

INDUSTRIAL CASE STUDY

Healthcare & Sterilisation

Microwave-Based Biomedical Waste Sterilisation & Volume Reduction

Continuous Industrial-Scale System — 500 kg/hr Treatment Capacity
Designed, Engineered & Validated by KERONE Engineering Solutions Limited

500 PLANT CAPACITY kg/hr Biomedical Waste	100°C PROCESS TEMP. Saturated Steam + MW	45 min RESIDENCE TIME Validated Hold
6.2 log SPORE INACTIVATION B. atrophaeus (Req. 4 log)	82% VOLUME REDUCTION Integral Shredding	~2.0 Yrs PAYBACK PERIOD At CBWTF Tariff

Project Reference Detail

Client Organisation	Common Biomedical Waste Treatment Facility (CBWTF) operator, Western India — name withheld under confidentiality agreement
KERONE Reference	KRDC/ICS/BMW-Steril/2026-04 Based on KRDC Lab Report 62/KRDC/LAB/09
Technology	Continuous Microwave Sterilisation Tunnel with Integral Shredder, Steam Injection & HEPA-filtered Extraction
Feedstock	Category-wise segregated biomedical waste — Yellow, Red & White (sharps) streams per BMWM Rules 2016
Product Output	Sterile, shredded, unrecognisable residue — $\geq 6 \log_{10}$ spore reduction, landfill / co-processing ready
Plant Location	Client CBWTF site — inline with existing receiving, weighing and barcode tracking system
Compliance Basis	BMWM Rules 2016 (as amended) CPCB Guidelines for Common BMW Treatment Facilities STAATT Level III/IV
Document Date	July 2026 Validated on KRDC Lab Data — March 2026

Healthcare Waste Management | Sterilisation Technology | Infection Control | Microwave Thermal Processing | Environmental Compliance | Pharma & Medical

Executive Summary

The client, a licensed Common Biomedical Waste Treatment Facility (CBWTF) serving more than 340 healthcare establishments across a Western India industrial cluster, faced a compounding operational and regulatory problem. Their entire yellow- and red-category throughput was routed through a single ageing incinerator and a batch autoclave line. Incineration costs were escalating with fuel prices, stack emission scrutiny had intensified, and the batch autoclaves — with 90-minute cycle times, manual loading and no integral shredding — could neither keep pace with rising collection volumes nor guarantee the "unrecognisable waste" condition mandated for red-category plastics.

KERONE Engineering Solutions Limited was engaged to design, validate and specify a continuous industrial sterilisation system capable of treating non-incinerable biomedical waste to full statutory inactivation levels while simultaneously rendering it unrecognisable and volume-reduced — at a sustained throughput of 500 kg/hr.

Following a structured validation programme at KRDC (Kerone Research & Development Centre) using an instrumented microwave sterilisation rig on the client's own segregated waste, with biological indicator challenge testing at multiple exposure times (15, 30, 45 and 60 minutes), the optimal industrial process envelope was established. The KERONE continuous microwave sterilisation tunnel — operating at 98–105°C with saturated steam injection and a 45-minute validated residence time — delivers a 6.2 log₁₀ reduction of *Bacillus atrophaeus* spores against the statutory 4 log₁₀ requirement, with 82% volume reduction through the integral twin-shaft shredder.

CHALLENGE	KERONE SOLUTION	OUTCOME ACHIEVED
Batch autoclaves at 90-min cycles with no shredding; rising incineration cost at INR 12–16/kg; red-category plastics not rendered unrecognisable; no continuous cycle data trail for SPCB audit.	Continuous 500 kg/hr microwave sterilisation tunnel at 100°C with steam injection, 45-min residence, integral twin-shaft shredder and full SCADA cycle logging — validated from KRDC trials.	6.2 log ₁₀ spore inactivation (STAATT Level IV), 82% volume reduction, 61% lower treatment cost per kg versus incineration, and a recyclable shredded polymer fraction.

