Université Laval
Faculté des sciences de l'agriculture et de l'alimentation
Département des sols et de génie agroalimentaire

Development of stand-off wintering pads for dairy cows in Quebec, Canada

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1. INTRODUCTION

Province of Quebec

The most important producer

Tie-stalls

A majority of dairy farms

Animal welfare

Questioned ProAction program

Benefits of exercise for dairy cows

Health measures on the welfare

Alternative year-long outside exercise yard

Stand-off pad

Dairy production

- The Canadian dairy sector. 10,000 farms, 1 M
- The province of Québec. 46% total manufacturing milk

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Tie-stall Barns

- Housing facilities.
- Tie-stall barns in the province of Quebec
- Recommendations for tie-stall.

Animal welfare

Tie-stalls

Lameness

Restricts the voluntary movement possibilities

Include hock swellings and abrasions

Neck lesions, broken tails.

(Popescu *et al.*, 2013 & Zurbrigg, 2005).

Exercise for dairy cows kept in tie-stalls

✓ Significantly lower scores for lesions on the hocks

✓ Fewer udder injuries and less medical treatment.

✓ Decreased likelihood of metabolic disease.

Options to provide exercise for dairy cows kept in tie-stalls

- **New Free-stall barn**

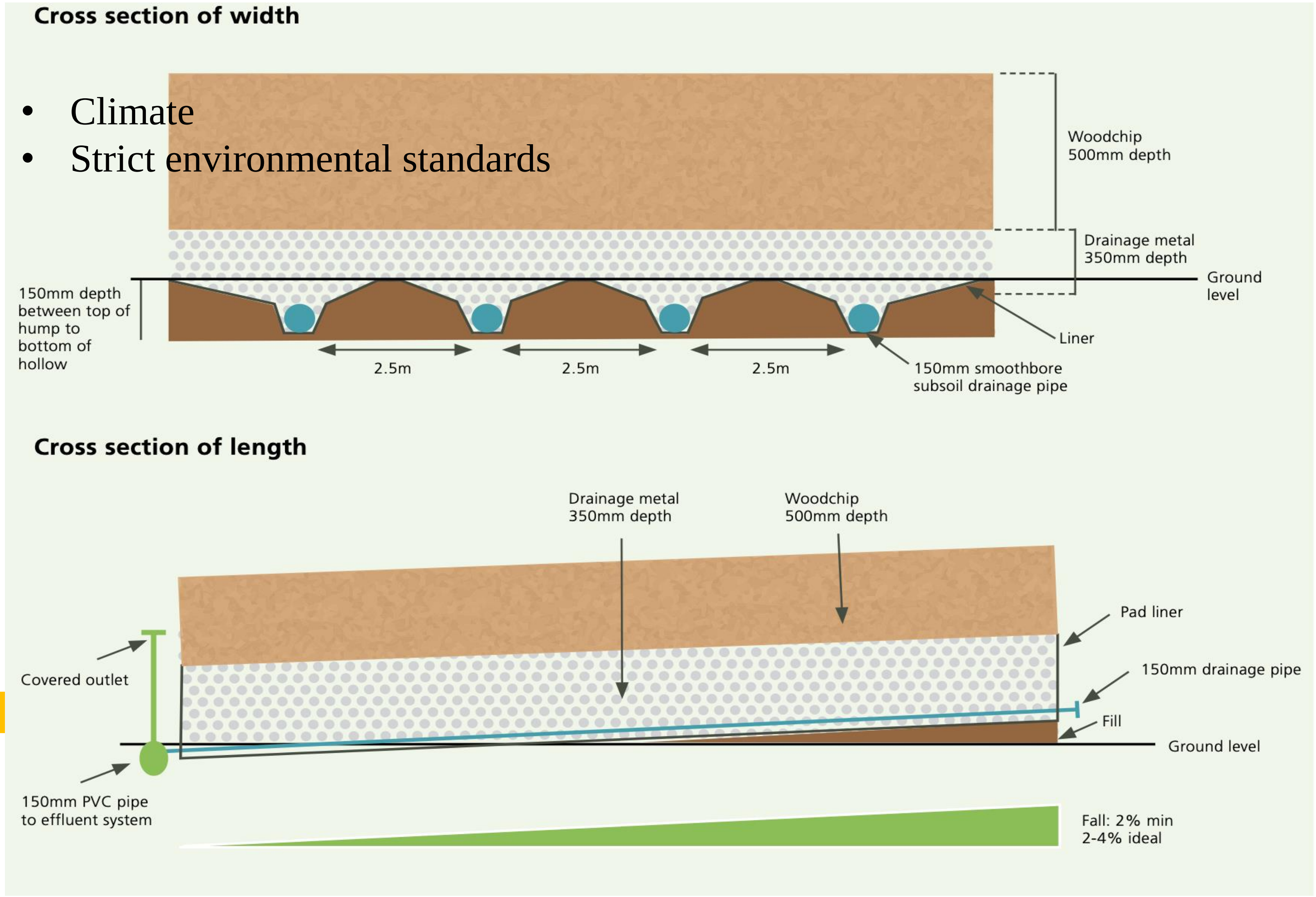
- **Conventional wintering pens**

- **Indoor exercise yard**

Alternative year-long outside exercise yard

Stand-off pad consists of a woodchip pad overlying an impermeable lining with drainage pipes delivering effluent to a tank

- Climate
- Strict environmental standards



Potential environmental impacts associated with stand-off pads

Leachate may contribute to eutrophication of water bodies and groundwater contamination.

The drainage from stand-off pads contains nutrients and faecal microbes.

Optimization of stand-off pad

- ✓ Surface type of the stand-off pad in Québec conditions.
- ✓ Air injection to improve oxidation even at low temperature.
- ✓ Layer depth.

Surface type of the stand-off pad in Quebec’s conditions

- Animal welfare: Time spent lying and mammary health.
- Effectiveness of pad materials retaining nutrients and pathogens.

Air injection

- The availability of dissolved oxygen (DO).
- Heat exchanger.
- Layer depth

OBJECTIVE

- Design an aerated exercise yard capable of effectively filtering dairy cow manure in Quebec weather conditions.

METHODOLOGY

The different stages of the research project are:

(1)Exploratory experiment in situ

(2) Pre-testing

(3) Laboratory experiment (BABE)

