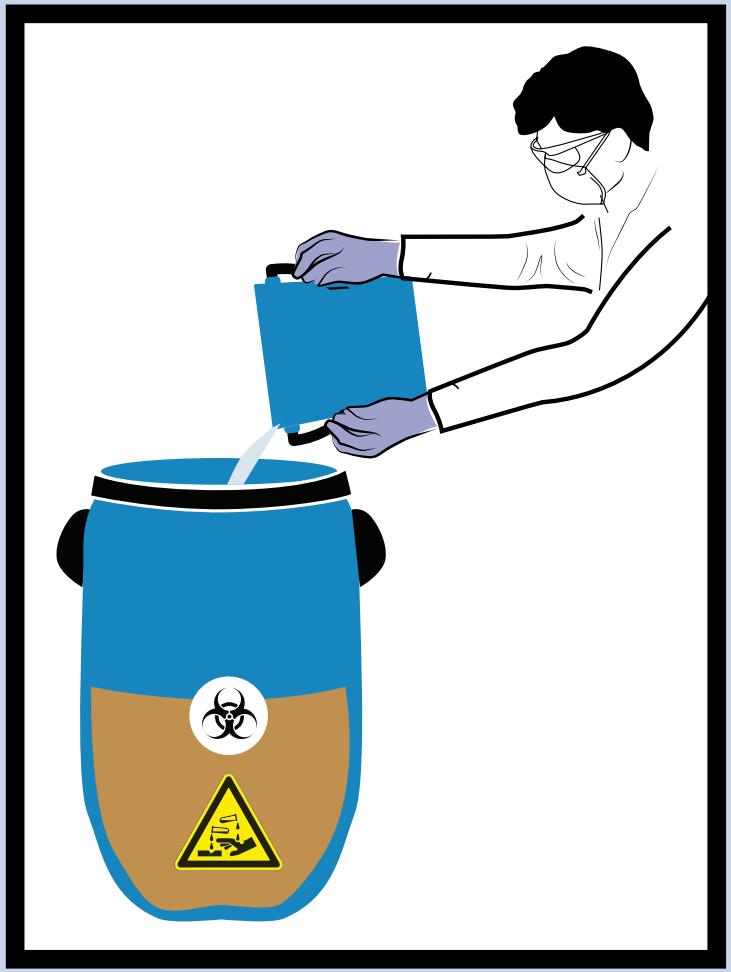
Lime dosing and treatment performance monitoring Manual

(Project SMaRT)



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User Guidance

This illustrative manual was produced as part of Project SMaRT (Safer Management and Reliable Treatment of faecal sludge in humanitarian setting) and focusses on an approach for monitoring and determining effective batch treatment of human excreta during periods of rapid accumulation during the onset of humanitarian crises, or during waterborne disease outbreaks. The manual provides guidance on how to establish, and monitor treatment efficacy (even during periods of fluctuation in faecal sludge composition or lime quality), to ensure that a suitable level of pathogen reduction has been achieved in the treated product.

The manual is principally designed for practitioners including non-governmental and public implementing organisations operating in low-resource, emergency settings, such as at existing or newly created faecal sludge treatment facilities.

Project SMaRT partners from the University of Brighton, Médecins Sans Frontières and BRAC, Bangladesh would like to thank the funder Elrha for their support and guidance, and the not-for-profit design company Roots and Wings C.I.C for their creative input.

This manual is one of a series of three funded and supported by Elrha's Humanitarian Innovation Fund (HIF) programme, a grant making facility which improves outcomes for people affected by humanitarian crises by identifying, nurturing and sharing more effective, innovative and scalable solutions. Elrha's HIF is funded by aid from the UK Foreign, Commonwealth and Development Office (FCDO). Elrha is a global charity that finds solutions to complex humanitarian problems through research and innovation. Visit **www.elrha.org** to find out more.

This manual has been developed to assist those working in emergency humanitarian settings where resources, including time, may be limited due to the urgent nature of the response. The manual is intended to support decision making and should complement, rather than substitute, sound professional judgement. The authors and publishers do not guarantee or accept legal liability of whatever nature arising from or connected to the content of this manual.

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Background

Humanitarian crises following natural disasters or armed conflicts can trigger sudden population displacement, leading to the rapid accumulation of human excreta. Safely managing excreta during these times is vital if waterborne disease outbreaks such as cholera or typhoid are to be avoided or contained. The use of hydrated lime as a treatment method has proved to be a scalable, rapid, in-situ approach for deployment during the initial phase of humanitarian emergencies, e.g. whilst longer-term biological treatments are established. This has led humanitarian actors such as Médecins Sans Frontieres (MSF) to develop protocols such as 'Standard Operating Procedure (Comprehensive Method) for On-site CTC wastewater treatment with lime' in March 2020, and UNHCR to produce 'Lime treatment of faecal sludge for humanitarian contexts: Guideline for onsite to centralized treatment' in March 2024.

