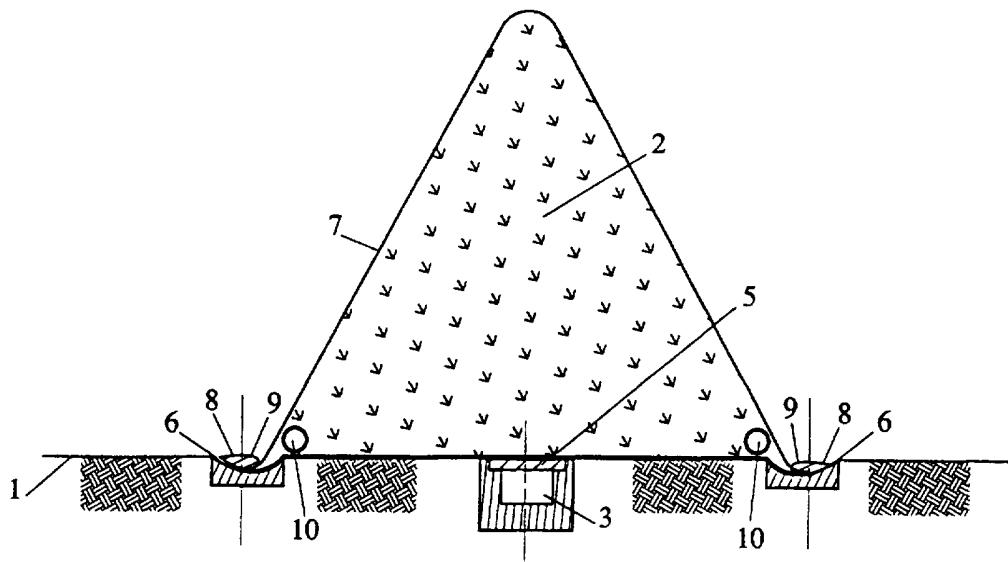




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>C05F 9/02, 9/04, 17/00, 17/02</b>		A1	(11) International Publication Number: <b>WO 97/19901</b> (43) International Publication Date: 5 June 1997 (05.06.97)
(21) International Application Number: PCT/AU96/00771		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).	
(22) International Filing Date: 29 November 1996 (29.11.96)			
(30) Priority Data: PN 6869 29 November 1995 (29.11.95) AU			
(71)(72) Applicant and Inventor: HOFSTEDE, Harrie [NL/AU]; 20 Caddy Avenue, West Leederville, W.A. 6007 (AU).			
(74) Agent: WATERMARK PATENT & TRADEMARK ATTORNEYS; 4th floor, "Durack Centre", 263 Adelaide Terrace, East Perth, W.A. 6000 (AU).		Published <i>With international search report.</i>	

## (54) Title: IMPROVED COMPOSTING SYSTEM



## (57) Abstract

Disclosed is a composting system comprising an area (1) for holding compostable material (2); a mass of compostable material (2) located in the area (1); and a weatherproof cover or structure (7), preferably conformable to and covering the mass of compostable material (2). The cover or structure (7) defines an environment in which composting occurs, an environmental condition being controlled to promote composting.

***FOR THE PURPOSES OF INFORMATION ONLY***

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

### IMPROVED COMPOSTING SYSTEM

This invention relates to composting systems for treatment of organic waste in a manner accepted to be environmentally sustainable.

Each day a large amount of solid municipal domestic waste is produced.

5 Of all solid municipal domestic waste produced in Australia approximately 50-55% consists of food and garden waste. Other components of the waste include paper (20%), plastics (6%), glass (10%), metals (5-7%) and other inorganics (10-15%). The organic fraction has a strong detrimental impact on the environment and may be hazardous.

10 Detriment results from the large volume of organic waste which may occupy 50-70% of landfill space. The waste is of a putrescible nature, thus making it a potential source of pathogenic organisms. A large volume of greenhouse gases, e.g. carbon dioxide and methane are released during uncontrolled decomposition. Finally, and significantly, decomposing organic

15 matter causes odour, attracts pests and is a major contributor to groundwater pollution through dissolution and its role as a carrier or inorganic pollutants such as heavy metals. In certain cases such pollution may make groundwater unsuitable for safe use.

Therefore, one of the main challenges in any integrated waste management strategy is the appropriate and effective treatment of organic waste. The current practice of landfilling organic waste is rapidly becoming an inappropriate waste treatment practice and will be unsustainable in the long term.

Landfilling consumes large areas of land, results in low land value and is 25 strongly objected to by residents. Consequently, landfilling is fast disappearing in major cities as a sole waste disposal strategy. In cities with low housing densities, transport costs may become prohibitive as suitable landfill space becomes available only well away from waste generation centres.

Organic waste nevertheless has considerable potential as a resource 30 when stabilised through composting. It is high in organic matter and contains nutrients such as nitrogen (2%), phosphorus (0.5-0.7%), potassium (0.7-1.7%) and trace elements.

Composting is the process whereby organic matter is decomposed by a range of microorganisms using oxygen. The process is appropriate for treatment of a combination of fibrous waste (e.g. green organics) and putrescible waste such as food waste, sewage sludge and industrial and 5 commercial organic residues. Composting has the advantage of reducing the waste volume by 30-40%. In addition, product compost has significant benefits as a soil conditioner.

A typical composting process may comprise four stages. Each stage is characterised by the activity of different generations of bacteria, fungi, protozoa 10 and actinomycetes. During each stage the microbes use original organic compounds present in the waste as well as by-products of the metabolism of the previous generation as a nutrient and energy source. Thus the organic matter decomposes until a stable humus is formed.

The incubation or mesophilic phase lasts for approximately 24 hours 15 during which the organic matter is rapidly invaded by mesophilic composting organisms including bacteria, actinomycetes and fungi. These organisms thrive at a temperature of 25°-45°C. The mesophilic organisms grow in this phase on the more easily assimilated substances present in the organic waste, for example: sugars, soluble protein, starch and organic acids.

20 The high metabolic activity of the organisms and the exothermic decomposition processes that result, in combination with the insulating properties of the composting material, causes the temperature to rise. The temperature rise strongly favours thermophilic sporogenous bacteria. The activity of these bacteria takes the process into the thermophilic phase.

