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SUCCESSFUL WASTE REDUCTION STRATEGIES FOR FOOD PROCESSORS

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Abstract

Some food processors have successfully reduced water use, waste discharge, and product loss. An understanding of the "Pollution Prevention Pays Concept" may have played an important role in making those waste-reduction programs work.

The relationship between water use and waste elimination in food processing is reviewed. The Pollution Prevention Pays concept is presented as is the environmental paradox that illustrates why conventional pollution regulations have not been environmentally successful or cost effective. The need to adopt conservation-oriented technology -which eliminates the causes of pollution before committing resources to clean up pollution-is explained.

Typical costs for water use, wastewater treatment, and disposal of food processing residues are given. The nature of food processing wastes and the environmental burdens they impose are explained. Waste reduction case studies in food processing plants are reviewed, and the benefits of waste reduction and the role of the waste audit are explained. Measures to control water use, product loss, and waste load are listed, as are seven successful approaches to encouraging conservation among employees.

Waste reduction concepts and employee motivation strategies discussed may be successfully incorporated by industries other than food processing. The most successful waste reduction programs focus on a management commitment, employee training, and stimulation of employees and mangers to develop a continuing program with achievable water use and waste reduction goals.

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The diversity of the food industry with its variety of inputs, processing techniques, and market uses is apparent not only in the vast array of final products but also in the water it uses and the waste it produces. Fortunately, waste from the food processing industry is not considered hazardous; however, the quantities generated can be overwhelming. The volume of wastes produced in food processing seems even more overwhelming when you realize that these “wastes” are often only raw material or final product lost during handling or processing and thatsignificant sums of money are utilized to buy raw material that is washed down the drain and to clean up the pollution this lost product is creating.

This realization, along with the more stringent environmental limits being placed on industrial dischargers, has turned the once simple biological treatment of food industry wastes into a major and ever-increasing expense. Facing these constantly increasing treatment and disposal costs and having the desire to remain a good corporate neighbor has forced the food industry to investigate alternate technologies for the reduction of waste.

The best approach to dealing with waste, in any form, is to establish an effective waste management program. A waste management plan should first investigate methodologies which can eliminate or reduce waste at its source, then recovery/recycle options, and finally treatment. These investigations may reveal new profit sources as well as waste reduction opportunities, for it is often possible to turn a “waste” into a new product. A waste-management plan can not only increase profits but also reduce the liability of violating environmental regulations.

Waste Disposal Regulations Have Costly Impact

Direct Dischargers. The managers of food processing plants discharging directly to the waters of the United States have found increasing restrictions with every permit renewal. Concerns about the discharge of nutrients such as nitrogenous compounds and phosphorus compounds which are common in foods have led to the need for advanced tertiary treatment systems to help protect water quality in the receiving water bodies. Requirements for aquatic toxicity testing may impose even more rigorous and costly treatment schemes. As the degree of treatment required is increased, so is the removal rate of pollutants and the rate of generation of sludges and treatment residuals. With landfills being closed to these residues, more costly disposal practices must be adopted.

MunicinalDischarpers. Carawan[1] reported that 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 were noted as imposing increasingly stringent restrictions on waste discharges to Publicly Owned Treatment Works (POTWs), with many food processors finding pretreatment technology adequate to comply with municipal restrictions prohibitively expensive.

the enactment and enforcement of sewer use ordinances, pretreatment ordinances, and surcharges were reported as threatening the economic viability of some food processing plants. Growing water supply and waste disposal costs will continue to take larger and larger amounts of all food processors' profits.

Only consistent and strong advocacy from top management can guarantee successful efforts to control 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.

Pollution Prevention Pays Concept Can Reduce Waste Costs

Joseph T. Ling[2] 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.

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 residues; 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 accrue to companies which seek more realistic and effective solutions to pollution through conservation-oriented technology.

Whether managers must act to comply with increased 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.

Food Industry Must Change Attitude About Water Use

Water is becoming in 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 the availability of such.

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 or 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 focal 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,[1]

*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.

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 other, 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 5 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 $0.002 per gallon for water use including production andprocessing. 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 consumer will pay, so how would such surcharges affect food industry profits and the availability of food products?

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, 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.

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 for large food plants 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 and those containing cooper, zinc, chrome, or chloride may require additional pretreatment.

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

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.

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

Five studies included a fluid milk plant (MILK)", a multiproduct dairy plant (DAIRY)[4], another set of changes at the same dairy plant (DAIRY II[5], a fisheries plant (FISH)[6], and a beef slaughter plant (BEEF)'. The potential reduction in waste load for these studies varied from 60,000 to 320,000 pounds of BOD_5 per year. (Table I) 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 ($0.40 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 FISH had increased costs exceeding this level (Table II) .

As FISH is in a coastal area and wastewater treatment costs will be more than for many other locations, savings of $3,589 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 BEEF to $3,589 per thousand pounds of BOD_5 reduction at FISH.

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 (DAF) 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 (Table III). Thus water use reductions pay not only by water and sewer cost reductions but also by reducing 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.

