Sustainability Report

iGEM Toronto
2026
PetaBite

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Key Terms

PetaBite	iGEM Toronto 2026 project name. Includes the entire optimized workflow(algorithm, assay, bioreactor, etc)
PETadex	Public database hosted at www.petadex.net. Derived from the Logan database by screening it for PETase homologs using the logan-diamond search.
PetaScale	The biotechnological startup translating PETadex enzymes into commercial biodegradation systems.
Logan	Planetary-scale genome assembly and search index of NCBI Sequence Read Archive (SRA). The SRA is a public repository housing every publicly deposited sequencing run, spanning 27.3 million datasets and approximately $5x10^{16}$ base pairs.
WWT	Waste water treatment
WWTP	Waste water treatment plant

Key Stakeholders

Ms. Jenny Hutagaol	Sustainability and Data Analyst at Seven Clean Seas; highlighted the importance of considering safety regulations and potential chemical hazards before deployment.
Ms. Savana Huskins	A graduate student at Colorado university in the department of Chemical and Biological Engineering; advised researching potential impacts on the environment surrounding waste water treatment plants.
Dr. Niti Sharma	Environmental scientist (India) studying river-sediment microbes; suggested completing an environmental risk assessment prior to deplomen t.
Ms. Susy Kamil	A specialist in Environmental Sustainability and Circular Economy, with experience in Waste Management; living in Bali, she brought a global perspective to the discussion.
Dr. Aamer Ali Shah	Professor in the Department of Microbiology at Quaid-i-Azam University in Islamabad, Pakistan; identified that there are differing regulatory systems in Pakistan regarding applications of biosynthetic research.
Dr. Natasha Anwar	Molecular pathologist and bioethicist on Pakistan's National Bioethics Committee; noted that there lack regulations regarding biosynthetic research deployment in Pakistan.
Dr. Julie Goddard	Educator & Director of Research in Biomaterials & Biointerfaces in Food and Agriculture at Cornell University; suggested investigating the target waste water treatment plant’s composition at various times of the year.
Dr. Sonia Su	PhD graduate from the The Goddard Research Group at the Cornell University Department of Food Science; identified several ethical implications to consider before deployment.
Mr. Excel Amaefule	Policy and governance expert engaged with Nigeria's NESREA; emphasized the importance of continuous community input rather than one-off consultations.

1. INTRODUCTION



1. Introduction

1.1. PETadex and Our Goal

PETadex is an AI-based database of sequences that have potential to exhibit PETase activity [1][2]. Our goal is to understand the potential for research and growth within PETases, MHETases and other related enzymes [3].

1.2. Problem Statement

From a global standpoint, PET production rates are skyhigh, recycling rates are low [4], and there is a specific cause of concern for microplastics in ecosystems (ie. in land and water), especially waste water treatment plants (referred to in this report as WWTPs) [5][6]; plastic pollution also has a disproportionate impact on Indigenous communities, developing countries in Southeast Asia and the South [7][8] that needs to be addressed by drafting better, comprehensive solutions, motivating this project.



1.3. The 3 Pillars of Sustainability

We define the 3 pillars of sustainability to include environmental, social and process sustainability. Each of these pillars connect to enzyme-based plastic management strategies and PETadex efforts as described in figure 1 below.

