Workshop
ASAE Workshop CPD # 18

Prevention, Mitigation and Control of Odors

Topic

Pit Additives and Covers to reduce odors from Livestock Manure Storage

By

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PROPOSAL: PRODUCT TESTING OF MANURE ADDITIVES FOR ODOR CONTROL
"Proposal VPT-1"
(Revised 6/97)

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AGREEMENT:

The agreement for the evaluation is provided in the attached memorandum of understanding.

PURPOSE OF PROJECT:

The purpose of this project is to provide the industry supplying pork producers with odor control product for manure pits, a scientific evaluation of odor control effectiveness. An ASTM approved evaluation procedure will be used for odor measurement.

INTRODUCTION

Manure additives may be a chemical, an enzyme, or a biological product or a combination of the material. The value of these products are reported to reduce odors, ammonia, break down solids, an[d] to release nutrients more effectively for the utilization of plants.

The procedure outlined within will address the testing of the product to determine the effect of materi[als] on treated swine manure with the exception of field trials for agronomic benefits.

COLLECTION OF SAMPLE

The manure for testing will be taken from a finishing building. Manure will be agitated and samples collected for putting into the columns. The room will be held between 60-65°F during the study. The feed used will be a standard finishing ration which will be provided in the report.

EXPERIMENTAL DESIGN

General

The experimental design will be a complete random design with four treatments (1 control, 3 samples) with three replications. The experimental unit will consist of 15 inch diameter by 48 inch columns. Three test columns will be assigned to each product. The prescribed quantity and frequen[cy] of the manure additive product will be added to the manure in the columns. Three control columns will be run simultaneously. The laboratory is set-up to run five products at a time, i.e., a total of 18 columns.

Equipment Design

The columns shown in Figure 1 are 15 inch diameter by 48 inches tall. Manure will be progressively filled to a maximum level of 36 inches with a minimum gas head space of 12 inches. Air will be exhausted from each column head space at the rate of 1/2 cfm continually. Gas sampling ports will be provided to withdraw samples as prescribed. A sampling tube will be input through the manure supply tube for solids evaluation.

LOADING COLUMNS

Manure

The test will run for a total of 35 days. Twelve inches of manure will be added to each column on day zero. Additional manure will be added as follows:

Day	Quantity of Manure Added (inches)	Quantity in Columns (inches)
0	12	12
7	6	18
14	6	24
21	6	30
28	6	36

Manure Additive

Manufacturer's additives will be added as described by the manufacturer. Some products may require adding only once at the beginning of the test which others may require more frequent loading.

DATA COLLECTION PROCEDURE

The data collection will consist of an evaluation of both the air and liquid fraction of the test column. The following table shows the frequency of sampling.

	Time of Data Collection Day					
	1	7	14	21	28	35
Air Samples						
NH_3		•	•	•	•	•
H_2S		•	•	•	•	•
Odor Threshold		•	•	•	•	•
Liquid Sample						
Total Solids	•	•	•	•	•	•
Volatile Solids						•
Fixed Solids						•
COD						•
pH						•
Total Phosphorous						•
Total Potassium						•
Ammonia						•
TKN						•
VFA*						•
acetic acid						•
propionic acid						•
iso-butricacid						•
n-butric acid						•
2-methyl butric acid						•
3-methyl butric acid						•
n-valeric acid						•

* Volatile Fatty Acids

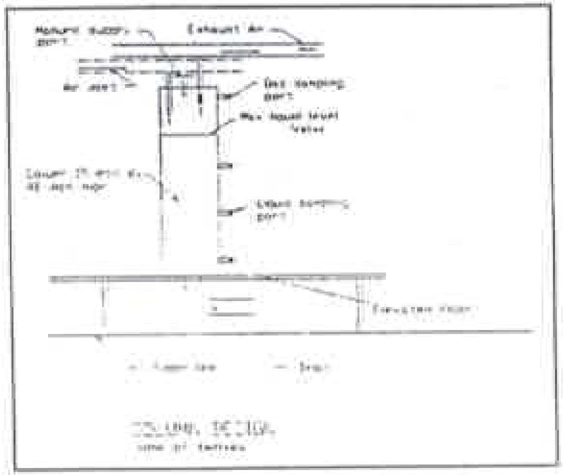
REQUIREMENT FROM MANUFACTURER

Prior to testing each product a disclosure of the ingredients in the product but not the recipe is required to insure the safety of laboratory personnel.

