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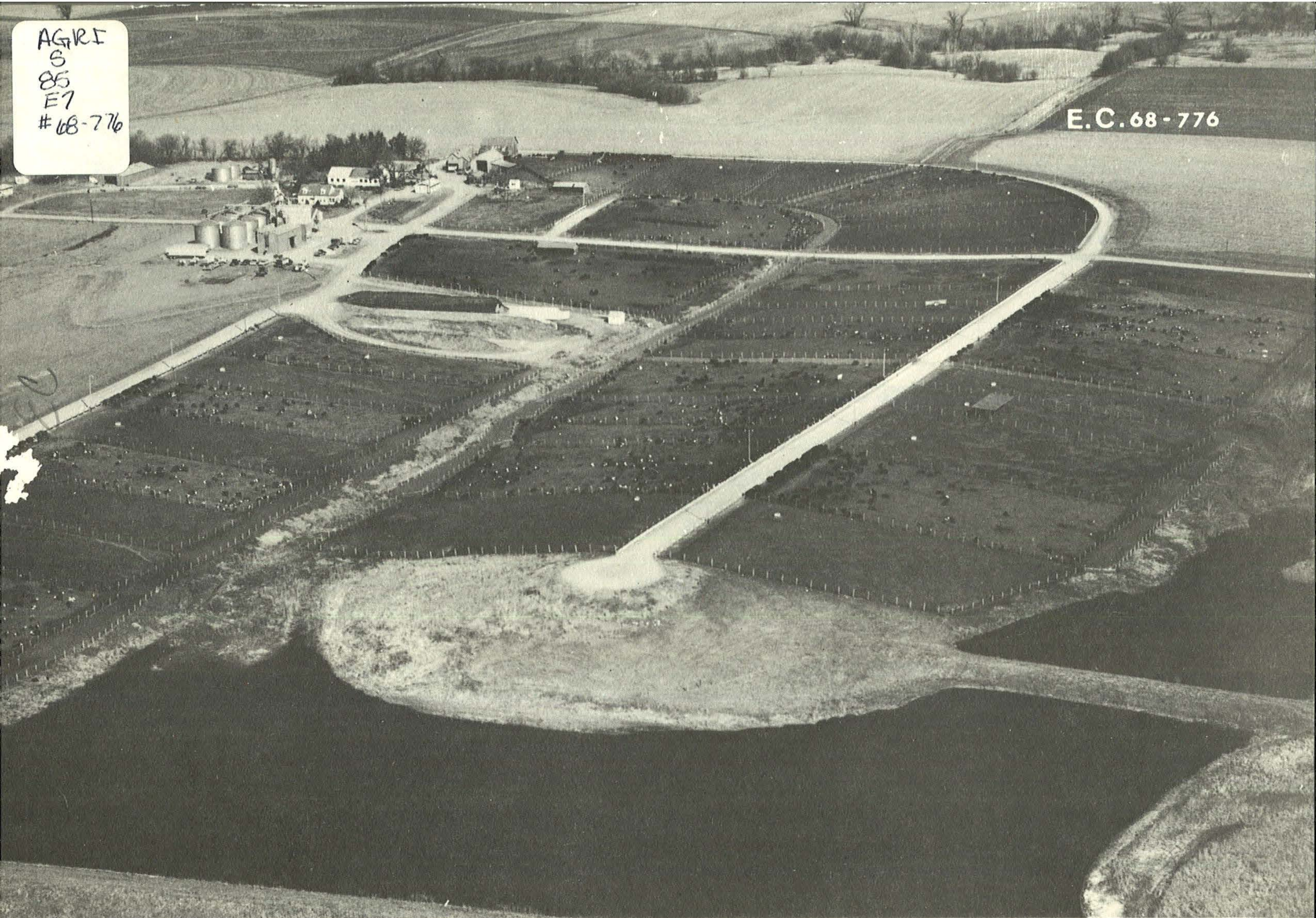
EC68-776 Livestock Liquid Manure Disposal Systems

