EBF

14th EBF Open Symposium

Science – Our Universal Language

Sustainability in Bioanalysis: Where are we now, where are we going?

Connor Walker, on behalf of the EBF YSS

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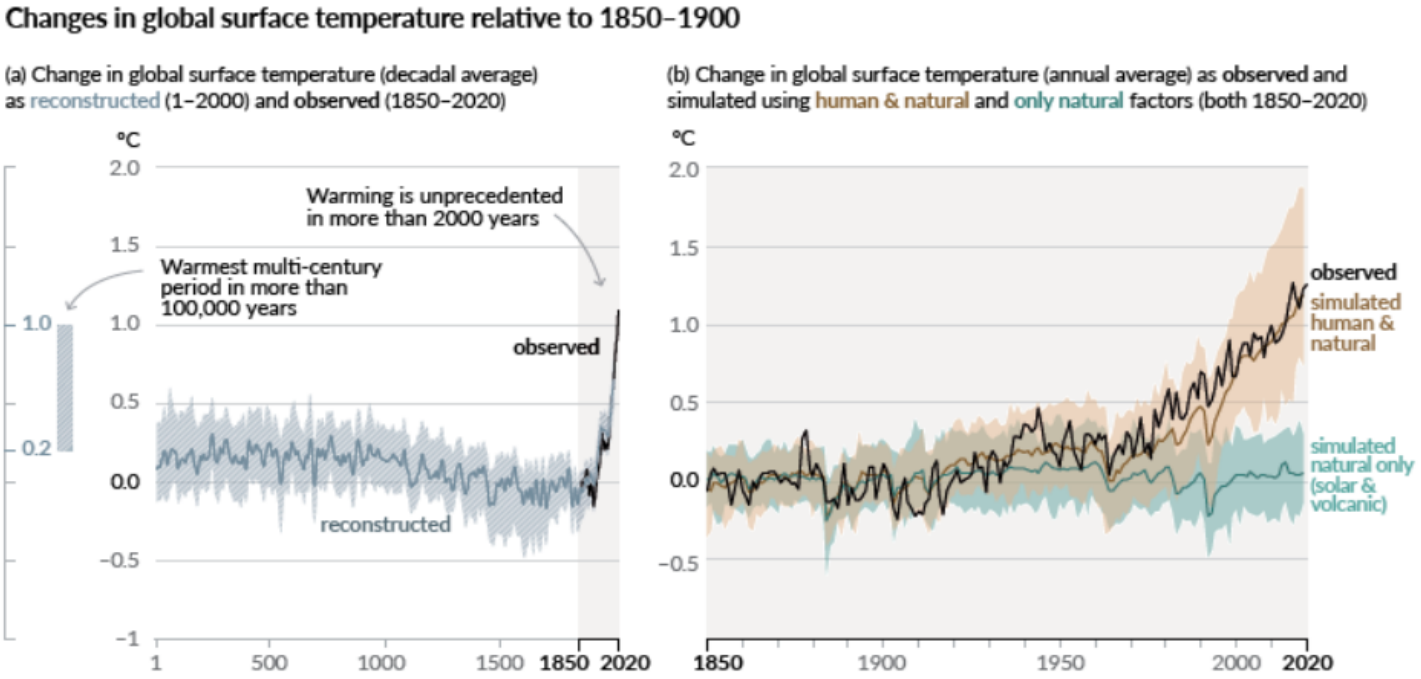
Sustainability – What's the big deal?

Lets cut to the chase

The earth is heating up at an unprecedented rate



A Changing World

Worldwide, the impact of this warming can already be seen in the form of:

Loss of ice caps, increasing sea levels

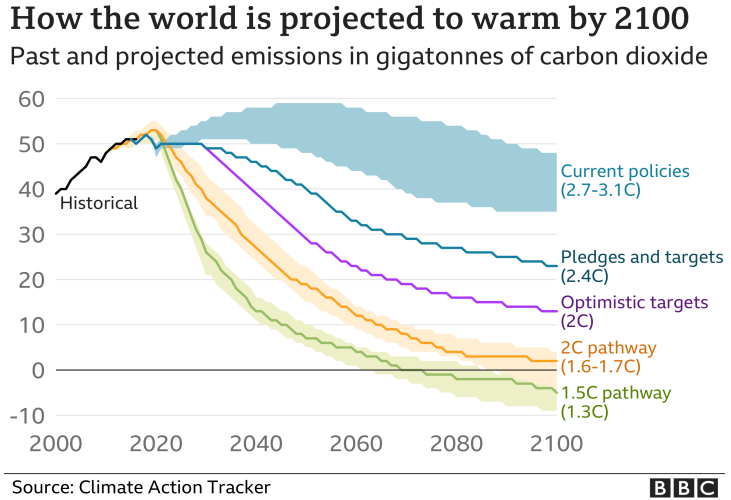
Higher recorded temperatures, triggering more droughts

