Final Report

Ohio Dairy Waste Separation and Wastewater Treatment Project

Andreas and Royer Dairy Farms

Conducted by

Crossroads RC&D Council

& Wastewater Inc.

9/2007 to 9/2009

For Farm Pilot Project Coordination

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Statement of Problem

Ohio dairy farmers face many waste management environmental constraints, including maintaining surface and ground water quality, achieving proper soil nutrient balance for crops, and reducing odors and community acceptance issues related to manure handling. The major concerns driving this project were:

- An impending ban on winter application of dairy manure, which would increase storage needs;
- Crop fields with high existing phosphorous loads, limiting where manure can be spread;
- Surface water quality degradation due to nutrient runoff, as identified in the Ohio EPA 303(d) report;
- Changing land use and urban sprawl, limiting freedom to transport manure and move farm equipment on local roads.

If it were possible to trap and dewater manure solids effectively on the farm, such that the effluent was treatable by conventional methods used for residential effluent, these concerns could be mitigated. The manure solids are a saleable commodity, and some of the effluent can be recycled into the operation. The remainder, if it could be treated with a commercial sewage treatment "package" plant, could be released into surface streams.

Project Proposal

The Crossroads Resource Conservation and Development Council (Crossroads RC&D) submitted a project proposal to FPPC to conduct a manure solids separation and treatment project located on two dairy farms in Ohio's Sugar Creek watershed. The project goal was to demonstrate that 99% of nutrients and solids could be captured in the solids component, leaving an effluent with less than 1% solids content. The effluent would have chemical and physical characteristics allowing it to be treated in a conventional small scale sewage treatment package plant.

A physical solids separation technique, using a brush screen, belt press, or screw press, would be augmented with the addition of biological and chemical amendments. Effluent would be tested at several points in the process to determine if the required characteristics were being achieved.

Because the two dairy farms had different, but commonly employed, waste collection systems, the project should apply to a majority of mid- to large-size dairies in the region.

Principal Parties

The project sponsor is Crossroads RC&D. RC&Ds are citizen-led groups assisted by federal funds and a federally funded coordinator through the Natural Resources Conservation Service (NRCS) of the US Department of Agriculture (USDA). Crossroads RC&D was responsible for overall project coordination, and the administration of funds and paperwork. The RC&D Coordinator was Sandy Chenal.

NRCS supplied some technical assistance and was prepared to assist the two farms financially through the Environmental Quality Improvement Program (EQIP). The Tuscarawas Soil and Water Conservation District (SWCD) provided outreach.

Project activities were carried out by Wastewater Services Inc., Or-Tech Inc, the Ohio EPA, the Ohio University Cooperative Extension Service, and FPPC staff.

Persons particpating in the following report:

Sandy Chenal, NRCS, serving Crossroads RC&D Coordinator

Tom Sewell, NRCS Area 2 Resource Conservationist

David Samsa, Waste Water Services

Mike Monnin NRCS State Conservation Engineer

Joel and Tim Royer, owners of Royer Farms

Dan and Matt Andreas, owners of Andreas Farms

Site Description

Two farms were selected for this project, the Andreas and Royer farms.

Figure 1. Andreas farmstead

Andreas Farms Inc. is the largest dairy in the East Branch Sugar Creek Watershed. It lies 10 miles west of New Philadelphia and 25 miles southwest of Canton. Farm headquarters are off Ragersville Road in Section 11, Range 4W of Auburn Township, Tuscarawas County. The Andreas brothers milk 1075 cows, holding an average of 155 dry cows and 40 replacements. Their permits are based on 1759 animal units. The farm has a conservation plan, a Comprehensive Nutrient Management Plan (CNMP), and an Ohio Department of Agriculture Manure Management Permit (2004).

The waste stream for this farm includes manure from the milking herd, 977,000 gallons per year of milk house waste, flush water for the waste collection system (much of this is reused), silage leachate, rainfall runoff from manure handling areas, and rainfall deposited in storage lagoons. An estimated 127 tons of sawdust and straw, used for bedding, also enter the waste stream.

Dry cows, replacements, and calves are housed under roof. The milking herd is housed under roof in free stall barns cleaned with an automated flush system.

Before the project commenced, the Andreas farm was using a mechanical brush screen separator to remove 70 to 90% of manure solids from the waste stream. The solids are hauled by CRW Corp., composted, and bagged for sale. 30 to 40% of nutrients are retained in the solids. Effluent is routed through two lagoons for settling and some biological amendment, and then used to flush the freestall barns. Manure and wastewater are applied annually to some portion of the farm's 3800 acres of cropland.

