Sampling and Health, Safety and Environment Standard Operating Procedures for GHG emissions measurements from On-Site and Small-scale Sewered Sanitation Systems

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1 Purpose

This Sampling and Health, Safety and Environment (HSE) Standard Operating Procedure ensure that fieldwork surveys aimed at measuring greenhouse gas (GHG) emission measurements from sanitation systems across different sites are conducted accurately, consistently and safely. This document outlines procedures for pre-fieldwork preparations, on-site sampling and post-fieldwork activities, covering both on-site and decentralised/small-scale sewered site locations. Considering that fieldwork involves intensive onsite sampling and handling of potentially hazardous biological and chemical substances and mechanical risks from handling equipment on site, we have identified key focus areas including personal safety, data integrity and equipment preparation and handling. This standard operating procedure was produced based on the research activities conducted as part of the EMISI project in Indonesia.

2 Health Surveillance and Preventive Controls

All personnel involved in fieldwork activities should be vaccinated according to the World Health Organisation (WHO)-recommended routine schedule, with particular attention to Hepatitis B and tetanus. Please note that Hepatitis B and tetanus vaccines require either 3 or 2 doses. Anyone feeling unwell should refrain from conducting fieldwork and prioritising rest is adopted as crucial to recover and prevent a minor illness from

escalating, particularly in stressful, demanding environments, where fieldwork is conducted.

3 Contact detail database

The team leader for each sampling survey must carry the database with the contact details of project leaders and all members of their team with their corresponding emergency contact number (next of kin or designated personal contact).

4 Personal Protective Equipment (PPE)

All personnel involved in sampling surveys must wear the following PPE:

1. Eye Protection: Safety goggles or face shields to protect against splashes.
2. Respiratory Protection: N95 (FFP3) masks or better to prevent inhalation of harmful particles or gases.
3. Gloves: Chemical-resistant gloves (nitrile or latex) to protect hands from contaminants.
4. Gauntlets (up to elbow length): To be worn either over gloves or by themselves by the operator of the flux chamber during the rotating stage and opening and closing of chambers
5. Closed Shoes: Steel-toed or heavy-duty (ideally waterproof) closed shoes to protect feet from heavy objects during the opening of container chambers and chemical exposure.
6. Protective Clothing:
    a) During initial set-up and close of monitoring: Cotton single-piece or split overalls, to protect skin from contact with hazardous materials (Disposable waterproof overalls are also suitable, but are rated unsuitable in hot weather conditions.)
    b) During sampling: Cotton single-piece or split overalls, to protect skin from contact with hazardous materials, are optional but will still be required for any adjustments that require physical contact with equipment used during sample collection or in direct proximity to the access point to the sanitation unit.
7. Crow or Pry Bar: To be used for levering chamber lids open with a minimum of two members of the sampling team assisting.

5 Area Security

Each sampling location has three main working areas: the sampling area, the washing area, and the clean area (i.e., for resting, eating, etc.). Mark the working areas as follows:

1. Cone Marking: Use cones to mark off the sampling area. Ensure the area is clearly delineated to prevent unauthorised access.
2. Signage: Display warning signs indicating hazardous materials and restricted access.
3. Access Control: Limit access to essential personnel only. Non-essential personnel should remain at a safe distance.

6 Materials for Cleaning Sampling Equipment

Make sure to prepare the following equipment and supplies before departure to the sampling and measurement locations:

1. Cleaning Solution: Use a suitable disinfectant or bleach solution to decontaminate equipment.
2. Jerry can: Container to carry water for equipment washing.
3. Spray bottle: A low-pressure manual spraying device to spray cleaning solution onto equipment – e.g. a small garden/weed sprayer (~1 litre).
4. Water will be mixed with undiluted cleaning solution (#1) into the spray bottle (#3) to create a cleaning spray. Note: When the cleaning solution is already diluted, mixing is not required.
5. Disposable Wipes: Provide disposable wipes for quick cleaning.
6. Scrub Brushes: Use scrub brushes for thorough cleaning of equipment if necessary. Only to be used in full PPE due to splash risk.
7. Plastic Bags: Have designated bags for disposing of used cleaning materials and contaminated gloves, and further bags for undressing into for clothing to be cleaned (i.e. cotton overalls).

