Dairy Processing Methods to Reduce Water Use and Liquid Waste Load

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As costs for water and treatment of liquid wastes have continued to increase, dairy processors and producers must be effective managers. They must balance the diverse issues of paying for these higher costs, being environmentally responsible, and conducting a viable business. Doing "the right thing" may mean carefully evaluating options that will satisfy environmental concerns and at the same time keep a plant operating. While a plant closing can have a devastating effect on the community, poor waste management of a facility also can have a detrimental effect on the quality of life in the area, be a burden to the waste water treatment system, and threaten the local environment.

In order to successfully save money and reduce impact on the environment, two major components must be addressed in dairy waste management: 1) control the amount of water used, and 2) reduce the waste load in the wastewater stream.

This bulletin shows the potential for savings in implementing a pollution prevention plan and illustrates how prevention is easier, cheaper, and more effective than waste treatment. Basic concepts are presented and problems, potential solutions, and other issues surrounding water use and waste load management in a dairy processing facility are discussed.

Why save water and reduce waste load?

While reducing environmental impact and negative media attention are good reasons to implement pollution prevention practices, considerable cost savings also can result. These savings can be realized if management takes a proactive role in the prevention process. In the end, reducing water and waste load can enhance both the image and the bottom line of many dairy plants (see Table 1).

There are several significant results of decreasing water use and waste load at a processing plant:

- reducing water use will usually decrease your water and sewer bill because water is normally charged by use and sewer charges are often tied to water use;
- much of the waste load represents lost product that costs for treatment rather than generates revenue;
- most municipal treatment plants apply a surcharge to wastewater with a 5-day biological oxygen demand (BOD_5) concentration above about 250 to 300 milligrams per liter;
- the cost for additional in-plant water treatment will be reduced;
- reduced energy consumption to heat water.

What is the effect of reducing water use?

You can save water and money. Water has many uses in dairy processing—heating, cooling, washing, and cleanup. Many plants use more than 4 gallons of water to process each gallon of milk. Through careful management, some plants have successfully cut water use to 1 gallon of water per gallon of milk processed.

Table 1. Important reasons to conserve water and reduce wastes:

- Water and sewer charges have more than doubled and will continue to increase.
- High water consumption is making availability critical in some cases.
- Pollution is being attacked aggressively by agencies and the public.
- Future regulations may require water conservation and reduction in pollutant discharges.
- A business' image can be tarnished and its sales hurt if its plants are perceived as harming the environment.
- Enforcement actions have become more severe. Heavy fines, lawsuits, and even prison terms may face those who are not fully in compliance with environmental laws.
- Preventing pollution is 'environmentally friendly' and the best approach.

Did you realize a 75,000 gallons per day dairy processing plant can use up to 110 million gallons of water a year—enough for a town of 2,600 people?

Cutting water use has double, and sometimes triple or quadruple, benefit: it lowers the plant's water bill, because charges are usually based on metered water use. It probably lowers the sewer charges because sewer cost is often based on water use. In addition, reducing water use will proportionately reduce sewer surcharges if the waste concentration does not increase proportionally. Also, water saved does not have to be in-house treated or heated.

Cutting costs is not the only reason to take water conservation seriously. Some dairy plants are located in communities without an abundant water supply. Because dairy processing plants are large consumers of water they have a major effect on local water supply. During a drought the impact can be disastrous.

Table 2. Water Conservation Tips

- Think of water as a raw material with a cost.
- Set specific water conservation goals for your plant.
- Make water conservation a management priority.
- Install water meters and read them each shift.
- Train employees how to use water efficiently.
- Use automatic shut-off nozzles on all water hoses.
- Use high-pressure, low-volume cleaning systems.
- Avoid using water hoses as brooms.
- Reuse water where possible.
- Prevent spills of ingredients and of raw and finished product.
- Always clean up spills before washing.
- Establish a recognition and reward program for employees and teams who do an outstanding job.

