CONCEPTS OF VALORIZATION OF DAIRY FARM WASTEWATER

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ABSTRACT

Two projects were initiated to develop techniques to facilitate the disposal of dairy farm wastewater while valorizing their nutrient and water content for crop production. Both techniques are based on the concept that dairy farm wastewaters, as well as any other agricultural wastewater, are of low nutrient content and can be disposed off on relatively small cropped surfaces (0.5 to 1.0ha). The first project consisted in developing and testing surface irrigation for the disposal of wastewaters on cropped land. A gated pipe is used to distribute wastewater over a length of 45m and allowing this wastewater to run down the natural slope. This technique reduces the cost of wastewater disposal from \$3 to \$5/m^3, to \$1.25 to \$1.50/m^3. This technique requires a ground water control valve at the outlet of the subsurface drainage system, to eliminate the environmental impact of the direct loss of about 0.25% of the wastewater volume, during the irrigation operation. Also, the irrigated plot must be rotated on a two year sequence to prevent soil K overloading. The second project consisted in developing and testing a modified septic tank system for the treatment of milk house wastewaters. A grease trap was added before the septic tank and the seepage field was designed to cover 0.45ha of cropped land. This system distributes the milk house wastewater and nutrients over a cropped area, to prevent the accumulation of nutrients in the soil, provide water for the crop and decreases risks of system clogging.

INTRODUCTION

Some of the dairy farms in Canada still handle their manure as solids thus having to dispose of large quantities of wastewater of low nutrient content. Solid manure storages are often open exterior platform collecting large volumes of rainfall, which must be managed as wastewater. The platform may be covered, but this requires an investment costing more than the land spreading the collected wastewater. Furthermore, the decomposition of the solid manure produces seepage representing 10% of its volume. Thus, a farm with 60 dairy cows, with its replacement herd, can face the handling of 850 m^3 of manure wastewater, with a nutrient value of less than \$1.00 Can./m^3 (Loehr, 1984). In Canada, the cost of land spreading wastewater runs between \$3 to \$5 Can./m^3, implying that dairy farm wastewaters are costly to handle. Furthermore, such low nutrient value implies a mineral fertilizer application following the disposal of the wastewater with a tanker, at a maximum possible rate of 100 m^3/ha.

Dairy farms produce large volumes of milk house wastewater, estimated at 15 to 20L/cow/da (Urgel Delisle et ass., 1992 and 1994). This wastewater must be treated since it can cause serious adverse environmental impacts (MENV, 1986). The farms that have not planned a suitable storage system to receive this high volume of wastewater are required to resort to treatment techniques or to completely rebuild their manure storage facility. On a long term basis, approximately 25% of the Canadian dairy farms will be required to comply. Currently, there is no economic system for the treatment of milk house wastewater. The recommended techniques do not valorized the nutrients and the water contained in the milk house wastewater. Most of the techniques are not tested under Canadian conditions and required an investment of over \$15 000 Can. In the United States, treatments such as reverse osmosis and aerobic fermentation are use, but those systems are designed for large herds and are not proven efficient in Canada. In the Atlantic Provinces, artificial wetlands are used, and although they seem attractive, they are expensive to build, freeze in winter, generally dry-up during the summer and, accumulate rather than eliminate nutrients such as phosphorus, with a risk of contaminating the ground waters.

Thus, the project aimed at developing two techniques to reduce the cost of disposing of dairy farm wastewater and of valorizing both the nutrient and water content of the wastewater. The two techniques developed are:

1) Surface irrigation for the disposal of the wastewater on a surface of 0.5 to 1.0ha, to provide water to the crop during the dry summer season and to apply all nutrients required, without the need for mineral fertilizer supplementation, and with minimal soil compaction;

2) A modified septic tank and seepage field system, using a grease trap before the septic tank to remove the grease and solids and a larger seepage field built without crush stone to minimize risks of clogging (Barrington et al. 1987), but to distribute the milk house wastewater and nutrients 0.5ha of crop land.

MATERIALS AND METHODS

For both projects, two different experimental farms took part. All the wastewater and water collected were analyzed using standard methods.

The first project consisted in sampling storage facilities for manure and milk house wastewater to determine the volumes produced and the nutrient load. The amount of wastewater to be applied was theoretically determined and an application factor was measured during irrigation operations, as not all the ground is covered with the runoff of the wastewater. To determine the impact of irrigating the wastewaters on drainage waters of the cropped field, sampling wells were installed on the subsurface drainage system of the irrigated plot and on a control plot next to that irrigated. Also, the volume of wastewater lost as seepage through the subsurface drainage system was measured at the outlet. The impact of irrigating the crop with water from the wastewater will be measured during the summer of 2004.

The second experiment consisted in regularly sampling the milk house wastewaters using the grease trap installed before the septic tank and also, measuring the amount of sediment and grease collected by the grease trap. Also, drains were collected between the seepage field drains to measure their impact on ground water quality. The level of soil sealing around the seepage field drains will be measured during the summer of 2004. The system has been in operation since early July 2003 and no problems have occurred with wastewater backing up in the system.