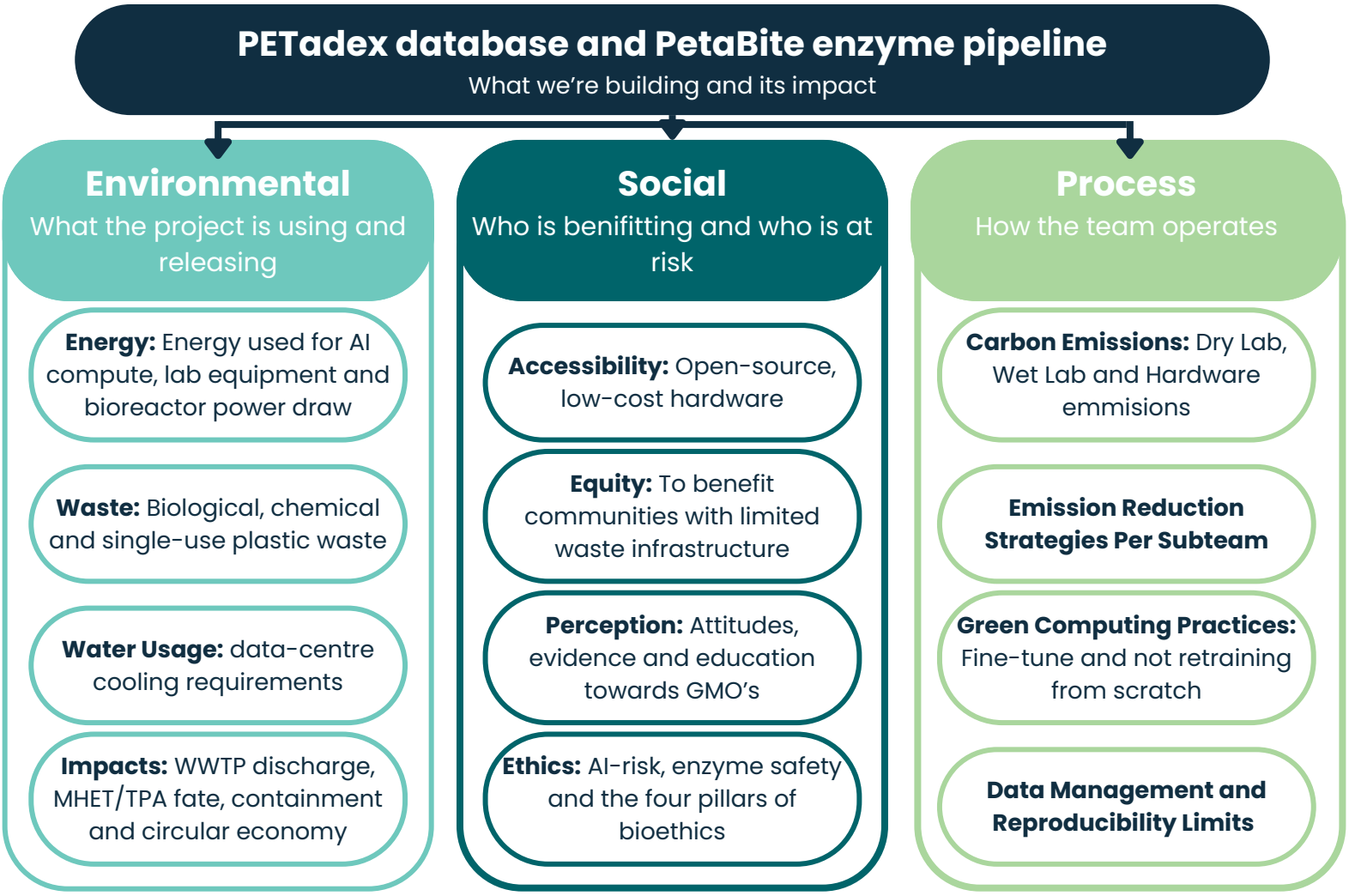


Figure 1. The three pillars of sustainability for PETadex/PetaBite

1.4. Scope of the Report

This report focuses on analysing impacts of PETadex on environmental (eg. energy, water, wastewater ecosystems), as well as social and ethical (eg. datasourcing, environmental concerns, public outreach and perception) dimensions. We also examine sustainability within the development process of the project as a whole, with key case studies in WWTPs.

2. ENVIRONMENTAL SUSTAINABILITY



2. Environmental Sustainability

2.1. Energy Considerations

2.1.1. Artificial Intelligence

Establishing and maintaining the PETadex database involves computationally intensive workflows, including large-scale sequence searches, model training and inference for relevant PETases, all of which require substantial energy for both processing and cooling. Recent analyses of AI and data-center infrastructure show that electricity demand and associated water use for cooling are rapidly increasing [9][10], underscoring the need to design AI systems with energy efficiency and resource-aware scheduling in mind.

In the context of PETadex, this motivates efforts to optimize model architectures, leverage energy-efficient hardware and explore low-carbon compute options wherever possible. The database was built in stages. All compute, cost and power figures reported in this section are internal measurements recorded by the Dry Lab, Wet Lab and Hardware subteams between June and October 2026. First, an initial development phase was run on four everyday laptops for roughly 24 hours a day over four months, alongside university cluster time, building on top of the pre-existing Logan index. Next, a database expansion phase was carried out by using roughly $10,000 of AWS CPU usage to grow the raw data set. This was followed by about $5,000 of combined CPU and GPU usage over three months to better refine the set with additional metadata and annotations. The next step consisted of model training using a single Nvidia L40S GPU running continuously over a span of 7 days, costing roughly $500, with a planned scale up to about $5,000 of GPU usage as the model grows and matures.

2.1.2. Ethics of Datasourcing

To derive and connect data on enzyme sequences and metadata from established databases such as NCBI, the ethics of crediting original authors and papers, avoiding biases, and following CC rights where applicable must all be considered.

PETadex relies on enzyme sequence and metadata derived from established databases such as NCBI and other curated resources [11]. As a result, it is essential to follow ethical data practices, including proper attribution of original authors and publications, adherence to Creative Commons and database-specific licensing terms [12], and transparent documentation of data provenance. Care must also be taken to identify and mitigate biases in publicly available sequence datasets—for example, overrepresentation of certain organisms, environments or industrial applications [13]—to avoid skewed predictions and to ensure that PETadex supports equitable and scientifically robust research outcomes.

