C. V of Dr. Lakshminarayana Rao

1. Research and Education Details

Associate Professor, IISc, Bangalore 2022 to date

- Working on green steel applications via syngas produced from gasification/co-gasification of biomass/municipal solid waste
- Working in the field of cold plasma science and technology in the areas of renewable energy and wastewater treatment and recycling
- Graduated 4 PhD students as main guide, 5 PhD students as co-guide. Currently supervising 3 Ph.D. students as the main guide and 4 Ph.D. students as Co-Guide
- 101 peer-reviewed international journal articles, 50 conference proceedings, 2 book chapters, 10 granted patents, and 1 patent application submitted. One technology transfer ongoing.
- Have secured funding of Rs 12.35 Crores (1.48 million USD) as Principal investigator and Rs 22.5 Crores (3 Million USD) as Co-Principal Investigator
- Societal impact of the research: work has resulted in a large-scale water recycling project for the state which is benefitting 20 Lakh (2 Million) farmers

Assistant Professor, IISc, Bangalore India 2016 to 2022

- Working in the field of cold plasma science and technology in the areas of renewable energy and wastewater treatment and recycling
- Graduated 2 Master's students.

Unilever Research Center, Bangalore India 2014 to 2016

- Research scientist – Strategic Science group working in the area of cold plasma consumer applications in the field of air and water hygiene and water saving programs

Industrial Research, PyroGenesis Canada Inc., Montreal, Canada 2010 to 2014
NSERC Industrial R & D Fellowship, PyroGenesis Canada Inc., Canada 2008 to 2010

- Led a thermal plasma torch developmental program which included physical experiments and 3D steady state mathematical modeling of a thermal plasma torch. Conducted physical experiments on a 150 kW plasma torch system to improve its life. The work resulting in an improved life of the plasma torch from 150 hrs to 1000 hrs.
- Chief scientist for the development of 'Steam Plasma Arc Hydrolysis System' for destruction of Ozone Depleting Substances. Successfully designed, constructed and performed proof of concept testing on a 2 kg/hr system to achieve 99.9999% destruction and removal efficiency, with R-12 as the feed material. Led the scale up effort for a 50 kg/hr commercial system.

- Design and development of high power thermal plasma torches ranging from 30 kW to 750 kW gross power. This work so far has led to two products & three patent applications.
- Development of thermal plasma waste to energy system.
- Led all contract research efforts undertaken by PyroGenesis Canada Inc.

Ph.D. Chemical Engineering 2004-2007
McGill University, Montreal, Canada. CGPA 4.0 out of 4.0

- Thesis work: Effect of Cathode Microstructure on Erosion of Copper Cathodes - An Experimental Study.
- Plan, produce and characterize nano-structured cathodes in close collaboration with the Industrial Materials Institute, a research lab of the National Research Council of Canada.
- Established qualitative and quantitative relationship between cathode microstructure and arc electrode erosion rate. Established that coatings with smaller grain sizes having 900 to 1500 micron grain size result up to 70% lower erosion rates compared to regular copper having 20 to 23 micron grains.
- Contributed towards fundamental understanding of atmospheric pressure arc movement and existence/movement of cathode spots.
- The work resulted in six journal publications.

M.Sc(Eng). Dept. of Metallurgy 2002-2004
Indian Institute of Science, Bangalore, India. CGPA 6.2 out of 8.0

- Thesis work: Mathematical and Physical Modeling of Boron Carbide Manufacturing Process.
- Design, development, procurement, installation, and troubleshooting of a 80 kilowatt Boron Carbide reactor (100 kg/batch) and its accessories.
- Mathematical modeling and numerical simulation of the process.
- Conducted physical experiments to validate the modeling results and established that the modeling results correlated with the experimental observations.
- Graduated with the best outgoing thesis of the year.
- The work resulted in two journal publications.

B.E. Chemical Engineering 1996-2000
Bangalore University, Bangalore, India. Overall average of 79.8%

- Graduated with distinction. Received University's 10th rank medal out of 500 students graduating for the year 2000.

2. Awards and Prizes

1. Industrial Research and Development Fellowship (30,000 $/yr), NSERC 2008-2010
2. W.H. Gauvin Graduate Fellowship (15,000 $/yr), McGill University 2004-2005
3. McGill Graduate Studies Fellowship (19,000 $/yr), McGill University 2005-2006
4. McGill Graduate Studies Fellowship (24,000 $/yr), McGill University 2006-2007
5. McGill Graduate Award (5,000 $), McGill University 2006
6. Graduate Student Research Scholarship (72,000 Rs./yr), IISc 2002-2004
7. Medal for the best outgoing thesis of the year 2004-2005, IISc 2005

Research Guidance

1. Graduated 2 Master's and 4 PhD. Currently supervising 3 PhD students as a main guide and 6 PhD students as Co-Guide.

2. At PyroGenesis Canada Inc, I have lead an active research team of five people comprising of two process technicians, one post doctoral student completing his post doctoral fellowship, one chemical engineer with Masters Degree and one automation engineer with a bachelor's degree.