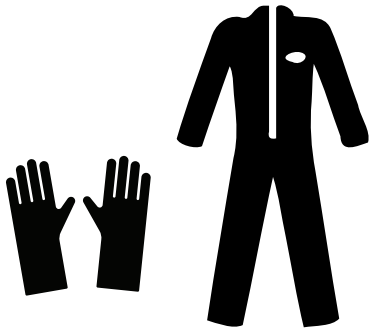
However, despite the development of such guidance, effective lime treatment comes with challenges that may arise from fluctuations in the volume and composition of excreta (faecal sludge); variations in available lime quality; and uncertainties around the survival of pathogens which mean that dosing needs to be monitored to ensure treatment efficacy.

The following manual outlines an approach for testing and monitoring the effectiveness of lime treatment in situations where the quality of lime and/or faecal sludge consistency, age may be highly variable. Such monitoring can ensure compliance with specific removal targets (e.g. 3 Log reduction), whilst optimising lime usage and reducing operating expenditures (OPEX).

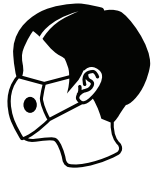
Safety – Personal Protective Equipment (PPE)

The hazards of working with lime include severe chemical burns when in contact with skin, eyes, or lungs. In addition, when lime comes into contact with faecal sludge potentially harmful ammonia (NH3) emissions can be released. Always use appropriate PPE when handling and especially mixing hydrated lime and faecal sludge.

Safety glasses/goggles



Heavy duty gloves (ideally PVC), overalls (full length)



Respiratory facemask (ideally FFP3, but any other type is better than no mask)

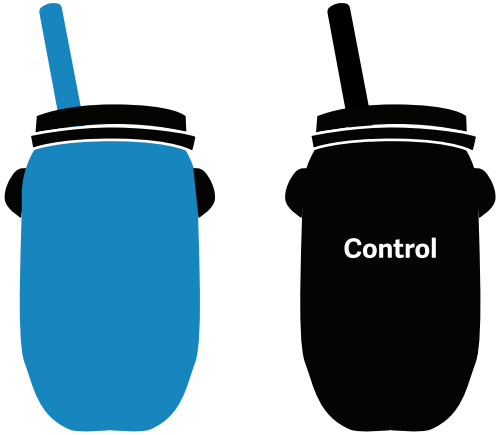
Rubber boots

Note: Lime dust can also cause harm to skin, lungs and eyes upon contact. Always wear appropriate PPE.

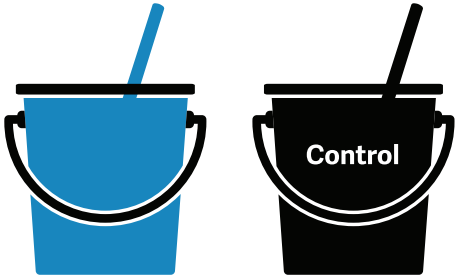
Step-by-step guide to establishing lime treatment efficacy

Materials

- 100-litre barrels/drum (with lids) - Number of barrels depends on how many lime concentrations and faecal sludge (FS) sources are being tested/ monitored. If possible use a different colour barrel for the control (e.g. containing just FS/No lime).



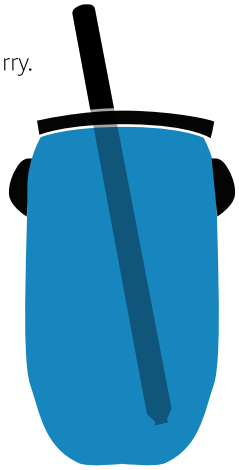
- 20-litre plastic buckets - Number of buckets will again depend on how many lime concentrations and faecal sludge (FS) sources are being tested/ monitored. If possible use a different colour bucket for the control (e.g. containing just FS/No Lime).



- Stirring rods (plastic, wood or metal) – A length of stiff plastic pipe can work well (make sure the rod is long enough to comfortably reach the bottom of the barrel (long), or bucket (short) and be gripped with two hands).
  Again, if possible, it is useful to use different colour stirring rods for the control (e.g. containing just FS/No lime).

Short (e.g. 0.5m) for mixing lime slurry.