O. E. Cross

E. A. Olson



LIVESTOCK LIQUID MANURE DISPOSAL SYSTEMS

EXTENSION SERVICE
UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE AND HOME ECONOMICS
AND U. S. DEPARTMENT OF AGRICULTURE COOPERATING
E. F. FROLIK, DEAN J. L. ADAMS, DIRECTOR

LIVESTOCK LIQUID MANURE DISPOSAL SYSTEMS

By O. E. Cross
Associate Professor, Farmstead Engineering
E. A. Olson
Agricultural Extension Engineer (Farm Buildings)

Introduction

Livestock and poultry production units have increased in size and have been concentrated into smaller areas during the past 10 years. Consequently, producers are looking for better methods of farm animal waste disposal.

At present only remote rural areas are not plagued with complaints because of odors or unsightliness of animal production units. The pollution of both surface and ground water supplies by animal wastes is receiving attention of various health and sanitation regulatory agencies.

These developments have created a demand for improved methods of animal waste management. Since progressive producers have not hesitated to move "indoors" they are receptive to ideas which will reduce labor and still maintain sanitation and provide pollution control.

The Ideal System

The era of "getting rid" of livestock manure is over. It is unlawful for livestock wastes to pollute our natural water resources. For example, it is unlawful to discharge into any waters of Nebraska waste which will reduce the quality of waters below the established water quality standards. The livestock producer is now faced with a definite management and disposal problem.

The "ideal" system is one which allows efficient and sanitary production of animals. The system must be reliable and must not require nuisance-type maintenance procedures. The system must not produce unwanted by-products which require hauling, handling, or unproductive use of the operators time.

This "ideal" system must be designed and operated to prevent pollution of our water resources, to control odors and air quality, and to eliminate breeding places for flies, mosquitoes, etc. Only by operating a system capable of meeting most, if not all of these objectives, can the producer hope to live harmoniously with his neighbors, community and state.

Digestive Principles of Animal Waste Disposal

All animal wastes contain bacteria which, under proper conditions, consume some of the waste as food and thereby multiply in numbers. During this process the bacteria produce gases, water and other solids. This process is called decomposition or digestion of waste material. The kinds of bacteria are generally classified as:

Aerobic -- require free (dissolved in water, not chemically combined) oxygen for their reproduction and growth.

Anaerobic -- these bacteria thrive in the absence of free oxygen and light and obtain their oxygen from the food wastes which they consume.

Facultative -- may thrive with or without free oxygen.

Aerobic bacteria produce water and carbon dioxide and convert nitrogen from proteins into nitrites and nitrates. Some free nitrogen may be released in the process. These "by-products" have a very slight "earthy" odor but are practically free from obnoxious odors. With ideal digestive conditions, aerobic bacteria will break down 75 to 80% of the organic solids. These ideal conditions include proper temperature, pH, (measure of acidity) and loading rate.

Anaerobic bacteria liberate such odorous gases as hydrogen sulfide, ammonia and mercaptan. Methane and carbon dioxide, odorless, are also liberated. A combination of the two digestive processes, anaerobic followed by aerobic action, may decompose 97% of the organic solids under ideal conditions.

The products of facultative bacteria depend upon the availability of oxygen. If free oxygen is available, the facultative bacteria take on the characteristics of aerobic bacteria. If free oxygen is not available, they respond as anaerobic bacteria. With ideal anaerobic conditions, anaerobic bacteria may decompose 50 to 75% of the organic solids.

Manure contains all three of the above kinds of bacteria. If sufficient free oxygen is provided, the aerobes thrive, resulting in a virtually odorless decomposition. However, if free oxygen is not provided, the anaerobes shortly take over and produce the odorous gases.