25 During the thermophilic phase, organic matter is decomposed rapidly. Temperatures may reach 70°C in the core of the composting material. This is undesirable, since at this temperature most process participating microbes, including some thermophilics, are killed. This may considerably reduce the decomposition rate of organic material. About 45°-50°C is optimum and above 30 55°C is typically required for pathogen destruction, thus 55°C is accepted as an optimum temperature compromising between these factors, at which the decomposition rate is highest. These temperatures assist in accelerating the

process and sanitising the material from pathogens, weed seeds and plant disease causing agents. This temperature, and below, allows the development of eumycetes and actinomycetes which are the main decomposers of long chain polymers, cellulose and lignin. The oxygen demand is very high in this phase 5 and aeration is required. This phase may last for 2-3 weeks depending on aeration and substrate.

The cooling phase commences when there is insufficient exothermic organic substrate left to maintain the high temperature. Accordingly, water evaporation and heat convection cause temperature to drop. If the temperature 10 drops below 45°C mesophilic bacteria and other organisms may reinvade the fresh compost. This phase may last a few days.

A maturation or stabilisation phase is required to allow the toxicity of fresh compost to fall to enable effective utilisation by plants. The activity of fungi, protozoa and actinomycetes may be highest during this phase, while bacterial 15 activity slowly falls. At this stage, large polymers such as lignin and cellulose are decomposed and a humidification process sets in. The activity of actinomycetes produces the compound "geosmine" which gives matured compost a fresh earthy smell. Three to four weeks may be sufficient to enable completion of this phase.

20 It is the objective of the present invention to provide a composting system that may enable the respective phases of the composting process to be completed in an efficient manner, under conditions that enable the most advantageous conditions for aerobic microbial decomposition of an organic substrate to occur.

25 With this objective in view, the present invention provides a composting system comprising an area for holding compostable material; a mass of compostable material located in the area; the area and a weatherproof cover or structure for the area defining an environment in which composting occurs, and an environmental condition which is controlled to optimise the composting 30 process.

In particular, the weatherproof cover is preferably to be secured or appropriately sealed to prevent ingress of water or other environmental,

especially climatic, impacts detrimental to efficient composting such as excessive drying out. Entry of pests and vermin is also prevented. A flexible or modular construction for the cover is preferred, particularly a cover which is readily conformable to the volume of material to be composted. The volume of 5 the environment is dictated primarily by the volume of compostable material to be treated.

In this respect, the invention is predicated on the discovery that the composting process is dependent upon a number of variables, the control of which ensures a more efficient composting process. Further, the cover prevents 10 escape of odour, water ingress and generation of leachate. Leachate generation is a particular problem in open air composting systems such as windrow composting and static pile forced aeration composting which are strongly dependent on weather conditions. Where rainfall is high, water may drain through compost windrows, leaching nutrients and soluble organic matter 15 from the compost. The generated leachate may usually require treatment before discharge to surface or ground water and compost quality is reduced.

For a first example, the control of aeration may be important to conducting the composting process. Aeration provides the oxygen necessary to sustain the aerobic organisms that promote composting. In a static pile, oxygen levels can 20 drop to below 1% by volume and carbon dioxide levels can reach 20% by volume. Such levels may be inhibitive to composting.

Therefore, aeration means to aerate the mass of compostable material are to be included within the composting system. The aeration means may provide a variable controllable proportion of recycled process air and fresh air 25 assisting in maintenance of the compostable mass moisture at desired levels importantly preventing drying out of compost, and may provide oxygen levels within the mass of 10-18% by volume.

Control over the level of carbon dioxide in the mass of compostable material may also be desirable. In this respect, air flow may be controlled such 30 that carbon dioxide levels are maintained below 10% by volume.

In this respect, the O<sub>2</sub> and CO<sub>2</sub> levels are interlinked and add up to  $\pm$  21%. Thus if oxygen is 15%, carbon dioxide is 6%.

Accordingly, the composting system may advantageously include means for maintaining an appropriate moisture level. In this respect, recirculation of spent process air or oxygen through the mass of compostable material may be conducted to cause a flow of moist air which maintains moisture in the mass at 5 desired levels and a carbon dioxide level of approximately 15% by volume. Recirculation of air or aeration by other means may also assist in achievement of a homogeneous moisture level throughout the mass avoiding stratification or formation of dry spots which adversely affect composting. Fresh air may then be introduced by blower or other air compressing means to maintain a ratio of 10 recycled air to fresh air, sufficient to maintain the desired oxygen carbon dioxide level. Alternatively, fresh air or oxygen may be introduced at any time to maintain a desired recycle air to fresh air ratio and/or carbon dioxide concentration.

This ratio may be maintained at the desired level in dependence upon 15 monitored oxygen or carbon dioxide level but may also be controlled as a function of other composting process variables, such as the temperature of the core of the mass of compostable material. Suitable sensors may be provided for these purposes and the composting system may be under the control of a microprocessor or like device.

20 Where warm, moist air contained within the cover is mixed with fresh air and recirculated through a blower or like means, the temperature and moisture level of the air entering the core of the compost windrow increases preventing drying out and/or premature cooling.

The weatherproof cover may be sealed at its edge by a low cost sealing 25 means such as sandbags, soil, a water jacket, beams rods or other means. It is important that the sealing be achieved in a manner that enables effective control over the microenvironment within the weatherproof cover. Space may be at a premium. In this respect, the system is ideally designed to exclude climatic influences over the composting process, chiefly drying influences and excess 30 rainfall which may base excess moisture and leachate generation or prolonged hot and dry conditions which may dry the compost to a point where microbiological activity ceases. The system is also advantageously flexible to

suit variation in the mass of material to be treated and sealing means may be selected with this in view.

