Waste Management
FACTSHEET

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SEQUENCING BATCH REACTOR WASTE TREATMENT SYSTEM

A full-scale Sequencing Batch Reactor waste treatment system has been operating since 1998 on a 220-sow farrow to finish unit in Langley, BC. The developmental work on this system was done by the U.B.C. Department of Bioresource Engineering and the BCMAFF Waste Management Engineer during 1988 and 1989. The HPSFG monitored and made modifications to the system from 1991 to 1993. This factsheet presents a summary of the system's design and treatment capability. For a full report on the system, contact Rick Van Kleeck, BCMAFF Resource Management Branch, Abbotsford, BC.

The initial goal was to produce discharge quality effluent (BOD_5 below 45 mg $0_2/1$). However, the system was never able to treat swine manure to this quality. As well, waste discharge regulations changed during the course of the project which increased the cost of discharging waste. A permit to discharge for a 250-sow farrow-to-finish operation would now cost in the range of $3500 per year. Because of this cost and because most hog operations have some land base, land application is probably the most cost-effective way to handle manure treated with this system.

With this in mind, we optimized the system to determine the level of treatment possible and to measure removal of nutrients, especially nitrogen, through the system as this is the primary limiting factor for land application of manure in BC.

Components of the System

The SBR waste treatment system consisted of four components, all of which contributed to treatment of the manure. A manure separator, a belt press made by SCS Biotechnology in England, removed coarse solids from the manure. An aerated "pretreatment" tank (16' by 14' by 18' deep) pretreated the manure straight out of the barn. A 24' diameter, 12' deep concrete holding tank held 7-10 days production of manure and acted as a settling tank. The final stage was the SBR tank, a 16' by 16' by 18' deep concrete tank equipped with diffusers for aeration.

Manure was flushed from the barns into the pretreatment tank where it was separated and aerated. It was pumped from there once daily to the holding tank for flow equalization and settling of fine solids. Finally, manure was pumped from the holding tank to the SBR in four equal increments each day.

SBR Function

The SBR is a 'fill and draw activated sludge' treatment system. The 'activated sludge' is a large population of bacteria and other microorganisms that breaks down organic matter and can stimulate denitrification of nitrogen if appropriate conditions are provided (loss of nitrogen to the air as nitrogen gas). 'Fill and draw' means that it is run as sequences of partial filling of the SBR tank with manure, followed by an aeration phase (the treatment phase where the manure breakdown occurs), a settling phase where the bacteria settle onto the tank bottom, and a decant phase where treated liquid is removed from the top of the tank to long-term storage. Following the decant phase, some sludge (settled bacteria) may be removed from the bottom of the tank. About 5% of the tank's volume turned over with each cycle. With each cycle, we added and removed about 8" of liquid from the tank, which was filled with a constant 15' of liquid. The SBR went through 4 six-hour cycles each day, with each cycle consisting of 4.5 hours of aeration, 45 minutes of settling, and the remaining time for decanting, sludge removal and refilling.

Potential of This System for Treating Swine Manure

Our data suggest that the most promising use for this technology in treating swine manure is for nutrient removal. We were able to remove 75% of the nitrogen and 70% of the phosphorus from the manure. Work by UBC's Department of Bioresource Engineering has shown that up to 90% of the nitrogen can be removed with this system under optimum conditions. Our results suggest that the treated liquid could be spread on 25% of the landbase that would be required to spread the same amount of raw manure. And because phosphorus is removed as well, there is no danger of overloading the soil with this nutrient.

Nutrient Reduction

Table 1 (following page) shows how the nutrient content of the manure changed as it moved through the treatment system while Table 2 shows the percentage reduction in nutrients following each stage of treatment. Most of the nitrogen was removed in the SBR. Much of this nitrogen was found in the SBR sludge while some was lost through volatilization of ammonia and denitrification. About half of the phosphorus was lost during anaerobic storage and half in the SBR. All of the removed phosphorus was found in the settled solids and sludge of these tanks.

If this system is used to reduce the land base requirement, the wasted SBR sludge, the settled solids from the holding tank and the separated solids from the separator must be removed from the farm.

BOD_5 reduction

Under optimum conditions, BOD_5 reduction of 92.7% was achieved (see Table 1 and 2 on following page), from raw manure with a BOD_5 of 8000, to BOD_5 of 600 after treatment in the SBR. Separation accounted for a relatively small reduction in BOD_5. The anaerobic holding and settling tank was responsible for 57.5% reduction in BOD_5. This reduction was a combination of anaerobic degradation and settling of solids. The SBR reduced BOD_5 by a further 35.2%.

Although for periods during summer we were able to achieve as low as 200 BOD_5, we were never able to treat to discharge quality. None of the research groups treating concentrated swine manure with a similar system have been able to do this, although UBC's Bioresource Engineering Department have been able to reach discharge quality at lab scale using swine manure diluted 50:50 with water.

Problem with the System

Cold winter weather reduces the effectiveness of treatment by reducing biological activity in the SBR and holding tank. To keep treatment constant year round, the SBR tank would need to be heated to a minimum of 15C or enclosed in a building. The system can be automated to a large degree but still requires daily observation to avoid blockages of pumps and lines due to debris in the system.

This system creates two waste streams that must be handled separately – the clean liquid to be land-applied and the separated solids and sludge to be hauled off-site. About 20% of the total manure volume is removed in solids and sludge.

