generic, composting system for application in non-agricultural situations.