Scientific Paper

Disposal of the large volume of sputum positive for Mycobacterium tuberculosis by using microwave sterilisation technology

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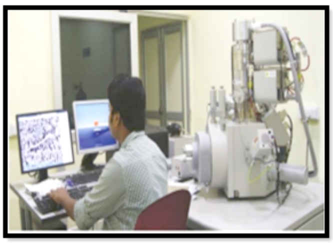

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Disposal of the large volume of sputum positive for *Mycobacterium tuberculosis* by using microwave sterilisation technology as an alternative to traditional autoclaving in a tertiary respiratory care hospital in Delhi, India

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S U M M A R Y

Background: Everyday, tuberculosis hospitals collect enormous amount of sputum containing viable *Mycobacterium tuberculosis* bacilli, the disposal of which is a challenging task. Chemical (5% phenol) and physical (autoclaving) disinfection methods involve cost, space and cause further environmental degradation. Over the years, use of microwave for sterilisation of biomedical waste has become widespread. However, its efficacy to sterilise large volume of *M. tuberculosis* positive sputum has never been investigated.
Aim: To evaluate the effectiveness of microwave in sterilising large volumes of *M. tuberculosis* positive sputum samples.
Methods: 226 sputum samples positive for *M. tuberculosis* were checked by Ziehl-Neelsen staining and liquid culture (MGIT ™) both before and after microwaving. χ^2 test was performed, and p-value <0.05 was considered significant.
Findings: Before microwaving, samples containing acid fast bacilli (AFB) and live *M. tuberculosis* bacilli were 93.8% and 95% ($\approx$94.7%) respectively; which came down to 14.2% (32) and $<$1% ($\approx$0.9%) in post microwave. In the 32 post-microwave AFB positive samples, bacilli appeared apoptotic, decreased in size, fragmented, loosely arranged and were easily missed as stain artefacts. Their beaded appearance was not appreciable. Background pus cells were of smaller size, did not take up methylene blue stain properly, and multilobed nuclear material was missing.
Conclusion: The study shows efficacy of microwave as an alternative sterilisation method for large volume sputum samples containing *M. tuberculosis* bacilli. Microwave can become an effective sterilisation method, especially for isolated tuberculosis care centres in countries which struggle for disposal of sputum, the biomedical waste.

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Introduction

Biomedical waste (BMW) management is a crucial aspect of any health care facility [1]. Nowadays, various BMW management guidelines [2,3] lay stress on the treatment of all infectious waste at the time of generation itself. For example, any blood component is initially decontaminated with 1% Sodium Hydroxide solution for 20 minutes before being discarded [4]. Similarly, sputum is to be sterilised by either autoclaving or chemically treated with 5% phenol before being discarded [4]. However, often, these wastes are generated in huge quantity or in such a condition where it is not feasible to decontaminate them at the site of generation itself. In big tuberculosis care hospitals, sputum is collected every day in copious volume. Sputum from pulmonary tuberculosis cases is dense, viscid, and sticky and has a spoiled smell. It is often teaming with *Mycobacterium tuberculosis* bacilli and may even be produced in large amount by active cases [4]. Therefore, handling and disposal of such BMW poses an administrative and environmental challenge.

Currently, available physical and chemical methods for sputum disinfection have both certain advantages and disadvantages [5]. Five per cent phenol, one of the commonest low-cost chemical disinfectants used, exhibits low biodegradability and is considered a health risk [6]. Moreover, the discarding process of this phenol becomes a challenge in itself. Autoclaving, whose setup requires space, money and rigorous quality check, is feasible only when the collection is not in significantly high amount. Furthermore, the pre-vacuum purge of autoclave air may contain live bacilli and is thus not feasible during sterilisation of semi-solid samples like sputum [7]. Very often, the use of HEPA filters and gravity cycle autoclave is limited because of the cost involved. It is to be emphasised *M. tuberculosis* is a biosafety level 3 organisms and belongs to Category C of Critical Biological Agents for public health preparedness by Centre for Disease Control and National Institute of Health [8]. Not even a single *M. tuberculosis* organism should go live into the environment after the BMW treatment because of its multi-drug resistant (MDR) and extended drug resistance (XDR) nature. Therefore, better and safer disinfection methods are required to replace them.

