IN FOOD PLANTS POLLUTION PREVENTION IS MORE ECONOMICAL THAN PRETREATMENT

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In the last 25 years, many food plants have experienced four-to ten-fold increases in municipal water and sewer bills. At the same time, new and expanded municipal ordinances are imposing increasingly stringent restrictions on waste discharges to Publicly Owned Treatment Works (POTWs), and many food processors are finding that pretreatment technology adequate to comply with municipal restrictions is prohibitively expensive.

The enactment and enforcement of sewer use ordinances, pretreatment ordinances, and surcharges are threatening the economic viability of some food processing plants, and growing water supply and waste disposal costs will continue to take larger and larger bites out of all food processors' profits.

Only consistent and strong advocacy from top management can guarantee successful efforts to control these escalating water and waste costs. Since the lowest cost control measures are usually those that attack the problem at its source, food industry managers should become thoroughly acquainted with the Pollution Prevention Pays concept and consider its potential applications in their plants.

Whether managers must act to comply with increased municipal waste load restrictions for existing plants, make decisions about process design for new or expanded facilities, or respond to bottom-line pressure from shareholders, adoption of water conservation and waste reduction programs should receive first consideration.

Pollution Prevention Pays

Joseph T. Ling of the 3-M Company is generally credited with originating the Pollution Prevention Pays concept. Dr. Ling advanced the idea that the conservation approach should be used to eliminate the causes of pollution--which he identified as waste--before spending money and resources to clean it up. Dr. Ling defines the conservation approach as the practical application of knowledge, methods, and means to provide the most rational use of resources.

Dr. Ling concluded that government, industry, and the public are beginning to become aware of the shortcomings and enormous cost of conventional pollution controls. He also pointed out that pollution controls do not solve but only alter pollution problems.

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For example, pretreatment of food plant wastewater does not eliminate pollution. It only generates sludge which must be handled in such a way as to prevent it from becoming a pollutant. As wastewater pretreatment or treatment requirements become more stringent, and sludge disposal becomes more difficult and costly, the resources that a company must commit to these processes continue to increase. Dr. Ling defined this environmental paradox as follows: "It takes resources to remove pollution: pollution removal generates residue; it takes more resources to dispose of this residue, and disposal of this residue also produces pollution."

It was his recognition of this pollution cycle that led Dr. Ling to conclude that significant economic benefits can accrue to companies which seek more realistic and effective solutions to pollution through conservation-oriented technology.

Food Industry Must Change Attitude About Water Use

Water is becoming an increasingly scarce and costly commodity. Increased domestic demand fueled by a growing population, increased industrial and agricultural demand, and degradation of many water sources have combined to bring an end to the era of cheap, high-quality water. Recent droughts have underscored the fact that there are now greater numbers of people competing for less high-quality water. Food processors need clean, pure water and should be concerned about water availability.

However, the people at the top of the management structure in the food industry should be concerned about more than just the short-term availability of water of sufficient quality for food processing. Those who are responsible for the future of the industry should also be concerned about the depletion or loss of water resources and about the effect on water resources of the disposal of industrial wastes including both processing residuals and wastewater treatment process residuals. Each area has technological, economic, legal, regulatory, and image concerns. These factors combine to make water supply and waste disposal issues critical in the location and continued operation of many food plants.

Over the last two decades, the public has become increasingly vocal about maintaining the quality of our groundwater and water in our streams, rivers, estuaries, and oceans. Public concerns about water quality have prompted new economic, regulatory, and political changes that necessitate a change in attitudes about water use in the food industry.

Food Processing Operations Use Large Volumes of Water

Water is important to the food industry. It is an ingredient in many food products, and it is used for washing products, blanching, making syrups and brines, cooking, cooling, cleaning, and sanitation. Obviously, food processors use large amounts of water. For example,

* dairy plants use about three gallons of water for every gallon of milk processed:

* meat processors use about one gallon of water for every pound of hamburger produced:

* vegetable processors use about one gallon of water for every can of sweet potatoes produced. (See Table 1 for other examples)

Table I

Water Use in Food Processing

ITEM	QUANTITY OF WATER USED FOR PROCESSING (GAL)
One Fryer	8 - 13
Can Sweet Potatoes	1-4
Can Apples	1-2
Can Green Beans	1-2
1 lb. Hamburger	0.5 - 1
1 lb. Pork Chops	1-2
1 gal. Beer	6 - 10
1 gal. Milk	1-3

As the water is used in the food plant, parts of the food product being processed are deposited in the water, and this wastewater must be properly handled to prevent pollution.

