Location: Royal University of Agriculture, Phnom Penh, Cambodia

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Description of facility:

RUA's headbox facility comprise

- Feed bunk adequate to feed and record intake of 12 cattle individually.
- Four (4) headboxes with associated metabolic crates for collection of faeces and manure.
- The air flow and gas sampling system are contained in a mobile cart so these valuable components can be protected from theft when no experiment is in progress.

Principle of operation:

Summary: The four headboxes all operate independently. Air is continuously drawn from the top of each headbox into an exhaust pipe then through an in-line recording air flow meter and into a side-channel blower that draws the air then voids it into the atmosphere. As air is drawn out the exhaust pipe from the headbox, fresh ambient air is drawn into the headbox around the loose-fitting shroud. A continuous subsampling of exhaust and ambient gas into Tedlar bags is made using miniature peristaltic pumps. Each bag of subsampled gas (1 per headbox plus one ambient air bag) is subsequently analysed by a multi-gas analyser. System details re as below:

Headbox details: 90 x 80 x 110 cm box, raised 30 cm off the ground. Box is made of welded steel covered with 6mm thick polycarbonate. Door is secured by 3 'butchers latches' to make airtight seal and has foam strip between door and box to ensure airtight seal. The shroud dimensions are as shown in Photo 1.

Air flow: Air is drawn through each headbox by a Side channel blower (Ventex 2RB010-7AA11; purchased from "Topgas" in Thailand), at a rate of 500L/minute. This is the maximum flow possible with this pump Flow rate is varied by a 'T-piece' fitted I the pipe between the flow meter and the blower, with a gate valve on the stem of the 'T' that is open to the atmosphere. By opening this gate vale, ambient air is allowed into the blower, reducing the amount of air being drawn from the headbox & through the flow meter. The flow meter is an Aichi Tokei TBX-30L that has a self-contained battery with 7-year life. The display on the in-line meter is recorded at the start and end of the 23h measurement period and divided by time elapsed to calculate flow rate.

Air Temperature and Pressure:
Because the Aichi Tokei TBX-30L turbine flow meter is NOT temperature and pressure corrected, we need to measure the temperature and pressure of air going through the flow meter. This is done by inserting a hand-held temperature and pressure gauge into a sampling port in front of the flow meter. This temperature and pressure is read 3 times per day and the values written down in the experiment log sheets. Typically pressure is only 3-6kPa less than the atmospheric pressure (approx. 100kPa depending on altitude))
Air Sampling: A continuous sample of air over 23h from when the chamber doors I closed is collected into a pre-evacuated 5L tedlar bag. The sample bag is left sealed and connected via tygon tubing to a miniature peristaltic pump (LONGER Peristaltic Pump Miniature BQ50-1J adjusted to pump at 2-3 ml air/minute. The bag is opened and the pump turned on when the headbox door is closed. The bag is pulled closed to seal 23h later and taken for immediate analysis.

Gas analysis.

The gas is analyser using an Aquagas GA40T+ multigas analyser, that reports O2, CO2, and CH4 gas levels directly on-screen. It is not linked to a computer. The analyser draws approximately 1.5L sample/minute and is used as below:

- The analysis is done in a well-ventilated room well away from cattle or other sources of methane (this is so the background CH4 level is truly 0ppm)
- The analyser is allowed to warm up for AT LEAST one hour
- The **'zero standard'** (pure N2) and the **calibration/span gas** (CH4 in N2) are run through the analyser. Ideally they should be transferred into evacuated tedlar gas bags directly from the cylinder and then let the gas analyser internal pump suck them from tedlar bag into the gas analyser. Write down the expected O2, CO2 and CH4 concentration in each gas and the observed concentrations.
- Then connect each of your 5 bags gas (background bag + 4 headbox bags) and le the sample be draw in for 40 seconds – the reading should have stabilised on the analyser display by then. Write down or print the results foe all 3 gases)
- Then repeat the measurement of each bag, recording the concentrations shown 40s after connecting each bag.
- The repeat the zero standard and the calibration gas bags.
- LOOK at the calibration bag results ~ was it within 10% of the value shown ion the cylinder itself? If it is crazy different we have a problem. If it is <10% different then we can correct ALL the gas bag readings by whatever the % difference is. So if the calibration gas was meant to be 1000ppm but we read it as 950ppm, the value is 5% low, so we would multiply up all the other CH4 ppm values by 5% before we use them.

Gas recovery procedure:

A short term 3-min recovery of tracer gas (CO2) delivered up the exhaust outlet is used, with the rate of weight loss of the (small) cylinder being multiplied by the flow rate to work out the expected (100% recovery) increase in CO2 level expected and this s compared with the ppm of CO2 observed. Co2 is released from a small cylinder at a fixed rate of 10-15g/min using a regulator with a rotameter. The cylinder is placed on an electric scale reporting to 1g and every 30s the cylinder weight and the CO2 in the exhaust air is recorded.