A clear manifestation of climatic influence is rainfall. Rainfall may markedly interfere with a composting process because the level of moisture in 5 the mass of compostable material is an important process parameter. While the composting microbes may require a minimum moisture content of about 40% to avoid reduced activity, levels of moisture above about 60% may lead to the occurrence of anaerobic conditions which change the process from a composting process to a fermentation (or rotting) process. This will occur when 10 the pores in the substrate fill with water to an extent that effective aeration is impaired. Further, excess water may be a cause of leachate generation, undesirable for environmental reasons, for example, base metal pollution and uncontrolled nutrient loss to the environment. Hence, the weatherproof cover is ideally to be a material that prevents ingress of water to the composting system 15 due to rainfall and which prevents excess moisture loss due to drying, especially of the edges, during hot weather. Ideally, the material should facilitate collection of moist spent air and dry fresh air.

In addition, temperature may be important. Composting involves a thermophilic stage and drop in ambient temperature may effect this. Thus the 20 material may be of a kind that prevents ingress of ambient air to the mass of compostable material and escape of odour. If necessary, provision for addition of make up fresh air may be made to minimise the effects of ambient temperature.

Typically, the system through controlled aeration and exclusion of water 25 enables compost to be held at a sufficient temperature, defined by some standards as 55°C or higher, for a sufficient period, a few, typically three, days to kill pathogenic organisms present in the material or biosolids.

Pathogens, both plant and human, are inherent to most types of organic wastes. In order to minimise risks to public health and flora, i.e. crops, such 30 materials must typically be processed such that substantially complete pathogen destruction is achieved.

The provision of air circulation through the compostable material may

assist in avoiding a situation where low temperature zones are formed at the base of a pile or a periphery of a windrow where excessive heat loss to the atmosphere and lack of insulation may prohibit temperatures reaching thermophilic levels. Drying out may also occur at this periphery in open 5 windows.

Product compost which may typically have less than ten (10) total coliforms per gram compost in comparison with ARMCANZ guidelines (see Agriculture and Resource Management Council of Australia and New Zealand Water Technology Committee, Guidelines for Sewage Systems - Biosolids 10 Management Occasional Paper WTC No 1/95 October, 1995) which specify that Class A compost may contain a maximum pathogen concentration of 100 thermotolerant coliforms per gram compost.

Typically, the compostable material may be turned once during the process (duration usually approximately 8 weeks) although turning may be 15 conducted more frequently. However, frequent turning is undesirable as labour and equipment costs may be increased and it is not an aspect of a preferred embodiment of the present invention.

In a further aspect, the present invention provides a composting method comprising delivering a mass of compostable material to an area for holding 20 compostable material;

The area having a weather proof cover or structure for the area defining an environment in which composting occurs, an environmental condition of which is controlled to promote the composting process.

The composting system and method of the present invention may provide 25 a number of advantages. Firstly, the system allows control over odour, the "balloon" formed by the preferably flexible weather proof cover around the mass of the compostable material including biosolids preventing odour emission. Recycled air may be deodorised by the compost mass acting as a biofilter and excess air which requires venting may be led through a biofilter for substantially 30 complete odour removal. Leachates are not generated in any significant amounts and may be contained and not released to the surrounding environment, at least in an untreated state. In addition, the "balloon" creates a

homogeneous microenvironment which is controllable to the benefit of efficient composting. The control achieved over moisture level and pathogens may allow, for example, a more rapid composting rate. In addition, the system offers a benefit of low cost with the various components available in most locations at 5 low cost. Low cost also offers the advantage of plant mobility with low capital risk when the system is moved from place to place.

The invention may be more fully understood from the following description of a non-limiting embodiment thereof made with reference to the accompanying drawings in which:

10 Figure 1 is a transverse section through a composting system in accordance with one embodiment of the invention;

Figure 2 is a plan view of the composting system in accordance with the embodiment of Figure 1;

15 Figure 3 is a temperature profile of a region of the system constructed in one embodiment of the present invention; and

Figure 4 shows a transverse section of a second preferred embodiment of the composting system of the present invention.

Referring now to Figure 1, there is shown a transverse section of the composting system which comprises an area or base 1 on which is piled a mass 20 of compostable material 2. The compostable material comprises organic waste, for example from domestic sources, biosolids, though other sources of waste, such as abattoirs, may be available. It may be necessary to separate the organic waste or green waste from a mixed solid waste containing paper, glass, metals, plastics and other refuse by appropriate steps, for example a system of 25 mechanical sorters, air classifiers, magnetic conveyor belts and the like. The material may require particle size reduction by means of shredding or other forms of comminution, for example in mills (usually hammer mills) to obtain optimum particle size from the point of view of porosity structure and specific surface area.

30 Heavy metal analysis for acceptability may also be conducted prior to treatment commencement. If desired, an adsorbent for heavy metals, such as bauxite processing residue, may be added in accordance with the method of

applicant's Australian Patent No. 661703, the contents of which are hereby incorporated by reference. Non-organic waste may account for 10-20% of the total mass of waste. Any putrescible waste may be delivered to area 1, if desired, as an amendment to the organic green waste. Moisture content of the 5 compostable material 2 may be controlled to prevent drainage of excess liquid from the material. Any excess process water may condense against the inside of cover 7 and drain sideways for collection by discharge trench 3 or like means. This effectively distilled water may be collected in a ground collection tank or similar means preferably to be used to humidify any influent air to the process.

10 The area 1 comprises a solid base, made for example, from concrete, brick, compacted limestone or other possibly impermeable material which provides an all weather working surface for the mass of compostable material 2 and ideally appropriate insulation to the climatic environment. However, as leachate is not generated in significant quantities it is not essential that the base 15 be water impermeable. The base may be modular and portable and may also advantageously insulate the mass 2 from surrounding ground advantageously avoiding of low temperature regions at the bottom of the mass. Such low temperature regions do not compost as desired and pathogen levels may remain high. Indeed, temperature is relatively homogeneous allowing 20 composting and entry to thermophilic phase by a substantial portion of the mass, resulting in general pathogen destruction. The base, together with the cover 7 define the composting environment, the environment has a volume sufficient to enable efficient composting of the mass of compostable material and, typically, the cover 7 will be in close proximity to the mass of compostable material. It is 25 not desirable that the non-composting volume be at all significant as this may detrimentally affect composting process control.