The distributor of the product will make a data sheet available showing results to the user of the analysis conducted at Iowa State University when stating that their product was tested at Iowa State University.

BUDGET:

The costs will be $7500 per sample tested. This includes three replications per product. A standard ISU Memorandum of Understanding is used for the contract.



Test Results of products tested at Iowa State University, Ag and Biosystems Engr Dept

Lisa Inc
713 Allen St.
Boone, IA 50036
1-888-432-5472
1-800-275-2352

APPLICATION: Four ounces of the product X-Stink was added to every six inches of manure so the amount of the product totaled 24 ounces per treatment. The first application was after the first load of manure with an amount of 8 ounces, while the following applications were done at each manure loading time with an amount of 4 ounces. The manure was well stirred prior to loading, however, there was no agitation of the manure within the column during the test.

RESULTS: At the end of the test, the product reduced odor threshold by about 87% as compared with the controlled samples. It did not statistically significantly change the levels of volatile fatty acids, chemical oxygen demand, total solids, total volatile solids, pH, total nitrogen, and total suspended solids. It did significantly decrease the ammonia nitrogen level based on this test. The level of product added was 0.66% by weight (54.8 lbs per 1000 gallons of manure).

End-of-Test Results

	Control	Treated
ph	6.0	6.0
Volatile fatty acids	11,254	11,983
COD	32,266	31,091
Total solids	40,738	35,676
Total volatile solids	32,032	28,664
Ammonia Nitrogen	800	372
Total Nitrogen	2,893	3,166

NEOZYME INTERNATIONAL, INC.
3333 West Pacific Coast Highway, 4th Floor
Newport Beach, CA 92663-4036

Product: Ecosystem Plus

APPLICATION: The level of product used was 100 ppm per unit of manure (1 gallon of product per 1 million gallons of manure).

RESULTS: No odor reduction was detected during the first week. Odor was reduced 31% from week 2 through week 5. No odor reduction was measurable during the last week of the 6-week test. Ammonia and hydrogen sulfide were not reduced by the treatment, nor were total solids or volatile solids. COD and volatile fatty acids were reduced somewhat by the treatment. There was a strong indication that the product dosage was less than optimum.

End-of-Test Results

	Control	Treated
ph	7.1	6.9
Volatile fatty acids	16,984	14,176
COD	82,333	62,067
Total solids	66,875	67,414
Total volatile solids	49,584	50,840
Ammonia Nitrogen	2,467	4,458

NU-AG Bosko
P.O. Box 546,
1704 S. 11th Street
Oskaloosa, IA 52577
515-673-3454

APPLICATION: 12.2 pounds of Manu-Rx were added to 1,000 gallons of swine manure.

RESULTS: The product reduced odor threshold by about 74%. The product reduced ammonia by about 18%.

End-of-Test Results

	Control	Treated
ph	6.94	6.94
COD	60,567	61,500
Total solids	35,840	36,272
Total volatile solids	24,075	24,555
Ammonia Nitrogen	3,747	3,753
Total Nitrogen	4,692	4,635

Shac Env. Product Inc.
PO Box 222
Dunmore, Alberta
TOJ1A0, Canada
403-528-4446

APPLICATION: The product was very well shaken; then 4 liquid ounces of product was added to each treated column at the beginning of the test for the entire testing period. The manure was well stirred prior to loading; however, there was no agitation of the manure within the column during the test.

