Self-built Low-cost Mobile Incubator for Field and Laboratory Use

There is broad demand for a low-cost, portable incubator for microbial testing of drinking water. This self-built incubator is based on widely available materials, can operate under a range of field conditions, and still offers the advantages of higher-end laboratory-based models. Ariane Schertenleib[1], Jürg Sigrist[2], Max Friedrich[3], Christian Ebi[4], Frederik Hammes[2], Sara J. Marks[1]

Introduction

Incubators are essential for a range of culture-based microbial methods for assessing drinking water quality. Under Sustainable Development Goal 6.1, governments have committed to regularly report on the bacteriological quality of drinking water at the national level [1]. In addition, operational monitoring of water infrastructure is regularly undertaken at the local or regional level [2]. These surveillance and monitoring campaigns are often in remote locations where infrastructure and resources are limited. In these contexts, conventional incubators may be inadequate or unavailable. Field incubators are commercially available, but manufacturers usually offer a fixed design and use is limited to specific settings or sample sizes. There is, thus, a need for an adaptable incubator that offers the advantages of laboratory-based models while remaining suitable for field applications (Table).

The purpose of this project was to develop an adaptable, low-cost and portable incubator that can be built using readily available components, and designed to combine the advantages of both conventional and field-based models.

Performance

The electronic core of the incubator was first developed. It was then tested under a range of conditions with three types of shells made of common materials: a polystyrene foam box, a hard plastic cooler box and a cardboard box covered with a survival blanket (Photo). Each set-up was tested at three ambient temperatures: moderate (27 °C), cold (3.5 °C and 7.5 °C) and hot (39 °C), while the inner temperature was set at 37.0 °C and 44.5 °C, the typical temperature settings used for detection of faecal contamination indicators in drinking water.

The electronic core performed similarly to a standard laboratory incubator in terms of the time required to reach the set temperature, inner temperature stability, temperature spatial dispersion, power consumption, and microbial growth. The incubator set-ups were also effective at low and moderate ambient temperatures (3.5 °C and 27 °C). At higher ambient temperatures (39 °C), the incubator designs presented here were prone to overheating, unless the set temperature was even higher (i.e. 44.5 °C). Better insulating shells (polystyrene foam box and hard plastic cooler box) showed better performance in terms of power consumption and time to reach the set temperature in a cold environment.

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Photo: Incubator shells tested. Polystyrene foam box (left), hard plastic cooler box (middle), and cardboard box covered with a survival blanket (right).

Conclusion

This incubator prototype is low-cost (< $300 when the material is purchased in Switzerland), adaptable to a variety of volumes and field conditions, and can be built from different materials. It can be used in both established laboratories with grid power or in remote settings when powered by a car battery. It is useful as an equipment option for field laboratories in areas with limited water quality monitoring resources. Practitioners with limited capacity can use this incubator to establish permanent or seasonal laboratories at reasonable costs. Through its use, it is possible to increase the number of laboratories in remote areas, making efforts to conduct regular water quality surveillance or punctual monitoring of system operations more feasible.

Characteristic	Laboratory-based	Field-based	Adaptable
User friendly design	✓	✗	✓
Large capacity	✓	✗	✓
Robust to wide range of ambient temperatures	✓	✗	✓
Maintains constant temperature	✓	✗	✓
Low cost	✗	✓	✓
Easily transported	✗	✓	✓
Energy efficient	✗	✓	✓
Resilient to intermittent power supply	✗	✓	✓

Table: Characteristics of commercially available incubators (laboratory- and field-based) and the adaptable approach. ✓ Advantages, ✗ Disadvantages

[1] World Health Organization (WHO). Safely Managed Drinking Water – Thematic Report on Drinking Water. WHO Press. Geneva. (2017).

[2] Peletz, R., Kumpel, E., Bonham, M., Rahman, Z., Khush, R. (2016). To what extent is drinking water tested in sub-Saharan Africa? A comparative analysis of regulated water quality monitoring. Int. J. Environ. Res. Public Health. *13 (3),* 275, doi: 10.3390/ijerph13030275

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