Figure 2. Royer Farmstead

Royer Farm Inc. is the largest dairy in the Nimishillen Watershed. It lies 10 miles north of Louisville, OH and 15 miles northeast of Canton. Headquarters are located off SR 44 in Section 21 of Marlboro Twp., Starke County. The farm has a CNMP (2004) but is not large enough to require a DOA permit.

Royer's 485 milking cows are housed under roof in a free stall barn cleaned with a scrape system. Including dry cows and herd replacements, the farm totals 782 animal units, of which 769 are on the project site.

The waste stream includes manure from the milking herd and 548,000 gallons per year milk

house waste, as well as 14 tons of sawdust. Manure and lot runoff are collected in a small reception pit and pumped to an 830,000 gallon above-ground slurry tank which provides 2-3 months storage. Slurry is applied to some portion of the 1678 acres of mixed cropland. Both farms were chosen because they represent the norm of dairy operations in Ohio and because the operators are known to be leaders in the region in conservation.

Project Goals/Planning

The project was based on being able to remove 99% of solids from the waste stream effluent, and treating the resulting effluent to render it acceptable for release to surface waters. In order to be suitable for release, the effluent must meet these criteria:

- CBOD 10-12 mg/l
- TSS 10-12 mg/l
- Ammonia nitrogen 1 mg/l
- Phosphorus 1 mg/l
- Fecal coliform 1000/100ml

To effect the treatment, the waste stream at the **Andreas Farm** would be subjected to these steps in addition to their existing system:

- The Kemira gravity belt filter and screw press system
- Running effluent through an onsite waste water treatment plant

The farm's intention is to be able to discharge 40,000 gallons/day (meeting discharge specifications) with the Kemira system, a holding pond for the effluent, and a pulse-jet irrigation system for applying effluent to cropland.

The waste stream at the **Royer Farm** would be subjected to these additional steps:

- Addition of biological amendments
- Installation of a brush screen separator
- Use of a dewatering belt system and/or a DAF
- Running effluent through an onsite waste water treatment plant

Project Activities

The project began in September of 2007.

[The following narrative of events is taken from a Summary Engineering Report submitted by Fritz Brothers Engineering, as well as notes supplied by FPPC and NRCS staff.]

Phase I of the project was intended to remove manure solids from the waste stream of each farm. These solids, at a concentration of 25 to 30%, would be removed by the hauler, leaving the liquid fraction to undergo further treatment.

Figure 3. Brush screen separator in operation at Andreas Farm

An initial attempt to use a Or-tec drum brush screen proved ineffective. Delays were caused by the equipment fabricator not meeting deadlines. There were also difficulties in operating equipment during tests due to winter weather. It should be noted that if this technology were adopted, it would have to be fully functional in all seasons.

The vendor interviewed more than ten equipment manufacturers before having two different types of solid separation companies provide quotes.

The MSD Environmental Services BDP belt press was selected as one option. The Integrity Kemira separation system provided a second option. Thermal Engineering's ammonia recovery system was held in consideration as a secondary treatment.

MSD Industries specializes in portable and skid mounted solid separators. They represent a belt press manufactured by BDP Industries in Greenwich, NY. Their current business is approximately 70% municipal and 30% industrial (cheese and food waste). The Agri-Sludge Company works closely with MSD and provides the pumps and a container to hold recycled effluent for the belt press operation. The belt press is built on a trailer; it has a lab facility, ferric chloride and polymer mixing stations, a gravity belt, two belts pressing manure on eight rollers, drain pans under the belts and a conveyor emptying the solids into a dump truck. This press has a capacity of 200 gpm. The press has a continuous self-cleaning system using recycled effluent. The average life of the belting is 2500 hours of operation. These systems need to have an operator present at all times.

After testing the brush screen and determining that it was insufficient, the vendor planned to install a belt press, concrete pad, 100,000 gallon tank, flow equalizer tank and the Thermal Engineering ammonia recovery system.

Andreas Farm

May 20-22, 2008: MSD Environmental Services conducted a solids separation test using a BDP one meter belt filter press. A limited number of samples were taken and the press was in operation only a short time.

February and March, 2009: a Kemira 812P two-stage system consisting of a gravity belt filter followed by a screw press was tested. The system was active for approximately three weeks (2/23/2009 to 3/17/2009) with samples taken on twelve days. An average reduction of 44% CBOD, 92% phosphorous, and 3% ammonia was obtained with a sludge cake of 20% solids.

Royer Farm

May 27-28, 2008: the MSD belt press was demonstrated and generated a 24% solids sludge cake.

