

ANNEX 4: ALTERNATIVE HEALTH-CARE WASTE MANAGEMENT TREATMENT TECHNOLOGIES

Type of technology	Description	General operating process	Range of capacities	Approximate capital cost in USD
Standard gravity-fed autoclave	Technology consists of a pressure vessel, typically cylindrical or rectangular, with or without outer steam jacket and designed to withstand elevated pressures. Steam is introduced by gravity displacement.	<ul style="list-style-type: none"> • Waste is placed inside the autoclave. • Pressurized steam is introduced at a minimum of 121°C. • Waste is exposed to the steam. • Steam is removed as condensate. • Waste is removed and processed in a shredder if desired. 	20 kg/hr to 3000 kg/hr; smaller units are available	\$30,000 to 200,000; small units cost about 100
Standard pre-vacuum autoclave	Technology consists of a pressure vessel, typically cylindrical or rectangular, with or without outer steam jacket and designed to withstand elevated pressures. A vacuum is used to remove air and then steam is introduced.	<ul style="list-style-type: none"> • Waste is placed inside the autoclave. • A vacuum is used to remove air. • Pressurized steam is introduced at a minimum of 121°C. • Waste is exposed to the steam. • Steam is removed as condensate. • Waste is removed and processed in a shredder if desired. • Some technologies compact the waste. 	15 kg/hr to 1000 kg/hr	\$30,000 to 500,000
Pulse vacuum autoclave	Technology consists of a pressure vessel, typically cylindrical or rectangular, with or without outer steam jacket and designed to withstand elevated pressures. Two or more cycles of vacuum and steam injection are used.	<ul style="list-style-type: none"> • Waste is placed inside the autoclave. • A vacuum is used to remove air. • Pressurized steam is introduced at a minimum of 121°C. • Waste is exposed to the steam. • Two or more cycles of vacuum and steam injection are used. • Steam is removed as condensate. • Waste is removed and processed in a shredder if desired. 	21 kg/hr to 84 kg/hr	\$120,000 to 240,000
Rotating autoclave	Technology consists of a cylindrical pressure vessel with an internal rotating drum lined with sharp vanes and designed to withstand elevated pressures.	<ul style="list-style-type: none"> • Waste is placed in the rotating autoclave. • A vacuum is used to remove air. • Steam is introduced at about 147°C. • Internal drum rotates causing waste containers to break and mix. • Steam is removed as condensate and waste is cooled. • Waste is removed and processed in a grinder. 	90 kg/hr to 2000 kg/hr	\$380,000 to 900,000
Hydroclave	Technology consists of a cylindrical pressure vessel with an outer steam jacket and an internal mixing arm, designed to withstand elevated pressures.	<ul style="list-style-type: none"> • Waste is placed in the hydroclave. • Steam is injected in the outer jacket until the inner chamber is heated to 132°C. • Internal mixing arm breaks the waste containers and mixes the waste. • Steam is removed as condensate. • Waste is removed and processed in a shredder. 	20 kg/hr to 1000 kg/hr	\$70,000 to 550,000
Steam treatment with internal shredding	Technology consists of a cylindrical or hemispherical pressure vessel with an internal shredder and outer steam jacket. Some systems are designed as mobile units.	<ul style="list-style-type: none"> • Waste is placed in the vessel. • Steam is introduced at 132° or 138°C. • Waste is shredded internally and exposed to steam. • Steam is removed as condensate. • Waste is cooled. • Waste is removed. 	40 kg/hr to 200 kg/hr	\$190,000 to 470,000

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Steam treatment with continuous internal maceration	Technology consists of a rectangular container with a treatment vessel connected to a pump-grinder and liquid separator.	<ul style="list-style-type: none"> Waste is placed in the vessel. Steam and hot water are introduced. Waste slurry is re-circulated through the grinder and held at 138°C. Cold water is injected and the slurry is passed through a liquid separator to filter out the waste. Waste solids are captured in disposable bags. 	68 kg/hr	\$200,000
Semi-continuous steam treatment	Technology consists of a hopper, shredder, rotating auger, dehydrator and discharge section.	<ul style="list-style-type: none"> Waste is automatically dumped into a sealed hopper. Waste passes through an internal shredder and a horizontally inclined rotating auger where it is exposed to steam. The dehydrator at the end of the auger removes excess liquid. The waste is discharged directly into a compactor. 	140 kg/hr to 1800 kg/hr	\$300,000 to 1,800,000
Large-scale microwave treatment	Technology consists of a hopper, shredder, rotating auger, microwave generators, holding tank, secondary auger and shredder.	<ul style="list-style-type: none"> Waste is automatically dumped into a sealed hopper. Waste passes through an internal shredder and a horizontally inclined rotating auger where it is exposed to steam and microwave energy. An optional second shredder at the end of the auger shreds the waste to a smaller size. The waste is discharged into a container. 	100 kg/hr to 250 kg/hr	\$600,000 and higher
Small-scale microwave treatment	Technology consists of a treatment chamber and one or more microwave generators.	<ul style="list-style-type: none"> Waste is placed inside the treatment chamber. Water or steam is added. Waste is exposed to microwave energy which generates heat inside the chamber. Waste is removed and shredded if desired. 	3 kg/hr to 200 kg/hr	\$12,000 to 85,000
Electro-thermal deactivation	Technology consists of size-reduction equipment, a conveyor and a high-voltage radio-frequency generator.	<ul style="list-style-type: none"> Waste is placed on a conveyor. Waste passes through a shredder. Shredded waste is sprayed with water, compacted and then exposed to low-frequency radio waves which heat the waste. Waste is discharged. 	450 kg/hr to 2700 kg/hr	Not available
Electron beam irradiation	Technology generally consists of a conveyor, beam accelerator and shielding.	<ul style="list-style-type: none"> Waste is placed on a conveyor. Waste passes through a treatment section where it is exposed to an electron beam at doses that destroy pathogens. Waste is discharged and passed through a shredder. 	180 kg/hr to 250 kg/hr	\$500,000 to 1,500,000
Dry heat treatment	Technology generally consists of a treatment chamber, resistance heater and fan to re-circulate hot air.	<ul style="list-style-type: none"> Waste is placed in the treatment chamber. Heated air at 177°C is circulated through the waste for a prescribed time. Waste is cooled and then discharged. 	0.15 kg/hr	\$5000

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Alkaline hydrolysis or alkaline digestion	Technology consists of a cylindrical pressure vessel with an outer jacket and an internal spray assembly or mixer, a heat source, alkali solution, load cells, pump and piping and controls. The technology is designed for digesting tissues, organs, body parts and animal carcasses.	<ul style="list-style-type: none"> • Waste is placed in the pressure vessel. • Sodium or potassium hydroxide solution is added to the vessel. • Steam or heated oil is circulated in the outside jacket. • Waste is exposed to a heated alkali solution for several hours until the digestion is complete. • Wastewater is neutralized if desired and discharged to the sewer or solidified and used as fertilizer. • Solid waste residues are discarded or used as soil conditioner. 	14 kg to 4500 kg per cycle	\$30,000 to 900,000 And higher
Chemical disinfection technologies	Technologies typically consist of a treatment chamber and internal shredder and mixer, and some use a solid-liquid separator.	<ul style="list-style-type: none"> • Waste is passed through an internal shredder. • A chemical disinfectant is mixed with the waste (e.g., calcium oxide, calcium hydroxide, peracetic acid or ozone). • Some technologies discharge the waste disinfectant; some remove and reuse the disinfectant solution; and others neutralize any residual disinfectant. 	20 kg/hr to 1000 kg/hr	\$30,000 to 400,000 And higher