I2I Landscaping exercise

Potter Tower

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Acronym List

CFV	Controlled flow valve
I2I	Innovation to Impact
IRS	Indoor residual spraying
LITE	Liverpool Insect Testing Establishment
PQ	Pre-qualification
SOP	Standard Operating Procedures
WHO	World Health Organisation

Summary

Aim and key questions addressed	- Used as a method of chemical spraying in the laboratory - Use is intended to provide a homogenous residual deposit of the desired concentration of active ingredient per unit area.
Context	- Laboratory
Test item	- Indoor residual spraying (IRS) formulations
Mosquito population	- N/A
Number of mosquitoes per replicate	- N/A
Endpoints measured	- N/A
Exposure time	- N/A
Holding time	- N/A
Indicative of personal protection	- N/A
Suitable chemistries	- IRS forumalations
Appropriate controls	- N/A
Relevant stage of production pipeline	- Product development - Bioefficacy assessment

Characterisation of output	- Application of insecticide onto surfaces is well characterised, but consistency between sprays is difficult
Accessibility	- Materials need to be sourced and training is required before use
Cost	- Cost of equipment and time to train staff in machine calibration and use
Level of validation and characterisation of outputs	– Need for validation within and between sites
Outstanding questions, gaps and priorities	- There is an urgent need to properly validate, both internally and across multiple centres, the method as well as proposed alternatives such as the track spayer
Key references, related SOPs, guidelines and publications	- Potter, C. (1952). An improved laboratory apparatus for applying direct sprays and surface films, with data on the electrostatic charge on atomised spray fluids. Annals of Applied Biology, 39(1), 1–28. Retrieved from https://doi.org/10.1111/j.1744-7348.1952.tb00993.x - World Health Organization. (2006). Guidelines for testing mosquito adulticides for indoor residual spraying and treatment of mosquito nets.

Overview

Indoor residual spraying (IRS) is one of the primary vector control interventions for targeting malaria vectors. It involves the application of long-lasting, residual insecticide to vector resting surfaces such as walls, eaves and ceilings (WHO., 2015). The World Health Organisation (WHO) list of prequalified (PQ) products (WHO., 2023) for IRS includes five insecticide classes, however with the rise in insecticide resistance new insecticides and formulations are urgently needed.

Initial testing of IRS formulations is performed in a laboratory, requiring controlled dosing of a representative substrate. The current WHO standard for laboratory applications of IRS formulations is the Potter Spray Tower (WHO, 2006) (Figure 1). The Potter Tower was developed at Rothamsted Experimental Station, Harpenden, Hertfordshire, England (Potter, 1952) and delivers insecticides onto surfaces such as mud, concrete, plywood and tiles for subsequent testing. It is internationally recognized as the most precise method of chemical spraying in the lab and it's use is intended to provide a homogenous residual deposit of the desired concentration of active ingredient per unit area.