Water use in food processing plants is dependent on the kind of products produced, the processes utilized (including whether the process is dry or wet), and production capacity. Some large food plants, such as bakeries, may use less than 20,000 gallons of water per day while others, such as canning plants, may use up to 20 million gallons per day. Most North Carolina food processing plants use less than 100,000 gallons per day. However, some of our poultry processing plants--which are among the largest in the country--use and discharge more than 4 million gallons per day.

In most food plants, water used for washing, conveying, processing, cooling, and clean-up is discharged as wastewater. However, breweries and soft drink plants incorporate as much as 90 percent of their water use into their products.

Wastewater Treatment Is a Hidden Water Cost

Water cost for food processors has not been a major concern in the past. Even today, most food plants pay only $0.20 - $2.00 per thousand gallons of water used. In North Carolina, most plants pay about $1.00 per thousand gallons. Is this a significant cost? In answering that question, remember that water not put into the product must be discharged, and treatment is often required. A food plant using 5 million gallons of water per day could face water and wastewater costs exceeding $2.5 million annually.

Past studies and the author's personal experience indicate that plants with the least amount of water use per unit of product processed have the least amount of pollutants per unit processed.

How can water use impact the food industry in the future? In South Dakota, legislation has been proposed that would impose a fee of $.002 per gallon for water use including production and processing. This would raise the cost of one pound of hamburger by $14 and the cost of milk would increase by $19 per gallon. Consumers have indicated they want clean water, but it is obvious there is a limit to food prices consumers will pay, so how would such surcharges affect food industry profits and the availability of food products?

Treating Wastewater Is Costly

Treatment of wastewater from agricultural products processing plants can be costly and complex. High strength wastewaters and highly variable seasonal loadings make many treatment schemes ineffective and not cost efficient.

Biochemical oxygen demand (BOD_5), is the most-used test for measuring the waste concentration in wastewater from food processing plants. The BOD_5 test indicates the amount of oxygen that will be consumed by the biochemical oxidation of wastewater. The test is widely used because in wastewater from food plants oxygen deficiency is usually the cause of polluted water and fish kills, and processes to reduce oxygen demand are often the most costly of wastewater treatment.

High BOD_5 in food plant effluent is usually an indication of inefficient processes and is directly related to food products in the wastewater. In fact, BOD_5 can be estimated in food plant wastewaters by determining the fat, protein and carbohydrates in a wastewater and using the following factors:

Food Constituent	Pounds BOD_5 per pound of food constituent
Carbohydrates	0.65
Fats	0.89
Protein	1.03

BOD_5 and other characteristics of food processing effluents are highly variable, as is effluent volume. The BOD_5 may be as low as 100 milligrams per liter (mg/l) or as high as 200,000 mg/l. Suspended solids, almost completely absent from some wastes, may be found in other wastes in concentrations as high as 120,000 mg/l. Wastes may be highly alkaline (pH 11.0) or highly acidic (pH 3.5). Nutrients such as nitrogen and phosphorus may be absent or they may be present in concentrations that inhibit efficient biological wastewater treatment. The volume of wastes may range from more than a million gallons per day per plant in heavy processing seasons to virtually a trickle at other times.

One food processing plant may have biochemical oxygen demand (BOD_5) equal to that of a city of a quarter million people. The BOD_5 concentration of food plant wastewaters is typically 10 to 100 times greater than domestic sewerage.

Agricultural products processing wastes are largely compatible with conventional biological treatment and land application of sludge. Common treatment processes for food plant wastes include land disposal, anaerobic ponds, aerobic ponds, activated sludge, clarifiers, trickling filters, and rotating biological contractors (RBCs). But, even after costly treatment, food processing wastewaters discharged directly into surface waters can impose a serious burden on small streams and even large rivers.