At the bottom of the mass 2 is an air inlet or aeration trench 3 which forms one portion of the means to aerate the mass 2. Air is circulated through the trench 3 by means of a blower 4, shown in plan view in Figure 2. The trench 3 is 30 of approximately rectangular section though the ditch is not required to be restricted to rectangular geometry. The geometry could readily be semi-circular, ovoid or any other convenient geometry. Similarly, the trench 3 might be

replaced with another kind of aeration means, located anywhere beneath the surface of the mass, for example the aeration means could take the form of a ditch or perforated tubing. A number of ditches, tubes or trenches could be employed, above or below ground surface level.

5 At the top of the ditch 3 is a grid 5, optionally made from a metallic mesh. The mesh is ideally constructed of a corrosion resistant material, such as stainless steel, to resist the corrosive influence of moist air from the mass 2.

10 The grid 5 serves two purposes. Firstly, the grid 5 prevents subsidence of compostable material into the ditch 3 which would reduce the effectiveness of aeration by blocking the air supply to the compostable material. Further, the apertures of the grid 5 tend to distribute the flow of air so as to better aerate the compostable material. Trench 3 or alternative means of similar function may also serve as a collection device for condensed water allowing recovery, preferably for use in humidifying influent air to the process.

15 At the edge of the area 1 is a gutter 6 that defines the perimeter of the area for holding compostable material. As well as receiving rainwater and allowing diversion of water away from the composting system, the gutter 6 provides a convenient location for sealing of the weatherproof cover 7 that surrounds the mass of compostable material 2. Rainfall may run off cover 7 and 20 may be directed to flow into the gutter 6 which may be permitted to run into a usual stormwater discharge system.

25 As observed from Figure 1, the mass of compostable material 2 forms a longitudinal approximately triangular pile to which the cover 7, being of a flexible low cost material, is conformed to create a microenvironment within the cover 7 in which composting can take place.

The cover 7 is conveniently of a low cost weatherproof material, such as high density polyethylene (HDPE) or PVC, woven or in the form of a film, though other polymers may also be suitable, that is waterproof and durable to prevent entry by vermin and insects, ingress of water due to rainfall which may cause a 30 leachate flow to ground 11 surrounding area 1. The cover 7 also excludes undesirable materials and chemicals such as weed seeds and pesticides from contaminating the compost. It is also advantageously robust to other climatic

influences such as windy and dry conditions which may cause drying out of the mass and a fall in composting rate to unacceptably low levels. Ideally, the cover 7 may be of air tight material to prevent ingress of air and prevent escape of odour and moisture caused by formation of volatile organic compounds and 5 ammonia during the composting process. The cover 7 may be made of area sufficient to adapt to varying mass and volume of compostable material and appropriate folding in the region of edge 8 to achieve the desired area may be undertaken for this purpose. Flexibility or modular construction to allow for varying volumes of compostable material may enhance this advantage. The 10 cover 7 itself could be provided with sealing means, for example, water pockets, as described below.

The edge 8 of the cover is sealed against ingress of water and escape of odour by a water jacket 9 above the edge 8 of the cover preferably forming an air-tight seal for the latter purpose. The volume of water imposes sufficient force 15 to maintain a seal, though other means for achieving a seal may of course be adopted. For example, sufficiently heavy objects such as beams, rods, sandbags or soil may be laid in the gutter 6 to achieve the same end. Alternatively, sealing may be achieved by straps extending over the cover 7 and surface area to enable securement and sealing. Simple sealing means 20 facilitate the conformance of the composting environment to varying volumes of compostable material contributing to system flexibility.

The aeration means is completed by the air recycle pipe 10 which takes spent process air away from the mass of compostable material 2 under the influence of blower 4 by suction. The pipe 10 may be simply perforated or 25 agricultural tubing which collects process air and recycles it to the blower 4 which, in a preferred embodiment as shown in Figure 1, has a substantial portion thereof provided along the bottom edge(s), one being shown in plan view in Figure 2, of the mass of compostable material, and which takes circulated air away from the mass of compostable material 2 under the influence 30 of blower 4. Alternatively, as shown in Figure 4, a substantial portion of the recycle pipe 10 may be provided at the top of the system, the flexible pipe being fixed by a portion of the cover 7 bridging section 7a and 7b thereof by suitable

fastening means.

Turning now to the plan view of the composting system shown in Figure 2 it may be seen that air inlet trench 3 extends longitudinally along the base of the mass of compostable material 2 preferably substantially the whole length 5 thereof.

The air passing through the air recycle pipe 10 is returned to the blower 4 and, upstream thereof may be located a moisture, oxygen or carbon dioxide concentration sensor 11 which monitors the concentration of one or other of the gases. In accordance with the monitored gas concentration, a valve or other 10 means, as understood in the art of blowers, may be set either manually or automatically to proportion fresh air, by means of blower 4, into the air inlet ditch 3 to achieve the desired levels of moisture, oxygen and carbon dioxide through, control via the blower and proportioning means, an appropriate ratio of recycled air to fresh air. If a valve is used, the valve may be of solenoid or other suitable 15 type as may be understood by those involved in engineering of pneumatic systems. The recycle/fresh air mixture passes through pipe 13 to air inlet ditch 3. pipe 13 may be of any convenient plastic material, e.g. PVC. Fresh air addition assists in maintaining preferred composting conditions. Any air discharged to maintain the balance of fresh to recycled air may be treated, for 20 example, by a suitable biofilter to remove odour forming compounds.

The rate of aeration of the mass of compostable material of the mass of compostable material 2 may also be controlled in accordance with the temperature sensed by temperature sensors located at desired locations within the system. The most advantageous locations for temperature sensors are at 25 the air inlet, the core and in the surface regions of the mass of compostable material 2. Temperature at these locations generally reflects the efficiency of the composting process.

Spent process air recycling may serve an important role in reducing odour as the odour causing compounds may typically be adsorbed by the 30 compostable material which may act as a biofilter after recycling.

The system may include a covered raw material storage area for material awaiting pretreatment and conditioning prior to being placed in the system and

air from this area may be extracted from this area by blower 4 for use in aeration of the windrow or otherwise treated for odour removal. Thus the potentially odorous air from the raw material storage area may be vented to the system accordingly, further assisting in odour emission control.