In the last few decades, the use of microwave radiation has gained much popularity in the medical field [9,10]. This technology is used widely for sterilisation of both laboratory items (media, plastic Petri dishes, towels and contaminated plates) [10,11] and BMW (scalpel, femoral head and dental implant sterilisation) [12,13]. Although studies have shown microwave effectiveness in killing common non-mycobacterial organisms [11,14], there is a lack of conclusive evidence about its ability to sterilise *Mycobacterium tuberculosis* bacilli, particularly when present in a large volumes of semi-solid clinical samples like sputum.

National Institute of Tuberculosis and Respiratory Diseases (NITRD), New Delhi, India, is a premier tuberculosis care institute in India. It has separate sputum sterilisation processes for the laboratory and wards. Since sputum samples received in the laboratory are very small in volume, they are first sterilised by autoclaving and then discarded. In the wards, the hospital encourages every sputum-producing patient not to spit in the open, but to collect sputum in steel cups provided free of cost. On average, around 350—400 cups, amounting to 30—35 litres sputum, are collected daily. It is a tremendous task to decontaminate such large amounts of sputum. The established method using 5% phenol would amount to using a large volume of chemical and thus more downstream environmental pollution. Likewise, the induction of a dedicated autoclave was not viable because of space and cost issues. Therefore, the hospital is currently following a very crude disposal method wherein phenol mixed sputum is poured from steel cups into a bigger steel vessel, mixed with water, heated for 15-20 minutes and then drained off in hospital drain lines for further treatment in the effluent treatment plant. It is done with the knowledge that *M. tuberculosis* is killed at 60^{0}C in 15—20 minutes [15]. Steel cups are later autoclaved and used again. Although this method is cheap and straightforward, it has many drawbacks. It requires a great deal of human manipulation and has abysmal compliance. When checked on a pilot basis, effectiveness to kill *M. tuberculosis* by this boiling method was not consistent every day.

OptiMazer™ 30 is a popular commercial microwave technology used for sterilisation of clinical biomedical waste. NITRD hospital has a dedicated 2540 MHz, 1500-Watt Microwave OptiMazer™ 30 machine. It is an automatic machine with digital display, inbuilt temperature sensors and pre-set time duration mechanisms for each stage of the sterilization cycle. It has an inbuilt mechanism which can adjust for brief power interruptions and thus does not abort the cycle if power supply is temporarily lost (a possible issue in low income countries). NITRD uses this machine for sterilization of routine (non-sputum) BMW. However, its efficacy was never determined to decontaminate large volumes of phenol mixed sputum samples. Therefore, the present study was conducted to evaluate the effectiveness of Microwave as an alternative method to autoclaving for sterilising large volumes of sputum with viable *M. tuberculosis* for safe disposal.

Methods

The prospective study was conducted in the Department of Medical Microbiology, NITRD, which has a national reference laboratory for tuberculosis diagnosis. A total of 226 consecutive sputum filled cups were collected over a four month period from patients diagnosed with active pulmonary tuberculosis. The diagnoses of these patients had already been confirmed by *Ziehl-Neelsen* (ZN) staining and cartridge-based nucleic acid tests (CBNAAT, Xpert MTB/RIF™). Every morning a new steel cup filled with 50 ml 5% phenol was given to patients and the previous days' sputum filled cups were collected back. Sputum was collected irrespective of the age, sex and previous or current comorbid conditions of the patient. Only naturally expectorated and discarded sputum was collected; patients were never asked for or were induced for sputum expectoration. To ensure no change in sputum collection habits and thus avoid any bias, patients collected sputum in routinely used steel cups and were never given plastic cups.

From every sputum filled cup, a small portion was processed by a NALC/NaOH [16] method; then tested by ZN staining and liquid culture-based method of MGIT (Mycobacterium growth Indicator tube) (BD BACTEC™ *MGIT*™) to appreciate structure and viability of *M. tuberculosis* bacilli respectively. A viability check was done because all of these patients were receiving antitubercular drug therapy, and the possibility of dead bacilli

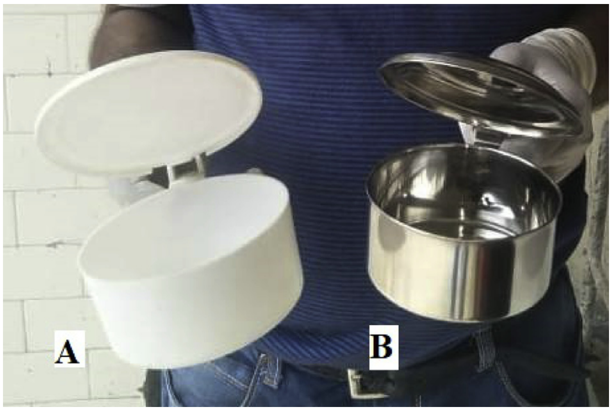

Figure 1. The cups used in the study. (A) Microwavable plastic cups, (B) Steel cups.