Experience has demonstrated that water use in the dairy industry can be reduced to less than one gallon per gallon of milk processed. Challenge and encourage employees to reach that goal in your plant. See the Table 2 for water saving tips.

As the U.S. Environmental Protection Agency (EPA) tightens regulations and states enforce restrictions on quality of water consumed and wastewater discharged into the environment, costs will probably rise even more than in the past. To face current conditions and be ready for the future, leaders in the dairy processing industry must look ahead and start water conservation actions now.

Saving Money by Saving Water: An Example.

How much could a dairy plant save by reducing water use to one gallon of water per gallon of milk processed? To find out, consider two plants that each process 75,000 gallons of milk per day. Each pays $2.25 per thousand gallons for water. However, plant A uses 1 gallon of water per gallon of milk processed while plant B uses 4 gallons. Water and sewer costs for the two plants are shown in Figure 1. Because plant A uses 3 gallons of water per gallon of milk less than plant B—a savings of 225,000 gallons per day—its operators can put $506.25 more in the bank each day, a total savings of $184,781 per year for water alone. In effect, plant B is pouring that amount of money down the drain. Sewer costs based on water use are often nearly as much as water. This in effect doubles the savings benefit. Additional savings may be realized from reduced water heating costs, in-plant water treatment, or sewer surcharges.

What is the effect of reducing waste load?

An excessive waste load means wasted product and lost income. More than 90 percent of a plant's total waste load comes from milk components that are lost and flow into floor drains during processing. Lactose, proteins, and butterfat are the major components. The wastewater also may contain cleaning agents, lubricants, and solids removed from equipment and floors. Wastewater analysis is useful to indicate a plant's processing efficiency.

Waste load can be determined by a number of different measurements, including BOD_5, biological oxygen demand; COD, chemical oxygen demand; TSS, total suspended solids; TKN, total Kjeldahl nitrogen; and FOG, fats, oils, and grease. The BOD_5 test is most often used by regulators and sewer utilities. BOD_5 is a measure

Figure 1. Example water and sewer cost and savings.

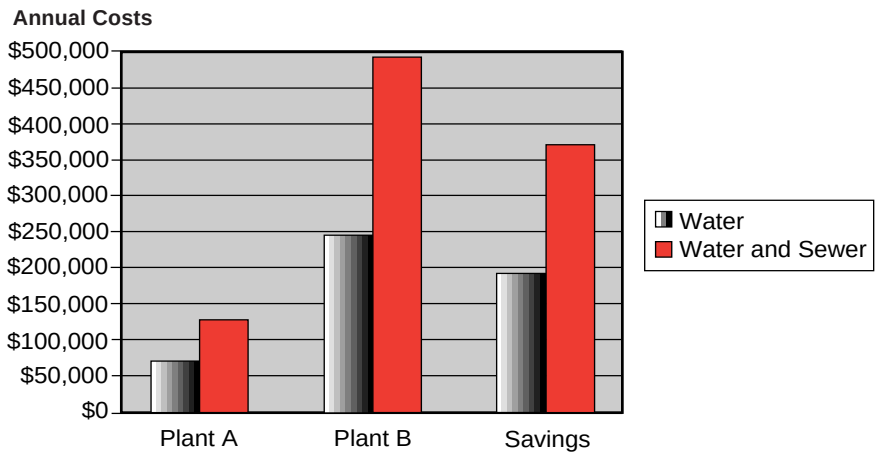

Table 3. BOD_5 and COD Values of Pure Dairy Products.

Product	BOD_5 (mg/l)	COD (mg/l)	BOD_5/COD
Milk	104,600	173,000	0.60
Ice cream *(10% fat)*	292,000	540,000	0.54
Whey *(acid)*	32,000	70,000	0.54

of the amount of oxygen needed to degrade the organic matter under specific conditions measured at five days and is expressed in milligrams per liter (mg/l).