The scraped manure was agitated and pumped from a Harvestore slurry tank through a macerator pump and into the belt press. MSD only had two polymers with them for the demonstration; one dry and the other a concentrated liquid. Both polymers were blended together for the demonstration and seemed to have good flocculation, although there was considerable foaming in the free water gathering tank. Before this belt would be used, proper testing of the manure would be done to find the most effective polymer for solid separation.

The continuous feed of manure, with the polymer already introduced, seemed to allow complete blending of the polymer. The mixture was pumped into a gathering tank from the bottom of the press, which filled and then flowed out the top, with the aid of moving paddle wheels, to deposit evenly onto the belt. This feed system prevented any clumps, surges, etc. that are current problems with many solid separation units. The gravity belt had “plows” which scraped the treated manure into rows, allowing free water to drain through the belt.

From the gravity belt the manure was fed between two additional belts and squeezed around 8 rollers. The tensions of the belts to the rollers were controlled hydraulically. The rollers and pumps were variable speed electric motors. The press cake was determined to be 21% solids on one occasion and about 29% solids on a second. The polymer dosage rate was 9 lbs/dry ton and ferric chloride was dosed at 141 lbs/dry ton prior to dewatering. Average phosphorus removal was 89%; TKN removal, 67%; and TSS removal, 92%. CBOD and ammonia content of the filtrate showed that further treatment would be needed before the effluent could be discharged. The 80 gpm belt press could accommodate the farm’s 20,000 gal/day manure load. A tentative cost estimate for using this system was developed by Fritz Brothers Engineering, however it was determined that the system would not be feasible for these two farms at this time.

Figure 4. MSD Environmental Services portable Belt Press at Royer Farm

Site Visits to Andreas and Royer Farms

Royer Farm—Or-tec Drum Screen—9/2007

There was some preparation for the project, and some tests taken. The test model of the Or-Tec drum-screen separator was demonstrated at the Royer Farm. Solids passed through the separator were not noticeably dewatered.

Figure 5. Or-tec Drum Screen tested at Royer and Andreas Farms

The OrganiSol products (microbiological amendment) had been used on the Royer farm for about two weeks. This material was sprayed on the floors and poured into the reception pit in order to reduce odors and assist in manure digestion. This product had been used on the Andreas farm for some time, usually added to the holding pond.

David Samsa stated that the effluent coming from the double Integrity drum-screen separators was at a 1% TSS level. A copy of this data was not available at the time this report was compiled. The effluent seemed very dark, as at the Royer Farm. The two separators had two different size screens, one finer than the other. Samsa reported the separators had the fine screens until the winter months. The manure would not separate the liquid due to the cold weather, so larger screens were put in to solve the problem. The warmer weather found the TSS rate too high, so the finer screen was used.

If the effluent can be screened to .25% TSS, a package plant would be feasible. One-third of the total effluent at the Andreas Farm would be treated, the other 2/3 recycled in the flush. At the Royer Farm, all of the effluent would be processed.

Andreas Farm—KEMIRA System—February 2009

The Kemira System was delivered on Monday, February 16th and due to electrical hook up difficulties and a ruptured hose saw very little operation in the first week. Kyle Rife, from Integrity Systems, set up the system and trained Matt Andreas.

See the Appendix for diagram of system flow and location of sample points.

On the first day staff observed the test, the ambient temperature was below 20 degrees F and the machine was icing at several points. One set of samples was collected. The machine was only able to run continuously for about one hour. Good flocculation was not obtained.

On the following morning, even with the heaters in the trailer, the machine would not start. Outside temperature was 8 degrees. In the afternoon, with slightly higher temperatures, the machine had trouble running on automatic and some pumps were not functioning. Performance was similar to the previous day. Polymer and ferric chloride additives were not behaving as expected. Some samples were taken on the third day.

The system was not able to adjust to a surge of solids from the pit; flocculation was lost when this happened. This system definitely needs an operator present at all times to observe changes. The floc seemed to vary depending on whether the reception pit pump was running or not. Agitation of the manure caused a change in the solids content. The ten minute lag from chemical adjustment to visible changes on the belt could be a concern especially if the solids content would vary during a given run. The system also failed to shut down automatically when a foreign object was inadvertently introduced from the pit, causing clogging and mechanical problems.

The system is designed to operate at a capacity of 1320 to 1840 gallons per hour. The farm needs capacity for processing 50,000 gallons/day. Two machines would be needed to handle the load.

Figure 6. The Kemira manure dewatering system, enclosed in trailer.