3. Research Expertise and Technical Skills

- Expertise in plasma reformers and ozonators
- Expertise in modelling of sewage treatment plants
- Expertise on design of plasma torches and plasma systems
- Expertise on design of refractory lined reactors
- Expertise on working with high power transformers and rectifiers
- Experience in installation and aligning of industrial CO_2 pulsed laser system.
- Proficient with characterization of plasma sprayed and HVOF sprayed coatings.
- Experience in design and development of data acquisition systems using NI Lab view.
- Adept in various material characterization tools : FESEM, EDS, AFM, XRD, Optical microscopy, high speed CCD camera imaging, Particle size distribution analysis and Two color pyrometer.
- Fluent with programming languages such as Matlab, Visual Fortran and Fluent.
- Teaching experience in Mathematical Analysis of Experimental Data and Design Principles in Environmental Engineering Courses.

3.1 Personal Details

Date of Birth	:	28th of November 1978
Marital Status	:	Married
Nationality	:	Indian

Dr. Lakshminarayana Rao - List of Publications

Journal Publications- Accepted/Published

1. Singh, P., Babu, G. S., Hoysall, C., & Rao, L. (2027). Comparative life cycle and techno-economic assessment of waste-to-energy plant with carbon capture, storage and utilization in the Indian context. *Fuel*, *429*, 140960. https://doi.org/10.1016/j.fuel.2026.140960

2. Verma, K., Das, R., Rathod, R. S. B., Nisanth, V., Rao, L., & Gupta, S. (2026). A sustainable approach to reuse treated wastewater in construction and its effect on cement mortar strength. *Environment, Development and Sustainability*, 1-22. https://doi.org/10.1007/s10668-026-07863-8

3. Mukherjee, Debapriya, Pallab Ghosh, Raju S. Rajmani, Kavita Verma, Akhil Gowda, Apoorva Birua, Lakshminarayana Rao, and Dipshikha Chakravortty. "Efficient Elimination of Microbial Infections in Wounds Using Plasma-Activated Water Hydrogel." ACS Pharmacology & Translational Science (2026). https://pubs.acs.org/doi/full/10.1021/acsptsci.6c00097

4. Pathak, Ram Mohan, Chinmaya Ranjan Das, and Lakshminarayana Rao. "Role of Flow Regime and Swirl-Induced Electric Field Enhancement in Dry Methane Reforming Using a Rotating Gliding Arc Reactor." *Industrial & Engineering Chemistry Research* (2026). https://pubs.acs.org/doi/full/10.1021/acs.iecr.6c00346

5. Athreya, Siva, Farah Ishtiaq, Tarun Khandelwal, Chitra Pattabiraman, Lakshminarayana Rao, Rajesh Sundaresan, and Reshma Mohan Thattaramppilly. "Localized wastewater surveillance showed correlation but no early warning during Bengaluru's Omicron wave." *PLOS Global Public Health* 6, no. 4 (2026): e0004684. https://journals.plos.org/globalpublichealth/article?id=10.1371/journal.pgph.0004684

6. Manisha, Manjari, Kavita Verma, Ramesh Narayanaswamy, Santrupt Raju Marigoudar, Sushma Krishna, Krishna Munivenkatappa, Chanakya Hoysall, and Lakshminarayana Rao. "Assessing public health impact of indirect groundwater recharge with recycled water in semi-arid regions." *Environmental Monitoring and Assessment* 198, no. 4 (2026): 364. https://link.springer.com/article/10.1007/s10661-026-15164-w

7. Chakraborty, Abhishek, M. Sekhar, and Lakshminarayana Rao. "Assessment of district scale ecosystem health in India using multi decadal carbon and water use efficiencies." *Discover Geoscience* 4, no. 1 (2026): 113. https://link.springer.com/article/10.1007/s44288-026-00473-x

8. Verma, Kavita, Manjari Manisha, Mohan Kumar, Chanakya HN, and Lakshminarayana Rao. "Sustainable Practices to Combat Water Crises: Assessing Impacts of Direct Recycled

Water Versus Indirectly Recharged Groundwater on Agroecosystem Health." *Groundwater for Sustainable Development* (2026): 101604.
https://doi.org/10.1016/j.gsd.2026.101604

