The Disposal of Dairy Wastes *

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In recent years progress has been made in understanding the waste-saving and waste-disposal problems of the dairy industry. Most workers in the field now agree that:

(1) Practically all the well-known methods of sewage disposal can be readily adapted to dairy waste.

(2) Dairy waste disposal is relatively expensive because most of the plants are small and the waste is strong. It therefore becomes of utmost importance to cut wastes in the plants as far as practicable and as far as the sanitarians will permit.

(3) The strong by-products such as buttermilk and whey should not be treated in waste-disposal units and should not be dumped into streams or sewers unless very large amounts of dilution water are available.

(4) Cooling waters and storm waters should in general not go to disposal plants except when and where they are needed for dilution.

(5) Wastes from toilets should go directly to a septic tank and not pass through screening units, etc., used for dairy waste. The effluent from these tanks, however, may join the dairy waste for further disposal if so desired.

(6) Small amounts of milk waste are beneficial and not at all detrimental to healthy stream conditions if at all times the total daily oxygen demand of the waste discharge from a plant is kept well within the available oxidizing and reaerating ability of the stream.

Most of these facts have been known for many years, but it has taken a long time for the dairy industry to heed this good advice. In the meantime, a rather undesirable reputation has been established which it will take some time to live down. Furthermore, a great deal of money has been spent on unnecessary damage suits and on improperly operated and inadequate waste-disposal units.

ELIMINATION OF WASTE IN THE PLANTS

An important contribution has been made by the equipment manufacturers. For instance, the foamless separators have cut out much waste. Large entrainment separators on vacuum pans are also quite essential, especially for making superheated condensed skim milk. New can washers are being built with long drip savers and frequently with a small preliminary water jet. But can washers can still be greatly improved. Dump equipment is being improved but careless dumping personnel continue to cause spillage on the floor in spite of relatively well-designed equipment. In general the new streamlined design of milk equipment has been of great help by facilitating complete drainage and easy rinsing of the equipment. Unfortunately, leaky sanitary valves, pumps, and fittings are still with us, but at least some plants use drip pans and collect all drips for animal feeds. The increasing use of paper gaskets has also been of help in reducing leaks.

Further progress can be made if continuous automatic samplers are installed in the sewage lines, taking samples in proportion to the flow every day. The volume of a daily composite sample and its turbidity makes it possible to determine the daily milk waste for a given plant. A premium system for reducing waste could be inaugurated, depending, of course, on the number and type of operations done in the plant each day.

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A photo-electric turbidity-volume recorder could also be installed without much difficulty, but this would naturally be somewhat more expensive than a simple homemade automatic sampler.

One of the greatest difficulties is that some health officials seem to think it is bad policy to permit collection of rinsings and drips because they are afraid that these waste products might find their way back into the regular milk supply. Most health departments now permit saving of drips and rinsings if specially marked cans are used to handle the material but there is still considerable disagreement as regards the proper utilization of these wastes.

Of course there are practical limits to waste saving, especially in plants where more complicated manufacturing is undertaken. In creameries and in cheese factories making washed types of cheese there will always be diluted wash waters to dispose of even if the strong buttermilk and whey are carefully collected and utilized. Also, when vacuum pans and drying rolls are used, there will be waste on the floor even if the "burnt-on" scrapings are collected and burned as they should be. These scrapings, if left on the floor, give strong waste as they gradually dissolve and are carried down the sewers.

A town or city disposal plant can usually handle such wash waters without trouble, and very frequently a stream of sufficient volume is available; but if this is not the case, then it becomes essential to know what procedure to follow to determine the treatment best suited for a given set of conditions. Frequently a partial treatment will be adequate, and sometimes it is only necessary to treat during certain seasons of low-stream flow. Fortunately low-stream flow does not usually coincide with our greatest milk production.

FLOW MEASUREMENTS AND SAMPLING

If an automatic sampler and flow-measurement device is not available, samples and flow-measurements should be taken at least every 15 minutes during the full time of the plant operation. Furthermore, this should be done each day for at least one full week since in most plants there are great variations in waste from day to day. The simplest way of making flow measurements is to time the filling of a five- or ten-gallon container. It is also easy to construct a still box with a measuring weir. Of course, if an automatic sampler is installed, a weir box is essential. The old-style tipping box with a counter can also be used to good advantage and can be made to sample automatically without difficulty.