7 Materials to be placed in the washing Area

1. Jerry Can: Provide a jerry can filled with clean water for handwashing and rinsing equipment. (~20 litres or similar) and place on a raised surface for ergonomic reasons.
2. Handwashing station: A container with a tap for hand washing. Can be #1 to avoid duplicating containers if possible.
3. Liquid soap: For handwashing (in a pump bottle).
4. Hand tissue paper: For hand drying.
5. Hand sanitiser: Make hand sanitiser available for additional hygiene after washing.
6. Eye wash station: Containers of sterile eye wash for emergency use.
7. First aid kit: To be stored in this area.
8. Waste Disposal: Have a container for disposing of any waste generated during the cleaning process.

8 No Smoking Policy

1. Designated Smoking Areas: Clearly define areas around the sampling site where smoking is not permitted. This should be outside the tent, away from supplies, and with open access points.
2. Communication: Ensure all team members and local liaisons (government officials, operators, community members) understand the importance of adhering to this policy to minimise fire hazards.

9 Measurement Recording

The team leader is responsible for ensuring the following recording equipment is available and in good condition:

1. Field notebook
2. Printed data collection forms
3. Charged Tablet
4. Black Pens
5. Portable Battery
6. Septic Checker or improvised device: for measurement of faecal sludge and supernatant depths

If you make a mistake when writing data, correct it by drawing a slash and rewriting the correct value in a nearby space. This is to avoid confusion when digitising the results in the database (e.g., 3 or 8?).

10 Equipment for sampling

The equipment to be used for onsite sampling and analysis activities is listed in the table below.

Instrument Name	Brand	Parameters
Lutron YK-2001PHA Multiparameter Water Meter	Lutron	Multiparameter
pH Electrode Meter Lutron PE-03	Lutron	pH
Lutron OXPB-11 Probe DO Meter/OXPB11	Lutron	Dissolved oxygen and temperature
Lutron ORP14 ORP Meter/ORP 14	Lutron	ORP
UT325F 4-Channel Thermometer	Uni-Trend	Temperature Probe (flux chamber)
Testo 511 - pocket-sized absolute pressure meter	Testo	Pressure (flux chamber)
Geotech Portable Gas Monitor: GA5000, Biogas5000	Geotech	Gas Analyser (flux chamber)

11 Preparation of gas analysers

Before starting sampling at the sites, the default shut-off time for the gas analyser (Geotech Portable Gas Monitor: GA5000 and Biogas5000) must be changed to zero to prevent automatic purging. This must be verified every time a new site is sampled. This operation is recommended to avoid alterations of the headspace pressure conditions within the flux chamber.

1. Press the menu key
2. In Operational Settings, press 1 for Timers
3. Change Auto Power Off to 0 Minutes

12 Sampling Procedure from Onsite Systems: Step-by-Step Plan

1. Preparation:
    a) Talk with any community sanitation workers, company operators, and private operators who are responsible for opening and closing any access ports to let them know what process will be followed. Consider taking a letter on UI letterhead if a new person approaches the group seeking explanations about the work they are doing.
    b) The team leader will review the health and safety protocol with all team members.
    c) Team leader to ensure all PPE is available and in good condition.
    d) All team members will gather all necessary sampling equipment and cleaning materials.
    e) Team leader to designate team roles for the duration of sampling. Including:
        a) Who will be carrying out the recording (paper and digital) and keeping time.
        b) Who x2 will be working with the Flux Chamber.
        c) This should be rotated to avoid risks of heat stroke. The person recording must wear, at a minimum, a face mask during the sampling process and must adhere to all handwashing and food/water intake restrictions.
    f) Site Assessment:
        d) Conduct a visual inspection of the site for any hazards (e.g., chemicals, ground conditions, road traffic, etc.)
        e) Set up cones and signage to secure the area. One team member to look for traffic (as applicable).
    g) Agree on what is being measured with the team, e.g. number of access holes, time periods, and who will be doing the measurements (i.e., who will be wearing the PPE, who will be taking measurements, and who will be recording).
    h) Clear the site area from unwanted obstacles that may cause hazards.

i) Set up gazebo tent if decided this is required (high rain or sun risks, wind risk low).