5 The system may be conveniently placed under manual or automatic control, for example, of an electronic control unit. A computer control system is desirable for this purpose. In accordance with measured variables, such as temperature, O<sub>2</sub> concentration, CO<sub>2</sub> concentration, moisture level, the blower 4 may be operated at a desired recycle air: fresh air ratio to maintain composting 10 conditions at an optimal level from the point of view of microbiological activity, and composting may proceed with little intervention from personnel.

Composting should continue for sufficient duration to diminish the levels of phytotoxic compounds caused by intermediate metabolites and high ammonia levels in immature compost. Ideally composting should proceed at 15 least three weeks and preferably eight weeks per tonne of waste.

The contained nature of the system allows stable composting under controlled conditions. The final product is more acceptable from the standpoint of both environmental and commercial considerations and may be implemented at relatively low cost with reduced processing time.

20 The present invention may be particularly advantageous where medium to large quantities of waste need to be processed in environments where odour emissions and leachates are of concern. Therefore, residential areas, such as cities, may be areas of typical application.

There will now be described the performance of a development system 25 operated in accordance with the system and method of the present invention as described above with particular reference to the preferred embodiment. In this example, the effectiveness of the system in processing a mixture of green waste and biosolids, in particular sewage sludge (anaerobically digested primary sludge, not typically treated in composting), was evaluated.

30 **Process Heat Distribution.**

The ARMCANZ guidelines (see Agriculture and Resource Management Council of Australia and New Zealand Water Technology Committee,

Guidelines for Sewage Systems - Biosolids Management Occasional Paper WTC No 1/95 October, 1995) require composting to be carried out at thermophilic temperatures ( $> 55^{\circ}\text{C}$ ) for at least three continuous days to produce grade 1A compost. The ARMCANZ grade 1A composting requirements were

5 met throughout the windrow using the method and system of the invention, including at the windrow surface. Reference is made to a Figure 3 which shows a temperature profile at the windrow surface and various depths within the pile. It has been found in previous practice that in open windrow composting systems the surface temperatures are too low (near ambient, at 15-30°C) to meet these

10 guidelines. It is thought, without wishing to be bound by any theory, that the preferably flexible cover of the system insulates the windrow from climatic conditions thereby preventing heat loss. Materials for the cover may be selected with this in view. Such a cover may also trap solar radiation which may assist in heating the windrow surface. It has been found that windrow surface

15 temperatures may reach up to 70°C during composting and this a special advantage of the present system. An air layer containing trapped air will typically be present and acids in insulation of the compost mass.

The thermophilic stage may be extended by including "thermophilic" amendments such as sawdust or wastewater skimmings to the compost.

20 Without wishing to be bound by any theory, skimmings, chaff or materials providing more energy per mole of carbon than sawdust may be preferred as an amendment though sawdust may be used. The lipid content of skimmings is a factor in providing a higher energy output.

It will be noted that in forced aeration composting systems known to the

25 prior art, the windrow core is often subjected to excessive evaporative cooling such that the above guidelines may not be met. In the present system, this problem may be alleviated by regulating aeration with a computer controlled system to satisfy the composting aeration requirements without excessive cooling. Further, recycling of moist and warm windrow exhaust air back into the

30 system may further reduce evaporative cooling.

#### Pathogen Levels.

It was found that pathogen levels in compost made by biosolids/green

waste using the present system complied with the above guidelines for compost of the highest standard, grade 1A compost. MPN <2 is only limited by the detection limit of the methodology. Therefore product compost from the system 5 was found to be suitable for unrestricted distribution. In an open windrow system, pathogen reinfestation of sanitised material from inside the windrow may occur at or after turning by mixing of the sanitised material with the pathogen infested surface material or and/or bringing the sanitised material from inside the windrow to the surface thus exposing the material to vectors like 10 insects and vermin.

**Table 1.**

**Pathogen Levels in the Final Biosolids Compost (82 days old)**  
**Compared to Grade 1A Biosolids.**

<b>Pathogen</b>	<b>Grade 1A</b>	<b>Grade 1B</b>	<b>Pathogens in ADPS compost (MPN)</b>			
	<b>Sample location</b>					
	1	2	3	4		
Salmonella (per 50g)	<1	<10	<2	<2	<2	<2
Thermotolerant coliforms (per g)	<100	<1000	43	23	9	<3

15 NB 1 = surface; 2 = surface; 3 = 1 m below surface; 4 = 15 cm below surface

It may be seen from Table 1 the product compost complies with ARMCANZ guidelines for grade 1A compost.

**Leachate Generation.**

The system of the invention is designed to prevent generation of leachate 20 during processing or composting. This is one of the benefits of the system. The ground directly beneath the windrow was tested for leachate. Ammonia nitrogen (found in higher concentrations in the windrow material) was used as a tracer to indicate leaching. The (compost) concentration of ammonia nitrogen in

1/5 (w/v) water extracts of the windrow material was 28 ppm compared to the soil ambient level of between 1 and 2 ppm. The ammonia nitrogen levels of the soil 15 cm below the ground surface under the windrow were at ambient levels, 5 i.e. at 1 to 2 ppm. Therefore it was found in the experiment that the transfer of ammonia nitrogen (hence leachate) from the windrow material into the ground did not occur and this lack of leachate percolation was advantageous.

**Odour.**

This was assessed qualitatively and only a slight smell could be detected 10 by persons located at the composting site, the smell being described as a "sweet" compost smell. None described the odour as unpleasant, as with pure untreated biosolids. The flexible plastic cover may provide a seal against emission odours which would otherwise have been much higher and this may be advantage of the system.

15 **General Compost Quality.**

This is most important to the marketability of compost especially as a soil amendment. Product complied with Standards Australia Draft Standard DR 95301. Quality parameters of produced compost in the experiment are shown in Table 2.