2.1. Energy Considerations

2.1.3. Enzyme Synthesis and Production

From a wet lab perspective, enzyme synthesis and production through purification, assay, and efficiency versus scale assessment workflows result in energy consumption. To increase energy efficiency when producing optimal environments for enzymes, we must conduct efficient resource use in lab environments.

To maintain environmental sustainability, laboratories and facilities implementing PetaBite must prioritize resource-efficient protocols, such as optimizing expression systems, minimizing redundant experiments and integrating energy-efficient equipment into the experimental pipeline. Wet lab is using three high-throughput assays to cheaply separate active from inactive PETase sequences first. After this, only candidates that outperform an established benchmark such as FAST-PETase [14] are advanced to full and more resource intensive characterization. Reagent and buffer quantities are also already being optimized during test runs.

2.1.4. Hardware Considerations

From a hardware perspective, each bioreactor utilizes hardware components that draw energy, as well as a mechanism that generates heat. These lead to increased required energy demand, with each bioreactor of our first iteration drawing approximately 15W of power at peak operation.

Careful hardware selection, process control optimization and integration with existing plant infrastructure can reduce unnecessary energy use and help align PetaBite deployment with broader sustainability goals.

2.2. Waste Management

2.2.1. PetaBite as a Sustainable Solution

PetaBite leverages PETases and associated enzymes as a sustainable alternative or complement to conventional PET waste handling, with the aim of diverting PET from landfills and reducing microplastic accumulation in WWTPs and receiving waters [3][16]. This is because enzyme-based recycling can reduce PET accumulation as a whole, promoting an overall better solution, creating a need and hinting at the potential for PETase-based recycling to be useful. Resources such as PAZY [17] and PlasticDB [18] illustrate the growing body of plastic-degrading enzymes and highlight the potential of curated enzyme databases to support more targeted, efficient PET degradation strategies.

2.2.2. Biological Waste

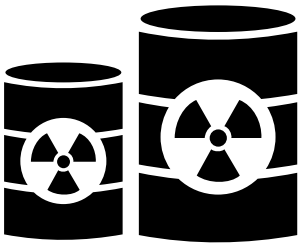
Biological waste generated during enzyme expression and assay work is disposed according to established biosafety procedures. Wet lab follows the containment, decontamination and disposal standards set out in the Canadian Biosafety Standards and Guidelines [19], which outline handling procedures appropriate to the risk group of the organisms and materials involved to ensure that PetaBite does not introduce unintended biological risks.

Implementation of PetaBite in the wet lab and in pilot WWTP settings generates biological waste, including cultures of engineered strains, enzyme-containing media and biomass from bioreactor runs. All such materials must be handled and disposed of in accordance with biosafety and ethical guidelines, including appropriate inactivation procedures, containment, and documentation. Following national biosafety standards (like the Canadian Biosafety Handbook [20]) for storage, treatment and disposal of biological materials helps ensure that PetaBite does not introduce unintended biological risks beyond the target PET degradation activity.

2.2.3. Chemical Waste

Chemical waste arises from enzyme production, assay development, and reactor operation, including buffers, solvents, reaction by-products and cleaning agents. As Ms. Jenny Hutagaol highlighted, ethical and safe management of these chemicals requires compliance with institutional and national regulations governing hazardous waste classification, storage, labelling, and disposal routes [21] (a helpful guide is the Canadian Biosafety Handbook [20]). Implementing rigorous chemical waste protocols in wet-lab and pilot plant environments is essential to prevent secondary pollution and to align PetaBite with broader environmental protection standards. Wet lab ensures that disposal routes are selected according to reagent hazard classification.

The biggest waste source we have identified is single-use plastic items like pipette tips and 96-well plates. While glass pipettes would be a greener alternative, wet lab is currently limited by what lab space and equipment can support.





2.3. Water Usage and Management

2.3.1. Considerations of Water Use

Water will be used to cool the data centers that power the PETadex database. Water is also used in wet lab processes to validate enzyme viability through experiments. Data-center cooling for AI systems can consume significant volumes of water directly and indirectly through electricity generation [9][10], which reinforces the need to consider water-efficient cooling technologies and site-specific water availability when scaling PETadex. In the wet lab and WWTP pilots, process water is used for enzyme production, reaction media, cleaning and dilution, making water recycling and reuse strategies important components of sustainable deployment. Water recycling must be considered when scaling this solution, to mitigate unnecessary water use at large scales.

One of our stakeholders, Ms. Savana Huskins, a graduate student at Colorado university in the department of Chemical and Biological Engineering, highlighted the importance of considering potential impacts including contamination of the environment through the introduction of synthetic organisms, especially with PETases being introduced into WWTPs. Furthermore, chemical by-products of reactions in the PETase recycling process must be carefully researched, tested, and validated, to ensure the environment is not further harmed by our proposed solution.