Surveys show 1 pound of BOD_5 in wastewater means at least 9 pounds of milk have been lost. By knowing the BOD_5 level in a waste stream, the amount of product flowing down the drain can easily be estimated.

The slogan "Let's not wash our profits down the drain," used by an ice cream plant in its employee training program, reflects the fact that an effective waste and water management program cuts waste and increases profits. A plant's waste load can be decreased substantially by controlling the amount of water used and reducing the amount of product lost into the sewer. Stopping pollution at its source is less expensive, more efficient, and more profitable than end-of-pipe waste treatment.

Most sewer utilities impose sewer surcharges when the level of contaminants in a plant's wastewater is excessive. Typically, when the BOD_5 level exceeds 250 to 300 milligrams per liter, many utilities apply a surcharge or require pretreatment. This makes water conserving and waste load management program even more attractive.

Defining load using BOD_5 and COD.

Chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5) are common measurements used to determine water quality. They measure the strength of the waste stream by measuring the oxygen required to stabilize the wastes. Most of the waste from milk processing plants or milk parlors are organic compounds, primarily lost product. As these substances degrade, they consume some of the oxygen dissolved in the water. The amount of oxygen used is thus a good indicator of the amount of organic waste present. The BOD_5 and COD values for three dairy products are shown in Table 3. The values indicate the amount of oxygen (in milligrams per liter of product) needed to oxidize or stabilize these products when they appear in wastewater.

COD and BOD_5 are important to the food processing industry because they can be used to indicate lost product and wasteful practices. High BOD_5 and COD levels indicate increased amounts of product lost to the waste stream. Measurements at various process locations can help locate sources of waste.

The advantage of using COD instead of BOD_5.

Although regulatory agencies require the monitoring and reporting of BOD_5 levels, the COD test has several advantages for the plant's operation staff. The comparatively short time to do the common 2-hour reflux test for COD is the major advantage. A COD test of easily oxidized waste may take even less time. The BOD_5 test on the other hand, is time consuming, requiring a 5-day incubation period. The rapid test results of the COD procedure provides an advantage when monitoring daily waste production and wastewater discharge.

Another advantage of the COD test is that strong oxidizing conditions are somewhat independent of variations in experimental conditions and procedures. This is not true for the BOD_5 test, which is sensitive to test conditions and can vary depending upon the seed (microbial) culture used. In addition, the BOD_5 test, unlike the COD test, does not measure biologically resistant compounds.

Relating COD to BOD_5.

At any point in a particular food processing operation, the relationship between BOD_5 and COD is fairly consistent. The ratio's of these two measures varies widely with the type of product, however (Table 4).

For example, a bakery product having a COD of 7,000 milligram per

Table 4. Typical Values of BOD_5 and COD for Different Food Plant Wastewater.

Type of Processor	BOD_5 (mg/l)	COD (mg/l)	BOD_5/COD
Bakery products	3,200	7,000	0.46
Dairy processing	2,700	4,700	0.57
Jams and jellies	2,400	4,000	0.60
Meat packing	1,433	2,746	0.52
Meat specialties	530	900	0.59
Poultry processor	1,306	1,581	0.83

liter might have a corresponding BOD_5 of 3,200 milligram per liter. The ratio of BOD_5 to COD, shown in the right column of Table 4, ranges from 0.46 to 0.83. The ratio also depends on where the measurements are made in the processing operation or in the wastewater treatment process.

COD values are always greater than BOD_5 values because of the nature of the measurement procedure. With the dichromate refluxing procedure used to measure COD, almost all organic compounds are oxidized. With the BOD_5 measurement procedure, some of these compounds do not fully oxidize, making the oxygen demand lower. The BOD_5 value may be much lower than the COD value when a substantial amount of biologically resistant organic matter is present. In addition, a few chemical interferences—primarily from chlorides, certain nitrogen compounds and other substances that could interfere with bacterial growth can affect the test results.