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 FISH. The concentration increased to 4,500 mg/l from 2,500 mg/l even though there was a significant reduction in waste load (Table IV). 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 regulatory compliance 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 POTWs with reduction 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.

The Waste Management Plan Begins with a Waste Audit

The successful reduction of waste in a food plant requires a waste management plan. The waste management plan should identify measures to control water use and reduce waste, plan for a waste audit, plan management and employee training, and consider how to make water conservation and waste reduction activities important and continually visible.

Some of the measures to control water **use and reduce waste are listed in** Table V. Each of the measures listed is important, but management commitment is number one in both priority and importance.

What Is A Waste Audit?

The first step to a waste management plan should be a waste audit. In *general,* a waste audit identifies sources, quantities, and various types of waste being generated. It further pinpoints procedures, practices, and operating parameters which have resulted in excess water usage, high waste loads, non-compliance with environmental standards and reduced profitability. The major focus of an audit is to reduce end-of-pipe waste thereby reducing lost product, reducing treatment costs, and increasing revenues. By identifying problem areas through analysis and monitoring, appropriate technologies can be formulated which will provide your company with both short term and long term economic and environmental health.

The first, and by far the most important, step in a waste audit is gaining corporate commitment of time, personnel, and financing. Without this commitment a waste audit and a waste management plan face formidable obstacles. A written corporate policy should be established outlining policies, procedures, and personnel responsibilities for all waste related activities. This will not only allow management and supervisors to understand the company's liabilities but will also send a message to employees that management is serious about waste reduction.

Once corporate commitment has been established, the second step-selection of an audit team-can be implemented. Depending on the size of the facility, the audit can be done by a single person or a team and can be performed in-house or by a private consulting firm. The team approach is felt to be superior, as it allows for a broader range of knowledge, expertise, and perception; however, the in-house team approach may save on the "learning curve" time that would be required with a consultant. No matter which approach is taken, the team should be selected by a leader who is technically competent, comfortable with the position, and has been given the authority to get the job done.

The team should be composed of personnel from management, facilities/environmental engineering, purchasing/shipping, finance, quality control, safety, the process line, and the cleanup crew. All team members should be treated as equals with all ideas and concerns being heard and evaluated.

The third step of the waste audit is the compilation of background data. This data will help to provide an understanding of why and how wastes are generated. Data collected should include the following:

* cost and quantities of raw materials purchased
* water usage and cost
* effluent generated and treatment cost
* solid waste generated and disposal cost
* type and quantity of product stored and produced
* environmental permit requirements
* chemicals stored and used for processing and cleaning
* location of all floor and storm drains
* operating schedules
* plant schematic and flow diagrams
* air emissions data

Possible sources for this information include but are not limited to plant blueprints, operating schedules, shipping and receiving invoices, utility bills, operating and maintenance (O&M) manuals, monitoring records, Material Safety Data Sheets (MSDS), etc. Additionally, a listing of all known waste streams should be compiled, in tabular form, and should include the location, concentration and quantity of the waste being generated.

With background data in usable form it is now time to put it in visual form by constructing a flow diagram of the facility, process by process. This diagram should indicate all inputs and outputs for each process. Process flow should be delineated from waste streams and all recycle and makeup activities should be indicated. All inputs and outputs should be labeled as to concentration and quantity. This process serves several purposes: it provides a visual expression of the compiled data which can provide an initial idea of high waste areas, it identifies data gaps, and it identifies process handling areas that are causing or have the potential for causing problems.

Once the flow diagram has been constructed and monitoring/sampling has been instituted to fill data gaps, it is time for the audit team to perform an in-plant survey. As the name implies, the team will actually go into the facility and observe all daily activities from receiving to cleanup. If a variety of products is run, the survey should be conducted on a representative sample for all products. The in-plant survey will help to verify background data, will allow the team to discuss plant operations with the employees, will give the team an opportunity to search for additional waste streams, and will provide an opportunity to evaluate housekeeping and O&M practices.

Monitoring/sampling that is being conducted in conjunction with the in-plant survey should be continued over a period long enough to provide representative data reflecting peaks and lulls in processing. Water usage should be monitored in such a manner as to determine usage by shift, by process and/or by product.

Step four of the audit is a materials balance. Inputs and outputs should be balanced for each and every process. This will pinpoint areas of extreme waste generation and water usage as well as quantify the wastage. Additionally, a materials balance should be conducted for the facility as a whole to determine procedures which are conducive to waste production, to identify cleaners/disinfectants which add to the waste load and to establish levels of stored chemicals which result in permit reporting requirements, etc.

Step five entails economic and technical evaluations of water usage and waste reduction alternatives. Each alternative should be evaluated for economic and environmental merit. All cost analyses should be performed on a life-cycle basis. This will help to determine the initial benefits as well as the long-term benefits of an alternative and help to determine the pay-back period. All economic and environmental considerations should be analyzed. For example, when considering substitute chemicals or cleaners, analysis should be performed to assure that one waste product is not being substituted for another.