RESULTS: The product reduced the odor threshold by about 83% as compared with control samples. It reduced the levels of volatile fatty acids, but it did not significantly affect the levels of chemical oxygen demand, pH, total solids, and total volatile solids. It increased both total nitrogen and ammonia nitrogen in the manure tested. The level of product added is 0.11% by weight (9.13 lbs per 1000 gallons of manure).

End-of-Test Results

	Control	Treated
ph	6.94	6.93
COD	60,567	62,000
Total solids	35,840	36,552
Total volatile solids	24,075	24,647
Ammonia Nitrogen	3,747	3,810
Total Nitrogen	4,692	4,732

KANE Mfg. Co.
1101 NE 56th St.
Des Moines, IA 50317
515-262-3001

APPLICATION: Manure was added at an increment of two inches, and a mixture of the product (MPC) was sparged on the surface area immediately after each two-inch loading. The dose for each two-inch loading was composed of 2 cc of MPC and 30 cc of water except for the first application which was made up with 4.8 cc of MPC and 300 cc of water. The manure was well stirred prior to loading; however, there was no agitation of the manure within the column during the test.

RESULTS: The product reduced the odor threshold by about 85% as compared to controlled samples. It reduced the levels of total solids, volatile fatty acids, and total volatile solids in varying degeres and increased both total nitrogen and ammonia nitrogen. It did not significantly influence the pH, or chemical oxygen demand in the manure. The level of product added is 0.04% by weight (3.32 lbs per 1000 gallons of manure).

End-of-Test Results

	Control	Treated
ph	6.42	6.30
Volatile fatty acids	6,450	5,791
COD	27,784	23,856
Total solids	23,405	17,025
Total volatile solids	13,202	6,042
Ammonia Nitrogen	355	425
Total Nitrogen	1,568	3,521

	Control	Treated
ph	6.42	6.35
Volatile fatty acids	6,450	5,791
COD	27,784	20,608
Total solids	23,405	21,328
Total volatile solids	13,202	9,148
Ammonia Nitrogen	355	795
Total Nitrogen	1,568	2,016

Biosolutions Systems, Inc.
904-167 Lombard Avenue
Winnipeg, MB, Canada R3B OV3
204-947-6939

APPLICATION: 20.7 pounds of BIO-409 were added to 1,000 gallons of swine manure.

RESULTS: The product reduced odor threshold by about 80%. The product reduced ammonia by about 22%.

End-of-Test Results

	Control	Treated
ph	6.94	6.91
COD	60,567	71,867
Total solids	35,840	43,658
Total volatile solids	24,075	30,206
Ammonia Nitrogen	3,747	3,767
Total Nitrogen	4,692	4,758

Chem-A-Co
5903 east Pierce Rd.
Monticello, IN 47960
800-383-5566

APPLICATION: 2.13 oz. of Pit Boss were added to 1,000 gallons of swine manure.

RESULTS: The product reduced odor threshold by about 72%. The product reduced ammonia by about 6%.

End-of-Test Results

Agro Solutions
1004 E. 5th St.
Tama, IA 52359
515-232-1103

APPLICATION: A dose of 12 grams of product was added after the first load of manure and before the last load. The manure was stirred prior to each loading; however, there was no agitation of the manure within the column during the test.

RESULTS: The product reduced odor threshold by about 58%as compared with the controlled samples. It did not statistically significantly change the levels of volatile fatty acids, chemical oxygen demand, pH, total nitrogen and ammonia nitrogen. It did significantly decrease the levels of total solids and total volatile solids in the manure. The level of product added was 0.02% by weight (1.66 lb per 1000 gallons of manure).

End-of-Test Results

	Control	Treated
ph	6.0	6.0
Volatile fatty acids	11,254	9,518
COD	32,266	33,664
Total solids	40,738	34,498
Total volatile solids	32,032	26,710
Ammonia Nitrogen	800	640
Total Nitrogen	2,893	2,980

American Biocatalyst, Inc.
P.O. Box 668,
804 8th St.
Durant, IA 52747
319-785-6840

APPLICATION: Two products were tested in combination with each other, ABC 100E and ABC 200M. 351.07 oz. of ABC 100E and 72.46 oz. of ABC 200M were added for every 1000 gallons of swine manure.