Some food plants are located so they can utilize land application of wastewater. Land application sites may need to exceed one thousand acres of suitable soil for proper disposal. Such sites are limited, and this limitation could hamper industry growth. Moreover, when chemicals are used (as lye for peeling vegetables, chlorine for sanitation and cleaning, or sodium chloride for pickling operations) unique disposal problems exist.

Toxics are not often a worry for the managers of most agricultural processing plants. However, laboratory wastes can present difficulties, and as regulations become more restrictive and analysis techniques more sensitive, highly alkaline or acidic wastewaters or wastewaters containing copper, zinc, chrome, or chloride may require additional pretreatment.

More Municipalities Are Requiring Pretreatment, Levying Heavy surcharges

The disposal of wastewater from food processing plants to POTWs incurs two types of costs: (1) cost of pretreatment and disposal of pretreatment residual or sludge, and (2) cost of discharge. Discharge costs include sewage fees and any surcharges. Currently sewer costs in North Carolina average about $1.00 per 1,000 gallons. Food plants in other states pay sewer charges that range from $0.20 to about $6.00 per 1,000 gallons.

Surcharges are levied for waste loads discharged above some limit. Surcharges are assessed for BOD_5, total suspended solids (TSS), fats, oils and greases (FOG), total kjeldahl nitrogen (TKN), phosphates, and other waste constituents. BOD_5 costs range from $0.25 to $2.00 per pound while TSS surcharges range to almost $3.00 per pound of excess suspended solids. The maximum surcharge for North Carolina food plants is about $0.40 per pound for both BOD_5 and TSS.

Pretreatment Is Costly and Usually Not Adequate to Meet Restrictions

Municipal pretreatment requirements for food plants discharging to POTWs can include effluent restrictions on selected wastewater parameters such as BOD_5, chemical oxygen demand (COD), FOG, TKN, and flow. Many municipalities have already imposed such limits in their pretreatment ordinance to help provide for safe and more efficient wastewater treatment and to control discharge of pollutants.

To meet pretreatment requirements, food processing plants may adopt processes ranging from pH control and flow equalization to full secondary treatment. Conventional pretreatment technology is based on use of equipment such as clarifiers, separators, and/or dissolved air flotation (DAF) units to remove settleable and/or floatable solids.

Pretreatment processes that are economical and easy to operate are not readily available for most food processors. As more municipalities require pretreatment, improvements in the processes become necessary. Perhaps the best pretreatment schemes involve using food residues to produce methane for fuel and treating and recycling wastewater into potable water for reuse.

Pretreatment Costs May Be Higher Than Sewer Costs

Pretreatment and sewer use ordinances can impose significant restrictions on food plants. Pretreatment costs are always significant, and sometimes there are no pretreatment processes available to the food processor that will accomplish what ordinances dictate. Special agreements are necessary to exceed limits in almost all cases the author has studied. Requirements for testing such as for chronic toxicity can easily push costs for monitoring above $ 1 million annually for a large food plant.

Recently, the author worked with a snack food processor who was predicting variable costs for treatment (fat separator, clarifier, activated sludge, sludge disposal) that exceeded $5.00 per pound of BOD_5, and this did not include a fixed cost in excess of $250,000 for a 20,000 gallon per day discharge. Analytical costs and permit records and reporting are also becoming significant costs.

A quick survey of a number of poultry and dairy plants produced interesting numbers. It appears that pretreatment costs may exceed the costs many municipal systems charge for BOD_5 and TSS removal. Not enough information is available for a comparison of pretreatment and treatment systems for nutrient removal. BOD_5 removal costs for pretreatment ranges from $0.11 to $0.27 per pound of BOD_5 removed at the pretreatment system. Thus, removal costs may exceed $0.30 per pound of BOD_5 removed. Many municipal systems operate more efficiently than this.

The environmental director of a large dairy firm has said, "You cannot operate a pretreatment system cheaper than the city." He indicated that current wastewater disposal charges in the Midwest for his plants ranged from $0.23 to $0.28 per pound of BOD_5. Some of these plants have pretreatment and some do not. Those plants with pretreatment have costs for pretreatment ranging from $0.21 to $0.24 per pound of BOD_5. Depreciation and capital account for 20% of these costs while power, labor, chemicals, and sludge disposal account for the remainder.