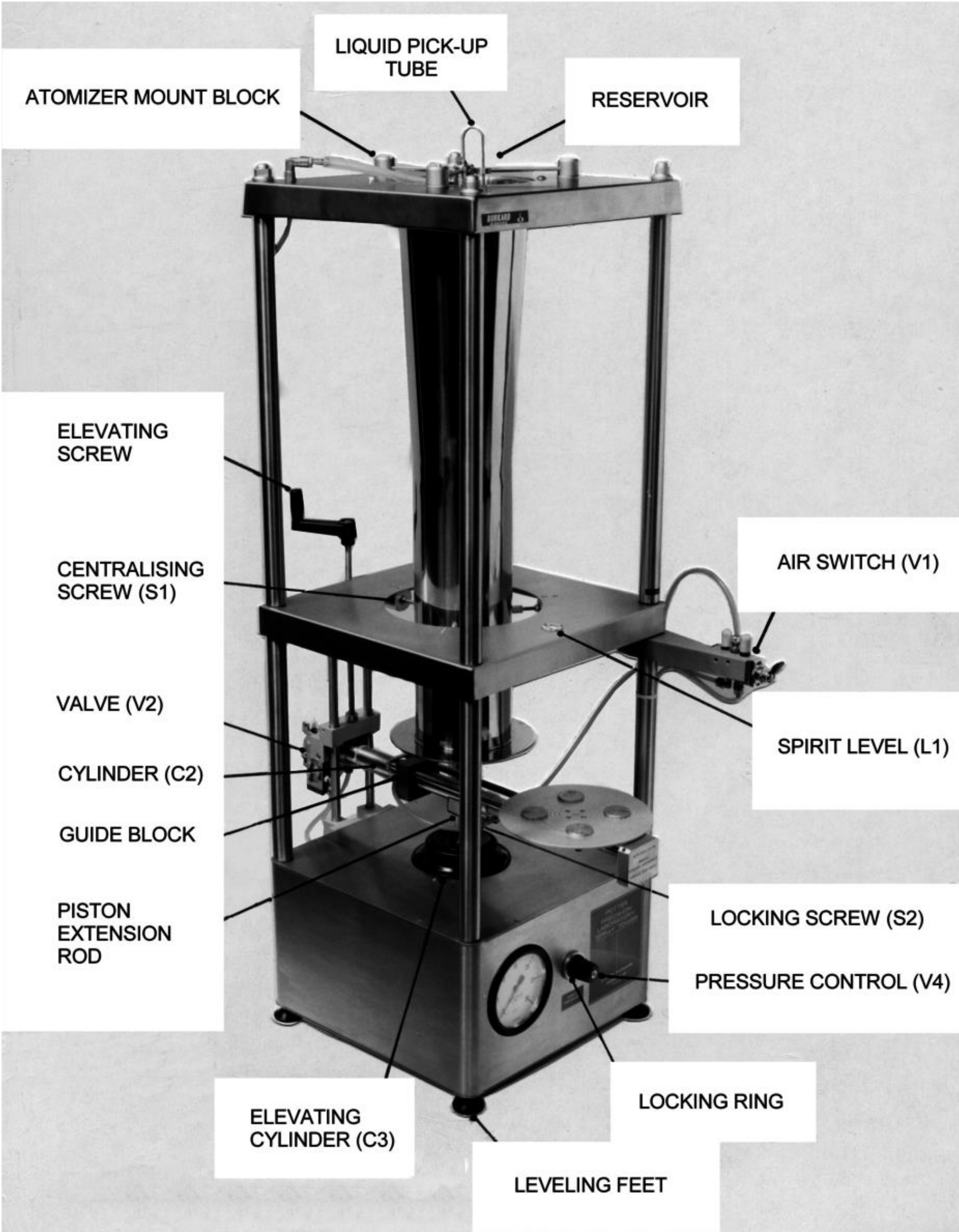

Figure 1. Diagram of a Potter Tower. Accessed from Liverpool Insect Testing Establishment (LITE) (https://lite.lstmed.ac.uk/our-services/testing-at-lite/lite-testing-equipment/the-potter-tower)

Define Accepted Methodologies

Are there existing standard SOPs/Guidelines detailing methodologies?

The standard operating procedure (SOP) implemented at the Liverpool Insect Testing Establishment (LITE) is "Application of compounds to surfaces using the Potter Tower" (LITSOP089).

Are these sufficiently detailed?

The current SOP for the Potter Tower is detailed suffiently enough to use the equipment.

Do these methods require specialised/non-standardised equipment and/or training?

Yes, training is required for use of the Potter Tower and associated equipment calibration and cleaning.

Are there issues with the methods or their interpretation?