**Table 2.**

**General Composting Parameters of the Biosolids/Green Waste Mixture.**

Parameter	Initial Material	Final Product (8 weeks)
Total organic carbon, %	31.1	28.7
Total organic nitrogen, %	1.67	1.95
Carbon to nitrogen ratio	18.6	14.7
Total phosphorus	0.61	0.72
Buffer capacity, % CaCO <sub>3</sub>	16.7	21.1
Ash, %	40.1	50.7
Salinity (Elec conductivity in mS)	2.37	2.46
pH	7.6	6.7

Typically composting increases quality of material by concentrating nitrogen and phosphorus. The C/N ratio typically suitable for land application after composting. Composting typically increases ash content as it is expected to remove the readily putrescible organic matter which may encourage 5 pathogen regrowth. It was found that the electrical conductivity (salinity) and pH of compost were ideal for land application.

It will be understood that modifications to the above described composting system may be made without departing from the scope of the present invention.

10 In particular, the system need not be controlled identically with the description above. Furthermore, the system may comprise an area with other than approximately rectangular geometry.

The air could be treated for odour removal, for example by treatment with an adsorbent prior to recirculation if adsorbent capacity of the compostable 15 material is insufficient.

Further, a full scale plant might comprise a number of, preferably parallel covered windows with air recirculation possibly being under the control of an integrated control system.

## THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A composting system comprising an area for holding compostable material;
  - a mass of compostable material located in the area;
  - the area and a weatherproof cover or structure for said area defining an environment in which composting occurs, an environmental condition being controlled to optimise the composting process.
2. The system as in claim 1 wherein said cover is conformable to and covers the mass of compostable material.
3. The system of claim 1 or 2 wherein said cover has an edge defining the perimeter of the area in which the compostable material is located, the edge being sealed to prevent ingress of water.
4. The system of any one of the preceding claims wherein aerating means to aerate the mass of compostable material are included.
5. The system of claim 4 wherein said aeration means provides a flow of moist process air through said environment.
6. The system of claim 4 or 5 wherein fresh air is added to the flow of moist processed air delivered by the aeration means.
7. The system of any one of the preceding claims including carbon dioxide control means.
8. The system of any one of the preceding claims wherein said compostable material has moisture in a controlled range.

9. The system of any one of the preceding claims wherein air is discharged through the system following treatment for odour removal.
10. The system of any one of the preceding claims wherein process water generated within the environment is employed in control of moisture levels in air delivered by said aeration means.
11. The system of any one of the preceding claims wherein control over environment conditions is effected by a manual or electronic control unit.
12. The system of any one of the preceding claims wherein the environment is substantially filled with compostable material leaving an insulating layer of air between the material and the cover.
13. The system of any one of the preceding claims including a covered raw material storage area vented for supplying air for aeration of said mass of compostable material.
14. The system of any one of the claims 5 to 13 wherein spent process air is recovered by a recycle pipe and returned to the blower.
15. The system of claim 14 wherein a substantial portion of said recycle pipe is located above said compostable material at the top of said cover.
16. The system of claim 14 or 15 wherein a substantial portion of said recycle pipe is provided along bottom edge(s) of said mass of compostable material.
17. A method of operating the system as claimed in any one of claims 1 to 16 comprising delivering a mass of compostable material to an area for holding compostable material, the area and a weatherproof cover or structure for said area defining an environment in which composting occurs, an environmental condition of which is controlled to promote the composting process.

18. The method of claim 17 wherein an absorbent, such as bauxite process residue, is added as an amendment to said mass of compostable material.

1/4

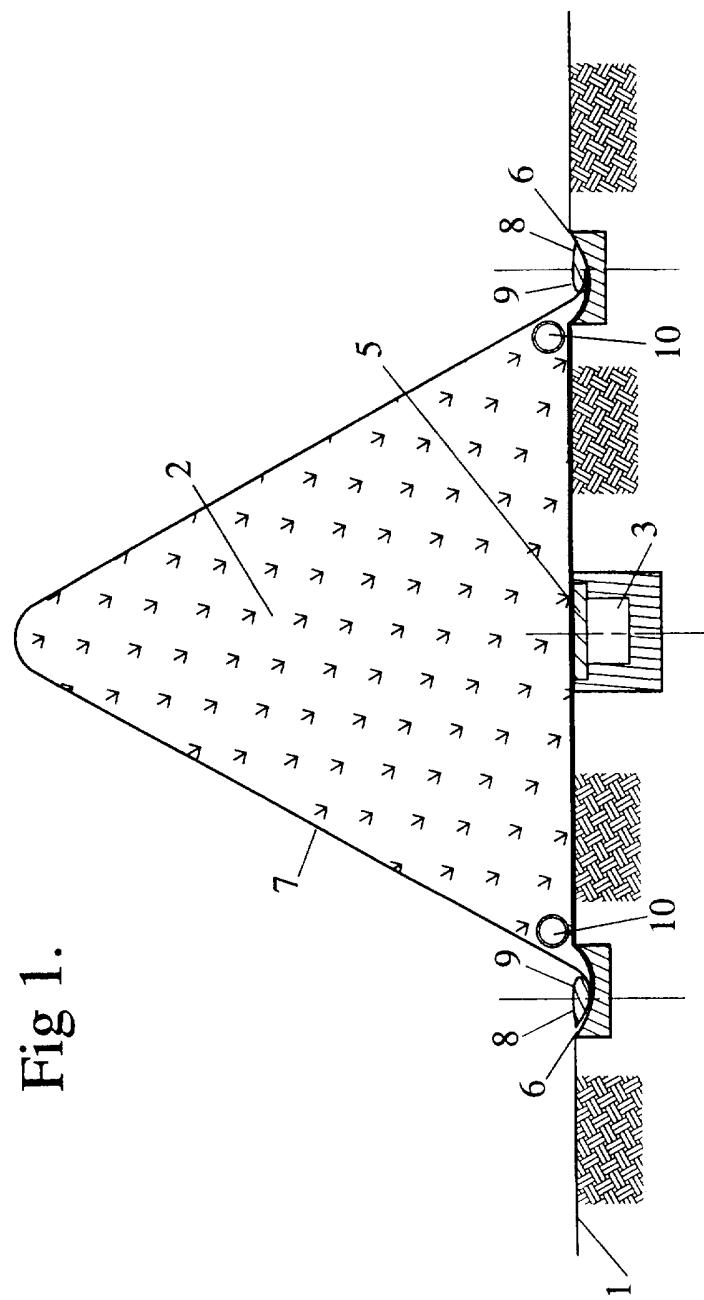
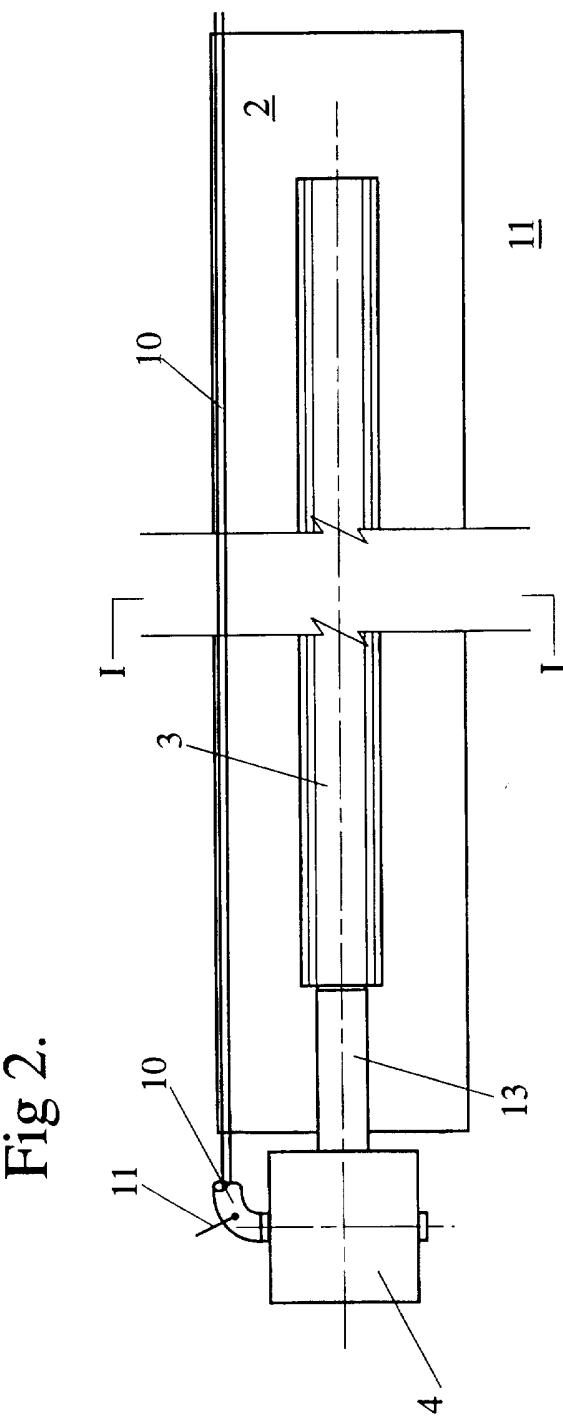