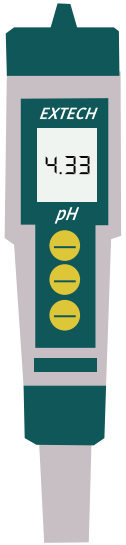
Long (e.g. 1-1.5m) for mixing FS/lime slurry.



- Balance (portable) Kitchen balance is fine.

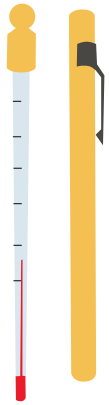
- Vortexer e.g. Whirlimixer™
(Fisher Scientific) or equivalent (x1)

- Handheld pH meter –
Note: Before storing the pH meter, ensure that the probe tip is clean: carefully rinse it with distilled water (or tap water if not available). Store the pH meter in a secure place with the cap covering the probe tip. Keep the probe tip moist, ideally in an electrode storage solution (4M Potassium Chloride solution (KCl)), or if that is not available, use pH 4 or 7 buffer solution. It is important to maintain and calibrate the pH meter according to the manufacturer's instructions. Calibrate at least once a week with buffer solutions (if available), or as frequently as needed.

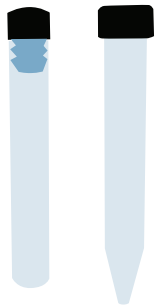


- 2L Measuring jug, beakers

- Thermometer



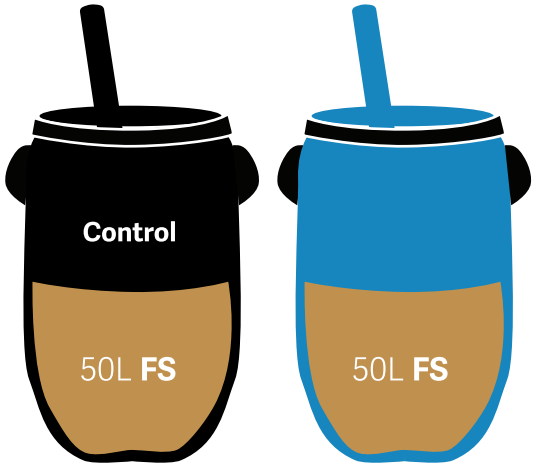
- Test tubes (10-12mL) with lids ideally disposable plastic (e.g. SterillinTM or Falcon tubes) though glass can be used (x100)



Field Testing Procedure

The following proceedure should be conducted outside, ideally undercover in a safe area e.g. at an existing faecal sludge handling or treatment facilitiy. The area should not be accessible to the public, especially children. It is up to you how many lime concentrations, faecal sludge samples and contact times to test. This may depend on the quality of avialble lime supplies, the consistency and volume of faecal sludge (FS) needing to be treated. The following is based on contact times of 1-hour, 1-day and 7-days.

Step 1. Fill 100-litre barrels with 50-litres of freshly collected FS (this ensures sufficient space in the barrel for the addition and mixing of the lime slurry). Thenumber of barrels will depend on the number of different lime concentrations being tested (plus control barrel containing only FS).

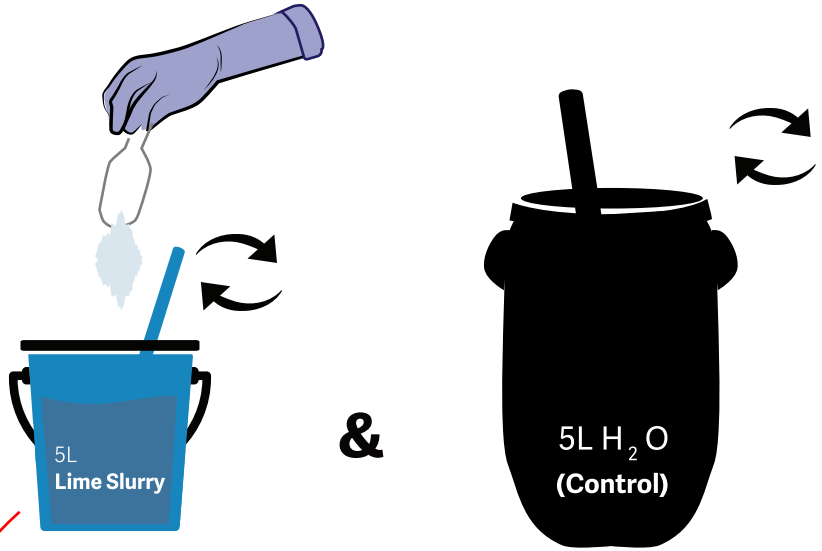


Step 2. Record details about the FS source, date/time of sampling, approx. age (if known) in a field notebook/data recording sheet (this information can then be transferred to an Excel document).