RESULTS: The product reduced odor threshold by about 70% as compared with the controlled samples. It also reduced the amount of ammonia by about 23%.

End-of-Test Results

	Control	Treated
ph	6.94	6.93
COD	60,567	61,433
Total solids	35,840	35,375
Total volatile solids	24,075	23,913
Ammonia Nitrogen	3,747	3,783
Total Nitrogen	4,692	4,792

Aspen International
500 Turtle Cove Blvd., Suite #150
Rockwall, TX 75087
800-561-5202

APPLICATION: 1,994 grams of Neutrafresh-Ag was added to 1,000 gallons of swine manure.

RESULTS: The product reduced odor threshold by about 89%. It also reduced the amount of ammonia by about 40%.

End-of-Test Results

	Control	Treated
ph	6.94	6.96
COD	60,567	62,433
Total solids	35,840	35,755
Total volatile solids	24,075	24,179
Ammonia Nitrogen	3,747	3,953
Total Nitrogen	4,692	5,072

Bio-Safe Company
PO Box 403
Bettendorf, IA 52722
319-328-4802

APPLICATION: A mixture of 50 parts water to 1 part enzyme was made. 100 milliliters of the mixture were applied to the manure in each column on day 0 and day 14, so a total of two doses with the same quantity and mixing ratios were added. The manure was well stirred prior to each loading; however, there was no agitation of the manure within the column during the test.

RESULTS: The product reduced odor threshold by about 83.5% as compared to control samples. It reduced the levels of volatile fatty acids, chemical oxygen demand, and total volatile solids in varying degrees, and increased both total nitrogen and ammonia nitrogen. It did not significantly influence the total solids level in the manure. The level of product added was 0.01% by weight (0.83 lb per 1000 gallons of manure).

End-of-Test Results

	Control	Treated
ph	6.42	6.36
Volatile fatty acids	6,450	4,979
COD	27,784	22,272
Total solids	23,405	17,450
Total volatile solids	13,202	12,225
Ammonia Nitrogen	355	485
Total Nitrogen	1,568	2,259

ASAE Workshop CPD #18
Measuring and Quantifying Odors

Control Manure Odor Emission Using Covers

Dwaine Bundy

ABSTRACT

A research project to determine the effect of controlling odor emissions from manure surfaces was studied by covering with low cost materials. The study included organic and inorganic covering materials. Special manufactured floating materials were also evaluated. Fourteen 6 ft diameter by 4 ft high steel tanks filled with 3 ft of manure were used. The tanks were buried to a depth of 3 ft. Covering materials were applied on the manure surfaces to reduce the emission of odorous gases from manure to the atmosphere.

Odor concentrations above the covers and liquid manure surfaces were sampled and analyzed weekly using and air samples (gas). Odor evaluation was conducted using the Iowa State University olfactometer. Ammonia, hydrogen sulfide, ethyl mercaptan and methyl mercaptan were identified and quantified using sample detector tubes.

The research report covers the findings of using chopped straw, cornstalks, polyethylene open mesh with a liquid surface film, *leka rock*, a substitute Leka Rock, and surface bubbles generated for controlling odors. The thickness and type of material presents different effects on the emission, emission rate with time, and integrity of the cover. Further research in finding cost effective and feasible covering is being continued.

INTRODUCTION

Malodors emanated from animal production operations have been a concern for many years. Increasing pressure from the public and the potential impact on the environment makes a feasible solution important. Two steps should be taken for solving the odor concerns. First, find feasible methods to control or reduce the odorous gases produced. Second, design new production systems, including buildings, ventilation and waste management systems that generate fewer odorous gases. Third, make modifications to improve the odor reduction efficiency of livestock structures in use or existing.