Measuring milk loss with COD.

We know that 1 pound of BOD_5, is directly equivalent to a gallon, or 9 pounds of milk. Thus if the BOD_5 level in your plant's wastewater is known this information can be used to make a reasonably accurate estimate of how much product (and lost income) is going down the drain. A plant's water use and the resulting volume and strength of its waste stream are strong indicators of how efficiently the plant is operating.

When the BOD_5/COD ratio, the COD concentration in the waste, and the volume of the waste stream are known, the volume of product lost can be estimated. Once the BOD_5/COD ratio is established for a process stream, BOD_5 is calculated using the measured COD value and the ratio (see Table 5).

Table 5. Worksheet for Calculating Yearly Value of Lost Milk.

	Example	Your Plant
COD (mg/L)	1,500	
k_{cod} (conversion factor)[1]	4.756×10^{-6}	
Wastewater Flow (gal/day)	300,000	
Lost Product (gal/day) = COD × k_{cod} × Wastewater Flow = $1{,}500 \times 4.756 \times 10^{-6} \times 300{,}000$		
Lost Product (gal/day)	2,140	
Product Value ($/cwt)	$ 12.50	$
k_{loss} (conversion factor)[2]	31.43	31.43
Yearly Loss = Lost Product × Product Value × k_{loss} = $2{,}140 \times 12.50 \times 31.43$		
Yearly Loss ($/year)	$ 840,800	$

[1] This conversion factor assumes a BOD_5/COD ratio of 0.57. This ratio should be determined for your facility by measurement at specific points in the plant.
[2] Conversion assumes operation at 365 days per year and a milk density of 8.61 lb./gallon.

How to implement COD measurement for a process.

In order to use the more readily-measured COD in place of BOD_5, both must be measured at specific points in the processing operation. These points may be floor drain outlets, wash water collection tanks, and other points where waste water is collected prior to being discharged to the sewer system. Data should be collected for a period of time to determine the degree of variability in BOD_5 and COD values at each point.

Using the example for dairy processing found in the table, the BOD_5/COD ratio was found to be 0.57. This means that for that process stream, the BOD_5 measurement would be slightly more than half the measurement for COD. Because of the ratio between BOD_5 and COD, this also implies that 1 pound of COD is equivalent to about 5 pounds of milk lost down the drain.

How to begin a water use and waste reduction plan.

Managers set the pace for water conservation and waste reduction. Their interest and involvement will let everyone in the plant know that reducing water use and waste load are important. There's no better time than now to take a close look at your plant and encourage your employees to work with you in conserving water and cutting waste (see Table 6).

The most important aspect of a successful plan is management commitment to creating an environment that will encourage and allow employees to adopt new methods. This means allowing time for learning new techniques and making mistakes. Old water use habits will take time to change, but with a positive attitude from management, the transition will be faster, more efficient, and result in fewer interruptions of daily operations. Consider establishing a reward and personal recognition program for

Table 6. Elements of a Successful Water and Wastewater Management Program

- Management must understand and be committed to the program.
- Appoint a water-waste supervisor.
- Survey water use and waste production in the plant.
- Set water use and waste reduction goals for the plant.
- Hold a regular management meeting.
- Train employees.
- Solicit ideas from employees.
- Monitor performance and maintain records.
- Implement the best ideas immediately; if suggestions will not be implemented right away or are rejected, let the employees know the reason.
- Provide rewards to employees.
- Ensure continued commitment of all employees.

employees and shifts who contribute significantly to savings.

Appointing an employee that will organize and implement the plan will increase the speed in which the plan can realize savings and results. Initiate a communication and reward system so employees will know how the plan is achieving its pollution prevention goal and have incentive to do their part.

