DOI: 10.5258/SOTON/PP0016

A response to the Environment Agency's Standard Rules Consultation No.25

13 September 2022

Executive summary:
In response to this call for evidence on Environmental permitting: standard rules permits consultation 25 by the Environment Agency, we make the following policy recommendations, in terms of the draft SR2022 No.5: Non-Hazardous Waste Recycling.

We call for clear recognition that bioelectrochemical treatment of non-hazardous waste may well result in *in-situ* treatment of incoming waste and *in-situ* generation of low levels of direct current (DC) electricity that can be used for low-power applications, such as on-site sensors and Internet of Things (IoT) equipment. Implementing such a technological solution would additionally provide recycling centres with the ability to detect toxic compounds that may accidentally enter such facilities, due to the live response from the living microorganisms, contained inside bioelectrochemical systems, such as Microbial Fuel Cells. Such technological integration is currently absent from recycling or any other treatment sites, and policy needs to be amended, to enable further refinement of this maturing technology, to fit the purposes of advanced recycling.

It is recommended that the Environment Agency should:

- Support the development of Bioelectrochemical Systems as real time toxicity sensors for recycling (and other treatment) facilities
- Support the integration of Bioelectrochemical Systems in recycling centres as a biological treatment method for the majority of waste types, included in Schedule 1
- Encourage/incentivise recycling centres to adopt low-power technologies, where available and appropriate, to enable direct connection with Bioelectrochemical Systems as energy sources, thereby enhancing the recycling facilities' sustainable energy capability

Response authors:

Ioannis (Yannis) Ieropoulos, Chair of Environmental Engineering and Head of the Water & Environmental Engineering Group at the School of Engineering, University of Southampton, UK. Professor Ieropoulos has published his work in peer-reviewed academic journals, such as Scientific Reports, Journal of Power Sources, Water Research, Chemosphere, Bioresource Technology, Applied Energy, Current Opinion in Electrochemistry and International Journal of Hydrogen Energy among others. He is the Editor-in-Chief for the Journal Sustainable Energy Technologies and Assessments and is one of the most cited authors in the field of bioelectrochemistry, biorobotics and bioengineering.

Professor Ieropoulos has been working with the Bill & Melinda Gates Foundation, under the "Reinvent the Toilet" project in collaboration with a number of senior research academics, industrialists and local government officials worldwide, as a part of one of the largest Water, Sanitation & Hygiene programmes.

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- Junfeng Zhai, Shaojun Dong. 2022. Recent advances in microbial fuel cell-based toxicity biosensors: Strategies for enhanced toxicity response. Current Opinion in Electrochemistry, 34, 100975.
- Iwona Gajda, John Greenman, Ioannis A. Ieropoulos. 2018. Recent advancements in real-world microbial fuel cell applications. Current Opinion in Electrochemistry, 11:78-83.

- Shivali Banerjee, Amit Arora. 2021. Sustainable bioprocess technologies for urban waste valorization. Case Studies in Chemical and Environmental Engineering, 4, 100166.

General consultation questions relating to all activities

1. Do you give permission for us to publish your consultation responses? We will not include personal information.

(•) Yes ( ) No
If, no, please tell us why below as we will need to understand this when responding to any Freedom of Information requests.

2. Would you like to receive an email to let you know that the summary of responses has been published?

By providing your email address you will be able to return to edit your consultation at any time until you submit it. You will also receive an acknowledgement email when you complete the consultation and we will notify you when the summary of consultation responses has been published.

Your email address: i.ieropoulos@soton.ac.uk

3. If you operate a permitted waste facility (or facilities), please tell us what kind it is (they are).

- [ ] Inert waste treatment facility or transfer station
- [ ] Materials Recycling Facility (MRF)
- [ ] Non-hazardous waste transfer station or treatment facility
- [ ] Non-hazardous waste treatment facility with hazardous waste storage and transfer
- [ ] Household waste recycling centre
- [ ] Wood treatment facility
- [ ] End of life vehicle depollution facility
- [ ] Metals recycling facility
- [ ] Other
- [x] I don't operate a permitted waste facility

If you answered other please give details of site type.

4. When we come to analyse the results of this consultation, it would help us to know if you are responding as an individual, or on behalf of an organisation/group.
Please select one of the following options:

(•) Responding as an individual
( ) Responding on behalf of an organisation or group
( ) Other

5. Please tell us how you found out about this consultation:

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- ○ From the Environment Agency
- ○ From another organisation
- ◉ Through an organisation you're a member of
- ○ Press article
- ○ Social media e.g. Facebook, Twitter
- ○ Through a meeting you attended
- ○ Other

If other, please specify.