This means that the decomposition process may be altered from one process to the other by supplying or omitting oxygen. If it is desired to operate a digestive system aerobically, oxygen must be supplied mechanically or naturally, almost continuously. Where electric power can not be supplied continuously to a mechanical aeration system, as in a power failure of 14 to 16 hours, aerobic systems may become anaerobic.

Systems in Use

There are numerous variations in the design and intent of types of systems. One of the first considerations is, "shall I try to conserve maximum fertilizer value of the manure and spread it on the fields or shall I try to achieve maximum digestion in the disposal system?"

To conserve maximum fertilizer value, the operator should spread the wastes on the fields rather frequently. Table 1 summarizes the quantity of fertilizer elements excreted by various animals.

By employing a digestive system at the expense of some fertilizer loss, the time between cleanout and spreading operations may be lengthened to years. The systems described in the following discussion are digestive or partially digestive.

Table 1. Fertilizer elements of various animal excrements per 1,000 pounds of live weight.

	Hens		Hogs		Cattle	
	lbs/day	lbs/yr.	lbs/day	lbs/yr.	lbs/day	lbs/yr.
Wet manure	56	32,300	70	22,400	64	20,600
Total mineral matter	3.9	1,400	1.8	600	2.1	800
Organic matter	12.2	4,400	9.4	3,400	8.2	3,000
Nitrogen (N)	0.93	333	0.50	185	0.38	138
Phosphorus (P_2O_5)	0.69	253	0.26	110	0.11	41.3
Potassium (K_2O)	0.34	118	0.48	172	0.31	112

Lagoons

A lagoon is a pond of water plus wastes (Figure 1). The waste materials are flushed from the holding pit, under a slotted-floor or from a feedlot, into the lagoon.

Lagoons are designed as a digestive system where the depth of the liquid and the rate of loading into the lagoon determine the type of bacterial action taking place in the lagoon.

At normal loading rates and a maximum lagoon depth of about five feet, the bacterial action will be basically aerobic.

With depths greater than five feet, the deep areas of the lagoon will operate anaerobically while the surface will be aerobic.

The aerobic lagoon is more desirable because it is practically odor free, but a large surface area is required. For example, a lagoon with a surface area of one acre will handle the wastes of only about 50 hogs.

To limit the size of the lagoon it is better to use a deep lagoon, 8 to 15 feet deep. With these conditions, a lagoon of one acre of surface area should digest the wastes of about 200 hogs.

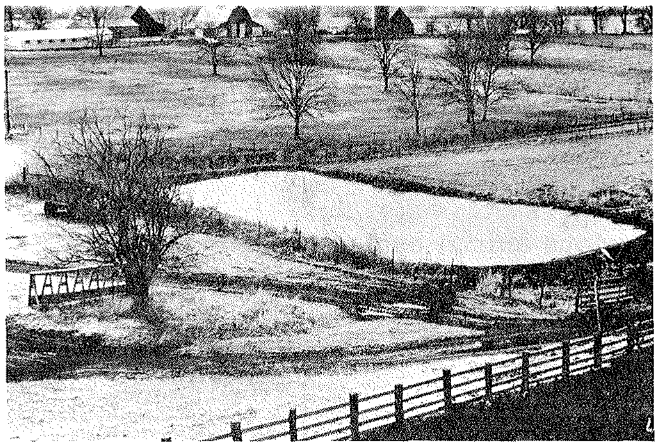


Figure 1. Small lagoon.

The design of anaerobic lagoons for disposal of animal wastes is not at this time a precise science. Experience has shown that design and management should include:

1. A minimum of two cubic feet of lagoon water per pound of total animal weight, plus additional lagoon volume for sludge storage. For example, for 125 hogs at market weight (200 lbs), the lagoon volume should be 125 X 200 X 2 = 50,000 cu. ft. plus a sludge storage volume of about 8,000 to 10,000 cu. ft.

2. A minimum liquid depth of five feet.

3. Adequate slope of collection system of housed animals to insure trouble-free manure conveyance. See Figure 2 for drainage of feedlots.