Fig 1.

2/4



3/4

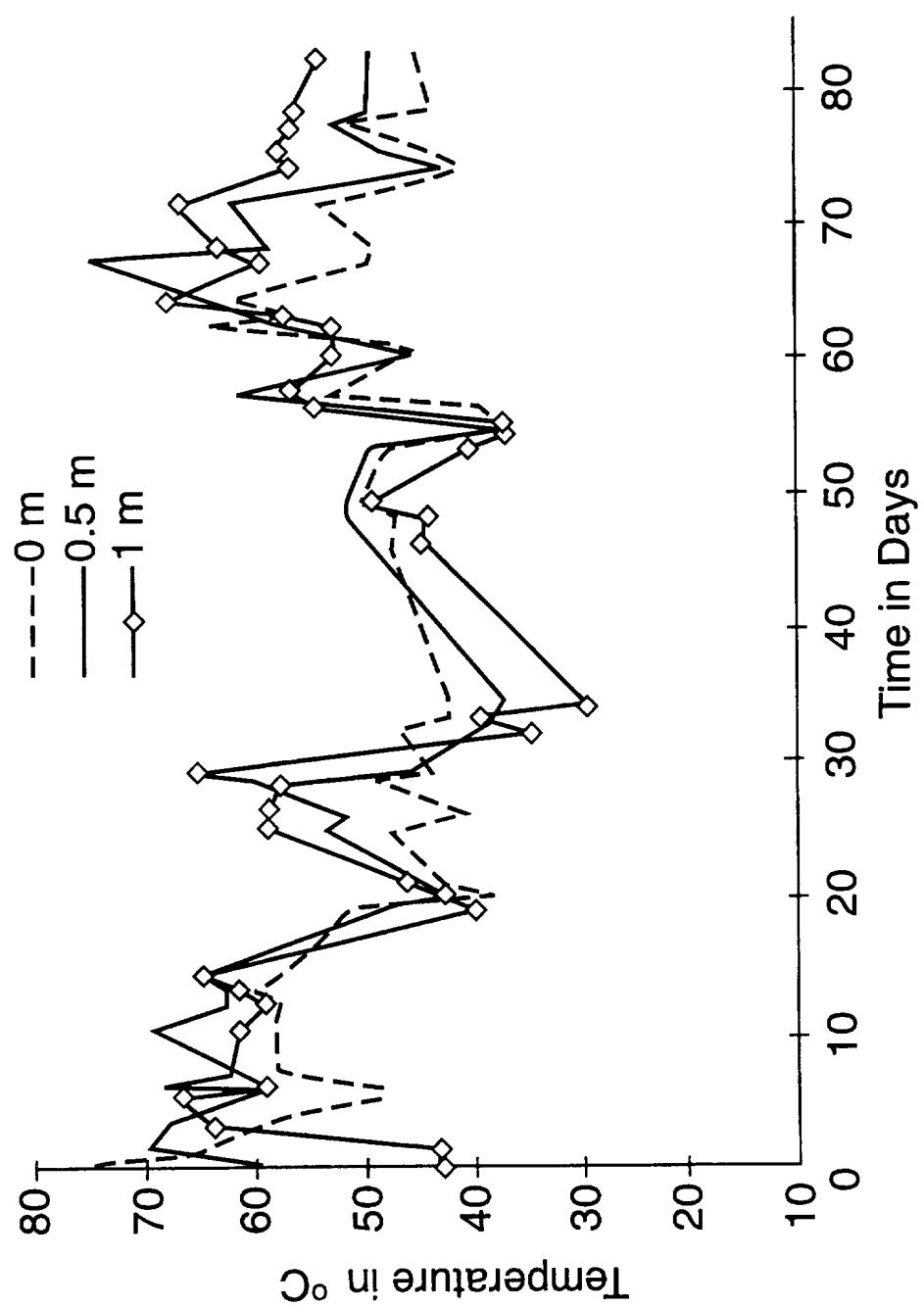


Fig 3.