Key Performance Summary

KPI	Existing Route (Baseline)	After KERONE System (500 kg/hr)	Improvement
Spore Inactivation (<i>B. atrophaeus</i>)	Not routinely verified	6.2 log ₁₀ (validated)	STAATT Level IV
Cycle Time per Batch	90 min (batch autoclave)	Continuous — 45 min residence	2x throughput/hr
Volume Reduction	Nil (no shredding)	82%	Landfill volume cut
Treatment Cost	INR ~14.5/kg (incineration)	INR ~5.6/kg	61% cost reduction
Waste Recognisability	Intact — non-compliant	Fully unrecognisable	BMWM Rules compliant
Recoverable Plastic Fraction	Nil — destroyed	~18% of red-category input	New revenue stream
Annual Treatment Capacity	~900 t/yr (constrained)	1,440 t/yr at 80% loading	+60% capacity

Table 1: Key performance indicators — existing batch route vs KERONE continuous microwave sterilisation system

Industry Context & The Business Challenge

India generates approximately 740 tonnes of biomedical waste per day across more than 2.7 lakh registered healthcare facilities, handled through a network of roughly 220 authorised Common Biomedical Waste Treatment Facilities. Under the Bio-Medical Waste Management Rules, 2016, yellow-category waste must be incinerated, while red-category waste — contaminated plastics such as tubing, catheters, IV sets, syringes without needles and gloves — must be sterilised by autoclaving, microwaving or hydroclaving, and then mutilated or shredded so that it cannot be recycled back into the medical supply chain in its original form.

Red- and white-category streams typically constitute 45–55% of a CBWTF’s total intake. Where a facility routes this fraction to the incinerator — either through capacity constraint or convenience — it incurs the highest unit treatment cost in the entire waste hierarchy, destroys a recoverable polymer resource, and adds avoidable particulate and dioxin load to a stack already under regulatory scrutiny. This is the specific economic and compliance gap the KERONE system addresses.

The Operational Problem — Why the Existing Route Fails

Parameter	Client’s Existing Operation	Statutory / Best-Practice Requirement	Gap
Microbial inactivation proof	Spot autoclave tape only	Biological indicator, $\geq 4 \log_{10}$ B. atrophaeus	FAIL — no validated proof
Shredding of red-category waste	Manual mutilation, partial	Mandatory — rendered unrecognisable	FAIL — non-compliant
Cycle record retention	Handwritten logbook	Electronic cycle data, 5-year retention	FAIL — audit exposure
Throughput vs collection growth	~300 kg/hr effective	≥ 450 kg/hr projected 2027 demand	FAIL — capacity shortfall
Treatment cost per kg	INR ~14.5/kg	INR 5–7/kg benchmark (microwave)	~2.6x cost gap
Odour & occupational exposure	Open loading, manual handling	Enclosed, HEPA-filtered, automated	FAIL — exposure risk

Table 2: Existing operation vs statutory requirement | Source: KRDC site assessment & BMW Rules 2016 (as amended)

The Commercial Opportunity — Diverting Waste from the Incinerator

The Opportunity: At 500 kg/hr operating 12 hours a day for 300 days a year at 80% loading, the annual treated volume is approximately 1,440 tonnes. Diverting this fraction from incineration at INR 14.5/kg to microwave sterilisation at INR 5.6/kg saves roughly INR 128 Lakhs per year in direct treatment cost, before accounting for the recovered polymer fraction. Incinerator capacity released by the diversion is redeployed to yellow-category waste, deferring a capital-intensive second incinerator train and extending the existing unit’s refractory life.

About the Client Facility

The client operates an authorised CBWTF with a State Pollution Control Board consent covering more than 340 healthcare establishments, including four multi-speciality hospitals of 200+ beds each. The facility runs GPS-tracked collection vehicles, barcoded bag-level traceability and an on-site effluent treatment plant. The KRDC validation trial was conducted on the client’s actual segregated red- and white-category waste (a 45 kg representative composite sample, dispatched 6 March 2026) to ensure that all process parameters reflect real load composition, moisture and packing density rather than synthetic surrogate waste.

Process Validation — From KRDC Lab to Industrial Scale

KERONE's engineering approach mandates laboratory-scale validation before any industrial system specification. KRDC conducted a structured experimental programme on the client's actual biomedical waste composite over 8 days (6–14 March 2026), using an instrumented 6 kW microwave sterilisation rig with steam injection, fibre-optic in-load temperature probes and biological indicator challenge packs, to establish the process envelope that informs the 500 kg/hr industrial plant design.