After management has made a commitment to development of a plan, a typical process to implement a water use and waste load reduction plan may generally follow the following steps:

1. Form a team that will investigate water use and waste discharge at the facility.
2. Review and update drawings of plant processes.
3. Conduct a survey of all plant processes and operations.
4. Identify sources of relatively obvious waste and minimize them. These are known as "low hanging fruit" because they achieve results quickly and easily.
5. For more difficult sources, survey the literature for known recovery methods. K-State Research and Extension can assist you.
6. Contact managers of other facilities and equipment manufacturers for ideas and suggestions for improvement.
7. Interview key employees while on the facility floor and in a workshop to obtain their ideas.
8. Review sources of waste and product loss. If a source cannot be eliminated, assess the feasibility of recovery methods.
9. Develop a plan for waste prevention and recovery of lost product that serves as a guide for the facility.

Some of the places to look for sources of lost product may sound simple or obvious, but will make a valuable difference.

Small daily savings at a plant can add up to true cost-saving measures when considered over a year long operation. For example, a 2-inch line, 20-feet in length may not drain properly and requires rinsing with water four times a day to remove the product. This length of line will hold 3.3 gallons of milk that goes to the drain during each clean-out. The value of the product lost each day is $14 (at $12.50/cwt), but over 260 days a year, that totals about $3,650. Include water and sewer costs for rinsing, and the yearly cost becomes even greater. How many sections of pipe can your employees find that do not drain before cleaning begins? Are management's attitudes or procedures requiring cleaning to begin before the lines are fully drained?

Table 7. Waste Reduction Hints

- Establish waste load reduction goals for your plant.
- Establish waste load reduction goals for all important processes and areas of the plant where waste can be monitored and controlled.
- Improve maintenance to prevent product leaks from valves, piping, and equipment.
- Reduce water use; remember that water used in a plant becomes wastewater that must be treated.
- Design and install lines that will allow proper draining of product, rather than relying on rinse water to remove product.
- Allow enough time for more viscous products to drain from lines and tanks.
- Inspect tanks and vats to verify they have completely drained before starting a clean-out procedure.
- Collect solids from floors and equipment by sweeping. Shovel the wastes into containers before actual cleanup begins. Do not use hoses as brooms.
- Adopt the attitude that waste load reduction is one of the most cost effective managerial decisions you can make.
- Orient employees toward preventing pollution, and train them how to do their jobs in a way that will reduce the discharge of wastes from your plant.

Some Final Remarks.

This bulletin discusses only the "tip of the iceberg" on several major issues, but points out that it is possible to save money and reduce impact on the environment at the same time. By setting goals, training employees properly, and adopting new attitudes toward water use and waste management, significant benefits can be achieved throughout the processing facility.

Additional Reading.

Water and Wastewater Management in a Dairy Processing Plant. R. E. Carawan and M. J. Stengel. CD-28. North Carolina Agricultural Extension Service.

Dairy CEOs: Do You Have a $500 Million Opportunity? R. E. Carawan. CD-29. North Carolina Agricultural Extension Service.

Using COD to Measure Lost Product. L. G. Turner and R. E. Carawan. CD-38. North Carolina Agricultural Extension Service.

Reducing the Waste Load from a Dairy and Ice Cream Plant. R. E. Carawan, J. E. Rushing and M. B. Jones. FSE 92-5. North Carolina Agricultural Extension Service.

Cut Waste to Reduce Surcharges For Your Dairy. R. E. Carawan. CD-26. North Carolina Agricultural Extension Service.

Liquid Assets For Your Dairy Plant. R. E. Carawan. CD-21. North Carolina Agricultural Extension Service.

The Food Processing Residual Management Manual. 1994. R.C. Brandt, K.S. Martin. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY. Pub. No. NRAES-92.

Glossary of Terms

BOD_5 —5-day biological oxygen demand, a measure of the oxygen demand during a 5-day incubation period, resulting from biological use of the wastes.

COD—chemical oxygen demand measures the amount of waste material that can be oxidized by chemical agents.

For Further Information Contact:

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