Teaching Activity: Ruminant Animals and Methane Emissions

Introduction: Methane emissions from the digestive processes in ruminant animals, including cattle, sheep and wild animals, is estimated to provide an atmospheric source of 65-100 Tg CH_4 per year. Methane emissions depend upon animal populations, as well their amount and type of food. It is difficult to estimate the change in this source over the last century accurately because the significant increase in the number of cattle and sheep has been partially offset by the decreases in populations of elephants and North American bison. One estimate suggests that the magnitude of this source has increased from 21 Tg CH_4 per year in 1890 to 78 Tg CH_4 per year in 1983.

Objectives:

- To read and discuss a scientific article about ruminant animal contributions to global methane concentration;
- To evaluate the process being used at present to measure methane emissions from ruminant animals;
- To calculate the average amounts of CH_4 contributed by different animal species on a daily basis;

Important Terms: Ruminant animals, methane, sulfur hexafluoride, tracer, microbes, gas chromatography, variable, average, Gt p/year;

Materials: Copy of **Student Activity Sheets**, calculator, paper/pencil;

Procedure:

1. Read and discuss the article "Sheep's breath: how sweet thou art!" with the class.
   - Review any new words or concepts in the article.
   - Present some questions to students to check comprehension.

2. Instruct students to study the two data Tables of methane measurements from cows and sheep.
   - Ask students what they notice about the data for each animal.
   - Ask for reasons why the data may appear as it does.

3. Tell students they are going to do some calculations using the data in these tables.
   - Students should compute the average CH_4 in g/day released by the two cows and sheep.
   - Students should fill in their data on the **Data Tables**.
   - Students should then compute the g/hr of methane released for each animal.'
   - Students should fill in their answers on the **Data Table**.
   - Students should the compute the average CH_4 g/hr released by the cows and sheep and fill in that data on the **Data Table**.
4. Students should complete the activity by answering the questions in the **Analysis** section.

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   - Review any new words or concepts in the article.

2. Study the two data tables of methane measurements from cows and sheep.

3. You are going to do some calculations using the data in these tables.
   - Compute the average CH_4 in g/day released by the two cows and sheep.
   - Fill in your data on the **Data Tables**.
   - Compute the g/hr of methane released for each animal.
   - Fill in your answers on the **Data Table**.
   - Compute the average CH_4 g/hr released by the cows and sheep and fill in that data on the **Data Table**.

4. Complete the activity by answering the questions in the **Analysis** section.

Student Activity Sheet #1

"Sheep's breath: how sweet thou art!"

By Keith Lassey,
NIWA,Wellington, NZ

A team of NIWA atmospheric scientists, in collaboration with scientists from AgResearch at Massey, Palmerston North, have been literally "out in the field" measuring methane respired by grazing livestock. The objective is to measure daily methane emissions from individual ruminant animals and ascertain the extent of variation among them. Methane is generated microbially in the rumen and belched during digestion.

New Zealand's livestock are believed to produce 80% of national methane emissions, with sheep accounting for more than half of the livestock emissions. New Zealand is unusual among developed countries in having a larger contribution from methane than from carbon dioxide to the national CO_2 equivalent greenhouse gas emission. In fact, the national methane emission would be sufficient to power the entire North Island domestic car fleet, converted to run on CNG (compressed natural gas), for about 12,000 km per year!

This sampling technique was first tried a year ago by the NIWA/AgReseach team in collaboration with its U.S. developers. A lightweight apparatus mounted on each animal continuously breathalizes the animal at a rate of less than 1 ml per minute through a 24 hour sampling period. The technique is calibrated using a source of inert tracer previously inserted into the rumen of each animal. The tracer, sulfur hexafluoride (SFl_6), is released from a small capsule through a permeable membrane. Breath samples are analyzed for methane and for sulfur hexafluoride using gas chromatography, and the methane production rate calculated from their concentrations in excess of background and the rate of release of sulfur hexafluoride.

Five daily samples are collected from each of 50 sheep and 10 dairy cows. In parallel with this, AgResearch scientists collect and analyze fecal material from each animal to provide a measure of feed intake, to which methane production can be related.

Student Activity Sheet #2

Data Table #1 Methane release from cows #233 and # 54

COW#233 COW #54

SAMPLE #	CH_4 (g/d)	Released (g/hr)	SAMPLE #	CH_4 (g/d)	Released (g/hr)
1	82		1	247	
2	120		2	247	
3	NA		3	NA	
4	182		4	NA	
5	111		5	137	
6	67		6	141	
7	223		7	NA	
8	213		8	NA	
9	172		9	NA	
10	164		10	NA	
11	189		11	NA	
12	158		12	NA	
13	165		13	NA	
14	134		14	224	
15	NA		15	220	
AVERAGE			AVERAGE		

Data Table #2: Methane release from sheep #0036 and # 0038

SHEEP # 0036 SHEEP #0038

SAMPLE #	CH_4 (g/d)	Released (g/hr)	SAMPLE #	CH_4 (g/d)	Released (g/hr)
1	22.7		1	10.8	
2	22.5		2	23.3	
3	24.6		3	23.6	
4	26.8		4	14.3	
5	24.5		5	19.5	
6	17.7		6	21.4	
7	23.1		7	12.0	
8	13.9		8	13.6	
9	36.7		9	18.5	
10	30.8		10	13.2	
11	17.1		11	18.0	
12	24.3		12	17.6	
13	18.4		13	13.2	
14	13.6		14	19.5	
15	12.8		15	11.6	
AVERAGE			AVERAGE		

Student Activity Sheet # 3

ANALYSIS

1. What type of scientists are measuring methane emissions from cows and sheep? _____

2. What country do these scientists represent? _____

3. What are the 2 objectives of this study? _____
_____

4. How is methane produced and emitted by animals? _____
_____
_____
_____

5. What part of the national methane emission is produced by ruminant animals in New Zealand? _____

6. Why is this fact unusual ? _____
_____
_____
_____

7. How could the national methane emission be used? _____
_____
_____
_____

8. Explain how the measurement apparatus works. _____
_____
_____
_____

9. What compound is used as a tracer in this process? _____
_____

10. How is the methane production rate calculated? _____
_____
_____

11. What types of animals and how many of each and are used in this research? _____

12. What else is studied in addition to the breath analysis? _____

_____

13. What was the average amount of CH_4 emitted by the cows? _____

_____

14. What is the average amount emitted by the sheep? _____

_____

15. Why would you think that the data for Cow # 54 was not helpful?

_____

_____

16. What could have caused this to happen? _____

_____

17. Which study group probably had fewer problems during the test?

_____

18. Animal nutrition specialists know that the higher in protein the food is, the less methane is produced. How could this be helpful in lowering methane missions? _____

_____

_____

19. Design a method for sampling animal fecal matter that would be simple to use and reliable. _____

_____

_____

_____

_____

_____

20. Even though New Zealand's contribution to global warming is not CO_2, why should they be concerned about the methane emissions? Explain.

_____

_____

_____