KRDC Experimental Programme — Key Findings

Biological indicator strips carrying a certified population of 1.0×10^7 *Bacillus atrophaeus* (subtilis var. niger) spores were placed at five positions within each load — including the geometric cold spot identified by thermal mapping — and incubated for 7 days post-exposure. Chemical indicators (Class 5 integrators) and *Geobacillus stearothermophilus* controls were run in parallel. Load temperature uniformity was recorded continuously at 1-second intervals.

Test Condition	Exposure Time	Peak Load Temp.	Spore Log Reduction	Assessment
Control (no exposure)	0 min	Ambient	0.0 log ₁₀	Baseline — untreated waste
Short exposure	15 min	92°C	2.1 log ₁₀	Insufficient — below statutory limit
Intermediate	30 min	97°C	4.3 log ₁₀	Marginal — no safety factor
OPTIMAL	45 min	101°C	6.2 log₁₀	Optimal — STAATT Level IV
Extended	60 min	104°C	6.4 log ₁₀	No material gain — higher energy

Table 3: KRDC laboratory results — microwave sterilisation trials on client biomedical waste composite | KRDC Test Report 62/KRDC/LAB/09 | Biological indicator challenge per STAATT / CPCB CBWTF guidelines

The findings establish 45 minutes at 98–105°C as the design point. Below 30 minutes, cold-spot inactivation falls short of the statutory 4 log₁₀ threshold; beyond 45 minutes, the incremental log reduction is negligible while specific energy consumption rises by approximately 28%. Temperature uniformity across the five probe positions at the 45-minute condition was within $\pm 3.5^\circ\text{C}$, confirming that microwave field distribution combined with steam injection eliminates the dry-pocket cold spots that limit conventional autoclaving of loosely packed plastic waste.

Scale-Up Methodology — Lab to 500 kg/hr

KERONE's scale-up process follows a structured engineering framework where laboratory parameters are translated to industrial equipment specifications using validated microwave field and thermal models. The key translation factors for this project are:

Parameter	KRDC Lab (6 kW Rig)	Industrial Plant (500 kg/hr Tunnel)	Scale-Up Factor
Treatment Temperature	98–105°C	98–105°C	1:1 (direct)
Exposure / Residence Time	45 min	45 min residence time	1:1 (direct)
Throughput	~2.5 kg/batch	500 kg/hr	200:1
Microwave Power	6 kW (single magnetron)	96 kW (12 x 8 kW magnetrons)	16:1
Specific Energy Input	~0.22 kWh/kg	~0.24 kWh/kg	Direct
Frequency	2,450 MHz	2,450 MHz	1:1 (direct)
Steam Injection	Manual, 0.5 bar	Automated, 0.5–1.0 bar modulated	Automated
Shredding	Post-treatment, offline	Integral pre-shredder, inline	Configuration change

Parameter	KRDC Lab (6 kW Rig)	Industrial Plant (500 kg/hr Tunnel)	Scale-Up Factor
Loading	Manual, static tray	Continuous auger conveyance	Continuous

Table 4: Scale-up translation factors — KRDC laboratory rig to 500 kg/hr continuous industrial system

Industrial Plant Design — 500 kg/hr Continuous System

Process Flow — Sequence of Operations

Stage	Operation	Key Condition
1. Waste Intake	Barcoded bag reception, weighing, category verification	Colour-coded segregation check
2. Charging	Automatic bin lifter into sealed hopper — no manual contact	Enclosed, negative pressure
3. Shredding	Twin-shaft shredder reduces waste to < 25 mm fragments	82% volume reduction
4. Conditioning	Saturated steam injection to raise moisture and remove air pockets	0.5–1.0 bar modulated
5. Microwave Sterilisation	Continuous auger transport through 12-magnetron tunnel	98–105°C 45 min residence
6. Hold & Verification	Temperature hold zone with fibre-optic probes and cycle logging	Automatic reject on deviation
7. Discharge & Cooling	Cooled sterile residue conveyed to sealed discharge bin	Outlet < 55°C
8. Air Handling	HEPA + activated carbon filtration of all extracted air	H14 grade odour control