Management and Process Changes to Reduce Water Use and Waste Generation Can Be More Beneficial than Pretreatment

For most food processors, pretreatment may be the least desirable way of reducing waste load. There are other proven ways to reduce water use, product loss, waste loads, and wastewater discharge. One method is to operate the plant more efficiently. The second is to institute process changes that result in a conservation-oriented operating environment.

The author has participated in a number of water and waste management studies. These studies were performed to help food processors apply their ingenuity to develop cost effective resource conservation know-how. Savings of up to 72% have been demonstrated in some plants.

Much of what is reported was known to the general industry but was not practiced by the plants studied. The help, resources and encouragement of the Pollution Prevention Program and the North Carolina Agricultural Extension Service made these accomplishments possible. In most food plants, corporate engineers could duplicate these accomplishments.

Table II

Pollution Prevention Potential

STUDY	POLLUTION PREVENTION (Pounds of BOD_5/year)
Hunter	226,400
Maola	320,000
Maola-II	320,000
Beaufort	250,000
Randolph	60,000

Several food processing plants were studied to determine the feasibility of process and management changes to reduce the waste load. The net savings were predicted for these plants using the following formula:

NS (L) = IR + RC - IC

WHERE NS(L) = NET SAVINGS (LOSS)
IR = INCREASED REVENUES
RC = REDUCED COSTS
IC = INCREASED COSTS

Table III

Ratio of Increased Cost, Initial Cost, and Waste (BOD_5) Reductions

STUDY	INCREASED COST / WASTE REDUCTION	INITIAL COST / WASTE REDUCTION	SAVINGS / WASTE REDUCTION
	....	($/l,000 lb BOD_5)	---------------
Hunter	333	737	278
Maola	347	645	1062
Maola-II	109	167	945
Beaufort	1243	1260	3589
Randolph	99	75	13

Five studies included Hunter (fluid milk plant), MAOLA (dairy plant), MAOLA II (an alternative study, another set of changes at the same dairy plant), BEAUFORT (fisheries plant), and RANDOLPH (beef slaughter plant). The potential reduction in waste load for these studies varied from 60,000 to 320,000 pounds of BOD_5 per year (Table 2). The increased cost is the total cost that the plant would incur with implementation of all the changes studied. As surcharge costs do not usually exceed $0.40 per pound of BOD_5 in North Carolina, any waste reducing measures incurring increased cost not exceeding $400 per thousand pounds of BOD_5 reduction ($.40 per pound of BOD_5) should be implemented by any food plant as long as capital considerations do not preclude the change. Of the five studies, only BEAUFORT had increased costs exceeding this level (Table 3).

As BEAUFORT is in a coastal area and wastewater treatment costs will be more than for many other locations, savings of $3589 per 1,000 pounds of BOD_5 were predicted. The savings predicted in these studies ranged from $13 per thousand pounds of BOD_5 reduction at RANDOLPH to $3589 per thousand pounds of BOD_5 reduction at BEAUFORT.

Studies Reveal Other Impacts of Reduced Water Use

A consulting engineer has estimated that a reduction in water use at a poultry plant could have a significant impact on the cost of a pretreatment system. The capital cost for a dissolved air flotation unit for a 200,000 - broiler - per - day processing plant would be $450,000 for water use of 8 gallons per bird and $375,000 for 3 gallons per bird. Thus water use reductions pay not only by water and sewer cost reductions but also by the cost of pretreatment facilities. Further, operational costs for pretreatment such as power and chemicals would be reduced with the smaller wastewater flow--another reason to properly manage water and wastes in food plants.