More severe and frequent storms, increasing the occurrence of flooding

Our present course

On August 9th 2021 the first part of the IPCC Sixth Assessment Report was published on the current impact of climate change. Findings included:

- Humans are “unequivocally” responsible for global warming.
- Some climate systems are already irreversibly damaged at least for a few centuries.
- If no changes are implemented, we are on track for a ~3 degree increase by 2100
- Worldwide pledges and targets put us on course for a ~2 degree increase by 2100



Without immediate changes to the way we live and work, we will not be able to keep warming below the suggested 1.5 degree threshold

Course correction

Not too late to change course and avoid the worst impacts of climate change by making changes in the way we work and live

Improving sustainability is an ever-increasing topic of importance in virtually all fields, from energy production to construction to analytical sciences.

Bioanalytical sciences, could be considered an area in need of an improvement in terms of sustainable practices, being a field that often relies heavily on single use sterile materials (plastics), strong solvents, and typically energy inefficient technology

So, what can we do in Bioanalysis to contribute to this endeavour?

Wait, is sustainability in regulated bioanalysis possible?

Simply put,

YES

It won't be without its challenges, and much like other scientific endeavors, our attitude, the sharing of information, and the means to overcome the challenges, will dictate our success at improving sustainability

How do we define sustainability in bioanalysis?

During the 6th EBF YSS science café, sustainability of regulated bioanalysis was defined as stimulating or applying the 3Rs:

Replacement, Reduction and Refinement,

the 6Rs:

Rethink, Refuse, Reduce, Reuse, Recycle, Replace

and/or principles of green lab/chemistry

Sustainability in bioanalysis – where are we now?

Areas of focus

At the 6th EBF YSS science cafe, some key areas were highlighted in regards to the implementation of sustainable practices, these were:

- Communication
- Sample preparation
- Instrumentation
- Waste management
- Training and awareness

Today we'll look at some examples of sustainable processes that can or are being implemented, the challenges/considerations associated with them, and possible solutions to these challenges

Additionally we'll briefly look at future developments that will affect sustainability

Communication – What can/is being implemented

To improve communications, some organisations have introduced forums for discussion on aspects to improve sustainability

These have taken the form of teams to introduce 5s and Lean clubs

Broader processes such as Skip meetings and Elephants, dead fish, and vomit meetings are useful for improving communication as a whole

More industry discussion e.g. EBF YSS and today

Communication – Challenges/considerations

If not properly setup, and if enthusiasm and support are not maintained, said forums may loose engagement and risk becoming just a place for idle chatter, with i.e. all talk and no action

A risk of gratification from just talking about sustainability or after the implementation of a single process, no drive to do more

Communication – Possible solutions

A way to ensure the success of these forums, is with a set agenda and chair for meetings

Ideally a management representative present to support and drive the team to continue introducing new processes / process improvements

Identifying “champions of sustainability” with the drive and enthusiasm to keep the forums going

Sample preparation – What can/is being implemented

There are a variety of ways to improve sample preparation in regards to sustainability:

- Direct analysis where possible (LA-ICP-MS)
- Reduction of sample volumes (e.g. micro-sampling, DBS)
- Use of low/no solvent extraction methods (SPE, SPME, LPME)
- Use of alternatives to extraction solvents (SWE, SFE, ILs)

Common theme in the elimination of solvents where possible, due to their impact on the environment and risk to the operator

There are already quite a few papers available with lists of alternative green extraction methods and materials

Sample processing – Challenges/considerations

Consideration must be given whether the green alternative is fit-for-purpose for the analyte in question, it is not always possible to use an alternative

Additional cost and time consuming to re-validate and modernise older less efficient/sustainable methods makes it a low priority

Requirements of current regulatory guidelines can hinder choosing the more sustainable choice

Sample processing – Possible solutions

In terms of re-validation these can be addressed at an organisational level with an understanding it will take the application of resources to update methods to be more sustainable

- e.g. starting an initiative to update and improve current methods with an assigned budget of resources

To overcome issues in regards to regulatory and FFP, a greater commitment to applying these processes, where possible, is required from the industry as a whole

Important to align the ideas of sustainable practices across the industry for a unified approach

Instrumentation – What can/is being implemented

Upgrading from HPLC to UPLC
- Smaller volumes of reagents used thus less waste produced

Validation of freezers at higher temperatures (-70 vs -80)
- This change alone can reduce energy usage by 37%
- Additionally prolongs freezer lifespan by reducing compressor usage

