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Setting up and operating faecal sludge laboratories: three case studies from developing countries

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The Pollution Research Group (PRG) runs a highly experienced wastewater and sanitation research laboratory in South Africa. The PRG laboratory team has offered their expertise to partner laboratories and played a pivotal role in developing faecal sludge (FS) laboratories through a capacity building programme in developing countries. The PRG has visited many laboratories where they assist with individualised programmes to set up or improve existing systems. This can include building an appropriate laboratory structure, establishing management systems, and improving health and safety when handling biologically hazardous material and the development of analytical methods. Laboratory management systems must be in place to govern laboratory processes as a whole. Laboratories should establish and follow health and safety procedures, laboratory management systems and standard operational protocols. There is a need for greater communication and collaboration between FS laboratories in developing countries to ensure best practice is shared and maintained.

Introduction

The Pollution Research Group (PRG) is a wastewater and sanitation research group based at the University of KwaZulu-Natal (UKZN) in Durban, South Africa. The PRG has partnered with the eThekwini Municipality to address local sanitation issues and provide sustainable sanitation solutions. This collaborative work has attracted funding from the Bill & Melinda Gates Foundation (BMGF) that aims to eradicate poor sanitation in developing countries. Through this partnership, the PRG has committed itself to capacity building by providing assistance in developing faecal sludge (FS) laboratories with other grantees of the BMGF in developing countries. This paper considers the requirements for setting up and managing an FS laboratory and gives three case studies that show how the PRG laboratory team have supported this process in other developing countries in Africa.

Principles for setting up a faecal sludge laboratory

Irrespective of the field of research, laboratories have essential similarities. However, setting up an FS laboratory needs special attention to certain aspects because of the biological hazards associated with the materials being handled. When working with FS, a carrier of numerous human pathogens, health and safety is of the highest priority.

A strategic workflow in the laboratory must be considered. The workflow is a systematic pattern that stipulates the order in which a sample will move through the space as it is received, prepared and analysed, until there is data output from that particular sample. When receiving biohazardous material, exposure to the material must be restricted for non-laboratory staff and to the equipment, if possible. The sample must move through sample receiving, storage and preparation areas before moving into the analytical areas. By ensuring that these areas are systematically laid out, the pattern of movement between areas should limit bulk sample movement throughout the laboratory and thereby limit the exposure of pathogens to non-laboratory staff.

When setting up a laboratory, this systematic approach to sample flow must be taken into consideration and will give guidance in setting up utilities. The desired laboratory workflow and installation of utilities can influence one other. As such, planning the workflow can assist in determining where to position laboratory utilities, equipment and designated rooms for specialized equipment and samples in a given space (APHA, 2012).

A laboratory requires utilities such as water, electricity, gas lines and extraction systems. Once the utilities are in place, the basic necessities of a laboratory are doors, workstations, sinks and taps. The workstations and the floors must be hard, non-porous and chemically resistant. This include furniture so that it is easy to disinfect. The sinks must be deep so that it is possible to use them for washing for a wide range of glassware and possibly equipment accessories (SBMA, 2007). They must be deep enough to prevent water splash backs from reaching electricity plug points. The plug points must be high, no plug points must be at floor level where they can be affected by water leaks, spillages or where wires can be a tripping hazard. Gas cylinders must be kept in a ventilated area, with the least possible exposure to sunlight. They must also be placed in a fire free zone (e.g. not close to Bunsen burners). There must be sufficient lighting and enough space to allow sufficient air circulation inside the laboratory.

One of the most important utilities when working with FS is an extraction system that can remove odours for general laboratory users and the public. Odour comes from contained FS, FS combustion and from chemicals used during analysis. High efficiency particulate air extraction systems are recommended and are coupled to pathogen filters to improve and maintain air quality in the laboratory.

There must be more than one emergency exit door and emergency exit doors must be accessible at all times. If possible, there should be drains on the floors that are linked to the sewerage system. There must be space allocated for safety showers, fire extinguishers and a gas bank storage area. Additional areas like an external wash area, chemical storage rooms, and equipment storage rooms are advantageous.