being expectorated in sputum could not be ignored. After this, the sputum was poured from each steel cup into a separate microwavable plastic cup and microwaved in the OptiMazer™ 30 machine according to the manufacturer's guidelines (Figure 1); steel and plastic cups were later sterilized by autoclaving and used again. The machine first sprinkled water over these loosely closed plastic cups and then operated at 2450 MHz, 1.5 KW to heat the entire load to 100^{0}C. Holding temperature and time for sterilisation were set at 100^{0}C for 30 minutes. The steps followed were according to the manufacturer's guidelines for routine BMW. Free falling loose lids over these plastic cups ensured proper steam and radiation effect. Spores of *Bacillus atrophaeus* (HiMedia Laboratories Pvt. Ltd.) were used as controls and kept alongside the sputum filled cups in the centre of the machine. Now, a small portion of this microwaved sputum was processed by NALC/NaOH [16] method; stained by ZN stain and cultured by MGIT to appreciate radiation-induced changes in the structure and viability of *M. tuberculosis* bacilli. Approximately 350–400 plastic cups were microwaved each day in 4–5 batches. Control ampoules were checked for any colour change.

All sample processing and handling techniques were done by professionals trained for *M. tuberculosis* culture under biosafety cabinets strictly according to Culture and Drug Susceptibility Testing guidelines (C & DST) published by Central Tuberculosis division [17], India. No ethical approval was conceived because the work was done on discarded sputum samples which were intended for disposal, and there was no change in sputum collection procedures for patients.

Statistical Analysis was done using SPSS version 20 (IBM®, New York, NY, USA). Chi-square test was performed, and p-value of <0.05 was considered indicative of a statistically significant difference.

Results

Out of 226 non microwaved sputum samples (Table I) collected from active pulmonary tuberculosis cases, 94.7% (214/226) were culture-positive for *Mycobacterium tuberculosis* on MGIT; however, this came down to a mere 0.9% (2/226) in post microwave samples (Table II) **(χ^2 = 16.02, p<0.05)**. Similarly, before microwaving, 93.8% (212/226) sputum samples were positive for acid-fast bacilli on Ziehl-Neelsen staining; but only 14.2% (32/226) in post-microwave samples **(χ^2 = 12.23, p<0.05)**.

The 32 AFB smear-positive post microwave sputum samples had altered image of bacilli. Compared to pre-microwaved sputum samples, where AFB was of beaded appearance and present in clumps on a background of clearly appreciable pus cells (Figure 2), AFB in post-microwaved sputum samples were of decreased size (both length and thickness), fragmented, were not in clusters and could be easily missed or ignored as stain artefacts. Also, their beaded appearance was not appreciable. The pus cells in the background were of smaller size, did not take up methylene blue stain properly, and their multilobed nuclear material was either missing or fragmented (Figure 3).

Table I
Sputum sample analysis before microwaving (n=226).

	MGIT positive	MGIT negative	Total
ZN smear positive	204 (90.3%)	8 (3.5%)	212 (93.8%)
ZN smear negative	10 (4.4%)	4 (1.8%)	14 (6.2%)
Total	214 (94.7%)	12 (5.3%)	226 (100%)

Discussion

This study was done to evaluate the effectiveness of microwave technology as an alternative sterilising method to traditional autoclaving for large volume sputum samples when collected from active pulmonary tuberculosis cases. In the present study, sputum samples were treated in an OptiMazer™ 30 with 2450 MHz, 1.5 KW microwave radiation for 45 minutes and then checked for *Mycobacterium tuberculosis* bacilli presence by *Ziehl-Neelsen* (ZN) staining and for viability by inoculating in highly sensitive MGIT™ liquid culture media. The percentage of sputum samples containing live *M. tuberculosis* bacilli came down from 95% (≈94.7%) in non-microwaved samples to <1% (≈0.9%) in post microwaved samples **(χ^2 = 16.02, p<0.05)**. Similar studies done for evaluating microwave effectiveness on non-mycobacterial organisms such as *Escherichia coli* [18,19], *Clostridium perfringens* [20], *Staphylococcus aureus* [21,22], *Salmonella* [23,24], and *Listeria* spp [25] have reported 99.99% reduction in organism count. Although quantitative studies for *M. tuberculosis* count could not be done in this study, 94% decrease in number of AFB positive sputum samples does show that microwave is useful in sterilising a large volume of sputum samples.