2. Put on necessary PPE:
   a) Be sure to apply repellent on the exposed skin, such as the neck, hands, and arms, before wearing the PPE.
   b) All personnel must put on required PPE before approaching the sampling area, following the PPE guidance stated in the PPE (Section 4, above). The person designated as the data recorder must not be within 2m of the access hole.
3. Sampling:
   a) The team leader or designated team member will physically inspect all recording equipment and the flux chamber to ensure all are in good working order.
   b) The GA5000/Biogas5000 will be turned on and stabilised at the atmospheric conditions. The fan should be activated and allowed to run for 90 seconds.
   c) The external sampling tubes will be connected to the flux chamber, and a tight and sealed inspection will be made at each connection point for the GA5000/BioGas5000 (inflow and outflow)
   d) The manometer will be connected via an external tube, and the thermometer will then be fixed to the centre of the bucket and tightened to create a seal

      Additional notes:

      a. Do not tighten the thermometer too much into the flux chamber, or you will crush it.
      b. Make sure everything is sealed by wrapping a PTFE seal on every connector (thermometer probe, GA inlet and outlet hose connector).

   e) The sampling point (maintenance hole cover) will be opened by team members wearing steel-toe boots or by the community/private operator, and the lid will be placed within the coned-off area.
   f) Tank characteristics will be recorded:
      - The distance between the tank surface and the top scum layer will be recorded.
      - The distance from the top of the scum to the bottom of the tank will be recorded:
      - Using a stick/prodding device to disrupt the scum layer enough to provide surface area for the flux chamber.
      - The tripod will be placed over the sampling point and adjusted as necessary.
      - One team member will attach the lead chain while another holds the flux chamber. They will then attach the chain to the tripod and loop it until a firm connection is made and the flux chamber is ready to be lowered.

- The flux chamber will be lowered until contact is made with the lip of the bucket, creating a liquid surface seal.
- The GA5000/Biogas 5000, thermometer, and manometer will be turned on.
- After 90 seconds, an initial reading will be taken for all three devices and will be recorded in both the field notebook and the electronic sample page.
    i. Parameters to read: Temperature, pressure, and gas concentrations (CO_2, methane, and dissolved oxygen).
    ii. After the reading is recorded within the field notebook. The fan on the Biogas5000 will be turned off.
    iii. After collecting data for 180 minutes, a Luer-lock syringe will be connected to the GC sampling port on the outflow tube from the Biogas5000 as applicable (if samples will be further analysed with GC-MS).
    iv. The port will be opened as indicated by the arrows connected to both valves, and a 10 ml sample pull will be made.
    v. The port on the outflow tube will be closed, and the port on the syringe will be opened to the atmosphere. The gas sample will be vented out.
    vi. The port on the tube will be changed back to facing the tube and the syringe, and the port on the outflow tube will be opened back onto the syringe.
    vii. A new sample will be taken.
    viii. The syringe port will be closed.
    ix. The tube port will be turned off from the syringe.
    x. The syringe will be removed from the tube and capped.
    xi. Following the sampling schedule (e.g., every six hours for 24 hours: four data sets per day for wet season; two data sets with 1 hour rest in between for dry season), measurements will be taken every 10 minutes for 180 minutes. See the Measurement Recording Sheet.
        1. When recording measurements on the GA5000/Biogas5000, the fan must be activated for 90 seconds, and then a reading will be taken. This allows time for the instrument to stabilise at a reading level.
        2. The fan should then be turned off afterwards to conserve power and reduce the need for internal purges.

3. In the event of no emissions being recorded, the field team must wait for an initial non-zero increase reading before the 100-minute timer begins.

   For example, if CH_4 is reading 0.4 for the first 30 minutes and then finally increases to 0.5 at minute 40, Minute 30 would be the first point in the 100-minute sampling period. All data before this should still be recorded.

xii. At the end of the run, the GA5000/Biogas5000 should be disconnected from the external tubes.

xiii. The same should be done for the manometer.

xiv. If the gas analyser is still activated, turn it off now and allow it to purge on 'normal air'.

xv. The chamber should be raised to just below the surface level.

xvi. The thermometer will be removed.

xvii. Using the gauntlets, one team member will carefully tilt the flux chamber and allow for gas to escape. Be sure to avoid liquid spillage from draining into the external tubes.

xviii. Keep the flux chamber tilted and reconnect the manometer, thermometer and gas analyser (after turning on) to the external tubes. Keep the flux chamber tilted until the gas analyser reads atmospheric levels of CO_2, CH_4, O_2, and balance.

xix. The flux chamber is now ready to be lowered back down into the sanitation system for a second reading.

1. If a break is taken between sampling, the gas analyser should be disconnected again and turned off until it is ready to use.

4. Faecal Sludge and Liquid Sludge Sampling

Once all gas sampling is complete, the field team should prepare to take measurements and samples from the sanitation system. This will consist of:

a) Faecal Sludge Sample

* Place the sample storage container and temporary sample bucket adjacent to the sampling point.
* Using the cylindrical tube sampler, lower the tube to the bottom of the tank.
* Once at the bottom, pull the closing mechanism.
* Extract the tube and empty it into the temporary sampling bucket.