2.4. Environmental Impacts

2.4.1. Environmental Impact of AI

The AI infrastructure supporting PETadex contributes to environmental impacts through electricity consumption and the associated carbon and water footprints of data centers. Studies on AI expansion show that global data-center electricity demand is projected to grow substantially, with cooling systems consuming large quantities of water per facility [9][10].



2.4.2. Environmental Impact Through Waste Water Treatment

Introducing engineered enzymes into a WWTP means considering how any residual chemicals behave in the control environment and eventually in the receiving waters. This requires evaluating several key factors such as chemical persistence, potential toxicity to aquatic organisms and interaction with existing treatment technologies [22]. By evaluating these factors we can ensure that PetaBite's addition to a treatment plant acts as a net environmental benefit as opposed to a new source of chemical burden.

A wastewater operations manager we consulted, at a plant processing roughly 20,000 m3 of influent per day, confirmed this by saying that an enzyme dosed after the plant's solid removal stages would need to be evaluated against the facility's existing chlorination and dechlorination processes since contact time with those chemicals could make the enzyme neutral before it has the chance to act.

Furthermore, deployment beyond WWTPs also raises a different set of considerations. Dr. Niti Sharma, a river sediment microbiologist we consulted emphasized that open water systems like rivers, lakes and wetlands are ecologically more complex as opposed to a contained treatment plant. She advised that before any deployment, data on pH, temperature, dissolved oxygen, sediment and water microbial composition, flow and the presence of aquatic animals should be collected and an ecological risk assessment should be completed beforehand. Furthermore, Dr. Julie Goddard and Dr. Sonia Su noted that the composition of waste water varies each season due to varying dietary habits; thus, it is important to test the waste water at a specific treatment plant at various points in time before deployment.



2.4.3. Regulatory and Safety Considerations

Any enzyme or engineered biological system intended for use in or near WWTPs must comply with regulatory frameworks governing biodegradability, toxicity, occupational health and environmental containment [23][24]. This includes demonstrating that enzymes and their intermediates degrade into environmentally acceptable forms, do not accumulate to toxic levels and can be contained under normal and upset operating conditions. This must include occupational health and safety considerations for anyone handling the engineered enzymes and containment strategies intended to prevent accidental release of engineered enzymes into the environment and open water systems.

PetaBite's design will explicitly incorporate these constraints by aligning with occupational health and safety guidance for WWTP workers, implementing containment strategies (such as closed bioreactor systems and downstream inactivation steps) and meeting standards for environmental release set by relevant authorities.



2.4.4 Microplastic Fate and Enzyme containment

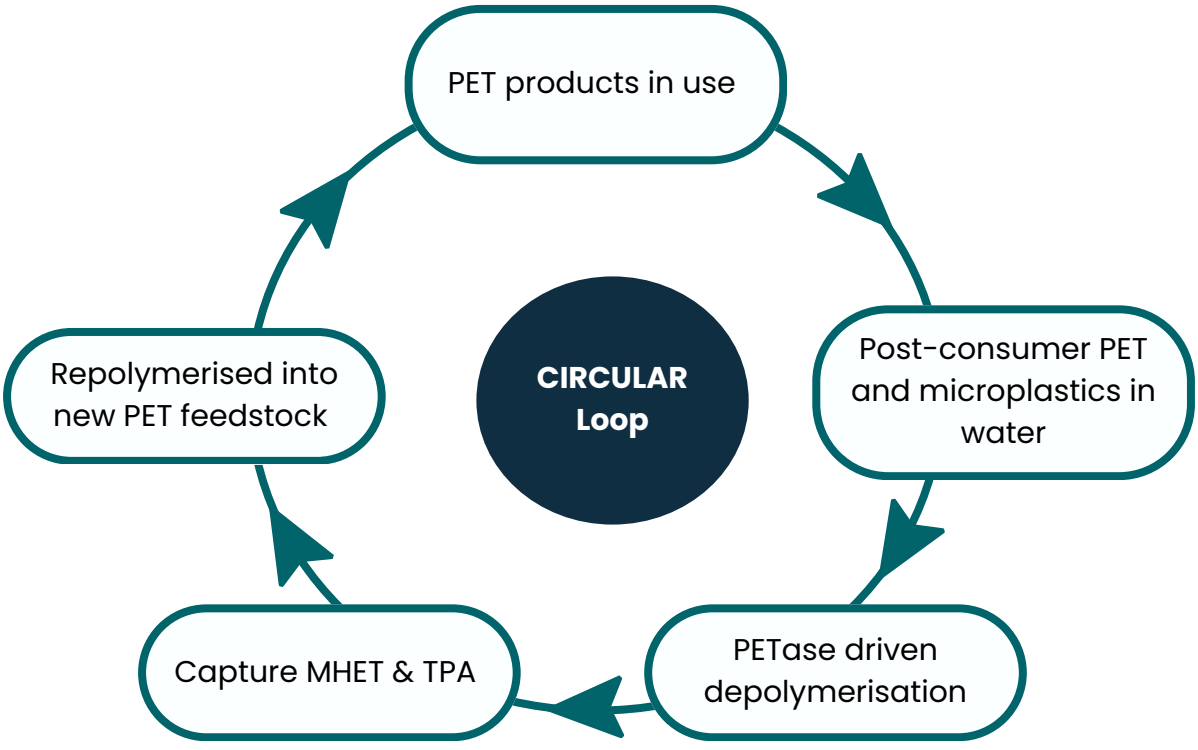
PET degradation introduces intermediates like MHET and TPA [3]. Each of these intermediates needs its own environmental safety evaluation instead of assuming them to be safe by association with the primary enzyme reactions. TPA has an established regulatory toxicity assessment [25] whereas, MHET does not, and we were unable to identify aquatic ecotoxicity data for it. Characterising MHET fate under WWTP conditions is therefore a prerequisite for deployment rather than an optional study. We are examining how PET fragments and their intermediates behave once released into WWTPs and how enzyme activity degrades over time under real world conditions. We also aim to learn what containment strategies would be needed to put in place to ensure that deployment does not produce a new contaminant stream.