Radiation induces apoptosis in the cell [26,27]. The decrease in the percentage of sputum samples containing live bacilli was due to apoptotic changes occurring at the cellular level as is evident by altered size and increased fragmentation of AFB and the surrounding pus cells (Figure 3). A similar study

Table II
Sputum sample analysis after microwaving (n=226).

	MGIT positive	MGIT negative	Total
ZN smear positive[a]	2 (0.9%)	30 (13.3%)	32 (14.2%)
ZN smear negative	0	194 (85.8%)	194 (85.8%)
Total	2 (0.9%)	224 (99.2%)	226 (100%)

[a] All acid-fast bacilli had altered morphology.

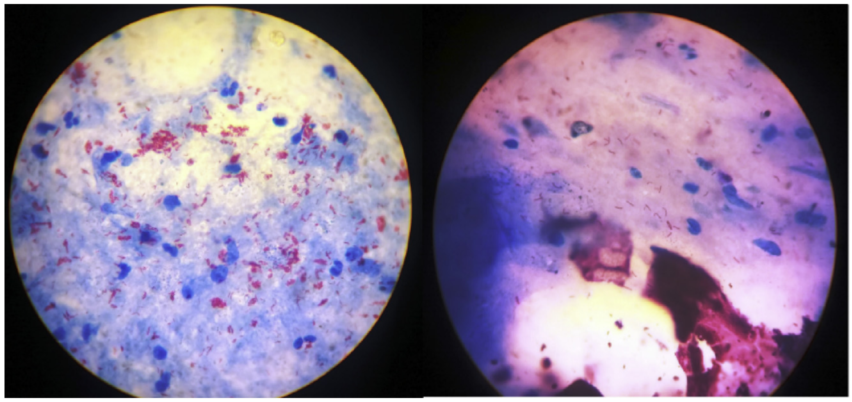

Figure 2. Pre-microwave ZN staining images showing AFB in clusters with large multilobed Pus cells in the background.

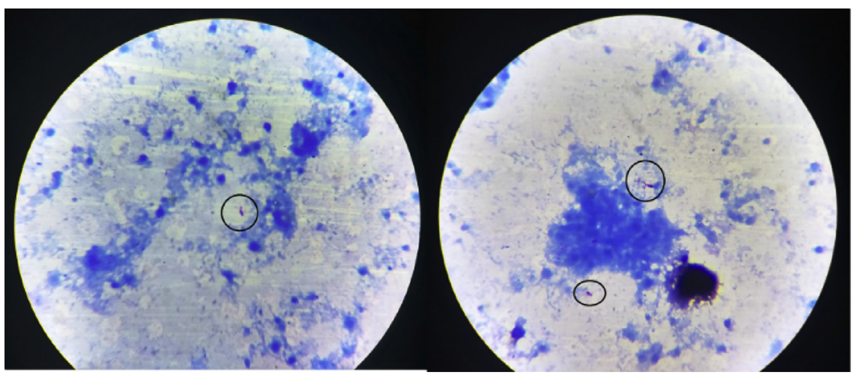

Figure 3. Post-microwave ZN staining images showing fragmented AFB of small size, and not present in clusters. In the background are the small Pus cells without multilobed nuclei.

done by *Kakita* et al. [28] on microwaved *Lactobacillus* phage PL- 1 particles also reported similar changes and proved that the effect of irradiation is more profound at the level of DNA chain. In the current study, radiation appears to break nuclear material of cells as is evident by altered nuclear material of background pus cells. However, whether this physical disruption also occurred in *M. tuberculosis* could not be proved.

The present study is more of an observational study wherein an attempt has been made to evaluate the effectiveness of commercially available microwave radiation technologies (OptiMazer™ 30) in sterilising *M. tuberculosis* positive sputum samples, especially when present in large volume. Complementing data by showing the linear relationship between microwave radiation dose and its effect on microbial load was not attempted because of lack of resources. Although the lack of resources and technological expertise did limit the use of high-end molecular techniques in knowing the exact level of apoptotic changes in *M. tuberculosis* DNA, the basic microbiological techniques of staining, culture and microscopy implemented do complement the data presented. To the best of our knowledge, this is the first study from a selected urban tuberculosis/respiratory speciality hospital of a developing country and provides an insight into the effectiveness of a commercially available microwave technology (OptiMazer™ 30) which is already being used for routine BMW while dealing with large volume sputum samples. Autoclaving issues such as long heating periods and heat loss can be bypassed by using microwave technology which runs in quick batches of small duration. This can become an effective sterilisation method, especially for isolated tuberculosis care centres in countries which struggle daily for disposal of sputum and biomedical waste.