(4) Development of a model optimizing the layers

(5) Test with an optimized stand-off pad

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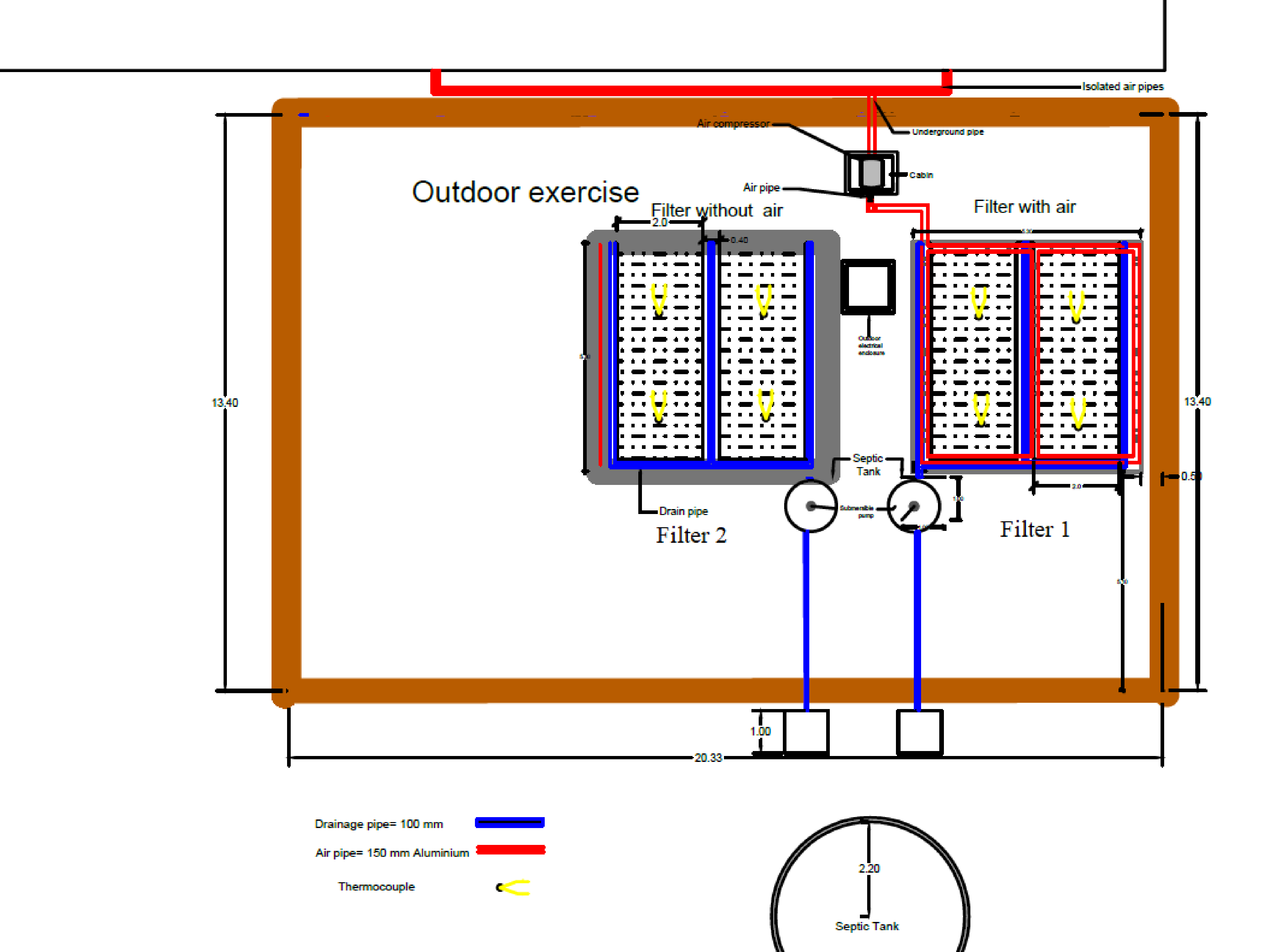
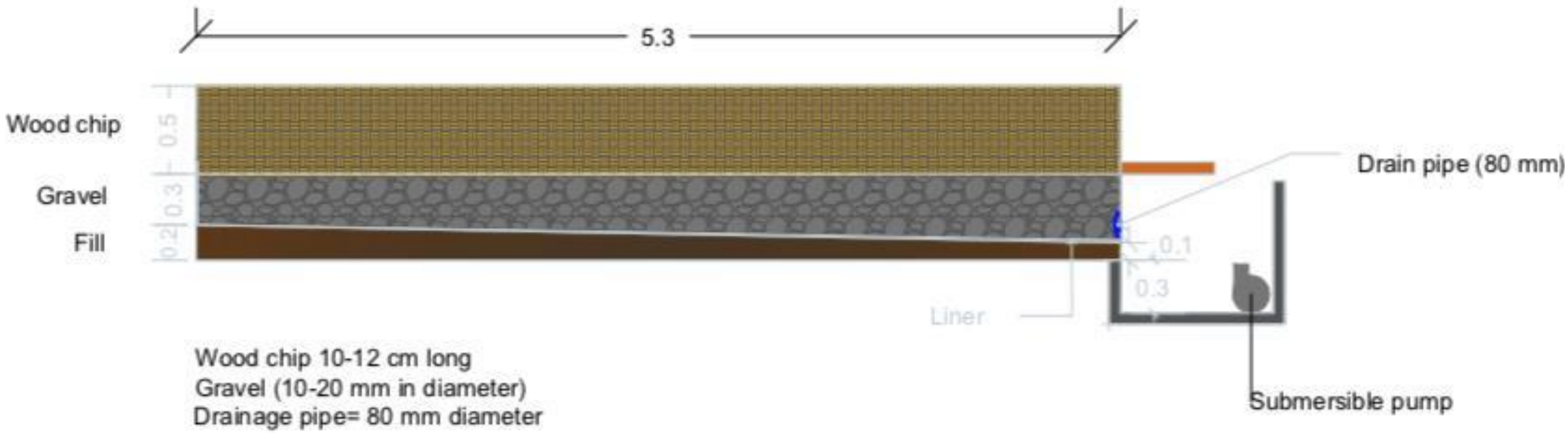
Exploratory experiment in situ

- **Phase 1 objective:**

Measure water and soil quality from outdoor cow exercise area and establish the impact of air injection into the biofilter.


Isolated air pipes
Air compressor
Underground pipe
Cabin
Air pipe
Outdoor exercise
Filter without air
Filter with air
2.0
0.40
13.40
13.40
Septic
Tank
0.50
Drain pipe
Filter 2
Filter 1
1.00
20.33
Drainage pipe= 100 mm
Air pipe= 150 mm Aluminium
Thermocouple
2.20
Septic Tank


5.3
Wood chip
0.5
Gravel
0.3
Fill
0.2
Drain pipe (80 mm)
0.1
0.3
Liner
Wood chip 10-12 cm long
Gravel (10-20 mm in diameter)
Drainage pipe= 80 mm diameter
Submersible pump

1 h per day
Summer (18)

Preliminary Results

Winter

Parameter	With Air	Without Air
DBO (mg/L)	175	81
DCO (mg/L)	1842	550
SS (mg/L)	29	94
Fecal coliforms (ufc/100 ml)	3700	220

Summer

Parameter	With Air	Without Air
DBO (mg/L)	19	8
DCO (mg/L)	2620	1340
SS (mg/L)	44	46
Fecal coliforms (ufc/100 ml)	20240	35000

PRE-TESTING

Phase 2 objective: Evaluate the effect of different filter materials on the potential for contaminant removal in dairy wastewater.