Step 3. Prepare lime slurry in accordance with Table 1 below. This can be performed using 20-litre buckets. Carefully weigh out the hydrated lime using a balance.

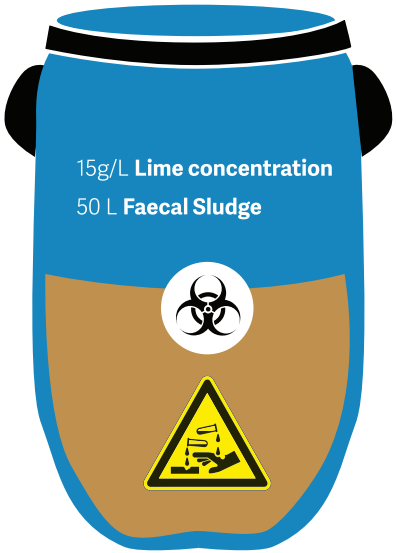
If lime stocks are of unknown quality, or have been stored for some months prior to use, then their quality (purity) can be assessed in the field (see the 'Lime Characterisation Manual' that accompanies this manual, and which contains a step-by-step guide to the process).

Step 4. Gradually pour the lime powder into 5-litres of H_2O (tap water/ rainwater) and using a stirring rod very carefully mix the lime suspension until fully dissolved. For the control bucket (containing FS/ no lime) add 5-litres of (tap water/rainwater).

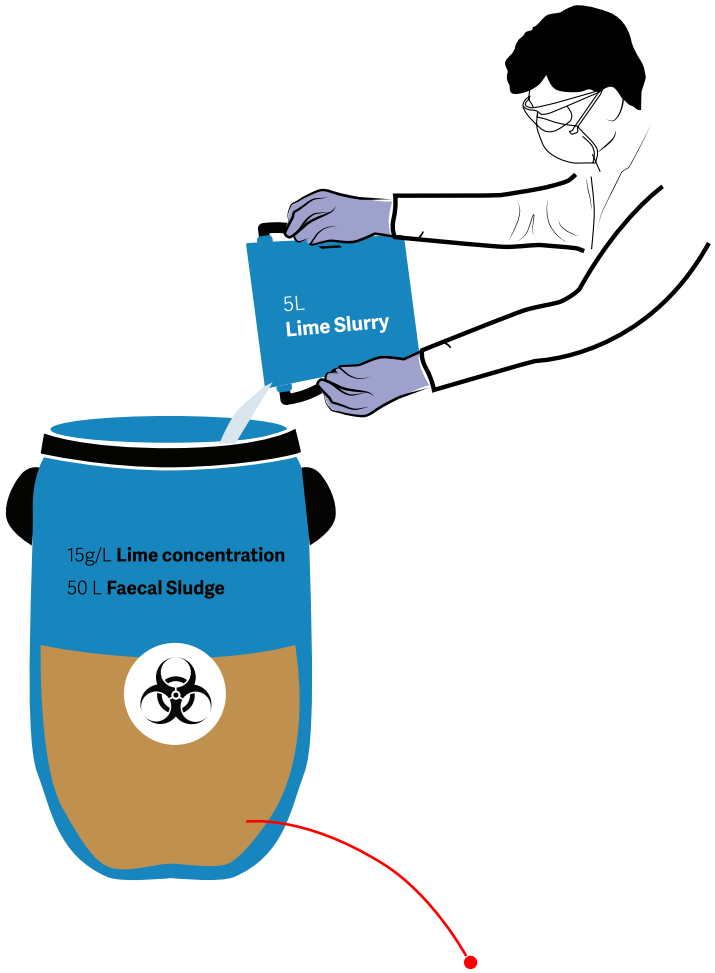


Note: It is VERY important to add the lime powder to the water, NOT the other way around a strong exothermic reaction will occur.

Step 5. Label the 100-Litre barrels (using a waterproof marker pen) to clearly show the lime concentration, FS origin and date/time treatment commenced. The barrels should also have a warning sign on them stating that the contents are biohazardous and corrosive.



Step 6. Decant the bucket containing lime slurry into the respective 100-litre barrel containing the 50-litre of FS. Repeat this process for each lime concentration being tested.