Fig. 1 (described): KERONE 500 kg/hr biomedical waste sterilisation — continuous industrial process sequence

System Architecture — Major Process Units

Unit / Section	Equipment	Design Parameters	Function
U-01: Waste Intake & Weighing	Platform weighbridge + barcode scanner + bin lifter	600 kg/hr rated 0.1 kg resolution	Record bag-level traceability; verify category before charging
U-02: Charging System	Sealed hopper with hydraulic bin tipper	Interlocked lid negative pressure maintained	Eliminate operator contact with untreated waste
U-03: Shredding Unit	Twin-shaft low-speed high-torque shredder	30 kW < 25 mm output 600 kg/hr	Render waste unrecognisable; increase surface area for uniform heating
U-04: Microwave Sterilisation Tunnel (Primary Process Unit)	KERONE Continuous Microwave Tunnel	96 kW at 2,450 MHz 12 magnetrons 45 min residence SS 316L chamber	Core sterilisation — volumetric heating to 98–105°C with validated hold
U-05: Steam Conditioning	Electric steam generator + injection manifold	80 kg/hr 0.5–1.0 bar saturated	Displace air pockets; ensure moist-heat inactivation at cold spot
U-06: Temperature Monitoring	Fibre-optic probe array + IR scanner	8 in-load points 1-sec logging	Continuous verification of sterilisation conditions; automatic reject logic
U-07: Discharge & Cooling	Cooled screw conveyor + sealed residue bin	Outlet < 55°C dust-tight	Safe discharge of sterile residue for baling or landfill
U-08: Air Handling & Odour Control	HEPA H14 filter + activated carbon bed + extraction fan	≥ 99.995% at 0.3 µm 2,500 m³/hr	Prevent aerosol release; control odour; maintain room depression
U-09: Process Control & Validation	PLC/SCADA with 21 CFR-style audit trail	Siemens S7 / Allen Bradley 5-year data retention	Cycle control, electronic batch records, SPCB audit reporting

Table 5: Process unit descriptions — KERONE 500 kg/hr continuous biomedical waste sterilisation plant | U-04 is the primary process unit; all others are ancillary

Core Equipment Specification — KERONE Microwave Sterilisation Tunnel

The KERONE Continuous Microwave Sterilisation Tunnel is the heart of the biomedical waste treatment system. Designed and manufactured in-house at KERONE's Ambernath facility, it directly scales the validated laboratory parameters from KRDC trial 62/KRDC/LAB/09 to industrial throughput while maintaining the identical field density, temperature profile and residence time that produced the 6.2 log₁₀ spore inactivation result.

MICROWAVE STERILISATION TUNNEL — CORE SPECIFICATIONS	
Design Throughput	500 kg/hr (shredded biomedical waste)
Operating Temperature	98–105°C (max design: 130°C)
Residence Time	45 min (adjustable 20–75 min via auger speed)
Microwave Power	96 kW installed — 12 x 8 kW magnetrons, individually switched
Frequency	2,450 MHz ± 50 MHz (ISM band)
Chamber Dimensions	L 9,600 mm x W 1,200 mm x H 900 mm (SS 316L)
Heating Zones	4 independently power-controlled zones
Steam Injection	Saturated steam, 0.5–1.0 bar, modulated by load temperature
Conveyance	VFD-controlled twin-auger, 5.5 kW
Installed Power	~168 kW (total connected load)
Microwave Leakage	< 5 mW/cm ² at 50 mm — IEC 60335-2-90 compliant
Sealing	Choke seals at inlet/outlet + interlocked access doors
Insulation	Mineral wool 100 mm with SS 304 cladding
Validation Ports	8 sealed ports for biological indicator and probe insertion

Table 6: Core equipment specification — KERONE Continuous Microwave Sterilisation Tunnel, 500 kg/hr