Many methods for odor control have been developed. Low cost covers have been found to have the potential in effectively reducing odors from the storage of livestock operations. Covering as a solution applied in Western European countries, are under question in the US because of the cost and required management. The covers must be easy to install, maintain, and to allow for easy and complete removal of the manure slurry.

The objective of this research is to find feasible cost effective covering materials, organic and inorganic, for manure storage and lagoons. Several organic and inorganic materials were tested in this experiment. A low density polyethylene open 2.25 inch by 2.25 inch mesh to reduce wind effects when applying a thin film layer on the manure surface was also investigated.

METHODS AND MATERIALS

1. Experimental Setup

The experimental site is located southwest of Ames, Iowa. Fourteen tanks were made using 16 gauge steel sheets and edged with steel angles (Figures 1 and 2). The tanks are 6 ft in diameter and 4 ft high. The tanks were buried 3 ft under ground. The tanks were placed in an east-west row. All the tanks were filled with swine manure with 4 - 5% solids at a depth of 3 ft.

The materials used for the covers were chopped wheat straw, chopped corn stalks, Leka Rock, substitute Leka Rock made in the US, floating mesh with film, and aerated bubble. The cover descriptions are shown in Table 1.

Table 1 - Covering arrangement

Tank Number	Covering Details
1	Straw chopped 4 to 8 inches long at a depth of 6 inches.
2	Straw chopped 4 to 8 inches long at a depth of 10 inches.
3	Low density polyethylene mesh 2.25 inches by 2.25 inches open with a liquid film on the surface.
4	Low density polyethylene mesh 2.25 inches by 2.25 inches open with a liquid film on the surface.
5	Leka Rock 3 inches thick.
6	Leka Rock 6 inches thick.
7	Raw swine manure without cover for control
8	Small bubble aeration to develop a bubble film on the surface.
9	Chopped straw 4 to 8 inches long at a depth of 3 inches.
10	Cornstalks from a large bale without further chopping at 6 inch depth.
11	Cornstalks from a large bale without further chopping at 10 inch depth.
12	Low density Leka Rock 1.5 inches thick.
13	Substitute Leka Rock made in the United States with rock from Colorado.
14	Raw swine manure without cover for control.

Low density rock material

Leka Rock is a porous materials made from lava rock and coated with an impervious material which is baked on the surface. It is often used as a building material. It has a specific gravity of 0.3 to 0.4. It floats on the manure surface and will tend to spread uniformly due to the magnetic property from the rock. In this experiment, three thickness' were tested to evaluate the effects on odor and other odor compound emissions. Another rock which was mined in Colorado which also has a magnetic charge was manufactured by Marsh Industries, Chattanooga, TN. An impervious coating was baked onto the surface of the US made product to prevent taking on liquid and becoming water logged. This material had a specific of 0.8 to 0.9 which resulted in having a tendency of sinking due to the density. Three other low density products are presently being developed by Marsh Industries as covers. They will be tested later in the fall and early winter.

Bio-material covers

Cornstalks were obtained locally. The lengths varied from six to ten inches. The material was a dry mixture of stalks, leaves and corncobs.

The wheat straw was winter wheat from southern Illinois. The wheat straw was chopped four to eight inches in length using a Gehl field choppet.

Floating mesh and film

The floating mesh was made by Dupont Company. The polyethylene mesh was 2.25 inches by 2.25 inches diagonal which had a specific gravity of approximately 0.7. This resulted in the mesh being allowed to float with the idea that wind currents would be broken up and minimize floating films to be driven to the side of the manure storage by wind currents. The film coating, a product from Water-Save, Inc, Madison, WI is a surface treatment. The film material was poured onto the manure surfaces and the Dupont mesh was placed on top to support the film and reduce wind effects.