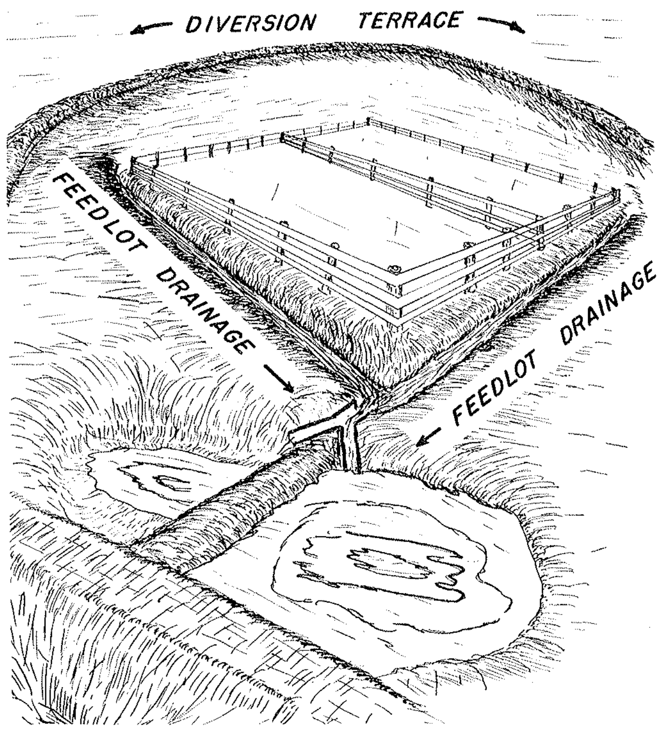


Figure 2. Typical feedlot drainage system.

4. A discharge conduit located above center of liquid surface.

5. A diversion ditch above the lagoon to exclude surface runoff water.

6. A fairly constant water depth. Load the lagoon regularly. Irregular, heavy loadings overload the lagoon and may cause production of odorous gases.

7. Fencing to exclude livestock. Keep weeds mowed around edges of lagoon. This will limit the amount of vegetative material falling into the lagoon. Also, high weeds restrict the absorption of sunlight into the lagoon.

8. No heavy loadings during winter. Low temperatures drastically reduce bacterial action. The lagoon must be large enough to hold all waste during this cold period. The warmer temperatures in spring and summer will increase the bacterial action, resulting in more rapid digestion.

9. Starting operation of lagoons in late spring or early summer so that the digestive process is well established before cold weather arrives.

10. Cleanout or abandonment of a lagoon. Numerous factors determine the rate of sludge build-up. Under normal operating conditions, sludge will accumulate at a rate of about 12 cu. ft. per year per animal.

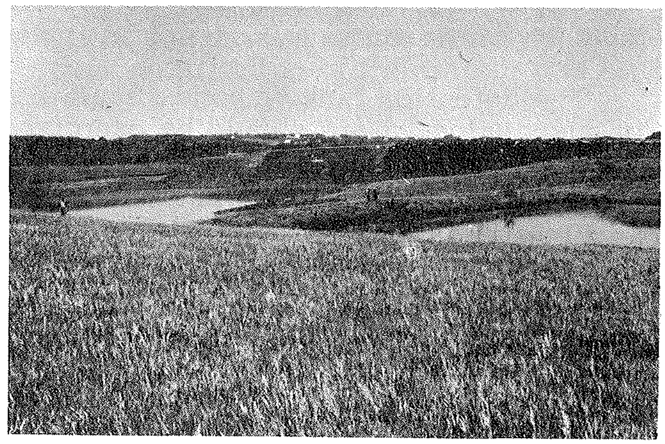


Figure 3. A disposal system consisting of two ponds.

Detention Ponds

A detention pond is nothing more than a device, pond or tank, to store waste until such time as it is convenient for disposal. During this storage time digestion may take place. However, the basic idea is to provide storage space for a specific volume of waste for a certain period of time.

