

CYCLUS ENVIROSYSTEMS' DAIRY WASTE ANAEROBIC DIGESTION TECHNOLOGIES

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Odors are a natural product of decay. Dairy manure decays in the barns, storage facilities and immediately after land application. During the decay process odorous gases are discharged to the atmosphere or retained in the manure. The gases include hydrogen sulfide, ammonia, and a variety of volatile organic compounds (VOC's). Odorous gases are released when manure is disturbed. Manure scraping, screening, and land application cause the release of retained gasses. During warm weather, stored manure decays at an accelerated rate causing the generation of gas, and the subsequent release of gas when wind blows over the top of the storage ponds. Consequently, the primary sources of dairy odor are poorly cleaned barns, manure storage ponds and composting facilities, and the land application of manure liquids and solids.

The primary objective of dairy managers is to maintain animal health for quality milk production while eliminating adverse environmental impacts. Preventing the open decomposition of manure through the use of flush systems limits animal disease while minimizing odor, and other adverse atmospheric impacts. Animal health is enhanced through the use of sand bedding and the rapid removal of manure from the dairy environment. As a result, manure flush systems in conjunction with sand bedding are used at large commercial dairies to reduce odor and enhance animal health. Some commercial operations use manure compost bedding. In Idaho such bedding contains substantial quantities of fine sand.

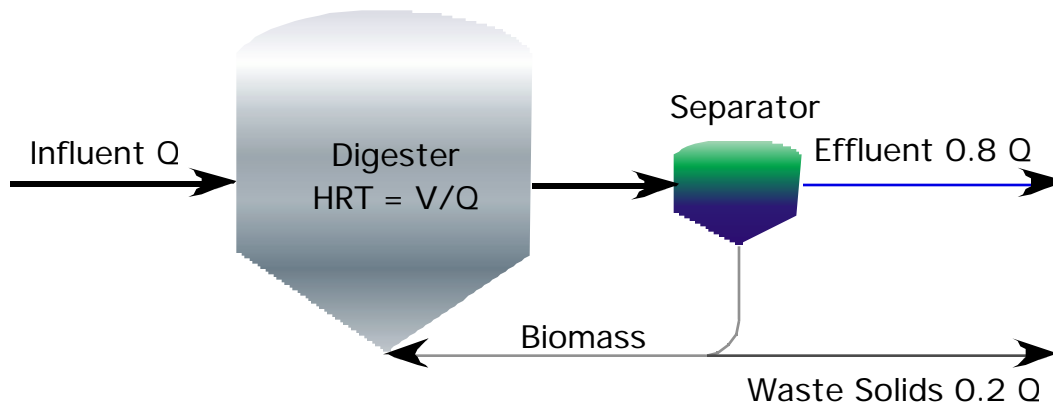
Anaerobic treatment is an excellent odor reducing technique. Anaerobic treatment converts the degradable manure solids to gas in a tank that retains the gas for use as a fuel. If substantial portions of the solids are degraded in the digester, little odor potential remains in the digested liquid and solid effluent. However, the use of sand bedding and manure flush systems is *not* compatible with conventional anaerobic waste treatment. The sand settles out in the digester and the larger quantity of flush water causes the digesters to be excessively large. If the sand is not completely separated it will accumulate in the digestion tanks. The manure slurry must be diluted to separate the sand. The quantity of waste to be treated is substantially increased through dilution. Conventional

anaerobic treatment of the diluted waste is not economical because of the large digester volumes required.

Over the past 30 years improved anaerobic digestion techniques have been developed and applied to a wide variety of waste materials. The improvements include a variety of fixed film and retained biomass reactors. These systems maintain substantial quantities of anaerobic bacteria as films or pellets, which rapidly convert organic waste to gas. The systems are very effective in treating dilute soluble waste but are not particularly effective in treating slurries containing particulate mater that must be broken down prior to assimilation within the film. The well-established anaerobic “contact” process remains the most effective means of rapidly converting dilute waste slurries to gas. Over the past 10 years significant improvements have been made to the “contact” process. Cyclus EnviroSystems’ AGF process is one of those improvements.