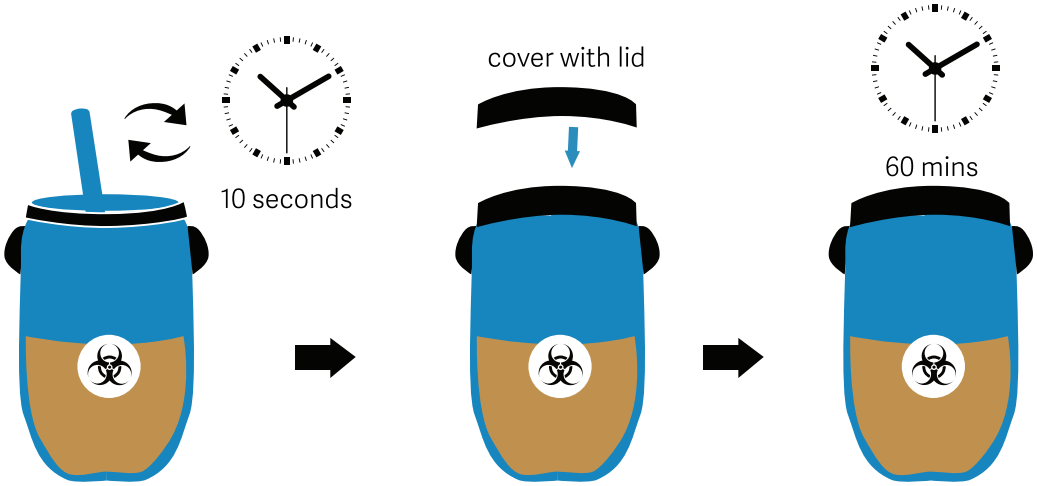


Note: It is important to follow the 1:10 ratio in terms of lime slurry to faecal sludge as it aids mixing; in this case 5 litres of slurry to 50 litres of FS.

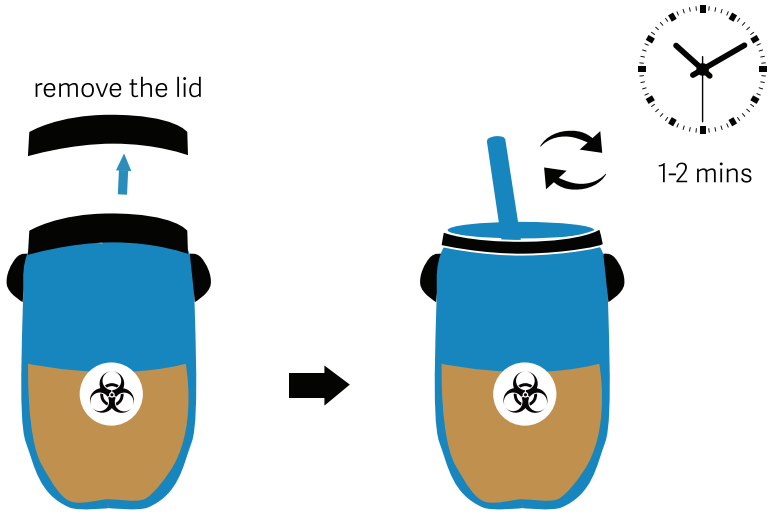
Step 7. For the 'control' barrel containing only faecal sludge (no lime) add 5-litres of H_2O (tap water/rainwater) and mix. This will be used to estimate treatment efficacy.

Step 8. Using a stirring rod (plastic, wood or metal) stir the lime suspension and FS for approx. 10 seconds to allow thorough mixing to occur (always use a different stirring rod for each of the lime suspensions/FS samples). After mixing cover the barrel with lid.

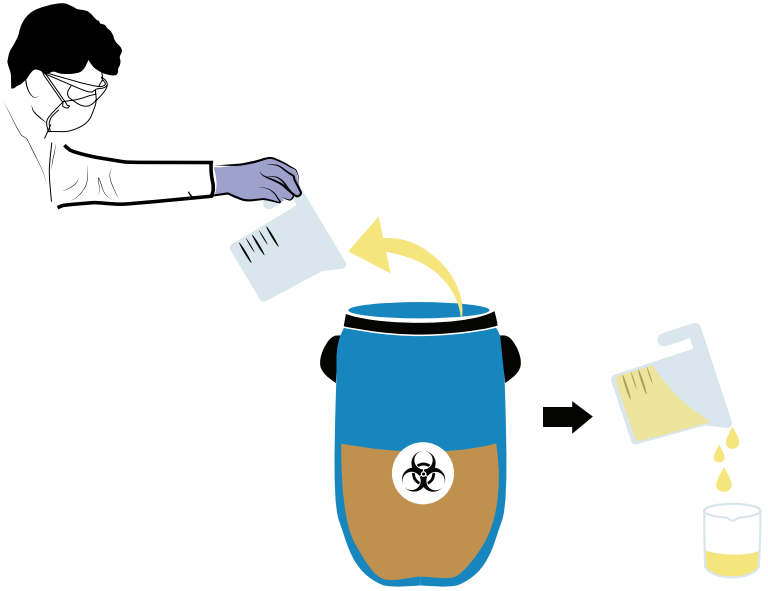
Step 9. Allow 1-hour contact time.