Introduction of outlet timers for some equipment
- Allows equipment to be turned off at night, but be ready for the morning
- Significant reduction in energy usage

Setting up micropipette repair programs on-site
- Cheaper than professional re-furbishment and less wasteful than just disposal

Instrumentation – Challenges/considerations

Significant short term financial and time investment to upgrade and install new instrumentation as well as on-site repair programs

Additionally regulatory requirements can also limit implementation e.g. validation of higher freezer temperatures

Some labs with shift patterns may not be able to make efficient use of outlet timers

Instrumentation – Possible solutions

While the short term investment, both financially and time wise, is sizeable, the long term benefits will outweigh the cons:

- Shorter run times with greater sensitivity i.e. more runs
- Reducing footprint will minimise any potential future taxes related to a labs environmental impact

Continued research and development by manufacturers, with a consideration into environmental impact, leading to more environmentally friendly instrumentation

Again, a wider industry discussion and alignment on regulations, with consideration to sustainable practices, would be greatly beneficial

Waste management - What can/is being implemented

Switching to vendors that are making efforts to minimise wastage

- Many vendors have begun to reduce their packaging or make it more recyclable
- Some have begun to include internal recycling programs

Method optimisation / pre-treatment to make workflow more efficient and use the minimum of consumable waste per run

Switching to glassware vs plasticware and washing/sterilizing where possible

Waste management - What can/is being implemented 2

Creation of more recycling streams to ensure whatever can be recycled, is recycled

- Pipette tip boxes, nitrile gloves, clean cardboard etc.

Designated shared reagent spaces, so reagents are not wasted

Consolidating bulk orders to lower frequency of deliveries

Waste management – Challenges/considerations

The human element, new processes rely on the commitment and motivation of staff
- e.g. Additional recycling waste streams require more labour to setup and monitor

Some consumables are required to be virgin/specialised materials, ruling out the use of recycled or reused without further work to find alternatives
- e.g. Analytes known to suffer binding issues typically require Lo bind tubes

It is at the discretion of the manufacturer how much packaging they use and whether not it is possible to recycle

Bulk orders are only possible when large amounts of materials are required and when there isn’t an urgency to acquire the materials

Waste management – Possible solutions

Engaging with staff, promoting the importance of recycling and proper training can help with the human element of waste management

Increased development and collaboration to identify possible alternatives for assays that require virgin or specialised materials
- Where alternatives are not possible, minimising the quantity of single use consumables

Reaching out to manufacturers and waste handlers to reach agreements on minimising packaging and maximise recycling
- There a companies in the US and some in the EU specialising in lab equipment/consumable recycling and zero emission waste disposal

Training and awareness - What can/is being implemented

Changes to training processes that involve a greater emphasis on sustainability, instilling better attitudes and behaviours that underpins everything

Some lab updated training includes focus on:

- Mindfulness of matrix usage
- Time management and workflow efficiency
- Focusing on quality over quantity to minimise error and wastage

Making others aware of available resources to aid in sustainable practices

- Research papers detailing alternative sustainable methodologies
- Websites with tips and guides for implementing new processes
- Current discussions on sustainability e.g. EBF YSS 6th science café feedback

Training and awareness - Challenges/considerations

Again, the biggest challenge is the human element

Even with new processes, methods, and training, it is all useless without committed individuals doing their part

This includes both the analysts performing the work, and the managers supporting them

Failure at either level impacts the success of the processes

Training and awareness – Possible solutions

Again, find those can act as “champions” of sustainability and working with them to help inspire others to get involved

Finding ways to incentivise or make sustainable content more engaging:

- Celebrating new ideas and working to implement them
- Recognising those who make conscious efforts to improve their own impact on sustainability in the lab

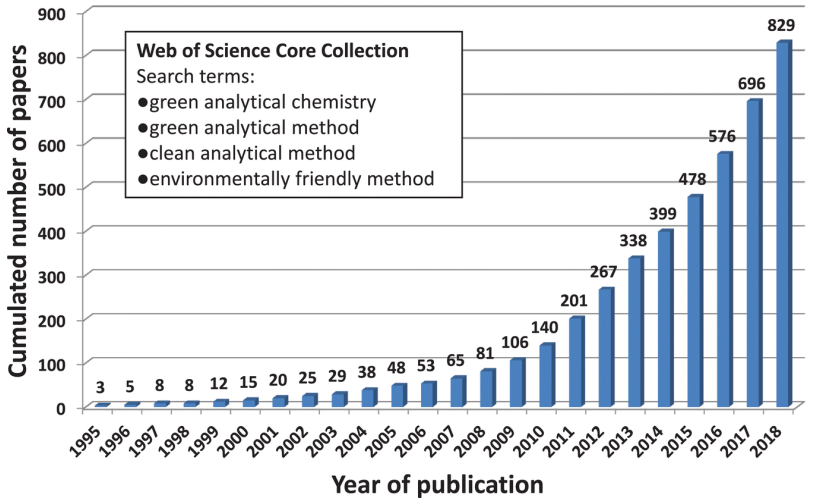
Managers and those in positions of responsibility to create an environment that promotes, supports and rewards positive behaviours and attitudes towards sustainability

Sustainability - Where are we going?