* Transfer samples from the bucket to sample containers/tubes.
* Repeat if necessary to obtain a total of 1 L of sample.
* Empty contents of sampler back into the sanitation system.
* Spray the sampler with water and bleach.

b) Liquid Sludge Sample

* Repeating the same process, lower the tube back into the tank, but this time only going slightly below the surface.
* Close the tube using the closing mechanism.
* Extract the tube and Empty into the temporary storage bucket.
* Transfer sample into sample tubes/containers.
* Empty bucket back into the sanitation system.
* Clean the bucket out using water and cleaning solution.

c) Depth of system measurement

* Now that all samples have been taken, the system can be disrupted further.
* Using the depth measuring pole, attach a piece of string to the bottom of the pole (the colour change will indicate the different layers present).
* Extend the pole and lower it into the sanitation system.
* Extract the pole and measure the different layers (bottom sludge, liquid sludge, top layer) using the measuring tape.
* Remove the string and throw it away.
* Clean the pole using water and cleaning solution.

5. Parameters to measure in the sampled liquid and sludge. The following table list the recommended parameters to measure.

Liquid: inlet and effluent	Sludge: water column within containers
a) Ammonia b) Nitrites (NO2) c) Nitrates (NO3) d) Chemical oxygen demand (COD) *Total sample volume = 100 mL*	a) Biomethane production potential (BMP) by triplicate – 1 Litre. b) Chemical oxygen demand (COD) c) Total organic carbon (TOC) d) Total Nitrogen (TN) e) Total Kendall Nitrogen (TKN) f) Total suspended solids (TSS) g) Volatile suspended solids (VSS) h) Total solids (TS)

	i) Volatile solids (VS) a) Bomb calorimetric (Calor potential) j) Redox potential (ORP) k) pH (check on sites at different depths in the entire chamber) l) Temperature (check on sites at different depths in the entire chamber) m) Dissolved oxygen (DO - check on sites at different depths in the entire chamber) *Total sample volume = 1.5 Litres*

6. Notes on the operation of the GA5000 and Biogas5000:
   a) The GA/Biogas5000 should not be restarted during a trial when the unit is connected to the FC tubes and when measurements are taking place. This is because the GA/Biogas5000 must start in fresh air.
   b) The GA/Biogas5000 has an auto-off timer. This is set to 15 minutes by default, but it can be changed to a longer duration (e.g., 1 hour) in the machine's user settings. This is suggested to avoid an accidental shutdown.
   c) The GA/Biogas5000 needs to be switched on/started in fresh air. When the GA/Biogas5000 is started, run the unit for 1 min in fresh air, away from the septic tank/pit, to ensure it reads zero CH_4. If this does not return to zero, you must user-calibrate the GA/Biogas5000 in fresh air using the "zero with fresh air" mode. Please look at the GA/Biogas5000 manual for guidance. Do not start any calibration procedure other than fresh air mode; otherwise, the unit must be returned to a lab for re-calibration.
   d) If the GA/Biogas5000 shuts down unexpectedly during a trial and the machine is still connected, then restart the machine and make a note of this. This is not ideal, but you do not have a choice in this scenario.
   e) Do not periodically restart the GA/Biogas5000 during a trial for "sticking" values or similar (e.g., values that don't change or don't seem correct) because this will not solve that issue. Instead, it will decrease the accuracy of the trial underhand. Instead, either restart the trial (disconnect the GA/Biogas5000, let it shut down and purge in fresh air, then start again and zero in fresh air if needed) or continue the trial and make a note of this.
   f) Ensure that, when the trial is ended, and the GA/Biogas5000 is to be shut down, the GA/Biogas5000 can purge itself in fresh air and is not connected to the FC by any tubes.

13 Equipment Cleaning

1. After sampling, a designated team member with full PPE will remove the flux chamber from the scum layer.

2. They will pull it to the top, while a second team member (in full PPE) adjusts the chain until it is secured at the access point level.
3. The designated team member will tilt the flux chamber to allow any liquid to return into the septic tank.
4. If the trial is to be repeated, tilt the flux chamber to allow gas to escape for 5 minutes and assess the condition of the flux chamber. If the gas analyser is low on battery power, replace the device with the backup at this time.
5. If all trials are complete for the sampling day, the designated team member will clean all equipment using the cleaning solution and disposable wipes.
6. The team leader will ensure all cleaning materials are disposed of in designated bags.
7. The lid of the septic tank sampling point will be moved back in place by the designated operator.