Step 10. Then, remove each barrel lid (including the blank) and gently stir the contents for 1-2 minutes (until the lime and/or FS are back in suspension and well mixed).



Step 11. Then carefully withdraw an approx. 500mL sample by dipping a wide-mouth container (e.g. plastic measuring jug) into the barrel. Alternatively, a container fixed to a length of wood can be used as a dipper.

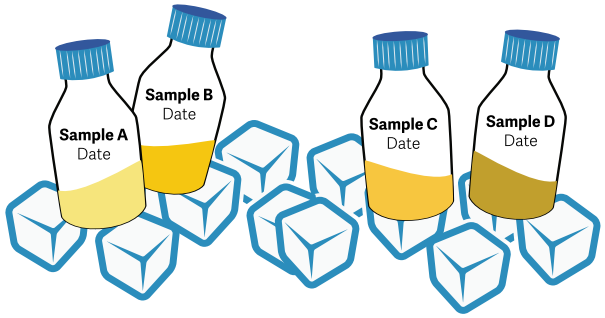


Step 12. Decant 50-100mL of the sample into a glass beaker or centrifuge tube, clearly labelled with the lime concentration and date.

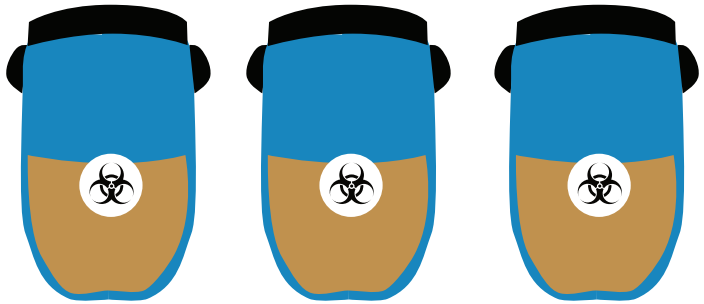
These samples will be used to create dilution series (see below) necessary to enumerate faecal indicator organisms (e.g. E. coli) and somatic coliphages in accordance with standard methods (ISO 9308-1:2000, ISO 10705-2:2000, respectively). Please also see the 'Somatic Coliphage Testing Manual' that accompanies this manual, and which contains a step-by-step guide to the detection and enumeration process.

Additional sample can be taken if testing further parameters such as COD, BOD, TSS, TDS, vibrios or helminth ova is an option (if such lab testing facilities exist).

Note: It is important to transport samples to the field laboratory as soon as collected and avoid leaving them in direct sunlight (as microbial die-off will occur). If samples are being transported off site, then cooler boxes with cooler packs or ice should be used.



Step 13. Place lid on the barrels when not in use.



Step 14. Repeat steps 10 to 13, if testing additional contact times e.g. 1-day and 7-days.

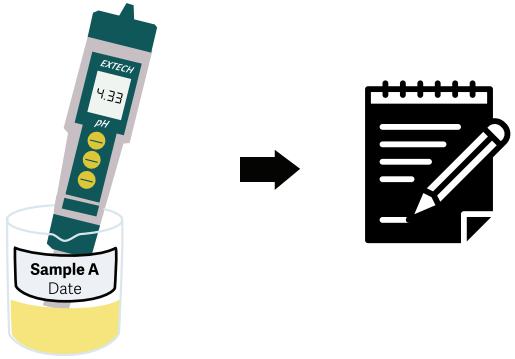
Table 1. Preparation of lime slurry based on treatment of 50-litres of faecal sludge (FS)

Lime concentration (g/L)	Lime needed for 50-litres FS (g)	Add and mix Lime Suspension using 5-litres H_2O (10% of 50L)
5	250	250 g dissolved in 5-litres of H_2O
10	500	500 g dissolved in 5-litres of H_2O
15	750	750 g dissolved in 5-litres of H_2O
20	1,000	1,000 g dissolved in 5-litres of H_2O