9. Tripathi, Priyanka, and Lakshminarayana Rao. "Downdraft Gasification of Refuse-Derived Fuels with Different Plastic Content." *Waste and Biomass Valorization* 17, no. 2 (2026): 1011-1028.
https://link.springer.com/article/10.1007/s12649-025-03170-x

10. Kumar, Prince, GL Sivakumar Babu, and Lakshminarayana Rao. "Improved Methane Estimations from Landfills Using a Multicomponent Multiphase Methane Generation Model Based on Three-Phase Degradation Kinetics." *Journal of Hazardous, Toxic, and Radioactive Waste* 30, no. 1 (2026): 04025044.
https://doi.org/10.1061/JHTRBP.HZENG-1548

11. Das, Reshmi, Kavita Verma, YJ Pavan Kumar Reddy, and Lakshminarayana Rao. "Smart and sustainable approaches for self-sufficiency: Modeling energy-efficient effluent treatment and water conservation in the pharmaceutical industry." *Science of The Total Environment* 1007 (2025): 180911.
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12. Singh, Prakash, GL Sivakumar Babu, Chanakya Hoysall, and Lakshminarayana Rao. "Assessing biogas valorization from municipal organic waste in India: Integrated environmental-economic analysis." *Bioresource Technology* (2025): 133675.
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13. Verma, Kavita, Reshma Mohan Thattaramppilly, Anshika Mishra, Rohan HS, Hitaishi Ramesh, Suneethi Sundar, Pandian Ganesh Kumar, Vijaysai Prasad, and Lakshminarayana Rao. "Assessing microbial biofilm growth on textile media and its efficiency for wastewater treatment." *Science of The Total Environment* 1004 (2025): 180784.
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14. Mukherjee, D., P. Ghosh, R. S. Rajmani, K. Verma, A. Gowda, A. Birua, L. Rao, and D. Chakravortty. "Plasma-activated water hydrogel enables effective clearance of wound-associated microbial infections." (2025).
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15. Balakrishnan, Indumathy, Ananthanarasimhan Jayanarasimhan, Lakshminarayana Rao, Suraj Kumar Sinha, and Yugeswaran Subramaniam. "Correction to: Effect of Argon in Nitrogen Gliding Arc Plasma for Ammonium Ions Enrichment in Water." Plasma Chemistry and Plasma Processing 45, no. 6 (2025): 2045-2045.
https://link.springer.com/article/10.1007/s11090-025-10605-9

16. Balakrishnan, Indumathy, Ananthanarasimhan Jayanarasimhan, Lakshminarayana Rao, Suraj Kumar Sinha, and Yugeswaran Subramaniam. "Effect of Argon in Nitrogen Gliding

Arc Plasma for Ammonium Ions Enrichment in Water." Plasma Chemistry and Plasma Processing 45, no. 6 (2025): 2031-2043.
https://link.springer.com/article/10.1007/s11090-024-10473-9

17. Das, Reshmi, Vishnudatha Venu, and Lakshminarayana Rao. "Total Suspended Solids as a Simplified Metric for Predicting Optimized Dissolved Oxygen in Wastewater Treatment: Comparing Process-Based and Artificial Neural Network Models." *Chemical Engineering and Processing-Process Intensification* (2025): 110599.
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18. Manisha, Manjari, Kavita Verma, H. N. Chanakya, M. S. Mohan Kumar, and Lakshminarayana Rao. "Securing India's Water Future Using Treated Wastewater: A Need for Groundwater Recharge Standards." *Water Resources* 52, no. 5 (2025): 1011-1033.
https://doi.org/10.1134/S0097807824606228

19. Tripathi, Priyanka, and Lakshminarayana Rao. "Combustion characteristics of refuse-derived fuel pellets having varying plastic compositions." Environmental Science and Pollution Research 32, no. 42 (2025): 24128-24140.
https://link.springer.com/article/10.1007/s11356-024-33779-9

20. Chakraborty, Abhishek, Muddu Sekhar, Soumendra N. Bhanja, and Lakshminarayana Rao. "Linking groundwater variability to ecosystem carbon and water use efficiencies across India." *Ecological Informatics* (2025): 103411.
https://doi.org/10.1016/j.ecoinf.2025.103411

21. Boopathy, Bhavadharini, and Lakshminarayana Rao. "VR, AR and MR in Consumer Behaviour Studies." *Engineering Innovations in Sensory Science* (2025): 284.