Figure 7. Interior of Kemira trailer, showing system

Monitoring

OSU Extension was asked to carry out an economic analysis of the project, as well as an evaluation of water quality impacts. The economic analysis and evaluation were not available at the time this report was compiled and it is not known if they were completed.

Manure solids and effluent were sampled by Wastewater Services and analyzed by Coshocton Environmental Testing; later samples were taken by OSU Extension and analyzed by a contracted lab.

See the Appendix for photographs of sample sites and results of laboratory testing.

Discussion

With the separation systems that were demonstrated, TSS of the effluent was adequately reduced; 92% of phosphorous was removed; BOD was reduced to 5,000 – 7000 ppm; ammonia was reduced by 50%.

Results were similar on both farms. The limiting criterion in both cases is ammonia.

The Integrity Kemira System results were similar to the MSD, but there were 2 effluent streams, one acceptable and the other requiring further treatment.

The Andreas farm requires 250,000 gal/flush water/day. Therefore the Kemira System would have to run 24 hours a day, 7 days a week to keep up or there would need to be two belt presses. Using a single MSD system, the Andreas farm ran out of water between flushes.

The goal of using the Kemira System was to reach .250% TSS (2500 mg/L) at the #2 sample location (effluent from the Band Filter). The test results showed an average of .061% TSS (608 mg/L). At the time it was thought that if the TSS goal could be reached, other essential parameters would be adequate for treatment. However, the cost of chemical additives was deemed prohibitive after all the systems were tested.

If the MSD belt press had been installed at the Royer Farm, the vendors felt the effluent could have gone from the belt press into a package treatment plant. The only problem was the ammonia. Thermal Energy was confident they could take care of the Ammonia. The phosphorus level was close to what is needed for a package plant to operate. Experience with high BOD cheese plant effluent indicates that BOD could be reduced with bio-augmentation. It was not clear if the ammonia would be reduced before or after the addition of biological amendments.

Although some of the goals for the project have been met, the overall goal to develop a low cost, low maintenance treatment system to remove pollutants from the manure stream and yield a dischargeable effluent was not achieved. There needs to be further study of nitrogen removal from the waste stream. Thermal Energy did not test their ammonia recovery system at either farm.

Resolution:

At the present time, the two farms do not have solid separation systems which will economically produce effluent appropriate for a water treatment plant.

<u>Andreas Farm:</u> Dan and Matt Andreas have concluded the economics do not justify purchasing the Kemira system, along with a package plant on their farm at this time. The Andreas farm intends to pursue other means to enable their meeting objectives of holding the farm's waste stream throughout the year. They currently have a firm recommending alternatives, including an additional holding pond and wet lands.

<u>Royer Farm:</u> The Royer Farm has decided not to purchase or lease the belt press from MSD Environmental Services, Inc. The Royers have made the decision to install an above ground slurry tank to allow them to have adequate storage.

Recommendations

The methods trialed in this project were unable to produce an effluent meeting the criteria for treatment by a package sewage plant. While the Total Suspended Solids criterion was met at certain times with the Kemira system, it is not clear if that system would meet the TSS limit of less than 1% solids in all weathers and under all conditions because the trial was fairly brief. In addition, the criteria for COD, BOD, and ammonia were not met. The ammonia removal system was not tested.

Given these results, the manure treatment industry needs to demonstrate more reliable and thorough methods of cleaning manure effluent before the investment into a package plant would be warranted. The technical findings and relative costs and complexities of the methods tried in this project are useful information to add to the knowledge base for others who may pursue similar projects.