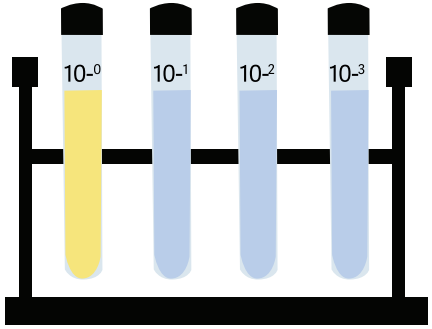
Note: The amount of lime (g) and H_2O (L) can be increased or decreased, provided that these proportions are maintained

Laboratory testing procedure

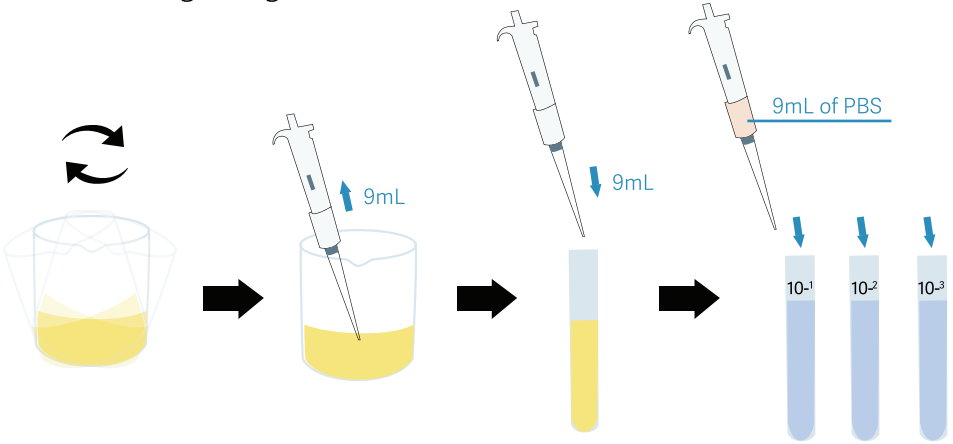
Step 1. Measure the pH and temperature of samples as soon as possible and record the results using a field recording sheet (e.g. MS Excel document).



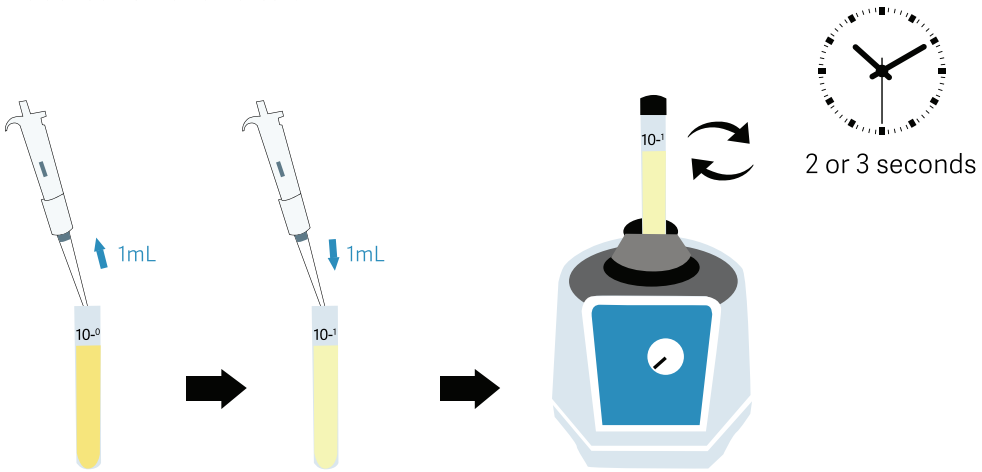
Step 2. Prepare test tubes tubes (e.g. disposable Sterilin tubes) for serial dilutions by labelling the tubes (dilution series) 10^{-0} (Raw sample) 10^{-1} 10^{-2} and 10^{-3}



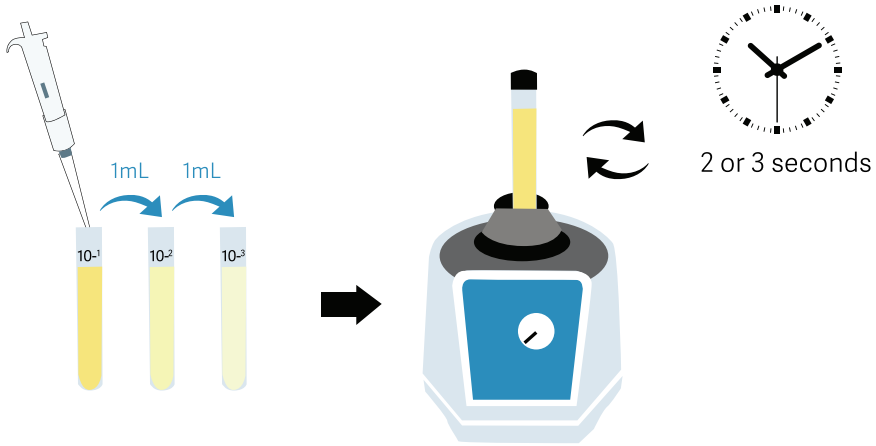
Step 3. Stir the contents of the 50-mL sample container and pipette 9-mL of sample into the tube (labelled Raw sample 10-0). Then with a new pipette tip add 9-mL of Phosphate Buffered Saline (PBS) or ¼ Strength Ringers solution.