Conflict of interest statement

The author(s) declare that there are no conflicts of interest.

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References

[1] Bhalla GS, Bandyopadhyay K, Sahai K. Keeping in pace with the new Biomedical Waste Management Rules: What we need to know! Med J Armed Forces India 2019;75(3):240–5. https://doi.org/10.1016/j.mjafi.2018.12.003.

[2] Ciplak N, Kaskun S. Healthcare waste management practice in the West Black Sea Region, Turkey: A comparative analysis with the

developed and developing countries. J Air Waste Manag Assoc 2015;65(12):1387—94. https://doi.org/10.1080/10962247.2015.1076539.
[3] Singh T, Ghimire TR, Agrawal SK. Awareness of Biomedical Waste Management in Dental Students in Different Dental Colleges in Nepal. Biomed Res Int 2018;2018:1742326. https://doi.org/10.1155/2018/1742326. Published 2018 Dec 9.
[4] Chao WC, Wu CL, Liu PY, Shieh CC. Regular sputum check-up for early diagnosis of tuberculosis after exposure in healthcare facilities. PLoS One 2016;11(6):e0157054. https://doi.org/10.1371/journal.pone.0157054. Published 2016 Jun 3.
[5] Abreu AC, Tavares RR, Borges A, Mergulhão F, Simões M. Current and emergent strategies for disinfection of hospital environments. J Antimicrob Chemother 2013;68(12):2718—32. https://doi.org/10.1093/jac/dkt281.
[6] Rutala WA. APIC guideline for selection and use of disinfectants. 1994, 1995, and 1996 APIC guidelines committee. association for professionals in infection control and epidemiology, Inc. Am J Infect Control 1996;24(4):313—42. https://doi.org/10.1016/s0196-6553(96)90066-8.
[7] Garibaldi BT, Reimers M, Ernst N, Bova G, Nowakowski E, Bukowski J, et al. Validation of autoclave protocols for successful decontamination of category a medical waste generated from care of patients with serious communicable diseases. J Clin Microbiol 2017;55(2):545—51. https://doi.org/10.1128/JCM.02161-16.
[8] Wurtz N, Papa A, Hukic M, Di Caro A, Leparc-Goffart I, Leroy E, et al. Survey of laboratory-acquired infections around the world in biosafety level 3 and 4 laboratories. Eur J Clin Microbiol Infect Dis 2016;35(8):1247—58. https://doi.org/10.1007/s10096-016-2657-1.
[9] Brondani MA, Siqueira AR. A critical review of protocols for conventional microwave oven use for denture disinfection. Community Dent Health; 2018. https://doi.org/10.1922/CDH_4372Brondani07 [published online ahead of print, 2018 Oct 16].
[10] Yezdani A, Mahalakshmi K, Padmavathy K. Orthodontic instrument sterilization with microwave irradiation. J Pharm Bioallied Sci 2015;7(Suppl 1):S111—5. https://doi.org/10.4103/0975-7406.155847.
[11] Barbosa-Cánovas GV, Medina-Meza I, Candoğan K, Bermúdez-Aguirre D. Advanced retorting, microwave assisted thermal sterilization (MATS), and pressure assisted thermal sterilization (PATS) to process meat products. Meat Sci 2014;98(3):420—34. https://doi.org/10.1016/j.meatsci.2014.06.027.
[12] Sabnis RB, Bhattu A, Vijaykumar M. Sterilization of endoscopic instruments. Curr Opin Urol 2014;24(2):195—202. https://doi.org/10.1097/MOU.0000000000000034.
[13] Dunsmuir RA, Gallacher G. Microwave sterilization of femoral head allograft. J Clin Microbiol 2003;41(10):4755—7. https://doi.org/10.1128/jcm.41.10.4755-4757.2003.
[14] Welt BA, Tong CH, Rossen JL, Lund DB. Effect of microwave radiation on inactivation of Clostridium sporogenes (PA 3679) spores. Appl Environ Microbiol 1994;60(2):482—8.
[15] Doig C, Seagar AL, Watt B, Forbes KJ. The efficacy of the heat killing of Mycobacterium tuberculosis. J Clin Pathol 2002;55(10):778—9. https://doi.org/10.1136/jcp.55.10.778.