2.4.5. Environmental Impact Assessment

PetaBite seeks to offer a lower-energy, more efficient alternative to existing PET degradation techniques while maintaining rigorous safeguards against unintended environmental consequences. PetaBite offers a lower-energy, more efficient alternative to existing PET degradation techniques. This comes at the cost of introducing a new biological system into treatment plants that will need to be carefully monitored. The main environmental benefits are reduced microplastic accumulation and a recycling path that does not degrade material quality with each cycle [26]. The main risks involve unintended release of active enzymes or intermediates such as MHET and TPA, potential ecological effects of these species and operational challenges in WWTP integration.

2.4.6. Circular economy integration

The Ellen MacArthur Foundation defines a circular economy around three design-driven principles: eliminating waste and pollution, circulating products and materials at their highest value and regenerating nature [27]. This approach intends to decouple economic activity from the consumption of finite resources. In a circular model, PET degraded by PETase activity is broken down into intermediates that could potentially be recycled and used as feedstock for new PET production, as opposed to being sent to a landfill. As recommended by Ms. Susy Kamil, we ensure PetaBite aligned with circular economy principles by using PETase-driven degradation to convert PET into intermediates such as MHET and TPA, which can be captured and potentially used as feedstock for new PET or related materials rather than being sent to landfill. In doing so, PETadex and PetaBite aim to support a more circular plastics economy in which enzyme-enabled recycling complements improved collection, sorting and policy measures to reduce overall plastic waste.



3. SOCIAL SUSTAINABILITY



3. Social Sustainability

3.1. Accessibility and Equity

3.1.1. Cost and Accessibility

One of our initial goals to reduce cost and increase accessibility was to design durable and accurate bioreactors that take less than 100 minutes and $100 to assemble. As of our first hardware iteration, the cost breakdown is as follows:

Item	**Cost**
Heater	$3.66
Thermocouple	$9.87
Peristaltic Pump (x3)	$34.00 x 3
Wires	~0
Breadboards	~$3
Stirring Fan	$14.28
Arduino Nano	$3.49
Stirbar	~16/8 = $2
OD sensors	$19.95
CAD	$5
TOTAL:	**$163.25** +