Appendices

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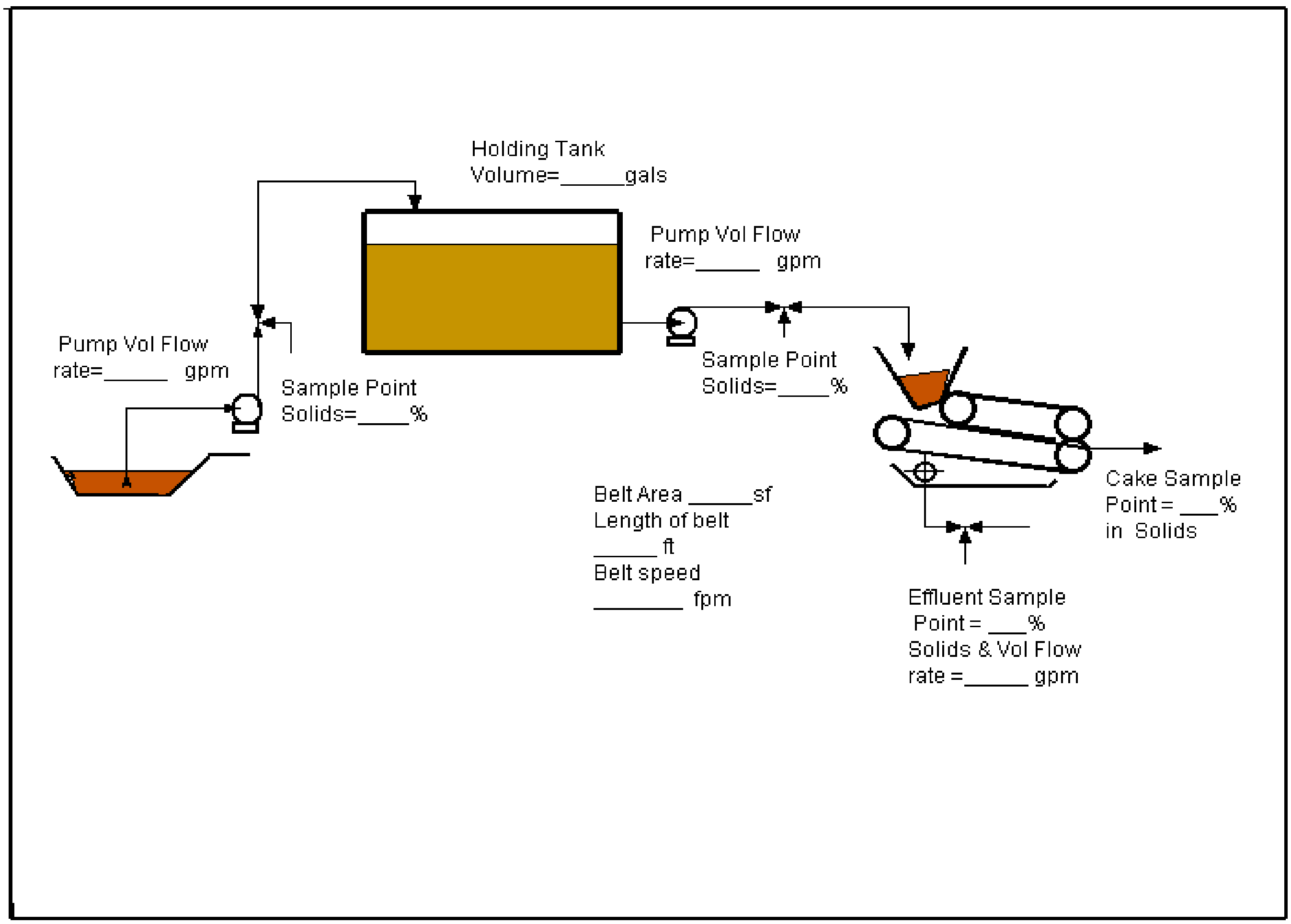

Figure 8. MDS Belt Press Schematic

Manure Sampling Data Sheet

Kemira 812 P Operation – Andreas Farms

Sample Lot # _____

Date:____________

Time:____________

Machine Operational Characteristics

Influent Feed Rate:_______m^3/hr

Coagulant Dosing Rate:_____________mL/m^3

Polymer Dosing Rate:_____________mL/m^3

Polymer Make-Down Fresh Water Input Rate:__________L/hr

Polymer Type: ☐ 1895 ☐ 2180 ☐ 4815 ☐ Other_________

Polymer Stirrer Speed:_______Hz

Description of Flock Quality:

Flock Size (Approximate Diameter): ☐ < .5" ☐ .5-1" ☐ 1-2"

Visual Appearance: ☐ Jagged ☐ Rounded ☐ Gelatinous

Environmental Factors

Outside Temperature:_______°F

Precipitation?:_________________________

Notes:____

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Figure 9. Form used to establish chain of evidence for manuer and effluent samples