Photo library of your system:

A summary of photos of key components of the system is provided below

Ball valve that allows the balance of air drawn from the he4abdox and from the outside atmosphere to be varied to ensure flow through the headbox is approximately 500L/min

The core of the headbox system is the mobile airflow and analysis hub. This system can be closed off for security but in it is housed
4 side-channel blowers (on floor of box) connected to the 4 air flow ducts (blue pipe) running along the top), which have a “t’ piece junction and a ball-type valve to allow outside air into the blowers and thus reduce the amount of air drawn from the headboxes. Fitted into the air flow system across the top of the trolley are 4 turbine flow meters. Narrow diameter tube samples air from each the 4 blue pipes and this air is pumped by a 4 mini peristaltic pumps (seen with V shaped stands on middle level) and into a tedlar gas collection bag (not shown)

Site of sampling ports in the air flow pipelines. The sampling tubing is connected to the peristaltic pump tube with peristaltic pump collecting 2-2.5 mol/min of air continuously.

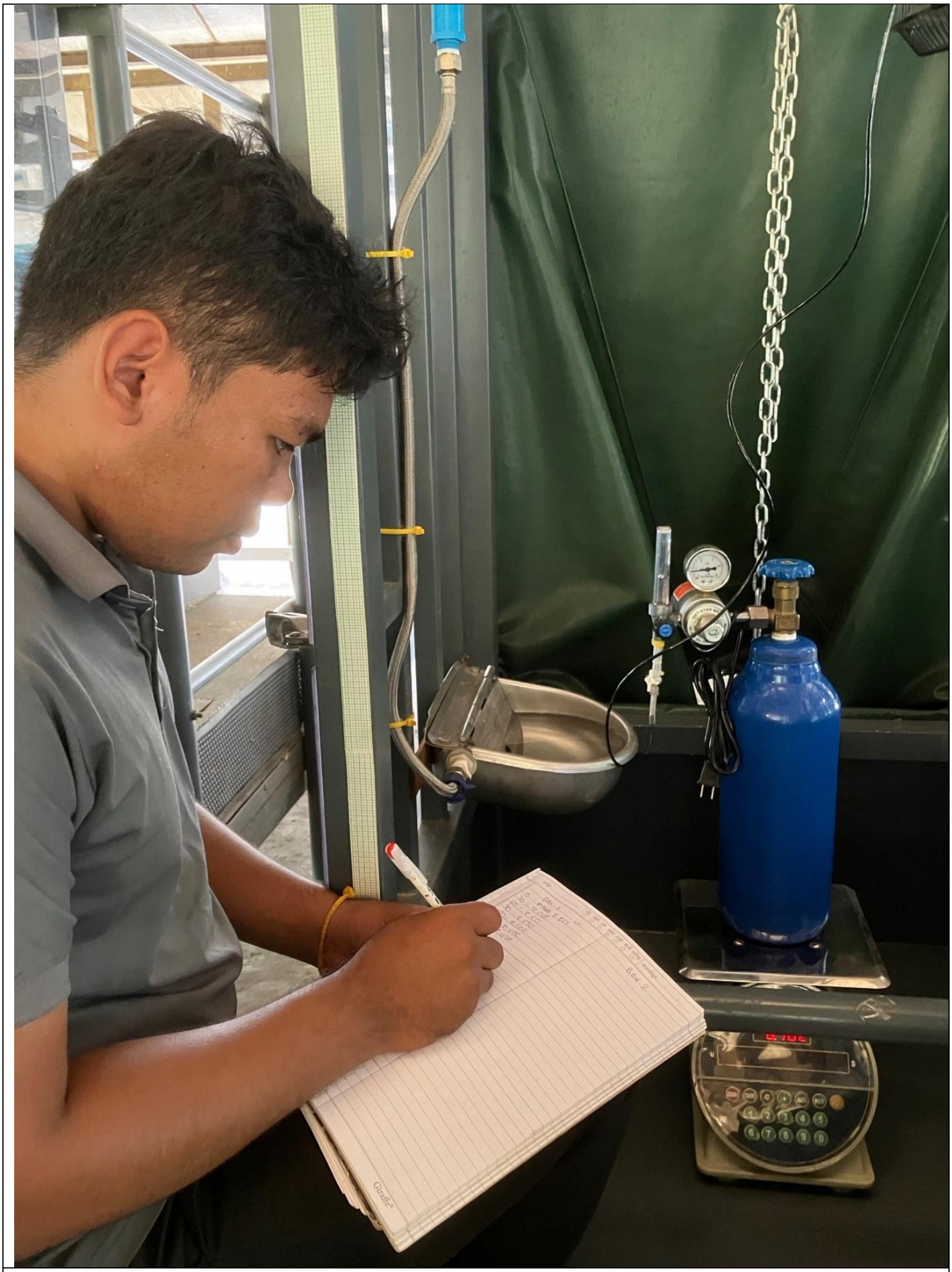
Shroud through which the cow places its head to enter the headbox

View of the inside of the headbox from the front door. Note bar across front which is used to tether cattle to and chain hanging down that can be used to secure the animal from excessive movement.

Metabolism crates fitted to headboxes to allow collection of manure and urine for nutrient digestibility and excretion sample collection

Battery operted turbine flow meters. These can be re-zeroed before each day’s study

Front view of the chamber showing the blue flexible ducting used to connect the exhaust port (top centre of headbox) to the analysis trolley (shown disconnected at right)



Student reproting the weight of the small CO2 clylinder releasing 5L/min over 3 minutes while othe sreord the average [CO2] in the airstream leaving the headbox