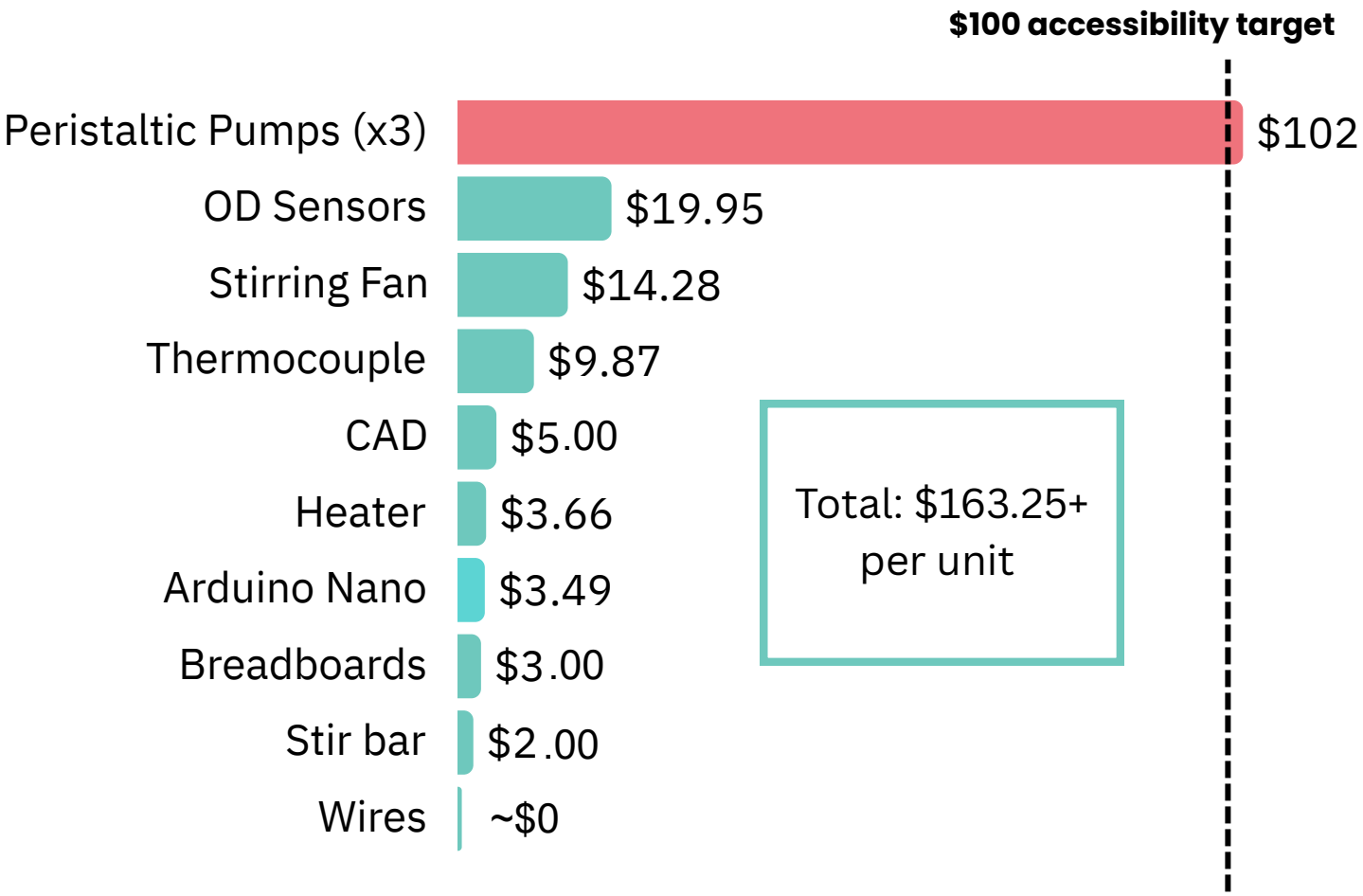


Figure 2. Bioreactor Cost per Unit, based on first hardware iteration

While this exceeds the target cost by approximately 60%, the primary issue is the cost of the peristaltic pumps which contribute to >50% of the cost. Buying them in bulk before assembly should eliminate some of these cost barriers. While the goal of assembling the bioreactor within <100 minutes has not yet been tested, the hardware team is working on a design that uses very standardized, cheap, easy to purchase parts, improving the feasibility of repairability and accessibility to the components. The Hardware team is developing open source CAD files and easily readable instructions to achieve the goal of quick and easy assembly for users.

3.1.2. Sustainability for impacted communities

Plastic pollution disproportionately affects communities in regions with limited existing waste infrastructure. Our main goal is to ensure that PetaBite doesn't just exist in a vacuum, to ensure that our project works for the people in the communities we aim to deploy it into. To ensure that this goal was met, we carried out extensive stakeholder research, reaching out to individuals from all over the globe.

Talks with Dr. Aamer Ali Shah and Dr. Natasha Anwar about deployment of technologies such as PetaBite in Pakistan revealed that there is currently no national regulatory framework for environmental or biosynthetic research present and that governance in these areas are still developing. They noted that currently institutional review boards handle biological research approval, but even then they are only limited to human subject research. Many parts of Pakistan lack centralized WWT infrastructure and most often clean water and sewage mix together. This means that the hardware team's bioreactor design, which assumes integration into an existing WWTP, may not be directly transferable into this context without modification.

A similar discussion was carried out during our interview with Mr. Excel Amaefule, the founder of the Eden Resilience Action Lab in Nigeria. He commented that while there are regulatory bodies like the National environmental standards and regulations enforcement agency (NESREA) [28], Federal ministry of environment, the national biotechnology development agency (NABDA) and the national biosafety management agency (NBMA) [29] present in Nigeria, a technology like PetaBite does not fall directly into any one of these bodies. As a result he mentioned that deployment decisions could be considered as unsupervised gray zones as opposed to a specific framework. Further, he mentioned that while there is centralized wastewater treatment infrastructure in populated cities like Lagos and Abuja, they are frequently run below capacity and that most secondary cities and rural areas typically rely on informal disposal or septic systems. Mr. Amaefule also stressed on the importance of continuous community input when developing technologies like PetaBite as opposed to a one off consultation, especially if we intend to use it in regions most affected by the problem we are aiming to solve.