SR2022 No.5: Non-Hazardous Waste Recycling

29. This permit is identical to SR2021 No.4, but without any hazardous waste codes. If we did not have a corresponding permit that is restricted to non-hazardous codes then operators would need to demonstrate they had appropriate Technical Competence to manage hazardous wastes. Do you support the inclusion of this rule set without any hazardous waste codes?

Yes

30. We have reviewed waste return data for the standard rule permits that this rule set will replace. We are proposing to remove waste codes listed below. Do you agree with excluding these waste types?

No. Excluding these wastes would imply being treated somewhere else and appropriate systems must be in place to ensure efficient recycling. If smart biological systems are to be implemented for more efficient detection of inappropriate or hazardous waste, then the codes listed below would act as feedstock for the microbial communities inside bioelectrochemical systems, and could be treated *in-situ* thereby contributing towards more efficient recycling.

01.03
01.04 (and sub-categories)
02.02 (and sub-category)
02.03
02.04
02.04.01
02.04.02
02.05
02.05.01
02.06 (and sub-categories)
02.07 (and sub-categories)
03.01
03.01.01
03.03
04.01 (and sub-categories)
04.02 (and sub-categories)

31. This permit requires the operator to manage and operate the activities in accordance with the non-hazardous and inert waste appropriate measures guidance unless alternative measures have been submitted and agreed in writing. Do you agree with this approach?

Yes, this approach is appropriate, but more is needed. Recycling centre operators must be incentivised to use smarter technologies for detecting toxic pollutants that may accidentally enter their recycling

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process; current practices, as captured in the draft SR2022 No.5 document would be inadequate to deal with harmful compounds. Technologies such as bioelectrochemical systems work on the metabolism of electroactive organisms, which means that any perturbance from the baseline, i.e. what should be entering the recycling centre, especially those caused by hazardous substances, would immediately show in real time so that operators can take action.

32. We want to ensure that this permit provides the right protection measures for people and the environment, without the need for a site-specific and bespoke assessment. Are there any other limits or restrictions you disagree with or think we should include?

Yes. Not necessarily limits or restrictions *per se* but smarter measures that would indeed enable operation without site-specific and bespoke assessment should be included. Our natural environment facilitates a continuous recycling process in which microorganisms play a significant role. Being able to bring this process inside recycling centres, through bioelectrochemical systems technology, such as microbial fuel cells, would undoubtedly require investment for integration – this implies further research & development for technology refinement and customisation – but the benefits of exploiting microbial power would outweigh this in the mid/long term. This way enables a transition towards biochemical, biophysical and bioelectrochemical ways of dealing with our different types of waste, which eventually can be adopted at a larger scale and a household level, rendering the whole process more natural and much more efficient.

Financial impacts question and further comments or information

52. Are there any other significant financial impacts, either positive or negative, that the introduction of the new or revised standard rules could have on your overall business?
We do not intend to publish information provided to this question as part of our response to this consultation.

(Required) ○ Yes ◉ No
Please specify which permit(s) your comments relate to.

53. Please use the box below if you have any further comments or observations that you would like us to consider as part of this consultation.

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References

- Chauhan, S. (2022). Mitigation of tannery effluent with simultaneous generation of bioenergy using dual chambered microbial fuel cell. Bioresource Technology, 351, 127084.
- Hemdan, B. et al. (2022). Bioelectrochemical systems-based metal recovery: Resource, conservation and recycling of metallic industrial effluents, Environmental Research, 204, Part D, 112346
- ElMekawy, A. et al. (2015). Food and agricultural wastes as substrates for bioelectrochemical system (BES): The synchronized recovery of sustainable energy and waste treatment, Food Research International, 73, 213-225
- Oza, T. et al. (2022). Potential of Extremophiles in Bioelectrochemical Systems and Biohydrogen Production. In: Joshi, ..J., Sen, R., Sharma, A., Salam, P.A. (eds) Status and Future Challenges for Non-conventional Energy Sources Volume 2. Clean Energy Production Technologies. Springer, Singapore. https://doi.org/10.1007/978-981-16-4509-9_14
- Santoro, C et al. (2017). Microbial fuel cells: From fundamentals to applications. A review, Journal of Power Sources, 356, 225-244
- Bolognesi, S., Cecconet, D., Callegari, A. et al. (2021). Bioelectrochemical treatment of municipal solid waste landfill mature leachate and dairy wastewater as co-substrates. Environ Sci Pollut Res 28, 24639–24649. https://doi.org/10.1007/s11356-020-10167-7

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