Figure 3 shows a two-pond system in which the upper pond could be called a detention pond or possibly even a settling basin. The settling basin idea allows the heavier solids to settle out thereby making easier the purification of the liquid by bacterial action.

The size of a detention pond depends largely upon the management practices of the operator. The loading rate per day is as follows: 6 gal/cow, 1 gal/hog, and 24 gal/1000 hens. To these figures one must add the quantity per day of wash water. Rainfall allowances for open feedlots are as yet undetermined. This final figure times the number of days of detention desired will give the volume of the detention pond. Some individuals suggest a 120-day detention period so that it is not necessary to empty the pond, or tank, during the winter.

Various methods may be used to dispose of this "stored" waste. The lower level pond in Figure 3 is fed by gravity overflow from the upper pond. This system should have sufficient volume to detain all of the liquids and solids and allow none of the liquid to flow into natural drainage ways. The gravity method from the first pond could be used to irrigate low-lying fields.

Another disposal method would be to use tank-wagon spreaders. In this case the manure slurry is picked up from under the slotted floor or from the detention pond and is spread on adjoining fields.

"Honey wagons" have been around for a number of years and further description will not be included. It is well to note, however, that during some seasons of the year the livestockman could not enter his fields because of wet soil conditions. Also, certain phases of crop growth would exclude the spreading of manure at that time.

The use of irrigation equipment to dispose of animal wastes is rapidly gaining favor in some parts of the country. Figure 4 shows a high capacity sprinkler which, with proper accompanying equipment, may be used for manure disposal. Gated irrigation pipe may also be used.

The detention tank or pond should be agitated so that the solid waste particles are in suspension. Care should be exercised in agitating a pond so that the water seal on the bottom of the pond is not broken. Propeller or hydraulic methods are suggested to achieve agitation.