Utilities & Ancillary Requirements

Utility	Specification	Consumption (at 500 kg/hr)	Source
Electrical Power	415V, 3-phase, 50Hz	~168 kW connected ~132 kW avg demand	Site utility
Water (steam generation)	Softened, < 50 ppm hardness	~90 litres/hr	Site softener plant
Cooling Water	30°C supply closed loop	6 m ³ /hr 36°C return (magnetron cooling)	Cooling tower
Compressed Air	6 bar dry instrument grade	10 Nm ³ /hr	Air compressor (site)
Disinfectant (bin wash)	1% sodium hypochlorite	~40 litres/shift	Client consumable
Space Requirement	Enclosed building / covered bay	L 24m x W 10m x H 6m	New shed or existing bay

Emission, Effluent & Occupational Compliance

Compliance Point	Parameter	Expected Level	CPCB / Statutory Limit	Status
Extraction stack	Particulate Matter	< 15 mg/Nm ³	50 mg/Nm ³	COMPLIANT

Compliance Point	Parameter	Expected Level	CPCB / Statutory Limit	Status
Extraction stack	Bio-aerosol release	Not detectable	HEPA H14 mandatory	COMPLIANT
Treated residue	Spore log reduction	6.2 log ₁₀	≥ 4 log ₁₀ (B. atrophaeus)	COMPLIANT
Treated residue	Recognisability	Fully shredded < 25 mm	Unrecognisable (BMWM 2016)	COMPLIANT
Work area	Microwave leakage	< 5 mW/cm ²	5 mW/cm ² at 50 mm	COMPLIANT
Work area	Noise level	< 78 dB(A)	85 dB(A) (8-hr TWA)	COMPLIANT
Wash effluent	Discharge to ETP	Disinfected, contained	CBWTF ETP norms	COMPLIANT

Table 7: Compliance summary — emission, residue quality and occupational exposure against statutory limits

Mass Balance & Energy Analysis — 500 kg/hr Operation

Detailed Mass Balance — Per Hour at Full Load

Stream	Material	Flow Rate (kg/hr)	Notes
Feed (IN)	Segregated red / white category waste	500	As-received, ~22% moisture, bagged
Steam (IN)	Saturated steam for conditioning	~80	Condenses into load; raises moisture for uniform heating
Moisture Loss	Evaporated moisture to extraction	~46	Captured, condensed, routed to site ETP
Residue (OUT)	Sterile shredded residue	~534	Includes condensed steam; < 25 mm fragments
Recoverable Polymer	Sorted PP / PE / PVC fraction	~96	~18% of residue; sold to authorised recycler
Landfill / Co-process	Non-recoverable sterile residue	~438	To secured landfill or cement co-processing
Filter Retentate	HEPA / carbon captured particulate	< 0.5	Recycled back into feed at next cycle
Volume Basis	Bulk volume reduction	—	Inlet ~ 6.4 m ³ /hr → outlet ~ 1.15 m ³ /hr (82% reduction)

Table 8: Mass balance — 500 kg/hr continuous biomedical waste sterilisation plant | Based on validated KRDC lab data scaled to industrial throughput

Energy Consumption Estimates

Energy Category	Equipment / Unit	Power (kW)	Load Factor	Consumption (kWh/tonne)
Microwave Generation	12 x 8 kW magnetrons + HV power supplies	96	72%	~138
Steam Generation	Electric steam generator (80 kg/hr)	60	55%	~66
Shredding	Twin-shaft shredder drive	30	45%	~27
Conveyance & Handling	Augers, bin lifter, discharge conveyor	12	80%	~19
Air Handling & Extraction	Extraction fan + HEPA / carbon system	11	95%	~21
Cooling & Utilities	Magnetron cooling pump, chiller, controls	9	85%	~15
TOTAL		~218 kW		~286 kWh/tonne

Table 9: Energy consumption estimate — 500 kg/hr biomedical waste sterilisation plant | Based on KERONE engineering estimates; actual values to be confirmed during detailed engineering

At an industrial tariff of INR 8/kWh, the specific energy cost works out to approximately INR 2.29 per kg of waste treated. Adding labour, consumables, maintenance and magnetron replacement provision brings the fully loaded treatment cost to approximately INR 5.60 per kg — against INR 14.50 per kg for the incineration route the system displaces.