Bubble surface film

A bubble surface film was generated by using a 1" MNPT model No. 878 injector by Mazzei Injector Corp. Manure was pumped with a 1/2 hp electric motor through the aspirator.

Small bubbles are generated when a pressurized operating (motive) fluid enters the injector inlet and is constricted toward the injector chamber and changes into a high velocity jet stream. The increase in velocity through the injector chamber results in a decrease in pressure, thereby enabling the air to be drawn through the suction port and entrained into the manure stream. A screen was placed on the inlet side of the line to prevent clogging. The return was at the bottom of the tank distributed through 4 - 3/4 inch diameter holes. The unit operated approximately 5 minutes per week to keep a film of air bubbles on the liquid surface.

2. Experimental Method and Procedure

Once a week, gas samples were taken from each treatment and from the controls. Large plastic sheets (8 feet by 8 feet by 6 mil) were used to cover each of the tanks for about 30 minutes before sampling. Gas samples were taken from each manure tank in a similar manner. A sampling tube linked to a sampling bag was placed under the top of the plastic cover. The 25 liter sampling bag was inserted into a rigid cylinder tank with and a vacuum pulled between the tank and plastic for filling the bag. After the tanks was sealed for 30 minutes, an air pump was used to vacate the air between the rigid plastic cylinder and the plastic sampling bag. The negative pressure caused the bag expansion. All the sampling bags were discarded after analysis to avoid cross contamination.

Samples were delivered to the Environmental Air and Odor Evaluation Lab at Iowa State University where the samples were analyzed within a few hours. Dilution threshold of the samples were evaluated randomly. The olfactometer was designed according to ASTM standard and four panelists were employed each time. Between each sample evaluation the panel took 10 minutes break to avoid fatigue. A triangular-forced choice method was used in determining the threshold odor level.

Ammonia, hydrogen sulfides and methyl and ethyl mercaptans were evaluated and measured using testing tubes at the same time. Ammonia and hydrogen sulfide were detected with testing tubes (Däger Tube 81 01 711, Postfach 13 39, Moislinger Allee 53-55, D-2400 Lubeck 1, Germany, for ammonia and Gastec Detector Tube No. 4LT, Gastec Corporation 6431 Fukaya, Ayase-City, 252, Japan, for hydrogen sulfide). Two measuring ranges of ammonia testing tubes were used. They were 0.25 to 3 ppm and 1 ppm to 200 ppm. Hydrogen sulfide testing tube measuring range was 0.01 to 4 ppm. Mercaptans including methylmercaptan and ethylmercaptan were monitored using test tubes (0.025 to 70 ppm and 0.05 to 120 ppm) (Gastec Detector Tube No. 71 and 72. Gastec Corporation 6431 Fukaya, Ayase-City, 252, Japan).

RESULTS

Most of the covering materials illustrate the ability of reducing odorous compound emissions from manure surfaces. However, some of the covers deteriorated over time and appear to have a short product life cycle.

Straw cover

Manure slurry covered with 10 inch thick wheat straw reduced odor emission significantly. During 9 weeks of sampling, the 10 inch thick straw consistently reduced odor more than 90 percent. There were no signs of sinking on the top of 10 inch thick straw cover. It remained dry and no deterioration occurred. The 6 inch straw cover was also effective in controlling odors; however, there was more variability from week to week in odor reduction. The 3 inch cover of straw also reduced the odor level significantly even though the surface of the straw remained wet after the third week. Further work will be conducted on the odorous air transmission through the straw layer. There was a manure odor observed over the 3 inch thick straw after about the second week that remained throughout the study. Furthermore, flies were attracted on the top of the 3 inch straw layer. In contrast, very few flies existed on the top of 10 inch straw cover.

