EcoMoBioLab: Next-generation precision agriculture using portable molecular biology equipments

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Background

Molecular identification of animal or plant remains or samples is an integral part of current field research in the sectors of ecology and agrifood. Similarly, various microbiomes are scrutinized in both sectors and this includes environmental ones, where sampling may be required over long distances, least accessible terrain and away from organized research labs and similar facilities (Zaky *et al.*, 2018).

Long spatial distance between sampling ground and processing facility entails sample integrity and biosecurity risks; long temporal distance mostly the former. Therefore, the initial processing of samples had better be implementable on-site and the processed sample be subsequently transported in a secure manner, precluding contamination by some accidental release during transportation, as it has been rendered itself stable and safe from deterioration; and this preferably without high-tech (and cost) packaging and sealing nor cold-chain transportation and storage requirements. Alternatively, the main processing and wet analysis may be performed *in situ* (sensu lato) or almost locally, collapsing the windows of risk and vulnerability.

Given that similar requirements are common in many biosecurity applications, especially biosecurity engaging over the issues of wildlife and natural environment (as opposed to urban, suburban and agrarian) following the prerogative of the One Health-One Planet concept (Beckham, Brake and Fine, 2018), the investments (material-instrumentation, and immaterial- procedures) for research purposes, but also for training of scientists, technicians and auxiliary personnel of various levels and specialties serving ecological and agronomic interests, may be exploited when under duress. That is, if they abide to specifications mentioned above, they are liable to emergency recruitment to respond to a crisis, in an effort to augment the mobilized and expanded biosurveillance mechanism (Goudoudaki *et al.*, 2023). The latter may be reaching overexpansion, striving to detect invasive alien species or acts of environmental and agro-terrorism, -crime and -warfare, such as the use of biosynthetic pathogens to eradicate habitats, ecosystems or species (Rogers et al, 1999; Williams *et al.*, 2020).

In this context, the proposed collaboration involves the following two intertwined objectives:

A. EcoSTEM

The first objective refers to the development of training syllabus in the use of a low-cost man-portable molecular biology laboratory. The selected device achieves a fine balance between cost and performance, with its low weight, simplicity, reduced infrastructure requirements and built-in robustness allowing the ad hoc establishment and prompt operation of advanced molecular analysis stations (for surveillance and/or screening tasks). The forward deployment concept allows relatively short reaction cycles (understood as resampling requirements in case of test failure or as briskly emerging need for additional sampling before the site of interest is compromised). The mode of employment may be two-fold: either full molecular analysis, based on specific or differential PCR reactions, or generic PCR reactions followed by differential restriction digestions (Kambouris *et al.*, 2020). Alternatively, for more high-end analyses the unit may be used for sample preparation to be sequenced, either according to the Sanger principle and its spinoffs (chromosequencing, capillary arrays sequencing) or to NGS formats. The above will be combined with the optimization of limited/zero environmental footprint DNA extraction protocols, which have been tested with both the mobile instrument and conventional benchtop PCR/RFLP infrastructure for specific applications and environments/sample types. These protocols present different combinations of capabilities and economy, understood as shrinking of logistical and environmental footprint and required support (expendables, energy, infrastructure, associated devices/accessories and personnel). Indicatively, the modular alkaline lysis protocol allows either immediate use of the crude DNA extract when following a very fast format; or prolonged storage/shipment of the refined DNA extracts if implemented in a more elaborate format (Goudoudaki *et al.*, 2021). The thermoosmotic protocol, on the other hand, is dedicated for immediate use of the extract, but employs no chemicals (reagents or enzymes) and using minimal plastic consumables per sample (Goudoudaki, *et al.*, 2023).

B. Microbe- and metabolite-mediated soil improvement

The second objective refers to the improvement of soil properties by using microbial species. This includes prior determination of the soil microflora by next-generation DNA sequencing and based on the results, the soil gets enriched with the adequate combination of microbial species and metabolites, ensuring a truly precision agriculture approach. Such an approach has proven to be successful, also in line with our preliminary findings (project PAGGAIA; https://2022.igem.wiki/patras).

References

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