14 Removal of PPE

1. Once all sampling has been completed, the flux chamber and accessories have been cleaned, and the lid is put back on the access point, PPE is ready to be removed.
2. Taking turns, team members will stand in the designated changing zone and remove their boots and split coveralls while keeping their gloves on. Placing the boots into a bag and then the coveralls into the laundry bag.
3. Gloves can now be removed before handwashing.
4. Washing:
    a) Wash hands thoroughly using the jerry can water and soap after removing gloves.
    b) Apply hand sanitiser as an additional precaution.
5. Removal of Mask and Goggles

After hands have been washed, team members will remove their masks and goggles. Masks that are visibly dirty or wet must be thrown away. Masks that are still in good working condition can be reused.

6. Area Securing:
    a) Ensure the sampling area is left clean and secure.
    b) The team member(s) assigned for recording will transfer the field notebook and tablet back into a secured bag for transport at the end of the sampling day.
    c) Pack away all equipment and accessories into appropriate storage boxes and bags.
    d) Remove cones and signage only after the area is deemed safe.

e) Take down the tent and put it away into its bag. Make sure travel arrangements are in place, so the tent is not taken down before departure during rainy conditions.

15 Clean Area: Health and safety recommendations during resting and mealtimes

When conducting gas emission measurements from sanitation systems, it is essential to maintain strict health and safety protocols during resting and mealtimes to prevent contamination and exposure to hazardous gases.

Separation of Clean and Work Areas: Ensure that clean and work areas are clearly separated. Mealtimes should only occur in designated areas away from any worksite where gas emission measurements are being taken.

Personal Protective Equipment (PPE): All personnel should wear the appropriate PPE, including gas monitors and respiratory protection, while working in or near septic tank areas. PPE must be removed before entering clean areas to avoid cross-contamination.

Hand Hygiene: Before eating, personnel must thoroughly wash their hands with soap and water to prevent the transfer of contaminants from the work area to the eating area.

Avoiding Food/Drink Consumption Near Work Sites: Never eat or drink in areas where gas emission measurements are being taken or where there is a risk of exposure to toxic or harmful substances.

16 Post-Sampling Review:

1. Conduct a debriefing session to discuss the sampling process and any safety concerns.
2. Report any incidents or near misses to the team leader for review.
3. Filling out the sampling checklist, which contains details of the activities that need to be carried out, such as gas sampling, documentation, a list of items, etc.

17 What to do during an emergency?

By adhering to the H&S protocol, risks can be minimised. However, there is still a residual risk of accidents. If someone requires urgent medical attention or there is an incident that the sampling group cannot control, please call the emergency contact numbers listed below or take the person to the nearest hospital, according to the sampling location.

Location	Police	Emergency Number	Nearest hospital address
Jakarta	Local Police Station (Polda Metro Jaya): Phone: +62 21 500-200	110 (National)	RSUPN Dr. Cipto Mangunkusumo (RSCM) Address: Jl. Pangeran Diponegoro No. 71, Jakarta Pusat, 10430, Indonesia
Depok	Local Police Station (Polres Depok): Phone: +62 21 7777-7777	110 (National	RSUD Depok Address: Jl. Raya Muchtar No. 1, Depok, 16431, Indonesia
Bandung	Local Police Station (Polresta Bandung): Phone: +62 22 727-7155	110 (National)	RSUP Dr Hasan Sadikin Bandung Address: Jl. Pasteur No. 38, Bandung, 40161, Indonesia
Balikpapan	Local Police Station (Polres Balikpapan): Phone: +62 542 761-411	110 (National)	RSUD Balikpapan Address: Jl. Mayjen Sutoyo No. 1, Balikpapan, 76114, Indonesia
Labuan Bajo	Local Police Station (Polres Manggarai Barat): Phone: +62 385 21234	110 (National)	RSUD Labuan Bajo Address: Jl. Trans-Flores, Labuan Bajo, 86711, Indonesia

If a minor incident involving a group member occurs, separate that person from the sampling area, call the fieldwork leader immediately, and decide together on the next step. Actions may include the leader picking them up to take them to a medical centre or home, or calling the next of kin, among others.

18 Closing statement

This Standard Operating Procedure (SOP) was developed for field work conducted to measure GHG emissions from sanitation systems in selected places in Indonesia. Please refer to local health and safety guidelines to complement this SOP, so local conditions as considered.

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