It is important to establish laboratory management systems that govern and maintain a functional laboratory. Laboratory management ensures that proper procedures and channels are adhered to all the times. Record keeping of all sampling field trips, samples received, laboratory daily usage, laboratory analysis, instrument usage, instrument maintenance plans and quality control management systems ensure that the lab is maintained and can be used to expand the capacity of the laboratory.

An FS laboratory requires instrumentation for analysing FS and for developing accurate FS analytical procedures. Whilst standard analytical methods for wastewater have been established and well published (APHA, 2012), this is not the case for FS analytical methods. There is still a need to develop standardised FS analytical procedures because FS represents a complex sample matrix. Analytical methods must be adopted and modified for setting up accurate analytical procedures for FS.

Capacity building

The PRG has a research grant funded by the BMGF to offer capacity building to other grantees that are starting up FS laboratories. The PRG provides advice and support through workshops on establishing laboratory management systems, health and safety and standard operational methods development based on their experience of working with FS, urine and fresh faeces. Hereafter, three case studies demonstrate how the PRG has supported other FS laboratories at different stages of their development.

Case study 1 – Planning laboratory workflows for new and existing laboratories

The PRG was contacted to advise on the design of a new laboratory which was still under construction. The PRG drew up laboratory plans as shown in Figure 1, which proposed how the space could be used efficiently whilst taking into consideration the best possible workflow for the space available. Considering workflow during construction allowed the laboratory to have a dedicated sample receiving area adjacent to the storage and sample preparation spaces. A clean room at the far end of the laboratory from the “dirty” area could accommodate precision analytical equipment. Finally, a data capture room, personal protective equipment (PPE) storage and an exit basin were placed near the main door to the laboratory.