Treated Output Specification & Downstream Applications

Parameter	Test Method	Untreated Waste	KERONE Treated Residue	Statutory Requirement
B. atrophaeus spore reduction	Biological indicator, 7-day incubation	0.0 log ₁₀	6.2 log ₁₀	≥ 4 log ₁₀
G. stearothermophilus	Biological indicator, 7-day incubation	0.0 log ₁₀	≥ 6 log ₁₀	Reference control
Vegetative bacteria	Standard plate count	10 ⁸ –10 ⁹ CFU/g	< 10 CFU/g	≥ 6 log ₁₀ reduction
Particle size	Sieve analysis	Intact articles	< 25 mm	Unrecognisable
Bulk density	IS 4032 method	~78 kg/m ³	~465 kg/m ³	N/A
Moisture content	Gravimetric	~22%	~28%	N/A
Odour	Sensory panel	Strong, offensive	Negligible	Controlled at source
Classification	BMWM Rules 2016	Infectious — Red / White	Sterile, non-infectious residue	Disposal permitted

Table 10: Treated output specification — untreated waste vs KERONE-processed sterile residue vs statutory requirement

Downstream Routes for Treated Residue

- **Recyclable Polymer Recovery**

The shredded, sterilised fraction contains recoverable polypropylene, polyethylene and PVC from tubing, IV sets and syringe bodies. Post-treatment sorting recovers roughly 18% of residue mass for sale to authorised recyclers at INR 18–24/kg, subject to State Pollution Control Board authorisation for the recycler.

- **Cement Kiln Co-Processing**

Sterile residue with a calorific value of approximately 4,200 kcal/kg is accepted by cement plants as alternative fuel and raw material (AFR) under CPCB co-processing guidelines, eliminating landfill dependency entirely and attracting a gate-fee saving.

- **Secured Landfill Disposal**

Where co-processing is unavailable, the 82% volume-reduced sterile residue is landfilled at a fraction of the original transport and tipping cost. Reduced bulk translates directly into fewer vehicle trips and lower per-tonne disposal charges.

- **Refuse-Derived Fuel (RDF) Blending**

The high-calorific polymer-rich fraction is suitable for blending into RDF for industrial boilers, subject to chlorine limits from the PVC content being managed through upstream segregation discipline.

- **Extension to Healthcare Sterile Processing**

The same validated microwave platform is deployable for in-house sterilisation at large hospitals, veterinary facilities, diagnostic laboratories and pharmaceutical plants handling biological waste, at capacities from 50 kg/hr upward.

Financial Analysis & Return on Investment

CAPEX Estimate — 500 kg/hr Plant

Cost Head	Scope	Estimated Cost (INR Lakhs)	Notes
Microwave Sterilisation Tunnel (Primary Equipment)	KERONE supply, factory tested	38–44	FOT Ambernath; includes magnetrons, HV supplies, chamber, augers
Twin-Shaft Shredder	Low-speed high-torque, hardened cutters	12–15	Includes spare cutter set
Steam Generation System	Electric steam generator + injection manifold	5–6	80 kg/hr, automatic blowdown
Air Handling & Odour Control	HEPA H14 + activated carbon + extraction fan	6–7	Includes ducting and stack
Waste Handling & Charging	Bin lifter, sealed hopper, discharge conveyor	5–6	Interlocked, contact-free charging
Electrical & Instrumentation	MCC panel, SCADA, cabling, transformer	8–10	PLC/SCADA by KERONE; site electrical by client
Validation & Monitoring Package	Fibre-optic probes, IR scanner, BI test kit	4–5	Includes IQ/OQ/PQ documentation
Civil & Structural	Foundation, shed, utility connections	6–8	Client scope; KERONE to provide layout drawing
Commissioning, Training & Startup	KERONE commissioning team, 15-day site support	3–4	Includes operator training and performance validation run
TOTAL CAPEX		INR 87–105 Lakhs	Approx. range; detailed quote on enquiry

Table 11: CAPEX estimate — 500 kg/hr continuous biomedical waste sterilisation plant | All figures indicative; formal quotation on receipt of detailed enquiry

Revenue & OPEX Model — Annual Basis (3,600 hr/yr at 80% loading)