The Potter Tower can take a long time to calibrate, only one surface can be treated at a time, and the accuracy of the dosing and the uniformity of the deposit is now in question. The standard operating procedure (SOP) implemented at LITE includes two calibration steps for use of the Potter Tower. The first step is to adjust the position of the spray nozzle until the weight of spray droplets deposited onto four cover slips placed centrally on the spray table deviates by ≤ 10 % from the mean spray weight. The second calibration step is to check that the required spray weight is deposited over the sprayed area within a margin of ± 5 % the target weight. Once these calibration criteria have been met, the application of IRS formulations to the test surfaces can proceed. No additional calibration checks are carried out during treatment applications since calibration can take a considerable time and it would be impractical to repeat it. Consequently, there is no confirmation that the Potter Tower maintains this uniformity throughout the treatment period.

What AIs or combinations of AIs have the tests been used for?

Actellic, Deltamethrin, K Othrine, Polyzone and Nitisinone.

Are they validated, for which AIs/entomological effects, and to what extent?

Within institution validation at LITE has been performed, but there is minimal literature around validation in other settings.

What inputs need to be characterised? e.g., samples, mosquitoes, equipment

The Potter Tower must be level before use, the nozzles need to be centralized, cleaning must be performed and after use and the equipment needs to be calibrated.

The volume, concentration or weight of insectides, along with which surfaces to be sprayed need to be characterised before use.

Are endpoints clearly defined and appropriate? Who were they defined by?

The resulting concentration of insecticide sprayed onto a surface will be defined by the subsequent testing to be perfomed.

Are their supporting SOPs? e.g., cleaning SOPs, mosquito rearing SOPs required

Supporting SOPs are required for:

- Performing serial dilutions and preparation of required insecticide volume/concentration

- Cleaning of Potter Tower equipment and test areas
- Maintenance of the Potter Tower
- Preparation of the surfaces to be sprayed

Define Current Use Practices

Does everybody use the same SOP?

All use and maintenance of the Potter Tower appears to use the same SOP, however, different institutions may implement their own cleaning SOPs.

Are there differences of interpretation of the method?

N/A

Are there results obtained largely consistent between studies?

End results (mosquito mortality) between studies appear to be consistent, however testing ran within LSTM has resulted in regular over application of insecticide. This could be resulting in higher than expected mosquito mortality in subsequent bioassays than we would expect, with effects (mortality over time) lasting for longer too.

Is further development, refinement or validation of the method required? Based on priority, significance, and relevance of method.

An ideal replacement would be a dedicated device with throughput, ease of use, and accuracy and uniformity of the applied dose equal to or better than the Potter Tower. A study comparing the Potter Tower and Micron Horizontal Track Sprayer has been published (Bonds et al., 2023), with more information on these results detailed in below sections.

The Micron Horizontal Track Sprayer with Spray Cabinet (Micron Sprayers Ltd, Herefordshire UK) utilises the same conventional Flat Fan nozzle (FF 80 02E), controlled Flow Valve (CFV), and pressurised spray tank as the backpack sprayers used for IRS application during operational deployment, so has the additional advantage of replicating the way IRS products are applied during spray campaigns. The nozzle is mounted on a motorised track along which it moves at set speeds to deliver the required spray volume to surfaces placed on the floor of the cabinet. The height of the nozzle above the target surface can also be adjusted. The nozzle is connected to a pressurised spray tank by a length of tubing. With constant speed and uniform nozzle pressure (by use of a CFV) during application, results from the track sprayer should be highly reproducible as well as allowing the treatment of multiple surfaces simultaneously. In addition, the Track Sprayer has the capacity to produce treated surfaces to test not only chemicals but also the application techniques used to apply them

Identify Potential Sources of Variation

What are the sources of variability in the method and are their means to minimise or characterise these.

Weight of the sample vs volume sprayed – calculations or previous conclusions these are based on may be incorrect. Calibrations do not tend to remain, and it is unknown whether that has much impact or not.

Does current method/s need to be adapted for new active ingredients/MoA/types of tool?