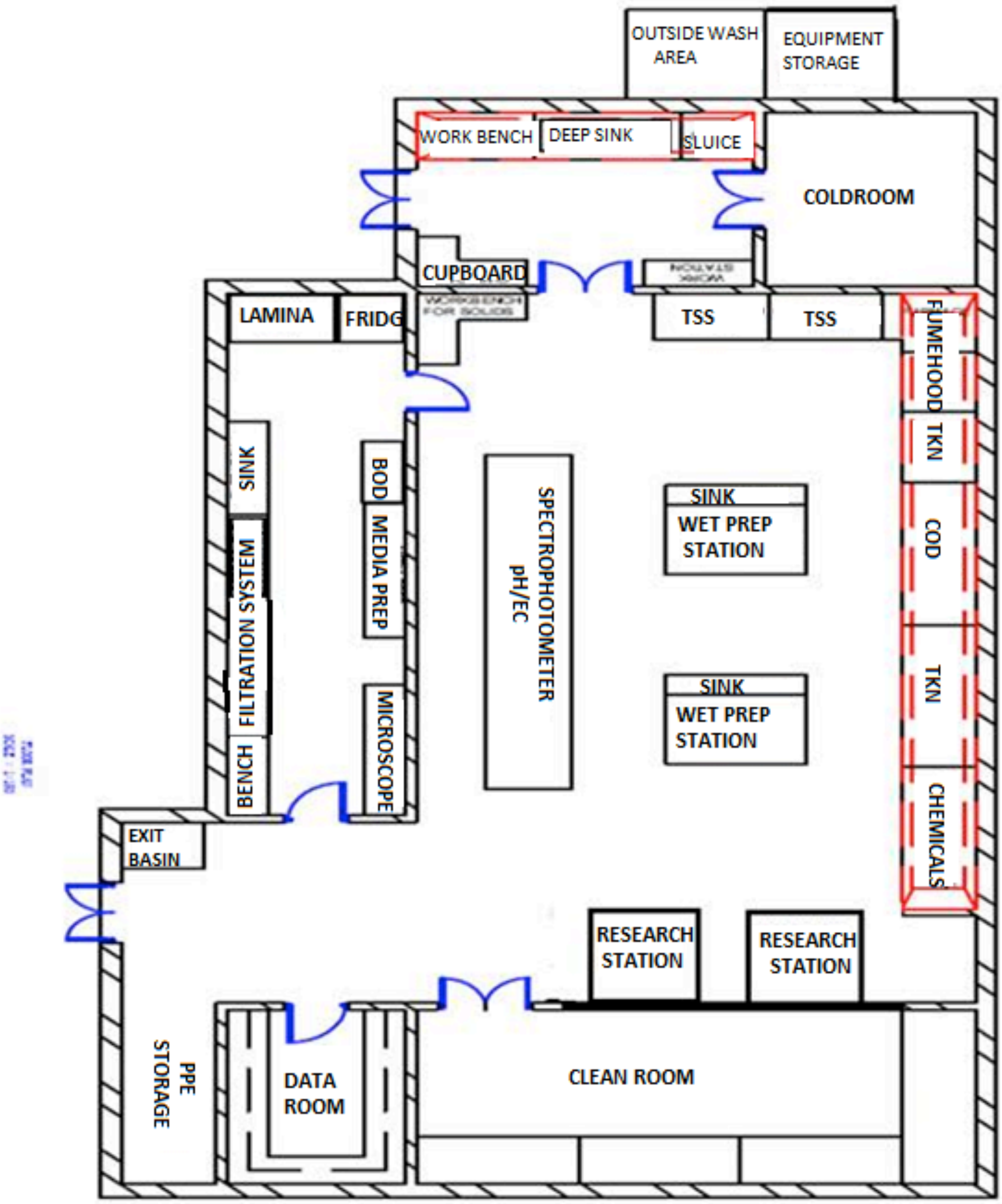

Figure 1. Proposed laboratory set up

Laboratory layout and workflow was also considered in the case of an existing laboratory shown in Photograph 1 and Photograph 2 which had plans to expand and to start FS analysis. The PRG designed a laboratory floor plan that took into account work flow around a central workbench for sample preparation with sample receiving, storage and preparation on one side of the laboratory and analytical equipment on the other side. In addition, a workshop on FS sample preparation, method development and data interpretation was given.

Photograph 1. Laboratory extension 1

Photograph 2. Laboratory extension 2

Case study 2 – Implementing laboratory management systems for existing laboratories

An existing laboratory contacted the PRG as they required laboratory management assistance. The PRG provided an interactive training session on health and safety, laboratory organisation and laboratory staff management. This was tailored to how they could use best their laboratory space and address limitations for meeting their laboratory objectives. One of the main challenges facing this laboratory was that its small footprint had multiple purposes as a teaching laboratory, processing FS samples commercially and carrying out experimental research. This had led to disorganisation and confusion as shown in Photograph 3. Storage areas were used as a dumping ground by laboratory users that were unsure of procurement, storage and disposal protocols and bench space was cluttered as it was used for different purposes. The PRG helped them to set up a laboratory management system, which was applicable to their needs, Photograph 4.

Photograph 3. Mismanaged lab

Photograph 4. Sorted lab

Laboratory management systems establish a protocol that guides laboratory processes and maintains a functional system. Laboratory management systems are different for each task. For example, laboratory management systems can be put in place for students working in the laboratory, which requires them to receive vaccinations, an induction, basic laboratory techniques training (e.g. pipetting and dilutions) and assessments of those techniques before they are allowed to work in the laboratory independently. Figure 2 shows the laboratory process from receiving a sample up to data distribution that was recommended to ensure that commercial and research samples were appropriately handled. By having procedures written down, there is less confusion about the steps necessary to process samples and where information about existing samples can be found. This is vitally important in a laboratory that serves more than one function.