The anaerobic “contact” process was developed 60 years ago. It has been applied to a variety of waste materials since that time. It’s most prominent use has been in the meat packing industry where it is used to convert meat-processing waste to gas. An odorless stable product is produced. The traditional contact process is depicted in Figure 1. It consists of an anaerobic digester followed by a separator that removes the anaerobic bacteria from the effluent stream and returns the bacteria to the anaerobic digester. The traditional method of separation through gravity clarification is cumbersome and far less effective than the AGF process. The development of the AGF (Anoxic Gas Flotation US patent 5,015,384) process has significantly improved the removal and concentration of anaerobic bacteria. As a result, the size of anaerobic digestion tanks is considerably reduced. Dilute waste can be treated in digesters sized for concentrated waste. A majority of the sand can now be removed through dilution prior to digestion.

Figure 1 – Anaerobic Contact Process



Sand remaining in the waste still poses a problem since any residual sand will drop out in the digester or accumulate in the recycled biomass. The “contact”

digestion system will eventually cease to function. The accumulation of inorganic refractory solids in the digester can be eliminated through the removal of sand by dilution and density separation prior to recycle (US patent 6,113,786).

The contact process can also be inhibited by the accumulation of refractory (non degradable or slowly degradable) organic material such as seeds and wood. This organic material can be removed through a variety of means prior to concentrating the bacterial biomass (US patent 6,309,547).

The method of separating the flocculent bacteria that are responsible for particulate degradation is extremely important. Traditional clarifiers are not as effective as flotation separators since anaerobic bacteria tend to attach to the gas bubbles and float. However, flotation separators are complex mechanical devices that use internal mechanical collectors and require a large surface area. Fortunately, we have developed flotation separators that are non-mechanical and require less than a quarter of the area of traditional flotation separators (US patent pending).

Although anaerobic digestion produces a stable solid product, the solids still contain a large number of bacterial pathogens. The solids can be applied to agricultural fields but cannot be sold or given to the public. Traditional methods of addressing this problem include the use of thermophilic digestion or pasteurization prior to digestion. Both of these techniques require large quantities of heat. In most cases they cannot be used to digest diluted waste because of the large quantities of heat required. The AGF pasteurization process provides a means of pasteurizing and re-digesting the solids for maximum gas production while using less than a quarter of the energy typically required (US patent 6,113,789)

The liquid byproduct of anaerobic digestion typically contains odorous organic acids and large quantities of ammonia nitrogen and hydrogen sulfide that are eventually discharged to the atmosphere. Such discharges are a significant environmental problem. Typically the ammonia nitrogen present in the liquid effluent represents more than 50% of the total manure nitrogen processed. We have developed a process for removing a substantial portion of the remaining organic acids, hydrogen sulfide, and ammonia nitrogen and sequestering those gases with organic solids, thus eliminating a significant environmental problem associated with the anaerobic digestion of dairy manure (US patent pending). This option conserves the nitrogen for crop use rather than converting the ammonia to nitrogen gas through the traditional approach of nitrification and denitrification.

In summary Cyclus EnviroSystems' improvements to the proven "contact process" are as follows:

1. Creation of the AGF process, which substantially reduces digester size while improving the rate of decomposition – achieving close to 80% volatile solids conversion to gas.
2. Solving the problem of refractory organic and inorganic solids filling the digester and hence decreasing the usable volume. Cyclus EnviroSystems' removes the sand before entering the digesters and in various stages while in the digesters.
3. Improved bacterial separation techniques.
4. Addition of the pasteurization step which takes advantage of the AGF thickening process.
5. Addition of the reactive gas removal step to remove ammonia and hydrogen sulfide from the liquid effluent and sequester those nutrients.

The improved technologies permit the anaerobic digestion of dilute waste containing refractory organic (wood chips, etc) and inorganic (sand) materials. The technologies also maximize the recovery of energy while producing a nutrient rich waste solids product free of pathogens and an effluent from which odors (organic acids) and gaseous products (ammonia and hydrogen sulfide) have been substantially removed and sequestered for reuse. The solid product contains substantially all of the nitrogen and phosphorus. Air and water pollution are eliminated while the nutrients and energy are recovered.