Title: Open uncontrolled burning of plastic waste – measuring / modelling prevalence, emissions and impacts on climate change and human health exposure

Supervisor (primary): Dr. Costas Velis, Department of Civil and Environmental Engineering

Supervisors (co): To be selected across Imperial, based on the specific topic focus (modelling/ field/ laboratory/ desk-based: AI) decided together with the suitable PhD candidate

Background: Solid waste management remains a major sustainability challenge globally, and especially in the Global South, where substantial quantities of (uncollected) waste are often set in fire as a means of disposal or resource recovery.

This practice of 'open uncontrolled burning' is much more prevalent and multi-faceted than it was perceived: our recent global model of plastic pollution SPOT, released in *Nature* (Cottom et al., 2024), showed that it is the prominent form of leaking plastics into the environment. Open burning is characterised by lack of any major engineering means of controlling the process, and therefore the outcome is extremely damaging to the environment and human / public health (Velis and Cook, 2021).

Multiple venerable receptors are exposed to hazardous emissions from burning, from the informal waste workers (waste pickers who may reclaim materials in a dumpsite, to communities living downwind. Preliminary assessments have revealed that waste could be causing around 270,000 premature deaths globally each year (Kodros, 2016). It contributes to the regional air pollution, for example it is estimated that the open burning of waste will become India's main source of air pollution by 2035 (Sharma et al., 2022).

Open burning also is responsible for the emission of major greenhouse gas pollutants, including black carbon, contributing to climate change. New concerted efforts to understand and mitigate open burning of waste, including the most damaging plastics such as PVC, are in place, including, those of the Royal Academy of Engineering in the UK, as part of the wider project Engineering X – a new research agenda was set out by our relevant report: Cook and Velis (2021).

The banning of open burning is also featuring in the drafts negotiated at the United Nations for a global treaty to end plastic pollution. However, major scientific uncertainties prevail for the topic of open uncontrolled burning, which stop us from understanding the extent of damage caused, possible effective mitigation measures and monitoring of progress towards its elimination.

Project description: Core areas where this PhD research could focus are: Creating new conceptual framework and typology to explain and typify the multiple variations of open uncontrolled burning, from pits outside households to dumpsites. In all cases revisiting

the basic science (chemistry, combustion conditions, associated emissions) is anticipated. More emphasis can be put then in specific sub-topics such as:

- Developing new sensor and AI driven satellite- / drone-based methodologies and methods to detect and quantify open burning, combined with on the ground validation protocols.
- Developing new scientifically robust models to quantify the climate forcing (change, heating) associated with GHG emitted by open burning of solid waste, with emphasis on plastics pollution and black carbon.
- Developing new external exposure models to quantify the human exposure to toxic and wider harmful chemical / and particulate matter emissions from open burning of solid waste, with emphasis on plastics pollution – setting a more robust basis for assessing harm to human health (global burden of health). Linking such models to local air quality assessment and monitoring.
- Developing new comprehensive theory of change and associated locally adapted action plans, policy and engineering interventions towards eliminating open uncontrolled burning, also via sound waste and resource management practices, including introducing waste collection where it is not available.

Given these many knowledge gaps regarding open burning, there is flexibility in customising the project on the skillset of the right PhD candidate.

Our research team and environment: As a PhD student, you will be joining our research team on waste, resources recovery and circularity, based at the Department of Civile and Environmental Engineering with links access Imperial and working across the world. We rely on core deep disciplinary expertise but work in teams that go well beyond disciplines (interdisciplinary / transdisciplinary / convergence science). Underpinned by Imperial's strategy *Science for Humanity*, our aspiration to make bold scientific contributions and enable step changes on major environmental and wider sustainability challenges of or times.

You will be immersed in a wider network of postdocs, PhD/MSc/UG students and benefit for unparalleled personal development opportunities at Imperial College London. You will directly benefit from, and contribute to, our research team ethos of worldwide excellence and genuine collaboration and mutual support: working hard, while genuinely enjoying this exploration, innovation, and personal development journey.

Who we are looking for: You are an exceptionally skilled and enthusiastic researcher, sharing the same values and ethos: We look for highly internally motivated students, aiming at addressing major scientific and engineering challenges, with substantial potential to rapidly change the world around us. Independent thinkers, able to generate and investigate ideas out of the box, fast learners able to seek and combine multiple strands of scientific information, and rapidly pick new skills, with aptitude for abstract

thinking and passionate about measurement and quantification. Willing to go the extra mile and keen on benefiting from the endless developmental opportunities and massively enabling environment of Imperial.

Start date: The start date of the position is flexible – ideally as soon as possible.

Applicant requirements:

1. First class degree (or international equivalent) in engineering or science, ideally including some good amount of mathematical (systems / statistics) and programming (coding), along with some core understanding of chemistry/ materials science.

General examples: Data Science / AI, Mathematics, Materials science, Physics, Computer Science, Chemistry, Chemical/ Environmental Engineering, Environmental Science.

2. Some expertise in any of combustion / chemistry / physics / air pollution at MSc or MEng level would be particularly beneficial for this post. Non-essential, but highly desirable for a competitive candidate.

3. Evidence of strong wider interest in research on pollution/ sustainability/ circularity.

4. Evidence of excellent technical writing and wider communication skills in English (ideally demonstrated by being first author of high-quality research outputs).

How to apply: Applicants wishing to be considered for this opportunity please send the following application documents to **Dr. Costas Velis (c.velis@imperial.ac.uk):**

1. Current CV including degree result and, if possible, class ranking
2. Cover Letter (1 page) explaining your motivation
3. Contact details of two academic referees

Application via the Imperial College Registry is not necessary at this stage.

Applications will be regularly reviewed until the position(s) in the research group are filled.

Funding: There is one potential studentship in my research team available which would provide funding for 3.5 years including tuition fees and a tax-free stipend at the standard UKRI London rate. Full funding is available to Home (UK) students. The funding can also be used to partly support an international student.

Applicants interested in this project are also welcome to apply if they intended to seek funding via scholarship schemes (Search our scholarships | Study | Imperial College London) or can self-fund.

References:

Cook, E., Velis, C.A., 2021. Global review on safer end of engineered life. London, UK.

Cottom, J.W., Cook, E., Velis, C.A., 2024. A local-to-global emissions inventory of macroplastic pollution. Nature 633(8028), 101-108.

Kodros, J.K., Wiedinmyer, C., Ford, B., Cucinotta, R., Gan, R., Magzamen, S. and Pierce, J. R. , 2016. Global burden of mortalities due to chronic exposure to ambient PM2.5 from open combustion of domestic waste, Environ. Res. Lett. IOP Publishing.
Sharma, G., Annadate, S., Sinha, B., 2022. Will open waste burning become India's largest air pollution source? Environ. Pollut. 292.

Velis, C.A., Cook, E., 2021. Mismanagement of Plastic Waste through Open Burning with Emphasis on the Global South: A Systematic Review of Risks to Occupational and Public Health. Environmental Science and Technology 55(11), 7186-7207.