Potentially, and work has been carried out using the Track Sprayer which is explained in more detail below.

Are new methods required? Identify areas where current method/s are not suitable or sufficient.

The use of the Track Sprayer as an alternative method to the Potter Tower has been examined in a recent study perfomed by (Bonds et al., 2023). This work aimed to perform a comparison between the Potter Tower and Track Sprayer in three ways:

- Observations of the operation and ease of use of the two methods were made to facilitate a comparison by following the calibration, treatment and cleaning procedures.
- Secondly, the performance of the two methods in terms of the treatment accuracy was made by measuring the volume of spray treatment deposited, the uniformity of that deposit and the residual efficacy of the treated test surfaces.
- Lastly, the dose of active ingredients deposited by both devices was assessed using HPLC.

A series of studies showed that deposition volumes can be calibrated for both sprayers. However, the uniformity of spray deposits was higher for the Track Sprayer compared to the Potter Tower. Less than 12% of volume sprayed using the Potter Tower reached the surface with the remaining 88% unaccounted for, presumably vented out of the fume hood or coating the internal surfaces of the tower. In contrast, the Track Sprayer deposited the majority of the spray on the floor of the spray chamber with the rest contained therein. The total sprayed surface area in one run of the Track Sprayer was 1.2 m^2 and the operational zone for spray target placement was 0.7 m^2 meaning that 58% of the applied volume deposits on the targets. The Track Sprayer can treat multiple surfaces (18 standard 15x15 cm tiles) in a single application whereas the Potter Tower only treats one surface at a time.

WHO cone bioassays showed that treatment applications with both sprayers at a quarter of the recommended dose, ≥80% mortality was maintained for up to 6 months. With applications at the full label rate using the Track Sprayer mortality was ≥80% mortality up to 7 months post-application, whereas with applications at the same rate using the Potter Tower, mortality fell below this threshold by 6 months. The shorted residuality of the full dose applied using the Potter Tower could be attributed to the uniformity of deposits. HPLC analysis run in conjunction with fluorimetry showed that the appropriate volume of spray solution (Actellic® 300CS and K-Othrine® WG250) was deposited but that the dosage of active ingredient (pirimiphos-methyl and deltamethrin respectively) within that volume was not as anticipated. The HPLC analysis showed that the Potter Tower applied approximately twice the target dose of insecticide to the substrate whereas the Track Sprayer tended to apply less than the target dose. It was observed that the IRS formulation was sedimenting out in the long line of delivery tubes of the Track Sprayer: this was addressed by agitating the spray tank, and by not letting the spray solution sit in the lines for extended periods. Repeating the experiment using Suspend® PolyZone® showed some overdosing (20%) using the Potter Tower, suggesting that formulation type maybe associated with the differences between actual and target application rates. Overall, the Track Sprayer represents an improvement over the Potter Tower in terms of the efficiency and accuracy of IRS formulation applications onto test substrates and offers a useful additional tool for researchers and manufacturers wanting to screen IRS or other sprayable formulations for insect control.

Gaps in biological or other understanding that hinder method development or validation

With the growing need to evaluate IRS formulations containing novel insecticides, researchers need a more reliable, efficient alternative to the Potter Tower for treatment applications. While pyrethroids give rapid knockdown and kill at relatively low application rates, new compounds in development may have an endpoint such as delayed mortality (the pro-insecticide chlorfenapyr for example) or sterilization (pyriproxyfen) which may be more sensitive to deviations from actual target dose application rates. It is therefore essentials to treat test surfaces accurately to minimise the effect of variability in application rates on bioassay endpoints.

Additionally, in less well controlled environmental conditions, the effects of aerosolisation and water droplet physics may not be well understood and could benefit from further research.

Prioritisation – is there an issue that needs to be addressed, what specifics, how urgent is the need?

There is an urgent need to properly validate, both internally and across multiple centres, the method as well as proposed alternatives such as the track spayer.

References

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