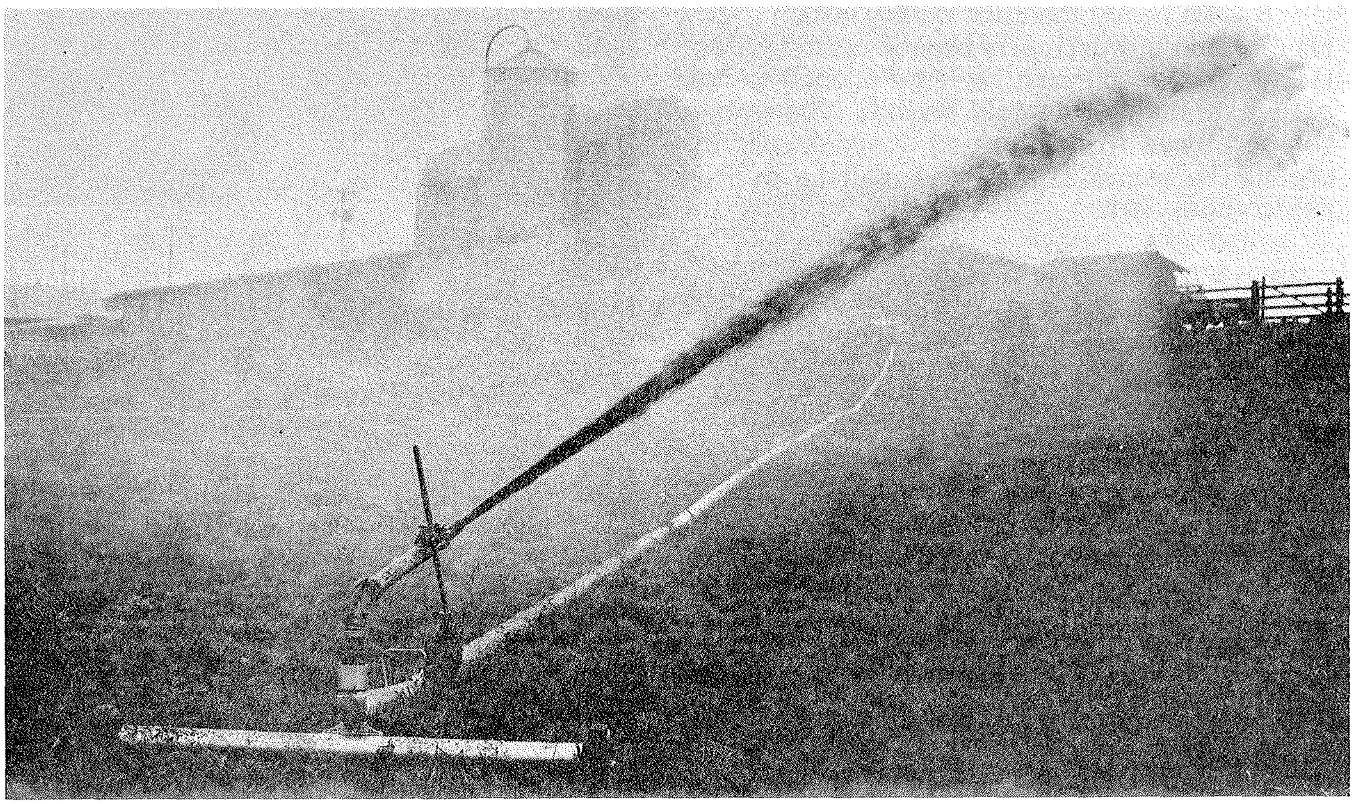


Figure 4. A large sprinkler nozzle designed for disposal of livestock wastes. (Courtesy of Mitchell, Lewis, & Staver, Portland, Oregon).

The pump should be of the low-volume, high-head type rather than the high-volume, low-head type used with a "honey wagon" system. The pump unit should have a chopper attachment to break-up large fibrous materials.

High dilution of waste is necessary when using this system. The liquid to be spread should contain no more than 15% solids. The sprinkler should be in the 100 to 400 gallon per minute capacity. This system has been used during winter months when proper precautions are taken to prevent equipment from freezing.

The system should be flushed with clear water as soon as practical after pumping manure. This flushing will clean the irrigation equipment and arrest the corrosive action of the manure. Furthermore, it is necessary to wash the manure off plant foliage. Light, frequently repeated applications are better than heavy, infrequent applications.

Still another disposal method is the plow-furrow-cover method. In this method agitation in the retention tank and pumping into a tank wagon is the same as that used in the "honey wagon" system.

The tank wagon is equipped with a discharge spout so that one to two inches of slurry is deposited in a previously plowed furrow six to eight inches deep.

In a second operation, immediately after deposition, the manure is covered by a moldboard plow as it opens the next furrow. By proper positioning of the tractor and tank wagon wheels, the disposal could be accomplished in one operation.

This method is not fully tested and presents some problems. Furrows must be plowed on nearly level ground or on the contour to prevent flow and concentration of the slurry. Winter and wet weather use of this disposal method cannot be accomplished. Furthermore, this disposal method is not compatible with the till-plant system of tillage.

Some fields on which this method was used were re-opened about a year after application. The manure in this case had decomposed very little. The exact application rate and frequency of application are unknown. Research is being conducted on this disposal method but at the present time it is not recommended for general use.

Pasveer Oxidation Ditch

The Pasveer oxidation ditch (commonly called oxidation ditch, Figure 5) consists of (1) a continuous open-channel ditch shaped like a racetrack which holds the waste and (2) an aeration rotor (Figure 6) that supplies the necessary oxygen for aerobic digestion and keeps the contents circulating, so that the solids will be kept in suspension. An oxidation ditch system may be operated as a batch system or as a continuous-flow system. The arrangement shown in Figure 5 is a continuous-flow system.