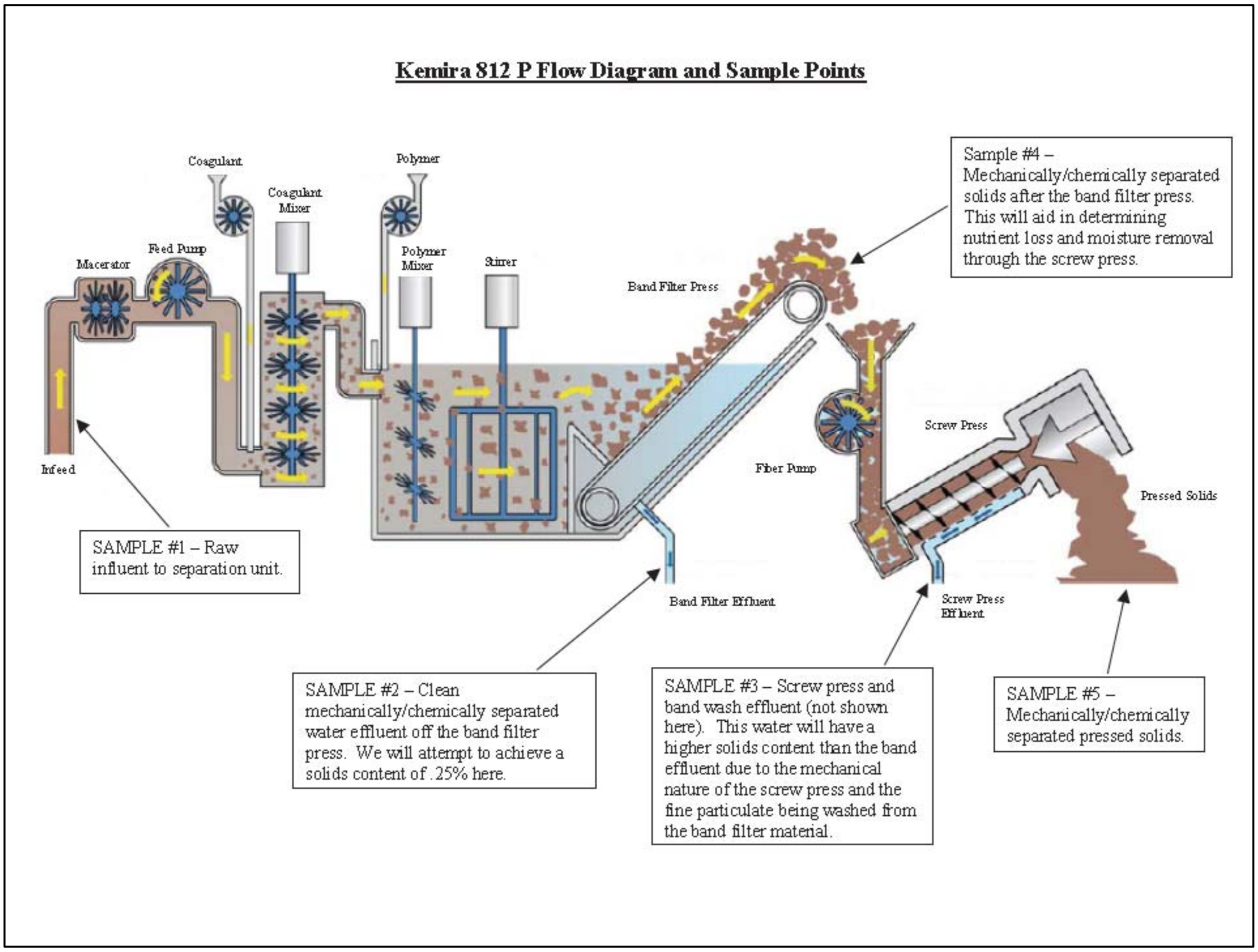

Figure 10. Kemira System Flow Diagram and Sample Points

Laboratory Data

There is a laboratory data set from Kemira, not included here, in which the samples are not identified as to location. Included here are a data set from the Coshocton Laboratory, from samples submitted by David Samsa of Wastewater Inc; and a set processed by Ohio State University, submitted by project staff. In the sets which follow, the sampling location is identified by number. Refer to **Project Photographs** for these locations. Most samples are also identified as "to press" or "out press", meaning unprocessed influent flowing to the press, or effluent flowing away from the press after solids removal.

Manure Sampling Data -- Kemira 812P -- Andreas Farm

DATE	SAMPLE	TIME	FEED RATE	COAGLANT DOSE RATE	POLYMER DOSE RATE	WATER INPUT	POLYMER TYPE	STIRRER SPEED	FLOC SIZE	VISUAL	EXTERNAL TEMP	WEATHER
2/23/2009	1 --test	2:30-5:00P	4 m3/hr	6500 mL/m3	1500 mL/m3	350 L/hr	1895	60 Hz	1-2"	Gelatinous	28 oF	No Precip
None												
2/24/2009	2--no test	7:00A									5 - 10 oF	No Precip
Lines walked out & drained Monday nite; leftover water frozen solid to lagoon & pit, also inside truck. Lines still frozen mid afternoon, no test.												
2/25/2009	2 - test	10:30A	5	6500	1450	375	1895	70	0.5 - 1"	Gelatinous	35	No Precip
Polymer started at 1400 and ferric was at 6750. Got best results at above numbers.												
26-Feb	no test	7:00A	5	6700	1550	370	1895				50	No Precip
Machine clogged w/ small stones or gravel-- auto shutoff did not work. No way to take pressure off w/o making a mess. Fixed around 3:00P.												
27-Feb	3 - test	7:00A	5	6500	1500	400	1895	70	0.5 - 1"	Rounded	53	Rain
Attempted to up ferric chloride rate to 7000 and polymer to 1750; result was too much water. Dropped dosages down and got best results at 6500 and 1500. Screwpress & augur both overloaded; no auto shutoff. Fiberpump sensors kept tripping.												