3.2. Public Uptake and Perception of PETases

3.2.1. Evidence and Education

Public understanding of enzyme based plastic degradation technology is limited and uneven. As a result, stakeholder interviews were conducted to identify where that understanding was strongest and where it was weakest, so that outreach materials can be targeted as opposed to generic. Existing literature on public education and evidence around emerging biotechnologies suggests that trust tends to grow with perceived transparency and benefit in comparison to technical detail [30].

3.2.2. Cultural and Regional Considerations

As Dr. Julie Goddard and Dr. Sonia Su identified, not everyone is comfortable with genetically engineered organisms being used in environmental contexts. This discomfort varies across regions and cultural contexts, sometimes reflecting past experiences with GMOs in food systems and agriculture [31]. To overcome these concerns and discomfort, PetaBite intends to maintain a consistent line of transparent communication and consultation. Our interview process was intended to map out where this discomfort is strongest in different regions so that outreach and deployment plans can be adapted to different regions as opposed to a singular strategy.

3.3. Risk Management and Ethical Considerations

3.3.1. Artificial Intelligence-Related Risks

Since artificial intelligence makes use of probabilistic algorithms to predict outcomes, the predictions are not always accurate and reflective of the real world [32]. It is important to keep track of information sources, and keep PETadex open-access and open-source to ensure mistakes or misinformation can be corrected.



3.3.2. Safety of Engineered Enzymes and Sequences

Engineered, heavily modified enzyme variants [14][16] have more uncertain ecological and safety issues to be considered in comparison to variants with close homology to naturally occurring proteins. Our current prioritization favours enzyme candidates with close homology to natural sequences as opposed to more heavily engineered variants. This is because this reduces uncertainty around ecology and containment risks. When we begin to look at more heavily engineered variants to improve activity, the variants will be subject to additional safety evaluation before being deployed into open environments.

3.3.3. Bioethics



Analyzing this project using the 4 pillars of ethics [33]:

1. **Beneficence: Designing for Real-World Benefit**

This includes targeting a shared harm of environmental and human health, and pairs discovery with deployment strategy and economic viability.

2. **Non-Maleficence: Containing Risk, by Design**

This includes implementing controlled systems for minimizing spread, developing controlled deactivation protocols, engaging stakeholders to foresee and minimize risks, and avoid misleading data to mitigate information risks.

3. **Autonomy: Informed, Transparent Engagement**

This includes consulting stakeholders instead of making assumptions, and documenting the database mechanics, information about assays, and bioreactor design on the wiki page to obtain stakeholder feedback.

4. **Justice: Equitable Distribution of Resources**

This includes prioritizing communities that are disproportionately harmed by microplastic waste, focusing on WWTP and developing PETadex as public infrastructure, and contributing to ‘open-science’ to promote open access and contribution.

3.3.4. Ethical Deployment Framework

We are developing our own deployment framework by focusing mainly on three questions that we believe existing frameworks do not fully anticipate, given PetaBite’s combination of an open access AI discovery toll and an engineered enzyme development pathway.

The first question we aim to address is who benefits from enzyme discoveries and how is that benefit shared with the communities and institutions connected to the original samples. Firstly, every candidate sequence PETadex surfaces retains its public accession, sampling date and geographic origin. This ensures that PETadex is freely searchable and that when a commercially valuable enzyme is found, the originating institution or community would remain part of the development pathway, as opposed to disappearing once the sequence becomes public. Doing this can be identified as a recognized form of non monetary benefit sharing under the Nagoya Protocol [34].

The second question is whether deployment decisions are made with affected communities or only for them and whether our stakeholder outreach actually shapes deployment plans. To answer this question, we first look at information provided by our stakeholders around the globe. For example, in Pakistan, Dr. Anwar's suggestion of a household friendly delivery format, such as a tablet placed directly in a sewage tank or a pipe, came from outreach that surfaced that a centralized bioreactor assumes infrastructure that much of the country still doesn't have.

Further, in Nigeria, Mr. Amaefule's recommendation to target informal waste aggregation points rather than centralized WWTPs, challenges us to change what we consider building and not to not just stick with how we currently describe it. Furthermore, multiple stakeholders we reached out to globally, also stressed on the importance of continuing engagement with the communities we aim to deploy PetaBite into as opposed to one time engagement. These recommendations have been taken into consideration and will be addressed by PetaScale.

Lastly, the third question lies in whether our intellectual property and licensing structures are designed to prevent commercialization to the point where communities in need are unable to afford our technology. What we currently have is that PETadex's underlying computational tools are documented elsewhere as an open source tool kit. However, there is currently no licensing plan for a commercialized enzyme or deployment product coming out of PetaBite or PetaScale. We propose adopting specific criteria such as tiered or waived licensing for public health, humanitarian or low income government use, a non assertion pledge for regions with a high plastic pollution burden and low ability to pay and public disclosure of any licensing terms attached to enzymes discovered from a specific region's biodiversity. Until one of the aforementioned is actually adopted, this question remains open.