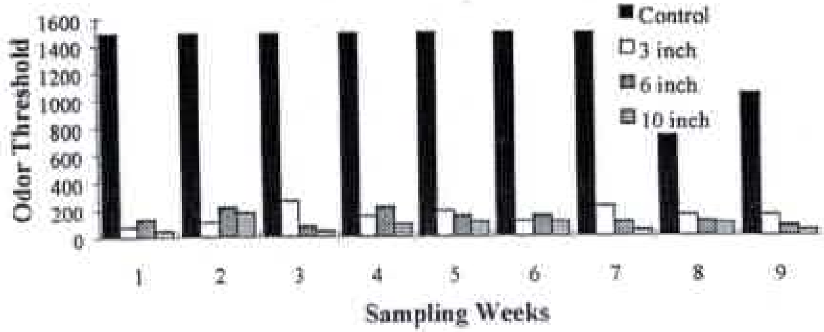


Figure Odor reduction after covering wheat straws. All three thickness' of straw evaluated resulted in a substantial reduction of odors.

Cornstalks

Between the two thickness' of cornstalk cover, there was no significant difference in odor emission reduction although they both clearly controlled odor emissions during experimental period. The cornstalks used consisted of leaves, corncobs and cornstalks. It is difficult to tell the content of each; however, corncobs and cornstalks presented higher resistance to decay and floating capacity than leaves. These may explain the results shown.

Flies were accumulated in summer days when part of corn stalks became wet and decayed. From these figures, no clear differences between the two thickness' of covers can be found. Liquid ponding around the edges of the tank started to occur within a few weeks of covering.

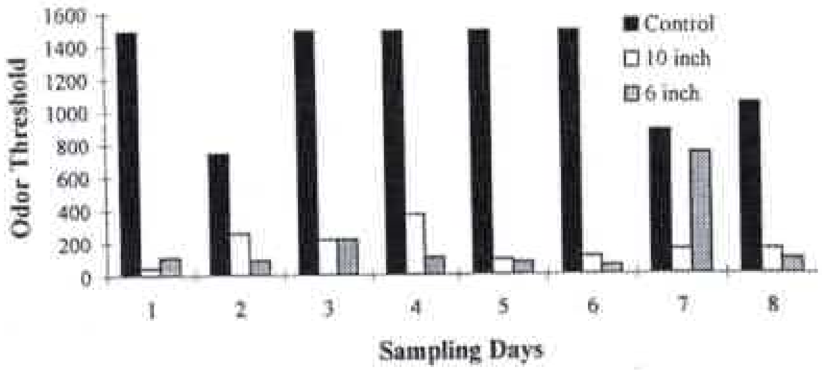


Figure Odor reduction after covering with cornstalks at a depth six and ten inches

Leka Rock

Leka Rock covering showed excellent results. Figure shows good odor reduction. The odor emission on the surface of Leka Rock was very low. There were no significant difference between the three thickness of Leka Rock regarding odor emissions. The 1.5 inch thick covering may be sufficient for manure odor control but further tests are needed on actual manure tanks to determine wind effects. Leka rock is about 0.25 to 0.75 inch in diameter. Thin layers may separate from wind effects. The top portion of the rock was nearly dry at all times except on raining day; however it dried very fast. The bottom half portion was wet and deterioration occurred on the surfaces of some Leka Rocks. Coatings on the rocks came off and hence the liquid may get into the rocks center and affect the ability to float. The pores on the rocks were very small and isolated each other, so the deterioration on the Leka rocks may have little influence on the covering results. The cost of Leka Rock shipped from Norway is five to six dollars per cubic foot which makes a substitute product important.

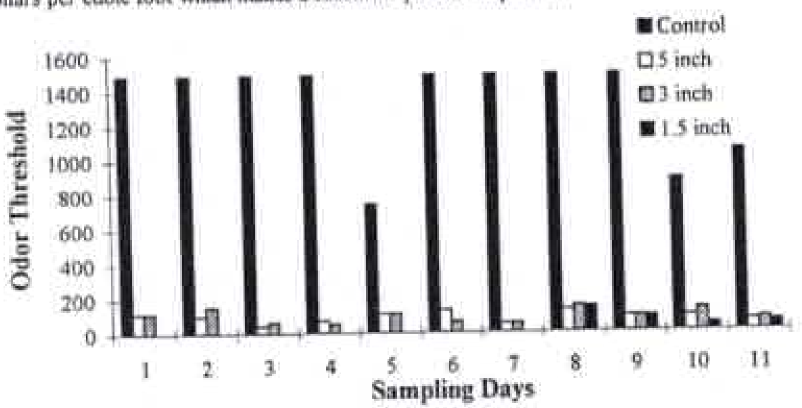


Figure . Odor reduction results of Leka material covering.