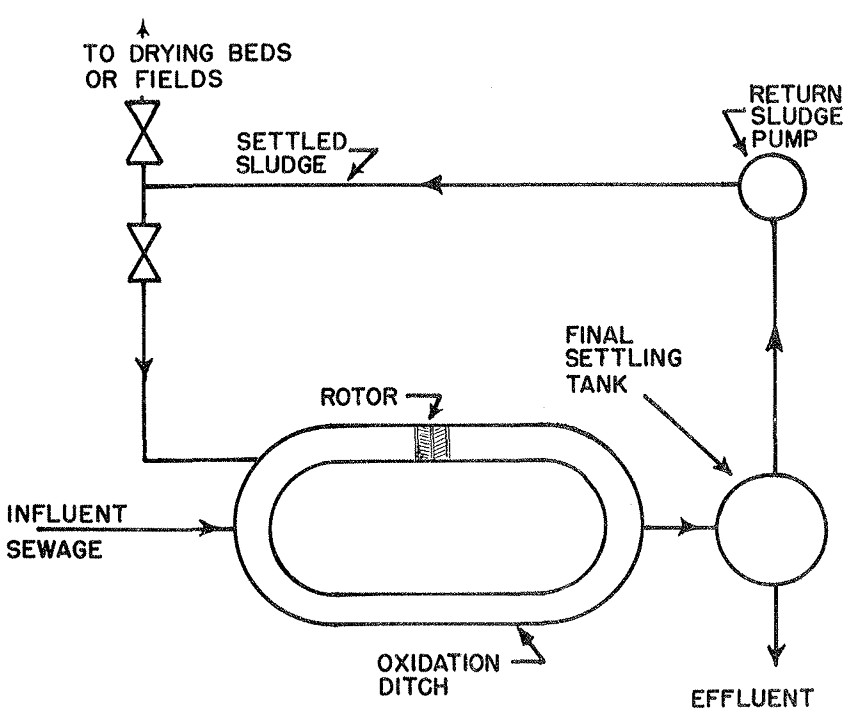


Figure 5. Schematic diagram of an oxidation ditch.

The basic operation of the system is as follows: sewage continuously flows into the ditch. The rotor operates continuously, forcing oxygen into the ditch contents. Overflow from the oxidation ditch passes into a settling tank. Undigested solids settle to the bottom and the liquid (effluent) is drawn off the top of the tank. This effluent is not pure and must be disposed of by some means as described previously. The sludge may be pumped into sand drying beds or spread on fields. Or, as the figure shows, the sludge could be returned to the oxidation ditch for additional treatment.

The oxidation ditch itself may be entirely out-of-doors or the pit area under slotted floors may be designed as an oxidation ditch. In the latter case, the rotor is normally placed inside the building and centrally located.

Under normal operating conditions, the oxidation ditch is aerobic and practically odorless. The reduction of solids is about 75%, which means that smaller quantities of undigested solids will need to be handled later.

The basic design of an oxidation ditch is as follows: provide 22 cubic feet of ditch volume per hog finished, 230 cubic feet per cow, or one cubic foot per 5-pound hen. With these loading rates, the digestive process will leave solids which will have to be cleaned out every six months. A four foot maximum depth of ditch is recommended.

The rotor (aerator) beats oxygen into the waste and causes the waste to move fast enough to hold the solids in suspension. This means that the surface speed of the waste in the ditch should be at least two feet per second.

Most aerators to date have been 26" to 32" in diameter. The aerator (Figure 6) consists of metal teeth, bars, or strips mounted on a drum and this assembly powered by an electric motor. Rotor speed, for best efficiency, should be about 110 to 130 rpm.

Rotor length and depth of immersion in liquid must also be considered. There are unsolved problems and disadvantages. In cases where the rotor operation stopped for a number of hours, the system soon became anaerobic and odorous. The action of the rotor has, at times caused severe foaming (Figure 7) and has actually suffocated animals in the pens. Additionally, the rotor is a high power-consuming device operating 24 hours per day.