Table IV

Capital Cost for Dissolved Air Flotation For Poultry Processing[a]

WATER USE (GPB)	COST
3	$335,000
8	480,000

[a] 200,000 birds/day
[b] gallons per broiler

The author has found that food plants that use the least amount of water per unit of product have the least waste load per unit of product when compared to other similar plants. However, sometimes water use reductions on a percentage basis will exceed waste load reductions. In such cases, plants can reduce their waste load only to see their wastewater concentration increase. Note the concentration of BOD_5 before and after changes for BEAUFORT. The

Table V

Estimated or Measured BOD_5
for Food Plants Studied

Study	Products Processed	MG/L BOD_5 Before Changes	MG/L BOD_5 After Changes
Hunter	Milk/Drinks	1,800	1,200
Maola	Multiproduct	2,900	1,900
Maola-II	Multiproduct	2,400	1,900
Beaufort	Menhaden-Surimi	2,500	4,500
Randolph	Beef	2,543	610

concentration increased to 4,500 mg/l from 2,500 mg/l even though there was a significant reduction in waste load. This supports the concept of mass load limits for food plants.

Public Image and Plant Efficiency Are Additional Reasons to Consider Water Use and Waste Generation Reduction

There are two reasons in addition to reduced cost and compliance with municipal POTW restrictions that management and process changes might benefit a food processor more than adoption of end-of-pipe pretreatment technology.

First, most food processing plants are very concerned about public image and do not want to be seen as polluters. Food plants processing under brand names are probably more concerned by this public perception. However, in this author's experience, almost all food plant managers try to be exemplary corporate citizens:

Reducing waste load from a food plant can not only reduce company costs but, in plants discharging to municipalities, can also help reduce municipal costs. Reduced loads for municipalities should reduce municipal treatment costs, minimize need for expansion of treatment facilities, help to maximize treatment efficiency and allow new citizens and businesses into publicly owned treatment works (POTWs) with reductions in peak loading.

Second, food plants that minimize wastes often find they have increased plant efficiency. As wastes are eliminated, more product is packaged for sale for any given throughput.

Municipalities and Regulatory Agencies Need to Consider Ultimate Environmental and Health Objectives

Considering the cost of pretreatment, which eventually is borne by the consumer, perhaps we need to ask if pretreatment requirements for food processors accomplish environmental goals in the most economical manner for society. The author believes that we must consider several vital factors when setting pretreatment requirements for food processors:

First, we should consider whether we might accomplish environmental goals more economically if "pretreatment" were defined as in the Nashville, Tennessee, ordinance to include process and management changes that reduce waste loads or alter the nature of the waste so as to make it more easily treated.

Second, we should consider the concept expressed in EPA Construction Grants Guidance that "Industrial use of municipal facilities should be encouraged when environmental and monetary costs would be minimized."

Third, we must consider human health and safety. Food plant biological pretreatment systems can be reservoirs of microbial pathogens that can and have contaminated food processing facilities. Some sites do not provide adequate room for a safe location.

Fourth, we should consider the processor's capability to dispose of pretreatment sludge and ask if it is reasonable to require pretreatment without an expressly stated municipal policy and procedure for sludge disposal.

Fifth, we should consider the Pollution Prevention Pays concept and examine all possible management and process changes that could bring about a conservation-oriented operating environment before end-of-pipe treatment alternatives are utilized.

Conclusion

Process and management changes can be used to reduce the water use and waste load from food processing plants. Process waste load reductions are more economical than pretreatment processes. Pretreatment at food processing plants often costs more than POTW treatment, may present health and safety concerns with microbial pathogens and perhaps viruses, and generates sludge which is difficult and expensive to dispose of in an environmentally sound manner.

Pretreatment of food plant wastewaters is necessary when fats may clog drains, when the food plant wastewater accounts for a large proportion of a POTW influent, and when special wastewaters (such

In most other cases, pretreatment may not be economically and environmentally sound, and in these cases municipal restrictions which dictate pretreatment should be re-examined. It is probable that smaller food plants should not venture into pretreatment without serious consideration of operational problems and sludge disposal.

Larger food plants, in terms of water use and waste load, and those with wastewater parameters that can pose operational problems for a POTW must install pretreatment and direct their management skills and resources toward meeting any restrictions necessary to protect the municipal POTW. We can expect more food plants to find pretreatment necessary in the future.

Municipal officials and food processors need to communicate mutual concerns about pretreatment so that society receives maximum waste reduction with a minimum of resources. As studies in food plants have shown, frequently the least expensive and most effective way to pretreat wastes is to implement management and process changes that "prevent pollution" by reducing water use and waste generation.

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