[16] Reid M, Arinaminpathy N, Bloom A, Bloom BR, Boehme C, Chaisson R, et al. Building a tuberculosis-free world: The Lancet Commission on tuberculosis. Lancet 2019;393(10178):1331—84. https://doi.org/10.1016/S0140-6736(19)30024-8.
[17] Central TB Division Directorate. Revised national TB control programme training manual for Mycobacterium tuberculosis culture & drug susceptibility testing. New Delhi: Cent TB Div Dir Gen Heal Serv Minist Heal Fam Welfare, Nirman Bhawan; 2009. p. 76. https://tbcindia.gov.in/showfile.php?lid=2991.
[18] Huang L, Sites J. New automated microwave heating process for cooking and pasteurization of microwaveable foods containing raw meats. J Food Sci 2010;75(2):E110—5. https://doi.org/10.1111/j.1750-3841.2009.01482.x.
[19] Benjamin E, Reznik A, Benjamin E, Williams AL. Mathematical models for conventional and microwave thermal deactivation of Enterococcus faecalis, Staphylococcus aureus and Escherichia coli. Cell Mol Biol (Noisy-Le-Grand) 2007;53(3):42—8. 2007 May 15.
[20] Ojha SC, Chankhamhaengdecha S, Singhakaew S, Ounjai P, Janvilisri T. Inactivation of Clostridium difficile spores by microwave irradiation. Anaerobe 2016;38:14—20. https://doi.org/10.1016/j.anaerobe.2015.10.015.
[21] Khalil H, Villota R. Comparative study on injury and recovery of *Staphylococcus aureus* using microwaves and conventional heating. J Food Prot 1988;51(3):181—6. https://doi.org/10.4315/0362-028X-51.3.181.
[22] Khalil H, Villota R. The Effect of Microwave Sublethal Heating on the Ribonucleic Acids of Staphylococcus aureus. J Food Prot 1989;52(8):544—8. https://doi.org/10.4315/0362-028X-52.8.544.
[23] Kim SS, Sung HJ, Kwak HS, Joo IS, Lee JS, Ko G, et al. Effect of power levels on inactivation of *Escherichia coli* O157:H7, *Salmonella Typhimurium*, and *Listeria monocytogenes* in tomato paste using 915-Megahertz microwave and ohmic heating. J Food Prot 2016;79(9):1616—22. https://doi.org/10.4315/0362-028X.JFP-16-044.
[24] Köhler B, Hübner H, Krautschick M. Die Nutzung ionisierender Strahlen zur Dekontamination von salmonellenhaltigen Broilerschlachtkörpern und Eipulver [The use of ionizing radiation for the decontamination of salmonella-containing slaughtered broiler chickens and powdered eggs]. Z Gesamte Hyg 1989;35(11):665—8.
[25] Coote PJ, Holyoak CD, Cole MB. Thermal inactivation of Listeria monocytogenes during a process simulating temperatures achieved during microwave heating. J Appl Bacteriol 1991;70(6):489—94. https://doi.org/10.1111/j.1365-2672.1991.tb02745.x.
[26] Zhou L, Yuan R, Serggio L. Molecular mechanisms of irradiation-induced apoptosis. Front Biosci 2003;8:d9—19. https://doi.org/10.2741/927. 2003 Jan 1.
[27] Eriksson D, Stigbrand T. Radiation-induced cell death mechanisms. Tumour Biol 2010;31(4):363—72. https://doi.org/10.1007/s13277-010-0042-8.
[28] Kakita Y, Kashige N, Murata K, Kuroiwa A, Funatsu M, Watanabe K. Inactivation of Lactobacillus bacteriophage PL-1 by microwave irradiation. Microbiol Immunol 1995;39(8):571—6. https://doi.org/10.1111/j.1348-0421.1995.tb02244.x.

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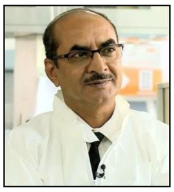

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Dr. Aruna Sharma IAS
Erstwhile Secretary
MeitY- Ministry of Electronics
& Information Technology

"Amongst the various methods... Incineration, Autoclaving, Deep burial, Microwave offers many advantages. The system developed has been validated for its efficacy at Haffkine's Institute, Mumbai- a leading Microbiology Test lab in the country."