Item	Basis	INR/Year (Lakhs)	Remarks
REVENUE / SAVINGS			
Treatment Charges Realised	1,440 t/yr x INR 14,000/t	INR 202	CBWTF tariff for red/white category
Recovered Polymer Sales	~276 t/yr x INR 20,000/t	INR 55	Subject to recycler authorisation
Incineration Cost Avoided	Capacity released to yellow category	INR 24	Deferred second incinerator train
TOTAL REVENUE / BENEFIT		INR 281	
OPERATING COSTS			
Electricity	286 kWh/t x 1,440 t/yr x INR 8/kWh	INR 33	Based on INR 8/kWh industrial tariff
Labour (Operations)	3 operators/shift x 2 shifts x 12 months	INR 18	At INR 25,000/operator/month CTC
Magnetron Replacement Provision	~6,000 hr life, staggered replacement	INR 9	Key consumable — budgeted annually
Maintenance & Spares	4% of CAPEX per annum	INR 4	Cutters, seals, filters, bearings

Item	Basis	INR/Year (Lakhs)	Remarks
Consumables	HEPA/carbon media, disinfectant, BI test kits	INR 7	Includes validation consumables
Validation & QC Testing	Monthly BI challenge + annual revalidation	INR 5	NABL-accredited laboratory
Miscellaneous & Overheads	Admin, insurance, utilities	INR 6	
TOTAL OPERATING COST		INR 82	Equivalent to ~INR 5.60/kg treated
NET BENEFIT BEFORE TAX		INR ~199 Lakhs/yr	Payback ~2.0 years on INR 96L CAPEX including ramp-up

Table 12: Revenue & OPEX model — 500 kg/hr plant at 3,600 hr/yr | Indicative figures; actual returns depend on prevailing CBWTF tariff, waste mix and recycler realisation

Cumulative Cash Flow — 5-Year Projection

Year	Capital Outflow	Net Annual Benefit	Cumulative Position
Year 0	INR -96 L (CAPEX)	—	INR -96 L
Year 1	—	INR +48 L (50% ramp)	INR -48 L
Year 2	—	INR +139 L (70% loading)	INR +91 L
Year 3	—	INR +199 L (full loading)	INR +290 L
Year 4	—	INR +199 L	INR +489 L
Year 5	—	INR +199 L	INR +688 L

Table 13: Cumulative cash flow — 500 kg/hr biomedical waste sterilisation plant, 5-year projection | Break-even at approximately 2.0 years including utilisation ramp

Project Execution & KERONE Scope of Supply

Implementation Timeline

Phase	Activity	Duration	KERONE Deliverable
Phase 0 — Pre-Order	Technical consultation, site visit, waste characterisation, process design freeze, commercial negotiation	3–5 Weeks	Process Design Basis (PDB), GA drawing, utility list, commercial offer
Phase 1 — Engineering	Detailed engineering: mechanical, microwave field design, electrical, civil layout, P&ID	5–7 Weeks	Complete engineering package, vendor drawings, DFM approval
Phase 2 — Procurement	Long-lead items: magnetrons, HV power supplies, SS 316L chamber plate, shredder, HEPA units	8–10 Weeks	Material test certificates, QC inspection reports, FAT invitation
Phase 3 — Fabrication	Tunnel fabrication, choke seal machining, shredder assembly, SCADA panel build	10–12 Weeks	Factory Acceptance Test at KERONE Ambarnath; client witness invited
Phase 4 — Installation	Equipment erection at client site; steam, water, electrical and instrument hook-up	3–4 Weeks	KERONE site supervision; civil and electrical by client as per KERONE drawings
Phase 5 — Commissioning & Validation	Cold trials, hot trials with actual waste, biological indicator challenge, IQ/OQ/PQ, operator training	3–4 Weeks	Commissioning report, validation protocol and report, O&M manual, training records
TOTAL PROJECT TIMELINE	Order to validated commercial operation	~32–42 Weeks	From purchase order to first compliant treated batch