Step 4. Then carefully withdraw 1 mL of the sample into the first tube labelled 10-1 and vortex.



Step 5. Then from the 10-1 dilution and using a new pipette tip each time, carefully withdraw 1 mL of this sample into the first tube labelled 10-2 and vortex. This step will be repeated for the 10-3 dilution.

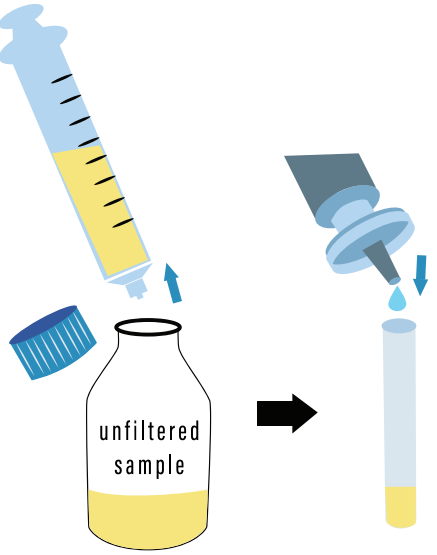


Step 6. Now that this serial dilution has been performed, these samples are ready to be tested for *E. coli* (within 4-6hrs) by membrane filtration in accordance with ISO 9308-1:2000. The *E. coli* (bacterial indicator) results should be recorded after 18-24 hrs incubation.

From the glass beaker containing the original sample, withdraw 10mL of sample and filter (using the 0.22µm syringe-driven filter) at least 4mL of sample into a test tube labelled 10-0 and use this volume to create another dilution series (as per above).

Note: It is recommended to perform this method on 10^{0} (raw sample) and 10^{-1}, 10^{-2} for FS samples exposed to lime (treated samples) and on 10^{0} , 10^{-1}, 10^{-2} , 10^{-3}, 10^{-4}, 10^{-5} for samples of FS not exposed to lime (untreated control).

Step 7. These dilutions will be used to perform the double agar somatic coliphage (SC) detection method (as described in the 'Somatic Coliphage Testing Manual' that accompanies this manual, and which contains a step-by-step guide to the detection and enumeration process). Initial SC results (viral indicator) will be ready after 3-4 hrs, though should also be recorded after 18-24 hrs incubation.



Step 8. The results of the *E. coli* and SC tests at each lime concentration and after each contact time should be subtracted from the equivalent control sample (just FS). This will allow the log removal to be established.

Additional safety considerations

- **It is compulsory that all personnel present on site wear safety glasses at all times and wear additional personal protective equipment, appropriate to the task being undertaken.**
- **Only authorised personnel are allowed on the treatment site.**
- **Always have constant access to a supply of 0.2% chlorine solution to deal with any accidental wastewater spills or leaks, as well as 0.05% chlorine solution for hand disinfection.**
- **Ensure a plentiful supply of drinking water to rinse skin that may come into contact with hazardous chemicals (e.g. alkaline solutions and powders).**
- **Ensure eyewash is available in case of accidental splash.**
- **Showers should be provided in case of accidents and also for staff personal hygiene.**

References

Anon. (2000). ISO 9308-1:2000; Water Quality. Detection and Enumeration of Escherichia coli and Coliform Bacteria Part 1: Membrane Filtration Method. International Organization for Standardization: Geneva, Switzerland, 2000.

Anon. (2001) [b]. ISO 10705-2, Water quality - Detection and enumeration of bacteriophages - Part 2: enumeration of somatic coliphages. International Organisation for Standardisation, Geneva, Switzerland.

Project SMaRT is funded and supported by Elrha's Humanitarian Innovation Fund (HIF) programme, a grant making facility which improves outcomes for people affected by humanitarian crises by identifying, nurturing and sharing more effective, innovative and scalable solutions.

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