Mr. B.M. Baweja
Senior Director (Retd.)
MeitY, GOI

"In order to promote "Make in India" & "Swachh Bharat Abhiyan" flagship programmes, and make these a success, there is immediate need for encouraging the above indigenous technology developed by Govt. of India R&D organization."

Dr. Charoo Hans
Head- Microbiology (Retd.)
RML Hospital, New Delhi

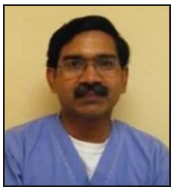
"RML had installed Austrian microwave disinfection system in the 90's. OptiMaser ups the technology with its mobility emission free, 1KW/hour usage & IOT. I am sure that this technology is the future of disinfection & sterilization."

FORSTA™ MEDTECH

OptiMaser®

PATENTED | AFFORDABLE | PLUG-N-PLAY | MOBILE

What experts say about OptiMaser® Microwave Technology...



Dr. V.P. Meenayadu
Department of Microbiology,
NITRD, Delhi

"Microwave can become an effective sterilisation method, especially for isolated tuberculosis care centres in countries which struggle for disposal of sputum, the biomedical waste".

Mr. Mahesh Nakarmi
Director
Healthcare Foundation, Nepal HECAF

"Nepal is very progressive in Infection & Epidemic Control with latest technology & experts constantly working to improve the National healthcare. OptiMaser's microwave technology can effectively be used for pre-treatment & disinfection of blood bags & other medical waste. OptiMaser's proposed dialyser disinfection has tremendous potential in reducing cost of treatment & reuse."

Dr. Parmeshwar Kumar
Asstt. Prof., Hospital Administration
AIIMS, New Delhi

"The microwave scenario was superior since its waste treatment equivalent cost was INR 9.18 per kg of waste instead of the autoclave scenario (INR 84.16 per kg of waste) and lime scenario (INR 117.05 per kg of waste)".

Dr. Shobini Rajan
Asstt. Director General (BTS)
& Director (NBTC)

"Considering the fact that blood bags cannot be chemically pre-treated, microwave may also be adopted by blood banks as a method for pre-treatment of blood bags".

Mr. Gary Box
Biomedical Waste Expert
United Kingdom

"OptiMaser® has tremendous potential in the European markets where environment & technology synthesis is the Ethos of any successful product."

Dr. Vamsi Krishna Reddy
Senior Resident
AIIMS, New Delhi

"Use of Microwave will bring new insight into how to replace the 100-year-old legacy of employing outdated methods with innovative microwave aided disinfection to battle hospital acquired infections and secondary infections caused by improper or inadequate solid waste disposal".

FORSTA™
MEDTECH

A P P L I C A T I O N S

WORLD'S FIRST MOBILE MEDICAL INFECTION CONTROL SYSTEM

- Microbiology Labs
- Isolation Wards
- CHC / PHC
- OPDs / OTs
- Clinics

- District Hospitals
- Medical Colleges
- Tertiary Centres
- Private Hospitals
- Blood Banks
- Dialysis Centres

- CBWTFs
- Medical Colleges
- Multi OT Hospitals
- Tertiary Centres
- Pharma Companies
- 500 +Modular Usage

Advantages of Integrated ONLINE Shredder:

- Versatile
- Solar Power Connectivity
- Total Infection Control
- Ease of Storage
- Low Down time
- Low Power Consumption
- Low Maintenance
- Easy to Clean

Capacity	:	10/20/30 Kg/hr	Rotor Diameter	:	150
Blades	:	Stainless Steel 316	Throat Size	:	250 X 280
Number of Blades	:	10	Sieve Hole Size	:	12 mm
Feed Width	:	250 X 280 mm	Control Panel	:	YES
Blade Length	:	250 mm	Speed of Rotor	:	<100 RPM
Number of Motors	:	ONE	Automation	:	Semi-Automatic

C O N S U M A B L E S

Contagious Waste Disinfection | Medical Waste Disinfection | O.T. Linen Disinfection | Dialyzer Sterilization & Reuse | O.T. Instrument Sterilization | Catheters, tubings Sterilization & Reuse | Veterinary Waste Disinfection

सत्यमेव जयते
(DietY)
Govt. of India ToT Project

MAKE IN INDIA

- Approved by CPCB / MoEF from Medical Waste Management
- In compliance with Latest 2018 BMW Management Rules
- Ultimate solution for Medical Waste Management