Before PetaBite moves to broader development, the remaining work is to turn these three questions into a checklist that a specific deployment decision can be measured against.

4. PROCESS SUSTAINABILITY



4. Process Sustainability

4.1. Carbon Emissions

All cost, power and compute figures reported in this section are internal measurements recorded by the Dry Lab, Wet Lab and Hardware subteams between June and October 2026.

4.1.1. Carbon Emission Calculation

Dry Lab:
Dry lab emissions are primarily driven by the compute time for training models and dealing with large scale sequences. A detailed breakdown of the compute includes local laptop and university cluster use for the initial database construction, AWS CPU usage for database refinement and expansion and single GPU training runs on Nvidia L40S.

Wet Lab:
Wet Lab's emissions primarily emerge from equipment energy use, production and disposal and cold chain storage for reagents and samples. Wet lab has also confirmed that assay development in itself is a resource and time intensive process involving a lot of factors like procedures, data handling and hands on lab time to build a working high throughput assay.

Hardware:
Emissions from the hardware perspective are associated with the manufacturing, transportation, and uses of the bioreactors. While data about emissions in the stage of component manufacturing was difficult to obtain as many suppliers did not disclose carbon emissions associated with each manufactured component, the manufacturing process of plastic and electronic components require electricity as well as chemical processes that result in the production of emissions. Furthermore, transportation of the parts, including those that were ordered from far locations including China add to the emissions produced. From the perspective of usage, the bioreactors require approximately 5W of energy for operation on average. As such, usage of bioreactors may also contribute to emissions depending on the energy source used to power the bioreactors.



4.1.2. Emission Reduction Strategies

Across Dry Lab, Wet Lab and Hardware there exist subteam specific waste reduction strategies. Firstly, for Dry Lab, this includes avoiding redundant retraining runs and reusing intermediate model checkpoints whenever possible. Secondly, for Wet Lab, this includes conducting assay runs in batches to reduce reagent overhead per sample and using reusable labware where biosafety protocols allow. Lastly, from a Hardware perspective, to reduce emissions, the following steps could be considered: 1. Use a minimal number of components; 2. Source components from local suppliers; and 3. Turn bioreactors off when not in use.

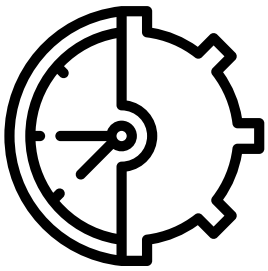
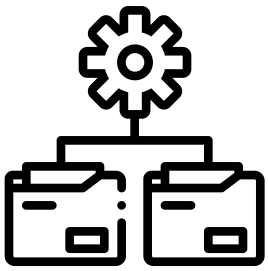
4.2. Improvements in Dry Lab Workflows

4.2.1. Sustainable Computational Practices & Green computing

Choosing energy efficient hardware and avoiding unnecessarily large model architectures when a smaller model achieves comparable accuracy are core to how PETadex is being trained and run. Dry Lab has confirmed that the model being trained is a fine tuned version of UniProt's existing ESM protein model [35] as opposed to a new model being trained from scratch. In doing this, the sequence curation process is optimized to avoid adding unnecessary candidates to the working set before expensive computation is run. It is important to note that computational efficiency is treated as a sustainability metric along with model accuracy. This is evident through design decisions that have already been made.

4.2.2. Data Management and Optimization

The run time and the complexity of PETadex's search scales with both the size of the sequence databases inquired about and the complexity of the underlying model. The process of data generation and gathering has been identified as the bottleneck and is the most expensive and time consuming step in the pipeline. This has a direct sustainability implication since regenerating this data from scratch is costly [1], full reproducibility of PETadex by outside groups is also constrained by cost. This is a limitation that we must be transparent about as opposed to assuming that open access alone solves it.


5. CONCLUSION AND RECOMMENDATIONS



5. Conclusion and Recommendations

5.1. Summary of Findings

PETadex and PetaBite aims to offer a sustainability advantage over existing PET disposal and recycling routes by utilising an enzyme based degradation approach that avoids quality loss with every cycle as opposed to mechanical recycling. This is backed by our own numbers, wherein, roughly $ 35,000 was used in Dry Lab compute across the full database generation process and hardware's measured power draw was 15W peak/ 5W average per reactor unit.

5.2. Recommendations for Enhancing Sustainability within the Field

To further improve sustainability in the field of microplastic enzymatic degradation, we recommend continuing to engage in stakeholder research and consultation and prioritizing enzymes with clean homology to naturally existing sequences during the early stage, reserving the heavily engineered variants [16] for instances with a clear activity gain that justifies the added ecological uncertainty.

5.3. Future Research Directions

Possible future research directions may include conduction of a lifecycle assessment [36] comparing PetaBite's process against other methods such as mechanical and chemical recycling, and tracking of enzyme activity and stability under real WWTP conditions, beyond lab assays.

6. Bibliography

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