EX 35

# Dairy Plant Product Loss Analysis Utilizing Effluent BOD

In 1993 the Food & Beverage Division of Ecolab Inc. initiated a project called Water Management Services **(WMS)**. The purpose of WMS was to assist Food & Beverage **(F&B)** customers reduce annual expenditures for water and sewer expenses. Annual expenditures for water and sewer expenses at individual customers often exceeded annual expenditures for cleaning and sanitizing products purchased from Ecolab Food & Beverage.

Studies started in 1985 indicated that the rates charged by Publicly Owned Treatment Works **(POTW)** for treating sewer volumes and pollution components were increasing at a much faster rate than inflation. Some industry experts predicted that sewer rates would increase 300% or more by the year 2000. In fact, in Environmental Protection Agency **(EPA)** Region 1, the sewer rates increased by 352% between 1985 and 1999.

The motivation behind the WMS project was to assist current and potential F&B customers reduce expenditures for water and sewer expenses so that the savings could be spent on other sanitation expenses in general and specifically on cleaning and sanitizing products.

Dairy plants were initially targeted by WMS because:

- F&B has a large dairy customer base
- Dairy plants are generally highly automated
- Dairy plants generally use continuous rather than batch processes
- Raw ingredients processed in dairy plants are generally more homogeneous than the raw ingredients processed in food plants
- Finished dairy products are generally more homogeneous than finished food products

One of the major components of sewer expense is Biological Oxygen Demand **(BOD)**. The EPA uses BOD concentration in milligrams per liter **(mg/l)** to measure effluent strength and to establish effluent guidelines as required by the Federal Water Pollution Control Act. Many POTW facilities use BOD to determine charges and surcharges for industrial users of waste treatment facilities.

BOD is a measure of effluent strength in terms of the amount of dissolved oxygen utilized by microorganisms during the oxidation of organic components in the effluent. BOD is determined by incubating a suitable dilution of effluent at 68°F. After incubation, the amount of dissolved oxygen consumed is obtained and the results expressed as mg/l of BOD. The BOD test requires a standard 5-day incubation period, thus the name $BOD_5$ test.

The pounds of BOD can be calculated by the formula:

Pounds of BOD = gallons of effluent divided by 1,000,000 x 8.34 x mg/l $BOD_5$

Effluent BOD from fluid dairy plants consists primarily (95% or more) of water born milk solids and sugars and (5% or less) of detergents, sanitizers, and conveyor lubricants. Conveyor lubricants account for the majority of the 5% or less value because many conveyor lubricants contain fatty acids that are relatively high in potential BOD. Dairy manufacturing facilities such as cheese or powder plants do not utilize conveyor lubricant. The effluent BOD from a cheese or a powder plant is virtually all the result of raw ingredient loss and finished product loss.

The quantity and strength of the effluent discharged from dairy plants varies depending on the quantity of water utilized, the type of process in the dairy and the control management exerts over various waste discharges.

The BOD of dairy plant effluent will vary as a function of the products manufactured since differences occur in the amount of oxygen that is required for the oxidation of different constituents such as proteins, fats and carbohydrates.

Potential BOD for a raw ingredient or a finished product can be calculated by applying specific factors to the specific protein, fat and carbohydrate composition of the raw ingredient or finished product. The specific protein, fat and carbohydrate composition of the raw ingredient or finished product is available from the "USDA Nutrient Database for Standard Reference, Release 13".

Here is an example:

# Milk, producer, fluid, 3.7% milkfat

## NDB No: 01078

| Nutrient | Units | Value per 100 grams of edible portion | Sample Count | Std. Error |
|---|---|---|---|---|
| **Proximates** | | | | |
| **Water** | g | 87.690 | 0 | |
| **Energy** | kcal | 64.172 | 0 | |
| **Energy** | kj | 268.000 | 0 | |
| **Protein** | g | 3.280 | 0 | |
| **Total lipid (fat)** | g | 3.660 | 0 | |
| **Carbohydrate, by difference** | g | 4.650 | 0 | |
| **Fiber, total dietary** | g | 0.000 | 0 | |
| **Ash** | g | 0.720 | 0 | |

The specific factor for protein is 1.03. The specific factor for fat is .89. The specific factor for carbohydrate is .70. Applying these factors to "Milk, producer, fluid, 3.7% milkfat" results in an estimated BOD potential of 9.9% by weight.