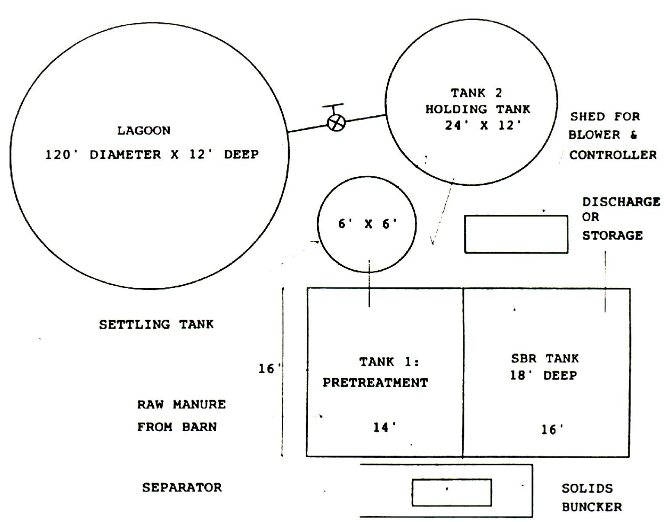

Table 1: Changes in various parameters through treatment system when short term anaerobically stored manure used as feed for SBR (average of 4 samples).

Parameter	Raw manure				Anaerobic tank liquid		SBR Decant	
	Pre-separation		Post-separation					
	Average	Range	Average	Range	Average	Range	Average	Range
BOD_5(mg O_2/L	8026	5720-9862	7820	5820-9680	3205	2960-3460	588	520-650
TSS (MG/L)	NA		9733	5280-15440	4410	3840-4960	501	84-1436
Total nitrogen	0.29	0.24-0.33	0.27	0.25-0.29	0.21	0.2-0.22	0.07	0.05-0.09
NO_2+NO_3 (ppm)	NA		4.0	3.7-4.2	2.3	1.9-2.8	185	3.5-518
NH_4 (ppm)	1901	1736-2092	1653	1414-1788	1531	1370-1622	494	298-772
Total P (ppm)*	900	700-1000	900	NA	600	none	300	200-400
Total K (ppm)**	NA		NA		1200	1000-1300	1010	950-1100

data based on 5 samples taken earlier in the year

** potassium levels of raw manure during sample period not available.

Table 2: Percentange reduction in various parameters through treatment system (derived from above table)

Parameter	Post separation +aer.	Post anaer. storage	Post SBR treatment	Total red'n
BOD_5	2.6%	57.5%	35.2%	92.7%
TSS	NA	54.7%	40.2%	94.9%
Total nitrogen	6.9%	20.7%	48.3%	75.9%
NH4	13%	6.5%	54.5%	74%
Total phosphorus	0%	33%	34%	67%
Total potassium	NA	NA	15.8%	15.8%*

*Potassium levels of manure pre and post separation not available

Capital and operating costs for new SBR treatment system (see also following page)

Notes on system costs:

– includes labour costs for concrete work and wiring

– for a larger size operation (500 sows), tank sizes would double, doubling the cost of concrete work.

More diffusers would be required for SBR tank to cover the increased size ($2400). Otherwise, the capital cost would remain essentially the same.

– treated liquid must be stored until it can be spread which may require a long-term storage pit.

Estimated annual operating costs to treat manure from 250 sow operation

– electricity - $250/mo. based on existing system

– farm tractor to load solids once every 2 weeks – 2 hours

– truck to haul solids once every 2 weeks

– tanker truck to haul sludge – 4-5 loads of a 2000 gallon tanker once yearly unless it can be land applied

– cost of spreading treated liquid

– annual cost of routine fixes - $10000.00

Estimated annual labour requirement

– 1/2 hour per day checking system

– 1 day per month hauling solids + 1 day per month routine maintenance

– 3 days twice yearly for major maintenance and repairs

Itemized cost for new SBR treatment system:

Item	Full cost option	Least cost option
Pumps:		
2 – 2.2 HP Flygt or other for foam control, - these pumps get heavy use so need to be sturdy.	6476	2000 – cheaper pumps or 2nd hand
1 – 1 HP Flygt submersible or other high quality pump. If liquid transfer is gravity flow, this pump not needed.	2085	0 – not needed if gravity flow out of this tank
4 – 1/2 HP Teel submersible – for liquid and sludge transfer and for mixing.	1400	700 -
Diffusers – Wyss fine air (95) – price may change if another type of diffuser is used	5700	5700
Blowers 1 – 3 P, 1 –5 HP – for aeration.	7000	3000 – 2nd hand equipment
Silencers for blowers (3) – necessary for noise control if this is a concern.	1200	0
Programmable controller and 2 expansion units	2300	2300
Float switches (6) – for operating and alarm liquid level control in all tanks	180	180
PVC – various sizes plus fittings	600	600
Wood for walls around SBR tank	100	0 – use salvaged lumber
Concrete and reinforcing – (includes labour) assumes that all 3 tanks are built from scratch. If any existing tanks are used, cost will fall accordingly. Also includes cost of solids slab and 2' walls around slab.	26,000 – all tanks and slab and walls built	5000 – minimal concrete work required
Electrical parts and labour for hookup	4000	4000
Miscell. chains, pipe etc. for hanging pumps and float switches	200	200
Total waste treatment system cost	**53,780**	**23,680**

Cost of solid-liquid separator, pump and attachments:

Item	full cost option	least cost option
Solid-liquid separator – cheaper one will save money but separate less efficiently. A range of prices and quality is available.	30,000 – FAN Engineering separator from Germany	6000 – 2nd hand inclined screen or similar separator
2.2 HP pump – Flygt is best, but less durable pump will be cheaper	3238	1000
Attachments – PVC pipe etc.	200	200
Lumber for separator stand, bunker walls	500	0 –lumber salvaged
Total cost of separator	**33938**	**7200**

This Factsheet was written by the Hog Producers Sustainable Farming Group

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