PVC columns (5 cm in diameter and 50 cm in height) will be filled with five product combinations (three replicates).

Treatment		Composition	
#	**Name**	**Section**	**Material**
	Control	Top	Gravel
1	Conventional	Top	Woodchips
		Bottom	Gravel
2	Alternative #1	Top	Woodchips /biochar[1] (20% v/v)
		Bottom	Gravel
3	Alternative #2	Top	Woodchips /sphagnum[2] peat moss (80% v/v)
		Bottom	Gravel
4	Alternative #3	Top	Woodchips
		Middle	Sand [3]
		Bottom	Gravel

[1] Produced by high-temperature (555ºC) gasification of a softwood.
[2] Washed thoroughly with tap water and sieve to obtain a 2 mm fraction.
[3] Washed and size to obtain 1.18 mm fraction.

- Synthetic dairy soiled water (DSW): DSW will be applied in equal volumes of 0.07 L four times daily, five days a week (5.6 L).
- Rain water: 80 mL of deionized water apply it manually (Monday and Thursday).

• Water Analyses

Laboratory methods used for analysis with multi-parameter or Hach DR/900 (Ebeling et al., 2006).

Equipment	Parameter	Method
Multi-parameter Hanna (model: HAHI991301)	pH, Conductivity	Electrometric method
HACH DR900 Colorimeter	Turbidity (21 to 1000 FAU)	Absorptometric Method 8237 HACH
	Nitrates (0.2 to 30.0 mg/L NO_3^- -N)	Chromotropic Acid Method 10020 HACH
	Nitrites (0.003 to 0.5 mg/L)	Diazotization Method 10019 HACH
	Phosphorus (0.3 to 45.0 mg/L PO_4^{3-})	Molybdovanadate method 8114: method 4500-P-E
	Total Suspended Solids	Photometric Method 8006 HACH (5-750 mg/L)
	Oxygen Demand, Chemical (3-150 mg/L and 20-1500 mg/L)	Absorptometric Method 8000 HACH: Method 410.4 EPA

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Filter media analysis

- Dry matter
- Total carbon and total nitrogen
- P, K, Ca, Mg, Na

Microbiological analysis

Enumeration of Escherichia coli.
Gravel = 12 chambers = 12 samples
Chips = chambers 1-4-5-7-10-12 = 6 samples
Alternative mix = chambers 2-3-6-8-9-11 = 6 samples

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Preliminary results

3^{e} Week= clogged filter

Traitement	% PO_4	% NO_3	% DCO	% NT	% SS	% turbidité
1. Woodchips	8,5^{b}	48,6^{a}	11,7^{c}	32,4^{a}	33,1^{b}	23,1^{b}
2. “” & biochar	7,6^{b}	47,2^{a}	21,0^{bc}	40,1^{a}	42,8^{ab}	31,1^{b}
3. “” & sphaigne	0,1^{b}	42,2^{a}	**38,6^{a}**	**53,3^{a}**	43,8^{ab}	22,5^{b}
4. “” & sand	**22,2^{a}**	**63,1^{a}**	31,8^{ab}	47,6^{a}	**57,6^{a}**	**58,4^{a}**

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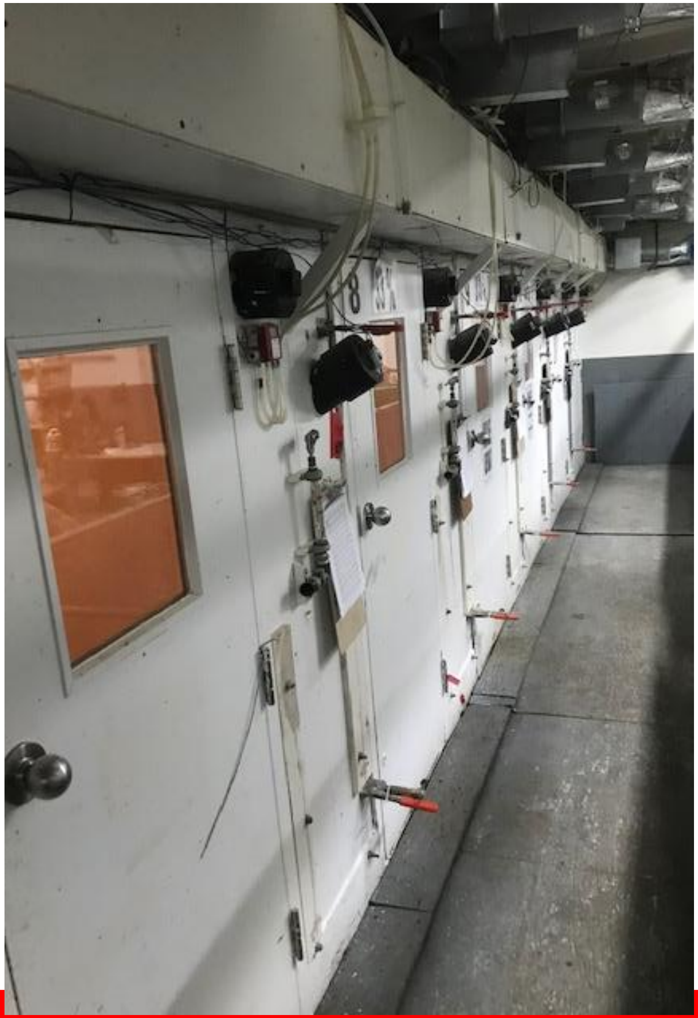
Tukey-Kramer : Significantly different (α = 0,05) / numerical difference