Table 14: Implementation timeline — order to validated commercial operation

KERONE Scope of Supply & Services

Category	KERONE Scope (INCLUDED)	Client Scope (EXCLUDED from KERONE supply)
Process Design	Process design basis, mass and energy balance, microwave field model, P&ID	Waste segregation discipline; plant operating schedule
Primary Equipment	Microwave sterilisation tunnel (complete), shredder, steam generator, conveyance, discharge system	Weighbridge and barcode tracking system if not included in enquiry scope
Air & Odour Control	HEPA H14 filtration, activated carbon bed, extraction fan and ducting	Stack height design and consent-to-operate from CPCB / SPCB
Controls & Validation	PLC/SCADA, MCC panel, fibre-optic probe array, all field instruments, IQ/OQ/PQ protocols	Routine biological indicator procurement after handover; NABL testing contract
Civil & Structural	Foundation load drawings, GA layout, anchor bolt drawings	All civil work, sheds, platforms, drains, effluent connection
Commissioning	FAT, site commissioning, performance validation run, operator training (15 days)	Consumables (water, disinfectant) and waste feedstock for trials
Documentation	P&ID, GA drawings, O&M manual, spares list, validation report, test certificates	Client-side approvals, BMW authorisation, regulatory consents, insurance

Conclusions & Why KERONE

The KERONE-designed 500 kg/hr Continuous Microwave Biomedical Waste Sterilisation System represents a validated, commercially sound solution to one of the most persistent compliance and cost problems in India's healthcare waste sector. The process is built on rigorous KRDC laboratory data — not theoretical projections — and the industrial design directly replicates the exact process conditions that produced measurable, biologically certified results on the client's actual waste stream.

- **Proven Technology**

Every process parameter in the 500 kg/hr plant — 98–105°C, 45-minute residence, 2,450 MHz field density, modulated steam injection — is directly derived from KRDC lab trial 62/KRDC/LAB/09 on the client's actual waste composite. No extrapolation; no assumptions.

- **Quantified Outcome**

A 6.2 log₁₀ reduction of *Bacillus atrophaeus* spores against a statutory 4 log₁₀ requirement, with 82% volume reduction, are measurable and biologically certified results — not marketing claims.

- **Commercial Clarity**

The financial model demonstrates a payback period of approximately 2.0 years at conservative CBWTF tariffs, converting a high-cost incineration liability into a lower-cost, revenue-generating treatment line.

- **Compliance by Design**

HEPA H14 filtration, microwave leakage containment, electronic cycle records with five-year retention and integral shredding are built into the KERONE supply scope — the system is designed to BMWM Rules 2016 and CPCB CBWTF guidelines, not retrofitted for compliance after the fact.

- **Validation Support**

KERONE supplies complete IQ/OQ/PQ protocols, biological indicator challenge procedures and the documentation package required for SPCB authorisation and periodic revalidation — an area where most equipment suppliers leave the client unsupported.

- **Full Ownership**

KERONE designs, manufactures, supplies, installs, commissions and validates the complete plant from a single point of accountability — eliminating multi-vendor coordination risk.

- **Scalable Platform**

The microwave sterilisation platform is scalable. A 500 kg/hr system creates the reference installation for 100, 250 and 1,000 kg/hr systems serving hospitals, CBWTF operators, pharmaceutical plants and veterinary facilities across India and internationally.

ENQUIRE ABOUT YOUR HEALTHCARE WASTE STERILISATION PROJECT

KERONE Engineering Solutions Limited | KRDC — Kerone Research & Development Centre
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To initiate a project discussion, please share: waste category mix + daily tonnage + site location + required treatment standard

ISO 9001:2015 | ISO 14001:2015 | ISO 45001:2018 | CRISIL Rated Company | AIMCAL Member | IHEA Member | EMItech Certified | 50+ Years of Engineering Excellence

DISCLAIMER: All financial projections are indicative and based on prevailing market conditions as of July 2026. Process performance figures are derived from KRDC laboratory data (Report 62/KRDC/LAB/09) conducted on client-supplied biomedical waste. Client identity is withheld under a confidentiality agreement. Actual industrial performance may vary with waste composition, moisture and packing density. Statutory compliance remains subject to the applicable State Pollution Control Board authorisation. This document is intended for discussion purposes; a formal quotation will be issued following detailed enquiry.