22. Manisha, Manjari, Kavita Verma, H. N. Chanakya, and Lakshminarayana Rao. "Reuse of Treated Wastewater: A Key Driver for Achieving All Sustainable Development Goals." *Journal of the Indian Institute of Science* (2025): 1-33.
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24. Tripathi, Priyanka, and Lakshminarayana Rao. "Downdraft Gasification of Refuse-Derived Fuels with Different Plastic Content." *Waste and Biomass Valorization* (2025): 1-18.
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25. Pathak, Ram Mohan, Chinmaya Ranjan Das, and Lakshminarayana Rao. "Chemical Kinetics Simulation of Toluene Dissociation With Diluted Nitrogen in a Rotating Gliding Arc Discharge: A Simulation Study." *IEEE Transactions on Plasma Science* (2025).
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26. Pathak, Ram Mohan, J. Ananthanarasimhan, Sounak Nandi, Chinmaya Ranjan Das, and Lakshminarayana Rao. "Investigating flow-induced changes in coaxial cylindrical dielectric barrier discharge using equivalent circuit modelling and chemical workbench simulations." *Plasma Chemistry and Plasma Processing* 45, no. 3 (2025): 795-828. https://doi.org/10.1007/s11090-025-10545-4

27. Pathak, Ram Mohan, and Lakshminarayana Rao. "Effect of Enhanced Rotation on Electrical, Optical, and Chemical Properties in Nitrogen Rotating Gliding Arc." *Plasma Processes and Polymers* (2025): e70021. **https://doi.org/10.1002/ppap.70021**

28. Latha, Gali Madhavi, Lakshminarayana Rao, and R. Venkataraghavan. "Guest Editorial: Sustainable Technologies (Part 2: CST)." *Journal of the Indian Institute of Science* (2025): 1-2. https://link.springer.com/article/10.1007/s41745-025-00467-7

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30. Pathak, Ram Mohan, and Lakshminarayana Rao. "Improving Hydrogen Production in Plasma-Assisted Bi-Reforming of Methane: Experimental Study in Rotating Gliding Arc Plasma Reactor." In *Journal of Physics: Conference Series*, vol. 2968, no. 1, p. 012005. IOP Publishing, 2025.

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32. Punith, N., Athreya V. Avaneesh, Boggavarapu Prasad, R. V. Ravikrishna, and Lakshminarayana Rao. "Unveiling the Impact of Operating Current on Active Species Generation in Pin-to-Water Plasma Activated Water System." *Plasma Processes and Polymers* 22, no. 1 (2025): 2400190.

33. Latha GM, Rao L, Venkataraghavan R. Guest Editorial: Sustainable Technologies (Part 1: ASTRA), *Journal of the Indian Institute of Science,* 2024, Nov 11:1-2. https://doi.org/10.1007/s41745-024-00450-8

34. Das R, Ananthanarasimhan J, Rao L. "PFAS" Exploring the Origins, Impact, Regulations and Remediation Technologies—An Overview. *Journal of the Indian Institute of Science. 2024* Oct 12:1-4. https://doi.org/10.1007/s41745-024-00442-8

35. Punith, N., Athreya V. Avaneesh, Boggavarapu Prasad, R. V. Ravikrishna, and Lakshminarayana Rao. "Unveiling the Impact of Operating Current on Active Species Generation in Pin-To-Water Plasma Activated Water System." *Plasma Processes and Polymers,* 2024 : e2400190.
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36. Manjari, Manisha, Kavita Verma, Anirudha Tadpatri Pranesh, Santrupt Raju Marigoudar, Chanakya Hoysall, and Lakshminarayana Rao. "Achieving water security in India through sustainable wastewater reuse: The roles of policy, politics, and people." *Utilities Policy*, 90. 2024, 101814.
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37. Manisha, Manjari, Kavita Verma, Ramesh Narayanaswamy, Santrupt Raju Marigoudar, N. Chanakya Hoysall, and Lakshminarayana Rao. "Role of indirect groundwater recharge using recycled water in promoting food security in semi-arid regions." *Environment, Development and Sustainability*, 2024, 1-33.
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38. Manisha, Manjari, Kavita Verma, N. Ramesh, T. P. Anirudha, R. M. Santrupt, H. N. Chanakya, Balachandra Patil, Mohan Kumar, and Lakshminarayana Rao. "Cost-benefit Analysis of Large-Scale Recycling of Treated Wastewater for Indirect Groundwater Recharge in a Semi-arid Region." *Groundwater for Sustainable Development*, 2024, 101284.
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45. Jayanarasimhan, Ananthanarasimhan, Pathak Ram, Shivapuji, Anand, and Rao, Lakshminarayana, Tar formation in gasification systems: A holistic review of remediation approaches and removal methods, ACS omega, 2024
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51. Reshmi Das, Chanakya H N, and Lakshminarayana Rao, Unveiling the Origin, Fate, and Remedial Approaches for Surfactants in Sewage-fed Foaming Urban (Bellandur) Lake, *Environmental Pollution*, 2023, 122773

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