LABORATORY EXPERIMENT (BABE)

Phase 3 objective: Establish the impact of air injection into the biofilter: To evaluate the efficiency of the aeration in the stand-off pad in Summer and Winter.

- ✓ The BABE includes twelve completely identical rooms (1.2 m wide by 2.4 m long by 2.4 m high) arranged side by side.
- ✓ The experiment will be carried out in 2 phases, the first to simulate a cold period (4 °C), and the second to simulate a warm period (23 °C).
- ✓ One week of adaptation and three weeks of experimentation.



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Treatments descriptions

Treatment		Composition		
#	Name	Section	Material	Depth (mm)
1	Conventional without air[1] (CA)	Top	Woodchips	500
		Bottom	Gravel	350
2	Conventional with Air (CWA)	Top	Woodchips	500
		Bottom	Gravel	350
3	Alternative without air[1] (AA)	Top	Woodchips /biochar[2]/ sphagnum peat moss (20-10-70% v/v)	500
		Bottom	Gravel	350
4	Alternative with air (AWA)	Top	Woodchips /biochar[2]/ sphagnum peat moss (20-10-70% v/v)	500
		Bottom	Gravel	350

1 Air Flow 10.0 L/m^2/s to obtain 2 mg/L of dissolved oxygen and temperature 15 C (Wang et al., 2020).
2 Produced by high-temperature (555ºC) gasification of a softwood (supplier: Airex énergie).
3 Quantity in kilograms for an area of 0.07 m^2

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BABE treatment disposition												
	With Air (A)						Without Air (WA)					
Room	1	2	3	4	5	6	7	8	9	10	11	12
Treatment	CA	AA	AA	CA	CA	AA	CWA	AWA	AWA	CWA	AWA	CWA
***C= conventional *A= Alternative**												

- ✓ A 1-section polyethylene drainage pipe 1 m deep and 0.3 m in diameter.
- ✓ Water Analysis
- ✓ Microbiological analyses
- ✓ Filter media analysis

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- The aeration in each filter will have a flow of 10 L/m^2.
- Controlled with an air flow meter
- Between the gravel and the woodchips will be installed Aeration Tubing.

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Dosage for Dairy soiled water and rainwater.

DSW: Manure collected from dairy farm 3 times per week, and mixed with tap water (200 gr manure per litre).

Day	DSW (L)	Tap water (L)
1	0,24	0,06
2	0,435	0,5
3, 4, 5, 6, 7…	0,63	1
Monday week 1, 2 and 3.	0,63	2

Expected results and contribution to knowledge

- Dairy producers using tie-stall housing to improve their production system for proAction and society by providing a green and economical exercise area concept ready for province-wide implementation. The results of the project are expected to contribute to the reduction of limb and locomotion problems in dairy cows. This will improve the competitiveness and sustainability of Quebec dairy farms.

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THANK YOU!

ANY QUESTIONS?

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Remerciements

PARTENARIAT CANADIEN pour l'AGRICULTURE

LES PRODUCTEURS LAITIERS DU CANADA

Canada

5th International Conference of the International Commission of Agricultural and Biosystems Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Virtually from Québec City, Canada – May 11-14, 2021

CSBE | SCGAB

DAIRY RESEARCH CLUSTER 3

GRAPPE RECHERCHE LAITIÈRE 3

CHAIRE DE LEADERSHIP EN ENSEIGNEMENT des bâtiments agricoles durables de l'Université Laval

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