Before implementing expensive process modifications or installing new equipment, simple approaches to waste reduction should be put into place. Such things as improved housekeeping procedures (dry cleanup measures, recovery activities, high pressure hoses- t o mention a few), more frequent maintenance practices, and improved operational procedures should be instituted. These activities may buy some breathing room and allow for an easier implementation of more expensive alternatives.

The final step to the waste audit program, employee training, is second in importance only to establishing a written corporate policy. Until employees understand that they can have a dramatic impact on waste reduction in the plant and ultimately on the environment, wasteful practices will continue. Cases show that once employees understand that proper waste management really is important to the management, to their jobs, and to the quality of the environment, they become eager program participants. Training is therefore essential to a successful waste management program. Training should begin with the top manager and work down through the ranks. Each and every employee should receive training on ways they can reduce waste. Training should be repeated on a regular basis to prevent backsliding, and all new employees should be put through the training program.

Some companies have found that an incentive or awards program goes a long way toward keeping enthusiasm for waste management at a peak. Offering simple but visible rewards for waste reduction ideas or having financial rewards for ideas have both worked. The old "ATTA BOY" with a visible sign of a job well done does, however, seem to be the most well received and appreciated program.

Successful Strategies Focus on Employee Involvement

Approaching waste reduction in food plants successfully involves management and employee commitment, understanding, motivation, and continuing action to work. Some strategies appear to be more successful than others. Canned approaches telling everyone what to do often fail. Much more successful are approaches that stimulate the interest of managers and employees in a continuing program with water use and reduction goals that are achievable and continually monitored. Several approaches that have worked for food plants are given in Table VI. Carawan and Stengel[g] have reported on a successful program in a dairy and soft drink plant.

Conclusions and Recommendations

The studies summarized in this paper and others [10, 11] each have provided evidence that water use and waste programs may be not only environmentally sound but profitable. Carawan and Merka [12] concluded that the United States broiler industry could save as much as $60 million if all plants participated in such a program.

Water use and waste load reductions are often inseparable. Saving water usually saves on wastewater and the benefits are substantial for food plants.

Carawan and Merka [13] reviewed the value of water conservation for poultry processors. Carawan and Sheldon [14] have reported on studies to recycle water in poultry processing.

Management understanding and support are the most critical factors in saving water and preventing waste in food plants. Management and employee training probably is the most vital factor in any successful program.

Even though these studies have all been with food processing plants, the waste reduction strategies would be useful to any industrial facility. Further, the savings shown for the adoption of a successful waste audit and water and waste management program would also be applicable. In fact, pollution prevention does pay, not only for the industry involved but for the public at large as we guard one of our most precious resources, our water.

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Table I

Pollution Prevention Potential

Study	Pollution Prevention (Pounds of BOD_5 year)
MILK	226,400
DAIRY	320,000
DAIRY-II	320,000
FISH	250,000
BEEF	60,000

Table II

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

Study	Increased Cost / Waste Reduction	Initial Cost / Waste Reduction	Savings / Waste Reduction
	($/1,000 lb BOD_5)		
MILK	333	737	270
DAIRY	347	645	1,062
DAIRY-II	109	167	945
FISH	1,243	1,260	3,589
BEEF	99	75	13

Table III

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

Water Use (GPB)[b]	cost
3	$335,000
8	480,000

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

Table IV

Estimated or Measured BOD_5 for Food Plants Studied

Study	Products Processed	BOD_5 Before Changes MG/L	BOD_5 After Changes MG/L
MILK	Milk/Drinks	1,800	1,200
DAIRY	Multiproduct	2,900	1,900
DAIRY-II	Multiproduct	2,400	1,900
FISH	Menhaden-Surimi	2,500	4,500
BEEF	Beef	2,543	610

Table V

Measures to Control Water Use, Product Loss, and Water Load

No.	Measure
1.	Management understanding, interest, and support
2.	Installation of modern processes, equipment, and piping to reduce loss of product to sewers and to minimize water used
3.	Appointment of waster use/water control supervisor
4.	Employee training
5.	Accurate records of waste use and waste
6.	Scheduling to reduce water use and waste
7.	Proper and efficient cleaning procedures
8.	Wastewater monitoring
9.	Planned maintenance program to reduce water use, losses, and waste
10.	Planned quality control program to reduce losses and waste
11.	Systems to recover wasted or undesired parts of product
12.	Developing of alternative uses for wastes or undesired product recovered
13.	Installation of processes that can recover lost product from the wastewater stream

Table VI Special Approaches

No.	Approach
1.	Photograph (slides areas where excessive waste is evident and discuss reasons and ways to reduce
2.	Take videotapes of processes, observe waste and obtain employee suggestions for eliminating losses
3.	Arrange in-plant demonstrations of strategies that have worked in other plants
4.	Encourage one process line to show how good they can be
5.	Provide hats or shirts with slogans or logos to enhance awareness and maintain interest
6.	Provide financial awards for waste reduction suggestions
7.	Plan employee training sessions and solicit ideas