4/4

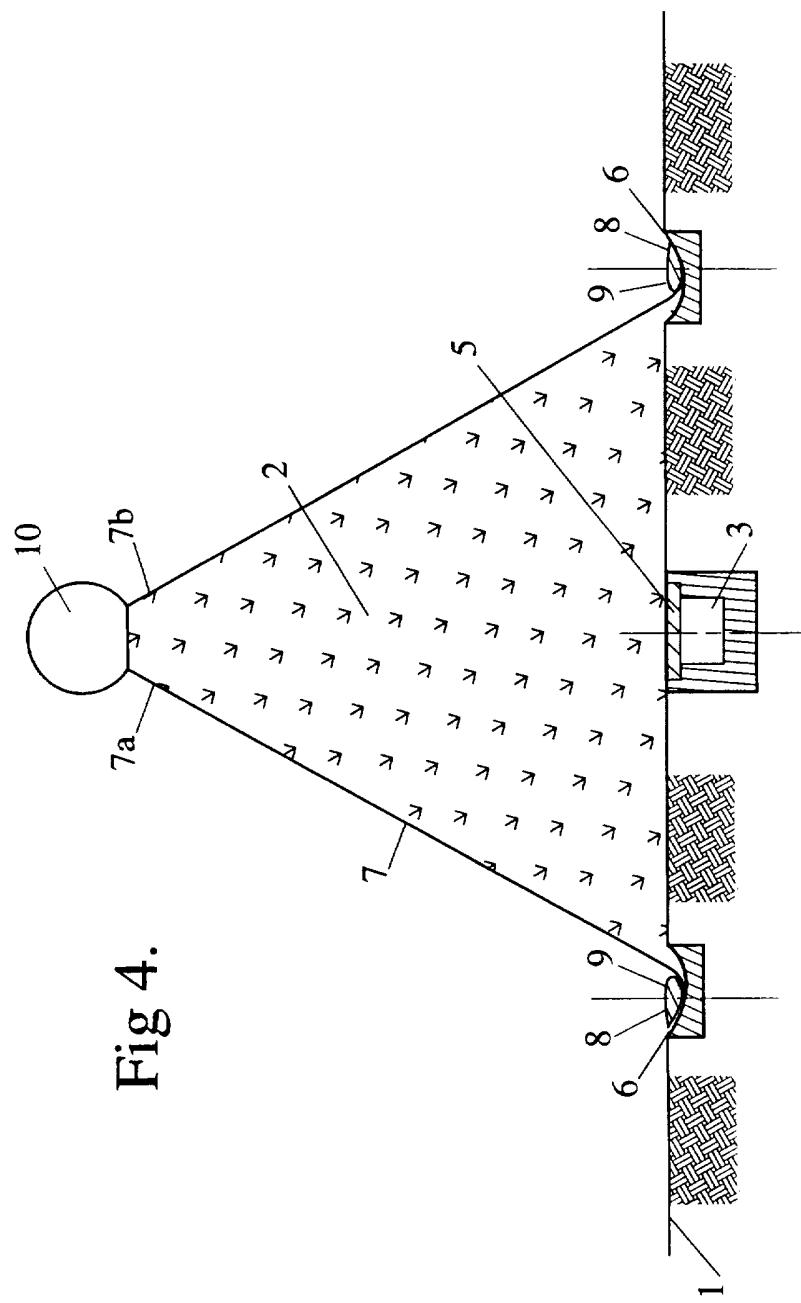


Fig 4.

# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/AU 96/00771

## A. CLASSIFICATION OF SUBJECT MATTER

Int Cl<sup>6</sup>: C05F 9/02, 9/04, 17/00, 17/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int Cl<sup>6</sup>: as above

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	AU 24180/92 A (COMPOST TECHNOLOGIES INC) 2 March 1993 Page 5 line 28 to page 6 line 21  AU 79864/94 A (WASTE ORGANIC RECYCLING MANAGEMENT SYSTEMS) 22 May 1995 Page 2 lines 20 to 35, page 6 lines 1 to 28	1-11, 17 18
X Y		1, 2, 3, 17 18

Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance		
"E" earlier document but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search

3 February 1997

Date of mailing of the international search report

13 FEB 1997

Name and mailing address of the ISA/AU  
AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION  
PO BOX 200  
WODEN ACT 2606  
AUSTRALIA Facsimile No.: (06) 285 3929

Authorized officer

DAVID GRIFFITHS

Telephone No.: (06) 283 2628

**INTERNATIONAL SEARCH REPORT**International Application No.  
PCT/AU 96/00771

<b>C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to claim No.</b>
X	EP 454595 A1 (SOCIETE DE VALORISATION DES DESCHETS SOVADEC) 30 October 1991 Whole document	1, 3-9, 11-13, 17 18
Y	FR 2693999 A1 (DEVILLE) 28 January 1994	18
X	Page 3 line 1 to page 4 line 31	1, 3, 8, 10, 11, 17 18
Y	US 5538860 A (CASTELLI) 23 July 1996	18
X	Whole document	1-17
Y	US 5206173 A (FINN) 27 April 1993 Whole document	18
Y	AU 22081/92 A (THE UNIVERSITY CO PTY LTD) 11 March 1992 Whole document	18

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International Application No.  
PCT/AU 96/00771

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
AU	24180/92	US	5417736	WO	9302990	US	5269829
US	5206173						
FR	2693999						
EP	454595	CA	2040860	FR	2661407	JP	5117068
AU	79864/94	WO	9511586				
US	5538860	EP	665200	IT	94890014		
AU	22081/92	WO	9527649				