Each day's composite sample should be sent, well iced, to a laboratory and analyzed for biological oxygen demand. From the dairy-waste volume and its biological oxygen demand, the daily pounds of oxygen demand can be estimated. This is the most important factor in determining the degree of treatment required for a particular plant and the cost of such treatment. Also this is the most important factor for determining whether or not a stream is capable of handling the waste by self-purification. No definite figures can be given since streams vary both in rate of flow and re-aerating capacity. However, experienced sanitary engineers can make fairly accurate estimates if they know the pollution value of the waste and the characteristics of the stream at various seasons of the year.

PRELIMINARY OR PARTIAL WASTE TREATMENT

Some preliminary treatment will usually be required to eliminate coarse suspended matter and to distribute the load either to streams or disposal plants. Frequently it may be possible to improve conditions sufficiently by preliminary treatment so that no further treatment is required. Various methods are available.

Screens and Fat Traps

Coarse suspended matter should be taken out of the waste as soon as possible. It is therefore advantageous to have many and large floor drains with perforated screens on top and large perforated screen buckets underneath. These buckets should be cleaned daily and the collected solids burned. A small amount of chloride of lime should be sprayed in and around each sewer outlet after the daily cleaning. The screen buckets are particularly important in cheese plants where it is difficult to avoid some spillage of curd particles on the floor.

The next best thing to screen buckets in the floor drains is a large screen-bucket or a screening tank in the main sewer outlet. In larger plants it is convenient to use brass screens of the slotted type next to a septic tank so that the screenings can be backwashed into the septic tank once a day, while the screened liquid may by-pass the septic tank directly to other waste-disposal units. In most cases, however, it is just as easy to collect screenings in a perforated metal bucket and burn them under the boilers. If the waste carries large amounts of fat, it is advantageous to build the screen tank rather long and to place a skimming baffle just ahead of the screens in order to keep fat and floating matter away from them. The tank should be skimmed once a day and skimmings disposed of with the screenings.

The depth of a combined screen tank and fat trap should be at least two feet under the normal liquid level. For good fat separation the surface area of the tank should be about two square feet per one hundred gallons maximum hourly flow, the tank being about twice as long as it is wide. The tanks and screens should be cleaned and sprayed with dry chloride of lime once a day. It is impossible to specify the size and mesh of the screens required since conditions vary from plant to plant; but in general it may be found convenient to use one screen with slotted openings of one-eighth inch by two inches and another screen with slots one-sixteenth inch by one and one-half inches.

When compressed air is available it may be better to separate fat and floating matter by aeration. As the aerated liquid cools down, the fat clumps together with other solid material and can be removed from the tank with a long-handled screen basket. The aeration tends to keep the waste fresh and free from odors. Some chloride of lime should be sprayed around the edges of the tank daily. A primary aeration tank also can be used as an equalizing tank or pump sump for a disposal unit or for equalizing the discharge to a stream or to a city sewer.

Septic Tanks

Most investigators agree that a septic tank is unsatisfactory for treatment of dairy waste. However, if the tank is properly built and correctly used, it is undoubtedly the simplest and cheapest waste-disposal unit available. The curious thing is that the very earliest investigators in the field apparently gave correct dimensions and methods of operation for septic tanks for dairy waste, but it is relatively seldom that one finds a tank which has sufficient capacity and which is being operated correctly.

The tanks should have a volume of at least twice the daily waste volume or two hundred fifty gallons per pound oxygen demand, whichever is the larger of the two. Furthermore, the pH should be kept neutral. This can be accomplished best by keeping them warm (preferably around 90° F.) and by introducing the waste through several inlets or otherwise distributing the waste as soon as it enters the tank. The heating of the tank will not be expensive in most milk plants since the boiler blowoff and other waste heat are usually available; furthermore, there is usually enough hot water used in the plant to keep the waste at a relatively high temperature. Boiler blowoff should be particularly beneficial since it gives both heat and alkalinity.