Andreas Farm Manure Testing ~ Coshocton Environmental

Reported March 11, 2009				Sampled February 23, 2009				all values from wet weight					
Lab #	**Location**	**pH**	**% Solids**	**% Volatiles**	**CBOD**	**TSS**	**P**	**Ammonia**	**TKN**	**T N**	**Alkalinity**	**COD**	**K**
902489	#1	8.01	1.89	66.1	6978	9900	177	806	1609	803	6094	20247	1316
902492	#2	7.27	1.14	51.4	5478	2300	42	770	1348	578	4168	10195	2326
902493	#3	7.44	1.41	63.4	4380	5250	106	617	1133	516	3403	14582	999
902494	#4	7.26	4.6	75.3	nd	nd	521	980	2859	1879	nd	109045	848
902495	#5	7.61	16.9	81	nd	nd	807	944	8918	7974	nd	135333	1561

OSU Lab Results									
Royer Farm									
Reported 6/18/2008				Sampled 5/28/2008				wet weight	
Lab #	**Location**	**Time**	**K mg/kg**	**NH3 mg/kg**	**P mg/kg**	**pH**	**TKN mg/kg**	**TSS mg/kg**	**BOD mg/kg**
805823	#1 to press	0845A	1197	1546	407	6.75	3510	41459	15743
805822	#1 to press	1000A	1295	1546	405	6.68	3126	33906	18446
805824	#1 to press	1030A	1071	1646	395	6.69	3582	46257	16191
805825	#2 out press	0905A	858	775	118	6.75	1174	414	4629
805817	#2 out press	1020A	1014	794	29	5.02	1116	813	5784
805819	#2 out press	NT	909	827	36	6.79	1023	1018	5449
Reported 6/18/2008				Sampled 5/27 & 28/2008					
Lab #	**Location**	**Time**	**% Solids**	**CFU/g wet**	**CFU/g dry**				
805819	#2 out press	1030A	24.6	180000	731707				
805822	#1 to press	1000A	5.41	24000	443623				
805826	unmarked	1130A	24.7	132000	534413				
805817	#2 out press	1020A	28.2	204000	723404				
805823	#1 to press	0845A	6	34000	566667				
805824	#1 to press	1030A	6.22	36000	578778				
805825	#2 out press	0905A	23.3	58000	248927				
Andreas Farm									
Reported 6/18/2008				Sampled 5/20/2008				wet weight	
Lab #	**Location**	**Time**	**K mg/kg**	**NH3 mg/kg**	**P mg/kg**	**pH**	**TKN mg/kg**	**TSS mg/kg**	**BOD mg/kg**
805641	#1 to press	1050A	998	909	421	7.52	1705	10454	9798
805642	#3 to pond	1530P	898	871	17	6.89	1267	180	5611
805643	#1 to press	1320P	445	880	272	7.49	2302	12855	7502
805644	#3 to pond	1315P	785	876	9.13	7.13	482	482	5341
Reported 6/18/2008				Sampled 5/27 & 28/2008					
Lab #	**Location**	**Time**	**% Solids**	**CFU/g wet**	**CFU/g dry**				
805641	#1 to press	1050A	20.6	1000000	4854369				
805642	#3 to pond	1530P	22	800000	3636364				
805643	#1 to press	1320P	2.84	19500	686620				
805644	#3 to pond	1315P	17.7	900000	5089746				

Project Photographs

Figure 11. Sample Site #1, Andreas Farm, Kemira System testing

Figure 12. Sample Site #2, Andreas farm, Kemira System Testing

Figure 23. Sample site #4, from belt press

Figure 3. Sample site #5, after screw press

Figure 15. Kemira Gravity Belt Filter and Screw Press

Conceptual Design for a
Package Wastewater Treatment Plant
for Surface Water Discharge

Robert P. Carnahan Ph.D., P.E., BCEE

Introduction:

Crossroads RC&D Council and Wastewater Inc. were faced with the problem of removing 99 percent of the nutrients and solids from a highly concentrated wastewater and disposing of 25,000 gallons-per-day to a surface water receiving body. The challenge was to design a wastewater treatment plant that would produce an effluent that would meet the Ohio permit standards shown below:

Table 1 Surface Water Discharge Standards

Effluent Standards		
CBOD	BOD_5	10-12 mg/l
Total Suspended Solids	TSS	10-12 mg/l
Ammonia	NH_3-N	1 mg/l
Phosphorus	P	1 mg/l

The quality of the influent wastewater is a function of the performance of the Kemira Filter Press. Table 2 shows what would be the quality of the influent wastewater to the package treatment plant.

Table 2 Influent Wastewater Quality

Wastewater Quality			
Biochemical Oxygen Demand	BOD	3,880	mg/l
Chemical Oxygen Demand	COD	7,219	mg/l
Total solids	TS	9,200	mg/l
Volatile Solids	VS	4,073	mg/l
Total Suspended Solids	TSS	902	mg/l

Based upon the influent concentrations the required efficiency of the package plant to meet the standards for BOD and suspended solids removal must be 99.74 and 98.89 percent, respectively.

The total suspended make up is only 9.8 percent of the total solids concentration in the waste stream, which means that the majority of the solids are in a dissolved state. Note, that the volatile solids represent 44.3 percent of the total solids concentration, which means that 55.7 percent of the solids are not bio-reactive or inert. This indicates that the installation of additional solids separation process should be considered; assuming that the inert solids have great specific gravity than the bio-reactive material.

Design Criteria used for Conceptual Design:

The initial concern was the selection of processes that could be used to treat the high CBOD and solids concentrations at a relatively low flow rate. Batch sequencing reactors processes, the extended aeration process, and step feed conventional activated sludge process were all considered as possible choices for treatment of the waste. However, both the batch sequencing reactor plant and the step feed plant requires more operational time and controls than the extended aeration plant. While the calculations indicate that the step feed process would be preferred, the extended aeration process was selected because of its ease of operation, capacitance, and ability to equilibrate quickly.

The Monod suspended growth model was used to design the biological reactor using the following kinetic coefficients:

k = max. substrate utilization rate = μ_m / Y = 4.00 d^{-1}

Y = max. yield coefficient = 0.45 mg VSS / mg BOD_5

k_d = endogenous decay = 0.06 d^{-1}

Θ_c = mean cell residence = 30 days

It was also determined that the concentration of the CBOD for the soluble fraction of the effluent should not exceed 4.75 mg/L, which resulted in a hydraulic retention time of 5 days and a reactor volume of at least 17,280 cubic feet. This resulted in a reactor that has fluid depth of 12 ft. width of 24 ft, and length of 60 ft. It was estimated that the concentration of the mixed liquor suspended solids within the reactor would be approximately 5,000 mg/L and that 80 percent of these solids would be volatile.

The volumetric loading rate for the reactor was estimated to be 48 lbs $BOD_5/10^3$ ft^3 d, which is high for an extended air activated sludge plant (Crites and Tchobanoglous 1998). The step feed plant is capable of treating waste with loading level; however, it is difficult to configure a package plant to operate as a step feed plant. The extended hydraulic retention time would compensate for the loading rate. The food to microorganism ratio is 0.19 d^{-1} , which is only slightly above the recommended F/M ratio for extended aeration (Metcalf and Eddy 2003).

A 6,800-cubic-foot aerobic digester would be required to treat the excess solids produced in the oxidation process. The aeration system for the digester would be linked to the aeration system for the package treatment plant. The volumetric oxygen demand of the system is estimated to be 735 pounds- per-day. With a safety factor of two and an estimated diffuser efficiency of eight percent, the estimated airflow rate would be 7,500 cfm, which is equivalent to five 10-horsepower standard rate surface aerators.

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Three manufacturers of package plants were contacted to see if their systems would bid on a project of this type. All three refused to provide a bid and indicated if they were to bid on a project of this type, they would not guarantee the plants performance. Based upon our estimation the treatment plant would have to have an equivalent capacity of 125,000 gallons, and would cost in excess of $500,000. This cost does not include site preparation. The conclusion was that the project was too expensive and that the cost to benefit ratio was too large.

Crites, R. W. and G. Tchobanoglous (1998). Small and Decentralized Wastewater Management Systems New York, McGraw-Hill

Metcalf and Eddy (2003). Wastewater Engineering Treatment and Reuse. New York, McGraw Hill.