# BOD POTENTIAL

| Nutrient | Units | Value per 100 grams of edible portion | BOD FACTOR | BOD GRAMS |
|---|---|---|---|---|
| Proximates | | | | |
| Water | g | 87.690 | 0 | 0 |
| Energy | kcal | 64.172 | 0 | 0 |
| Energy | kj | 268.000 | 0 | 0 |
| Protein | g | 3.280 | 1.03 | 3.38 |
| Total lipid (fat) | g | 3.660 | .89 | 3.26 |
| Carbohydrate, by difference | g | 4.650 | .70 | 3.26 |
| Potential BOD | g | 9.90 | | 9.90 |

There are variations between breeds. Milk from a Jersey cow has higher protein, fat and carbohydrate than the previous example. The BOD potential for milk from a Jersey cow is 12.1% by weight.

# BOD POTENTIAL: Jersey

| Nutrient | Units | Value per 100 grams of edible portion | BOD FACTOR | BOD GRAMS |
|---|---|---|---|---|
| Proximates | | | | |
| Water | g | 86.060 | 0 | 0 |
| Energy | kcal | 64.172 | 0 | 0 |
| Energy | kj | 268.000 | 0 | 0 |
| Protein | g | 3.980 | 1.03 | 4.10 |
| Total lipid (fat) | g | 5.130 | .89 | 4.56 |
| Carbohydrate, by difference | g | 4.830 | .70 | 3.38 |
| Potential BOD | g | 12.1 | | 12.1 |

The potential BOD for a gallon of raw milk ranges from .85 pounds to 1.04 pounds in these two examples.

WMS decided to use 1 pound of potential BOD per gallon of raw milk for product loss calculations. The decision to use 1 pound per gallon was based on the fact that it is an easy calculation when discussing product loss with customers.

The potential BOD values for other raw ingredients were calculated but raw milk, because of volume, is the single largest source of potential BOD in a dairy plant. When WMS receives pounds or volumes of ingredient information and pounds of effluent BOD information from a customer, a "% BOD Loss" calculation is performed. Dividing the pounds of effluent BOD by the pounds of potential BOD equals "% BOD Loss".

The "% BOD Loss" analysis for a dairy plant sometimes indicates a product loss which that is higher than a traditional shrink report in a dairy plant. There should be a reconciliation of "% BOD Loss" with the traditional shrink report.

Product loss analysis by using BOD information was originally intended to assist dairy plants reduce sewer expense. Some plants divert high strength BOD streams to non-POTW outlets (such as animal feed) so product loss is understated when calculating a "% BOD Loss". Infrequent and/or inaccurate effluent sampling can result in questionable effluent BOD loading. Unresolved discrepancies between milk shrinkage and "% BOD Loss" may indicate effluent overcharges.

The purpose of calculating a "% BOD Loss" was to qualify customers and prioritize where WMS would allocate limited resources to assist in reducing sewer expense. If a multi-plant dairy organization had some plants with "1% BOD Loss" and other plants with "3% BOD Loss" the logical decision was to allocate resources to the plants which had the greatest potential for expense reduction.

There are a number of factors that can contribute to effluent BOD (product loss):

- Number and types of products produced
- Large product line: frequent change-overs at HTST and fillers
- Viscosity: how well does a line or vessel drain
- Processing equipment design
- Leaks: no gasket, bad gasket, loose clamps
- Malfunctions: tank overflow, fine saver failure
- Commitment by plant management
- Participation by hourly employees

When a plant is analyzed the information is entered into a database. This database is organized by plant process. The processes in the database are fluid, cheese, ice cream and evaporator (balance).

Some milk handling techniques, which are common and acceptable in dairy manufacturing plants, are not available to fluid milk plants because of regulatory compliance concerns. The intent of the database to compare similar dairy processes.

There are currently 147 plants in the database. There are 51 cheese plants. The graph below illustrates the distribution of cheese plants from the lowest "% BOD Loss" to the highest "% BOD Loss".

I therefore conclude that the average cheese plant loses (as measured by pounds of BOD in its wastewater discharge) 2.35% of the milk components that entered the plant as fluid milk.