It is essential that septic tanks be started right by filling them with water, some lime, and some ripe septic sludge from a disposal plant, possibly about one pound of lime and one gallon of sludge per one thousand gallon tank capacity. Horse manure has been found to be helpful in getting the right fermentation started. Under these conditions, it does not appear to be very difficult to keep the tank from going sour. A relatively large volume of methane and carbon dioxide gas is formed under these conditions but very little hydrogen sulphide. On the larger tanks the gas should be collected and sent through a flame trap to the grates under the boiler.

If the septic tank is operated without seeding with sludge, it will soon go sour. This will help to precipitate protein, but the protein digestion is slowed down to such an extent that there will be very little BOD reduction in the tank. In addition to this, the tank has a tendency to fill up too fast and to create bad odors. Also, a heavy layer of scum is formed on top, although this can be kept down to some extent if a fat trap is used ahead of the tank.

Chemical Precipitation

It is highly probable that a stream of reasonable reaeration ability can handle waste with 0.01 to 0.02 percent lactose or lactic acid (100 to 200 ppm.). If so, a chemical precipitation process could be used to great advantage in many cases. Lactic acid itself appears to be toxic to fish life in soft water, but in most natural streams the water has enough hardness to neutralize the acid (1). At least, it is possible by chemical precipitation to produce a clear effluent free from odors with considerable reduction in biological oxygen demand. This would be a satisfactory solution in many cases, especially where it is simply a matter of reducing the load on a stream during certain seasons of the year. If chemical precipitation is followed by chlorination, still better conditions can be produced in small streams and in city disposal plants. Chlorination can be used to delay the decomposition of the milk sugar until the waste reaches a point where more dilution is available.

Various chemicals have been suggested for treatment of milk waste. A combination of copper sulfate and lime does a complete job of precipitating proteins, but it is expensive. Ferrous sulfate and lime will also do a good job but leaves an effluent highly deficient in oxygen. Ferric sulfate is better in this respect and also gives a sludge which is easier to handle. However, the pH range of these compounds is rather narrow so that frequently quite large amounts of lime are required in order to get the best results. Aluminum sulfate has the advantage of being easy to handle and of having a rather wide pH range. This seems like the cheapest and best chemical at the present time and there should be a number of places where it could be used to advantage. From 200 to 400 ppm. of aluminum sulfate are usually required to get satisfactory precipitation.

For large plants it may be more economical to use continuous precipitation. It is more economical to use vertical cylindrical settlers made of steel than horizontal flow concrete tanks placed in the ground. Wooden tanks are not very satisfactory unless they can be kept filled with liquid all the time. The retention required in vertical flow tanks is much shorter than that required in horizontal flow tanks. Possibly four hours' retention should be provided on the basis of maximum hourly flow. In some cases it may be economical to have a flow-equalizing tank ahead of the settler in order to reduce the size of the latter. Of course this will be economical only if very heavy surges are expected. Since very few plants operate both day and night, the ideal method may be to pump the waste into a tall steel tank, feed chemicals in proportion to the flow, then allow this to set for a while after the cleaning operations have been finished in the plant at night, and then during the night let clear liquid run out the top by the use of a flexible hose attached to a float. In the morning the sludge can then be let down to a lagoon or large septic tank and the tank hosed out and sprayed with a small amount of dry chloride of lime in order to keep it in good condition.

COMPLETE TREATMENT

The various treatments described above will not do a complete job. A number of complete treatments are now available to the industry at a reasonable cost but they should, of course, not be installed except where absolutely needed.

The available types of treatments fall into two main classifications, namely, processes using trickle filters, and processes using activated sludge. In addition to these there are a number of combination processes involving the use of chemicals in combination with one or both of the above. All of the processes have this in common, namely, they require some means of:

1. Preliminary treatment with screens or fat traps.
2. Storage and equalizing with a pump.
3. Aeration in tanks or on tricklers.
4. Settling.
5. Sludge disposal (which is usually not included in the price quoted for the unit because it can frequently be done with old lagoons or septic tanks already available.)

TRICKLER FILTER

As originally designed, very large crushed rock units were required, but development work in the last several years has made it possible to reduce the size of the unit to such an extent that they are competitive with other methods of treatment as regards construction costs. In our own work (2) we have been able to get very satisfactory results by the use of tin-can tricklers. Tricklers are rather difficult to keep free from odors at all times. Also there is always the danger of flies even when the rapid-and-continuous-flow type is used.