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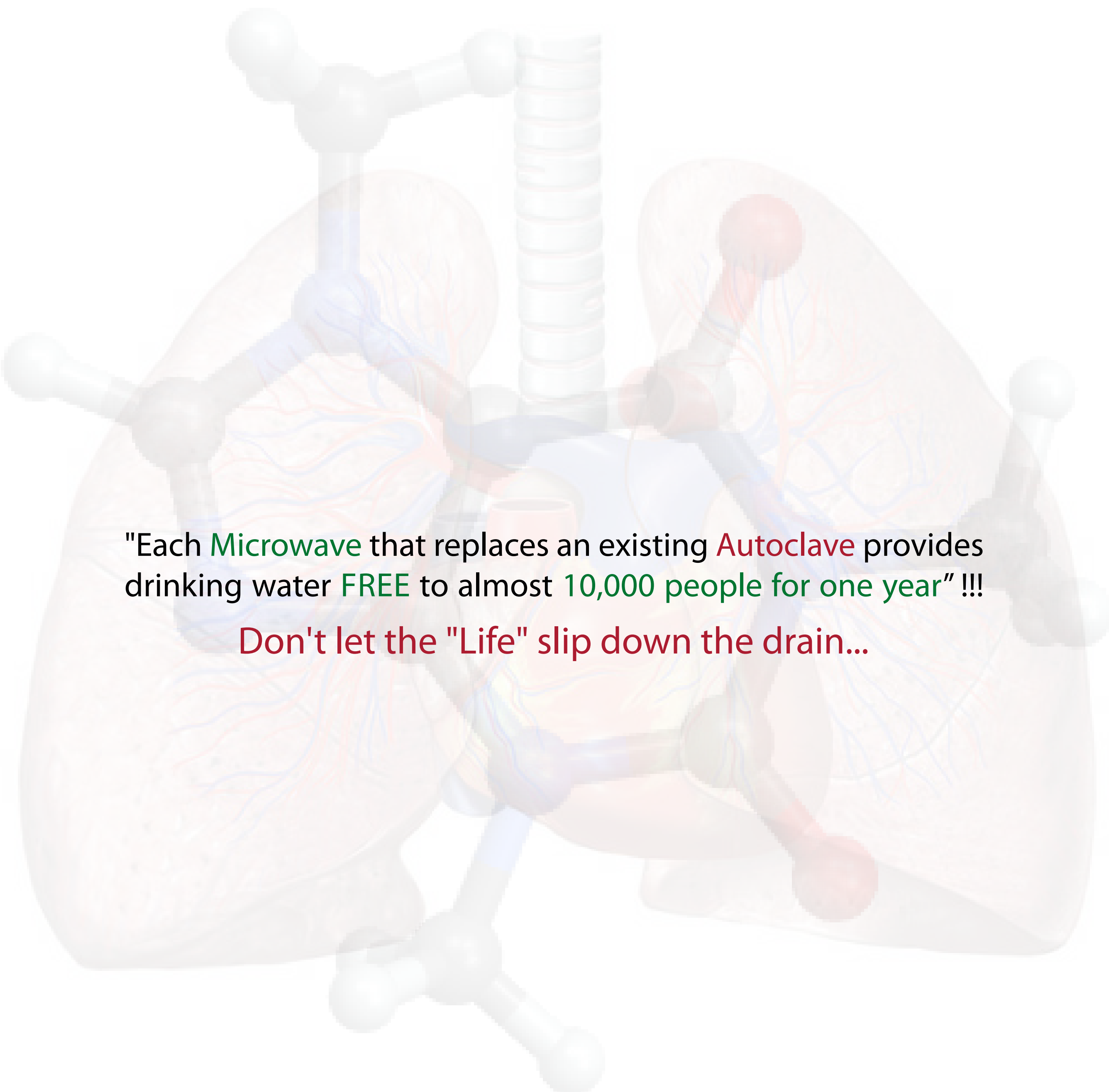

"Each Microwave that replaces an existing Autoclave provides drinking water FREE to almost 10,000 people for one year" !!!

Don't let the "Life" slip down the drain...

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OptiMaser Research, Development & Incubation Centre:
Microwave Assisted Clinical Translation Research Program

FORSTA™ MEDTECH

Translational Research Program

AMTZ-Andhra Pradesh Medtech Zone Ltd.
C/o STERILA, Survey No. 480/2, Nadupuru Village,
Pedagantyada Mandal, Visakhapatnam