Wider industry, research, discussion and collaboration

In the past few years discussion and research on sustainability within analytical chemistry has seen an increase year on year, and this is likely to keep rising

EBF YSS meetings now have continuous eye on sustainability in the industry and promote discussion among young scientists on the topic



Miguel de la Guardia and Salvador Garrigues, Chapter 1:Past, Present and Future of Green Analytical Chemistry , in *Challenges in Green Analytical Chemistry (2)*, 2020, pp. 1-18

As the industry begins to consider sustainability more, advances in instrumentation, alternative extraction techniques and even regulatory guidance with consideration of sustainability will appear more frequently

AI and automation

The emerging use of AI in the drug development process has huge potential

The implementation of AI to:

- Determine viable drug candidates
- Participant recruitment
- Clinical trial design

Will allow significant reductions in wastage across the board

In combination with automation technologies, the effect this will have on the efficiency, and thus the sustainability, in bioanalysis is not to be understated

Lab-on-a-chip technology

The principal of LOC is to fit an entire lab process/technique onto a single small chip, by making use of microfluidics

Allows bioanalysis to be performed on a portable handheld device, usable in clinics, medical offices or out in the middle of nowhere

By minimising an entire lab process down to a single small chip, there is a huge reduction of consumable and reagent use, along with reduced waste produced

The technology is still in its infancy with many proof of concept devices, but very few ready for commercial use

Summary

It is our ethical and moral duty as scientists to consider both the positive and negative contributions of bioanalysis to our communities

Sustainability in regulated bioanalysis is a realistic goal we should all be striving to reach given the consequences of climate change

There are many ways to improve sustainability and many are already taking steps to improve sustainability that we've looked at

While these changes all come with challenges, but they are not insurmountable

The EBF YSS, and in extension the EBF, is committed to contribute by providing a platform for continued discussion on sustainability of our activities and stimulate behavioural change towards increased sustainability.

Summary, cntd

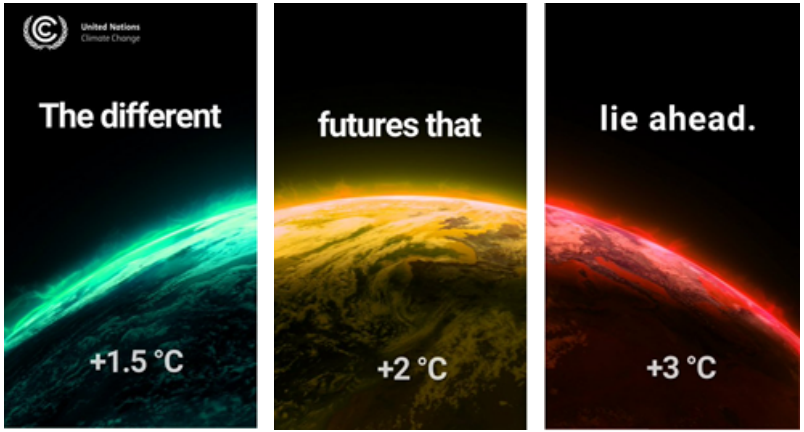
Common solutions to the challenges faced included:

- Increased discussion amongst the wider bioanalytical community
- Reviewing regulatory guidance with consideration to sustainability
- Accepting the short term financial and time investment, in the long term the benefits far outweigh the cost
- Working to better motivate and engage others to improve sustainability

It will not be easy, but with efforts from both individuals as well as a united and committed approach from the bioanalytical industry, it is well within our ability to effect and implement change

Closing remarks

The best time for change was yesterday, but the second best time is today
What we do now will define the future of not only bioanalysis but the world



When we think back to our actions of the 2020's, will be it with pride or regret?
That choice is ours, today

Image from the United Nations Climate Change website: https://www.un.org/en/global-issues/climate-change

Acknowledgements

I would like to give thanks to:

My colleagues on the 6th, 7th, and 8th EBF YSS organising committees

The EBF community as a whole

Thank you for your time!

Contact Information

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