Rapid-flow trickle filters followed by precipitation with aluminum sulfate give excellent results, and this may be the ideal solution for many plants. The chemical precipitation step might have to be used only in the summer time. Chemical precipitation preceding a rapid-flow trickle filter also gives good results. However, in using chemical precipitation ahead of a biological process, there is always the possibility of an accidental excess of chemicals interfering with the subsequent biological process.

ACTIVATED SLUDGE

It has been claimed that it is difficult to operate an activated sludge plant for dairy waste because it requires much more attention than the corresponding trickle filter plant. Both plants really require considerable attention when used in connection with certain types of dairy waste. One thing is certain—it has been shown both here and abroad that it is possible to treat dairy waste by activated sludge in a very satisfactory manner. The straight activated sludge process, however, does appear somewhat expensive both to install and to operate, since a long time aeration and considerable lime are required in order to get the best results.

COMBINATION PROCESSES

Some of the recently developed combination processes appear to offer good promise since they are cheaper to build and appear less delicate to operate than the simpler processes mentioned above.

The Guggenheim process uses a small amount of ferric sulfate and a small amount of lime followed by four hours' aeration. The sludge is then settled out; part of it is returned to mix with the incoming waste as in an activated sludge process, and part of it goes as waste to a lagoon or septic tank or to sand beds. All that this really amounts to is to shorten the aeration time of an activated sludge process by the use of a small amount of chemicals. The process is giving good results in two cheese plants. There is no royalty to be paid for the use of the process but a reasonable license fee is included in the construction cost of the unit.

The most recent combination process, and possibly the most interesting one, is built by the Lancaster Iron Works. This firm conceived the idea of making a small disposal plant consisting essentially of two eight feet diameter steel tanks which, except for foundation, can be put on trucks and set up in less than a day's time. The treatment consists of an activated sludge step and a chemical precipitation step using aluminum sulfate. The operation is simple, and first costs and operating costs are low. Therefore, it looks as though this may be a very satisfactory solution for plants where a perfect purification is required.

Both the Guggenheim and Lancaster plants are capable of taking care of overloads for a short time, but this does not necessarily mean that we can afford to work with smaller plants as a continuous proposition. Trickle filters also will take occasional large overloads, but they must be given time to recover. Most waste disposal firms and consultants make complete surveys of the plants before they design any units, and they also give advice on waste-saving precautions in order to keep the size and the cost of the units within reason.

CONCLUSION

In conclusion it may be said that the essential thing is to cut down the waste in the plants to the absolute minimum, since every pound of milk solids which has to be treated in a disposal plant is going to cost a great deal of money both in installation cost and treatment cost. After wastes have been cut to the practical and economical limit, conditions should be investigated carefully to determine if a partial treatment, possibly for only part of the year, would be satisfactory. There are any number of streams which have plenty of water during three-quarters of the year and, consequently, treatment may be required for only three or four months each year at the most. If complete treatment is necessary, it is strongly recommended that one of the well established firms which are now specializing in dairy waste disposal be consulted. This would be far more satisfactory than trying to experiment with all kinds of homemade units which most likely will not do the job after they have been installed.

REFERENCES

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[2] Trebler, H. A., Ernsberger, R. P., and Roland, C. T. Dairy Waste Elimination and Sewage Disposal. Sewage Works J. 10, 5. Pp. 868-887, 1938.

The Phosphatase Test in Canada

In August, 1940, at the request of Dr. T. H. Butterworth, Chairman of the Committee on Applied Laboratory Methods of the INTERNATIONAL ASSOCIATION OF MILK SANITARIANS, a letter was addressed to each of the Provincial Health Departments in Canada requesting information concerning the use of the phosphatase test. Replies received from seven of the nine provinces are summarized briefly on the accompanying table.

As might be expected, there is considerable variation in the extent to which the phosphatase test is being used. Ontario, where compulsory pasteurization was introduced in October, 1938, makes the greatest use of the test, closely followed by Quebec. Where, as in the Prairie Provinces, cities are smaller and the rural population is proportionately larger, the test is not employed to the same extent. However, there is a general recognition of the value of the phosphatase test, and its use will doubtless increase considerably in the near future.

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