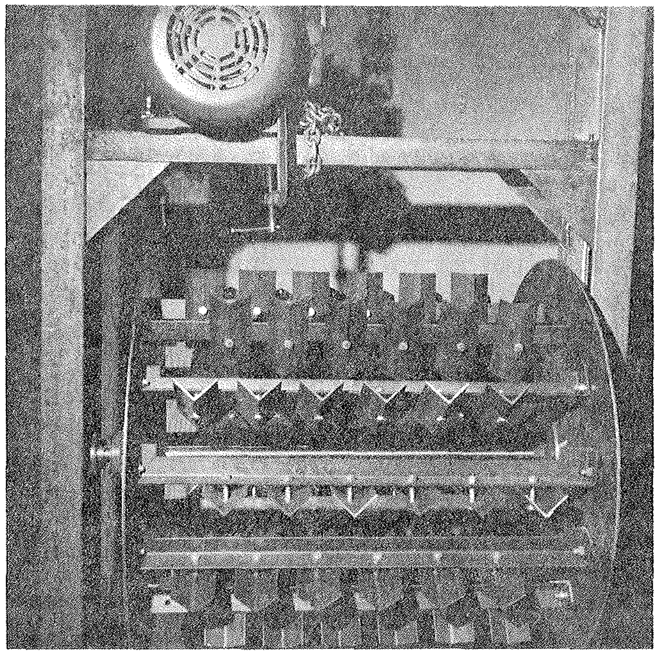


Figure 6. Aeration rotor designed by Agricultural Engineering Department, University of Illinois.

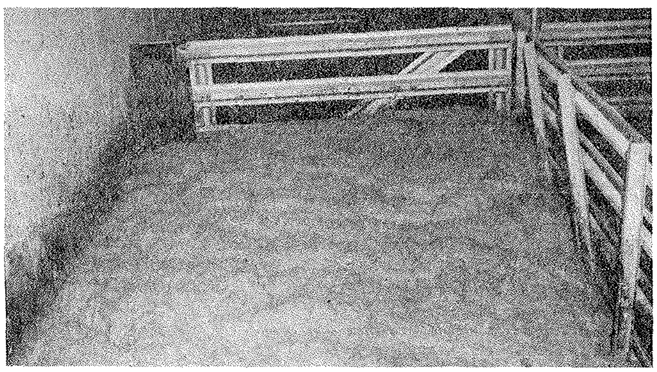


Figure 7. Foam caused by rotor action. (Courtesy University of Illinois).

General Remarks

None of the systems described, or combination of components from different systems, will totally digest all solids. Consequently, regardless of the system used, the producer will sooner or later have to dispose of undigested solids or abandon one lagoon and install a new one.

In cleaning out the holding pit under slotted floors, the herdsman should supply maximum building ventilation or remove the animals. The agitation of the liquid sewage in the pit releases large quantities of gases. Cases are on record in which some animals within a closed building have been suffocated by the excess release of gases. A similar danger exists for operators working inside closed buildings.

Any investment in a production system of any size requires that the investor plan for future expansion and operation.

Improper disposal of animals wastes may cause serious pollution to the water resources of Nebraska. This pollution potential is not limited to surface water. The subsurface waters may also be polluted.

The Nebraska Water Pollution Control Council has recently adopted a regulation requiring the registration of certain feedlots and the data gathered will be compiled into a current inventory of feedlots in the state. Based on this inventory and present research work, it is anticipated that recommendations will be prepared relative to design, construction, and operation of facilities to prevent pollution of our waters from this industry.

Compliance with those regulations will be mandatory, by law. Individuals considering new installations, or extensive changes in existing installations, should first check with the Nebraska State Department of Health. This will help the producer establish a system which conforms with the requirements of the Pollution Control Council.

Assistance may also be obtained by contacting your County Extension Agent or by writing to Agricultural Extension Engineering, Agricultural Engineering Department, University of Nebraska, Lincoln, Nebraska 68503.