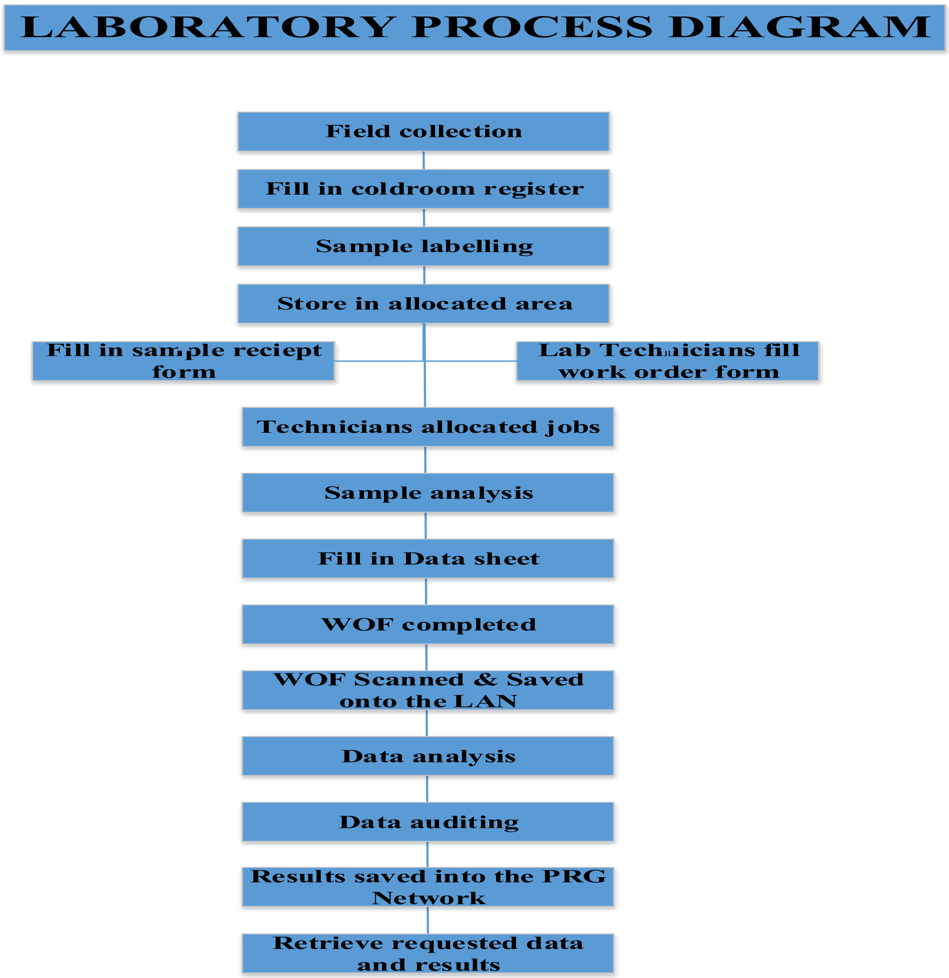

Figure 2. Sample management system

Case study 3 – Improving health and safety in existing laboratories

Inappropriate use of PPE, such as wearing an open laboratory coat, or not using gloves for certain tasks like reading agar plates is common in inexperienced FS laboratories. Similarly, the risks of moving notebooks and pens between the laboratory and the office are not recognised. This is dangerous because laboratory users and contaminated personal items can become vectors for pathogens like *Escherichia coli* or *Ascaris lumbricoides* that have a negative impact on human health. Often the support that the PRG provides in improving health and safety is not initially the focus of a visit as laboratory staff do not see that their laboratory practices are unsafe. However, on numerous occasions, when the PRG have been contacted for support with laboratory management, one of the key issues faced is poor health and safety. In these cases, the PRG provides interactive training sessions on health and safety and how laboratory management must ensure that all practices take the hazards of working with FS into account.

Conclusion

The PRG has provided support for developing sanitation laboratories for different international organisations. Support varies from designing laboratory floor plans and maximising laboratory potential by considering workflow to helping establish laboratory management systems. Laboratories that do not have prior exposure to FS face challenges when they start working with the material, due to the biological hazards associated with it. Additionally, it has been observed that for many existing laboratories workflow and set procedures are not considered. This might be due to the lack of information, guidance or sometimes space to set up an ideal laboratory. There is negligence when it comes to health and safety. Laboratories without management systems in place become easily disorganised and cluttered. Laboratories need support from all levels in an organisation in order for them to operate safely. This allows both the laboratory and the organisation to meet their objectives. The importance of these systems must be appreciated and adhered to by everyone in the organisation. Further capacity building workshops are needed to spread awareness of the risks of working with human excreta and to improve sanitation laboratories in developing countries. A better network of sanitation laboratories needs to be established as follow up visits or better communication between laboratories is important to monitor if changes or procedures are implemented and to ensure that best practice can be shared.

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