RESULTS AND DISCUSSION

Table 1 summarizes the nutrient content of the wastewaters collected on the two farms participating in the project. Farm A-1 collects both manure seepages and milk house wastewater while Farm B-1 collects only manure seepages. During the irrigation of wastewater, it was observed that from 0.1 to 0.25% of the total volume of wastewater applied was drained through the subsurface irrigation system. This drained wastewater also contained 85% of the nutrient and bacterial levels contained in the irrigated wastewater. Therefore, in 2004, a control valve will be installed and tested at the subsurface drainage outlet to retain this wastewater into the soil and minimize the environmental impact of the process. A time study of the operation demonstrated that the cost of spreading wastewater using surface irrigation, as compared to using a conventional tanker, was reduced from \$3-\$5 Can./m^3 to \$1.25 to \$1.50 Can./m^3. Tables 2 and 3 summarize the characteristics of the milk house wastewater and the water collected from the drainage systems used to monitor the impact of the seepage field on ground water quality. In general, the results are consistent among farms and the drainage water from the seepage field is similar in contaminant concentration, as compared to that collected in a nearby control drain.

***Table 1**. Wastewater characteristics.*

		Farm A-1		**Farm B-1**	
Element	**Unit**	**Average 2002**	**Average 2003**	**Average 2002**	**Average 2003**
Solids					
- total	%	0.23	0.26	0.75	0.75
- dissolved	%	0.20	0.23	0.70	0.68
- suspended	%	0.03	0.03	0.05	0.07
pH		6.8	7.1	7.4	7.3
NTK	mg/L	54	136	311	172
PT	mg/L	19.5	19.1	20.7	14.7
KT	mg/L	777	526	612	338
Total colif	10^3 b/ml	20	84	81	4.0
Fecal coli	10^3 b/ml	1.7	3	8.3	1.0
Fecal strep.	10^3 b/ml	2.2	1.1	102	28.0
Volume	m^3	840	690	150	120
Total mineral	kg	45	94	47	21
N-P-K		16.4	13	3	1.8
		653	363	92	40.5
Total minerals	kg/ua/an	0.64	1.34	1.24	0.56
N-P-K		0.23	0.19	0.08	0.05
		9.33	5.19	2.42	1.07

***Table 2**. Mean chemical composition of the milk house wastewater.*

Months	**Farm SG**								**Farm PB**							
	TS %	*DS %*	*SS %*	*StS %*	*pH*	*TKN mg/L*	*TP mg/L*	*TK Mg/L*	*TS %*	*DS %*	*SS %*	*StS %*	*pH*	*TKN mg/L*	*TP mg/L*	*TK mg/L*
June	0.26	0.19	0	0.07	7.8	55	26	828	0.19	0.16	0	0.01	6.0	518	7.5	667
July	0.29	0.22	0	0.07	7.4	60	19	498	0.47	0.26	0	0.2	6.0	101	17	174
August	0.24	0.22	0	0.02	7.9	85	213	187	0.18	0.15	0	0.03	5.9	129	N/A	511
September	0.27	0.26	0	0.01	7.6	48	116	245	1.6	0.3	0	1.3	5.3	319	162	488
October	0.18	0.10	0	0.6	7.3	11	42	152	0.35	0.27	0	0.08	7.1	33	48	245
November	0.38	0.1	0	0.34	7.6	5	N/A	246	0.24	0.19	0	0.05	5.9	293	206	373
February	0.39	0.3	0	0.1	7.1	40	50	257	0.4	0.3	0	0.1	6.4	46	98	200
March	1.6	1.6	0	0	7.4	42	41	359	1.6	0.3	0	1.3	6.0	107	95	204
April	0.19	0.21	0	0	9.4	3.7	81	57	0.29	0.3	0	0	5.7	8	103	177
May	0.19	0.19	0	0	9.6	1.7	78	75	0.37	0.4	0	0	5.4	39	59	171
Mean	**0.40**	**0.34**	**0**	**0.17**	**7.9**	**35**	**74**	**290**	**0.57**	**0.23**	**0**	**0.31**	**6.0**	**159**	**88**	**321**
kg/c/yr	22.3	19.0	0	9.5		0.20	0.41	1.62	32.7	13.1	0	17.8		0.91	0.50	1.84
kg/yr	936.6	798	0	399		8.4	17.2	69	1046.4	419.2	0	569.6		29	16	59
*Hay(ha)**							0.67								0.63	

** Refers to the CPVQ. 1996. Fertilisation reference grid. "Conseil des productions végétales du Québec", Québec.*

***Table 3**. Drainage water monitoring.*

Sampling	**Farm SG**				**Farm PB**			
	pH	*TKN mg/L*	*P mg/L*	*K mg/L*	*pH*	*TKN mg/L*	*P mg/L*	*K mg/L*
November (system)	6.8	0.2	3.0	54	7.2	0.8	6.9	62
November (control)	6.6	0.3	2.6	58	7.3	0.9	6.7	65
March (system)	7.7	0.12	0.35	29.6	7.6	0.11	0.21	1.73
March (control)	7.4	0.08	0.05	14.5	7.5	0.08	0.34	2.58
April (system)	7.4	0.34	0.39	23.3	7.2	0.13	0.08	3.75
April (control)	7.7	0.12	0.17	16.4	7.0	0.06	0.02	2.76
May (system)	7.4	0.06	0.04	28.9	7.0	0.12	0.05	1.50
May (control)	7.4	0.08	0.52	11.5	6.9	0.12	0.03	1.04

CONCLUSIONS

This surface irrigation of dairy farm wastewater was found to drop disposal costs from \$3-\$5/m^3 to \$1.25-\$1.50/m^3. This technique was also found to require a ground water control valve at the outlet of the subsurface drainage system, to eliminate the environmental impact of the direct loss of about 0.25% of the wastewater volume, during the irrigation operation. Also, the irrigated plot must be rotated on a two year sequence to prevent soil K overloading. The modified septic system designed to treat milk house wastewaters has been working well since July 2003. The grease trap added before the septic tank removes an important amount of sediments and grease. The seepage field has not clogged yet and does not represent a risk for ground water contamination.

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