Substitute Leka Rock manufactured in US

More than 80% of the substitute Leka Rock sank into the manure within a few days. The powder stayed on the surface and mixed with the manure. It resulted in a thin scum on the top which kept part of testing rocks from sinking. During the several weeks' testing, the odor threshold was significantly lower than the control. The reduction was over 95% demonstrated good odor control. Because this test started later than the others and there was no available data for hot summer days; therefore, further evaluation is needed. The higher density material may resulting less effective due to wind effects because only thin layer can be floated.

Mesh and film

There is no laboratory data available for the thin liquid film produced by Water Save, Inc. No odor reduction was observed.

The floating mesh by Dupont is low cost. Even though, the system did not work with the liquid by Water Save, Inc. further work is on going with the process. It did reduce wind effects on the surface.

Surface bubbles

The purpose of bubble aeration in this experiment was to develop a bubble layer on the top with a strong enough surface tension to resist wind effects and deterioration from rain. It is believed that bubbling air through the manure solids helped provide strength to the bubbles. The bubble aeration was operated five minutes per week which would not effect the dissolved oxygen level. Odor reduction was shown to be greater than 90%.

Other odor compounds

In the first two weeks the ammonia concentrations were detected at 80 and 10 ppm on two control manure tanks, 0.1 and 0.2 ppm on Leka covers with five and three inches thickness respectively. Leka cover of 1.5 inches, which were tested seven weeks later than others, were 3.5 ppm in the first week and 3.0 ppm in the third week. For the remainder of the experimental period, no ammonia concentration higher than 0.25 ppm was detected.

Hydrogen sulfide was only detected on the raw manure surface with concentration of 0.33 ppm in the first week. No hydrogen sulfide concentration more than 0.01 ppm was found in the rest of the experimental period from the raw manure surface and all the treatment tanks. Methylmercaptan and ethylmercaptan concentrations of higher than 0.025 ppm were not detected during the whole experimental period.

DISCUSSION

Covering manure surfaces is a reliable method and in some applications cost effective, to control the emission of odor from liquid surfaces. Covering can increase the resistance of mass transfer of odorous compounds between liquid surfaces and the atmosphere, thus reducing odors. The problems left for application are the odor reduction rate and the cost. If the two requirements can be met, the strategy of covering manure surfaces will be acceptable.

Straw, cornstalks, Leka Rock, and surface bubbles can reduce odors. Among the materials, Leka rock is more costly, but has the ability to be reused. Presently Leka rock is about $5 to $6 per cu ft.

This experiment was conducted in small tanks. Wind effects still remain unknown. The longevity and integrity needs further investigation in the field.

Natural organic material appeared less resistance to decay caused by manure and cost effective, although they can also succeed in controlling odor inexpensively. Inorganic material seemed to be able to avoid this defect. Therefore, cheap and light inorganic materials and the organic materials with high resistance to the effects of manure should be the targets. The specific gravity should be less than 0.7.

CONCLUSIONS

- Straw and cornstalk covers may be a cost effective alternative for reducing odor emission from manure surface. Different thickness' behaved differently.
- Inorganic material, Leka covering presented an excellent ability of controlling odor.
- The aerated bubbles generated are easily generated at a low cost, further work is needed to develop the process.
- Substitute materials, organic and inorganic, with similar characteristics to Leka Rock needs to be developed and evaluated.
-