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For Efficient Dairy Plant Operation

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SOME ASPECTS OF DAIRY PLANT EFFLUENT TREATMENT

This bulletin includes technical and latest development on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information on different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue is **Some Aspects of Dairy Plant Effluent Treatment**. It may be understood that the information given here is by no means complete.

In this issue:

- ***Introduction***
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- ***Primary Treatment***
- ***Secondary Treatment***
- ***Reducing Pollution Load***

1. INTRODUCTION

Effluents generated from dairy processing facilities can present difficult treatment problems because they contain large amount of carbohydrates, protein, fat and mineral salts. The effluent can produce distinct odours and heavy pollution of water if the discharge is not properly treated. Organic matter of these wastes must be treated by biological stabilization process before it is discharged into a body of water. Improper waste disposal is a hazard to humans and to aquatic life.

Consider the following:

* The organic matter in the effluent provides a food source for rapid microbial growth, with a result in reducing the dissolved oxygen contained in the water. Water normally contains approximately 8 parts per million (ppm) of dissolved oxygen. A minimum standard for fish life is 5 ppm of dissolved oxygen, below which fish can suffocate.
* Further, such a system would be unsuitable as a source of potable water.
* Milk proteins, solution of detergents and some sanitizers contribute to the phosphorous and nitrogen load of the effluent. Both elements promote unwanted growth of algae in lakes and slow-running waters.
* Surfactant present in the effluent tend to form a foam on water surfaces, thus impeding the uptake of oxygen into water. As a result of low oxygen concentration in water, fish may die. Therefore, surfactants must be biodegradable.

Therefore, there is increasing demand by regulatory authorities and the public for better effluent treatment by industry. Processors and regulatory authorities are responsible for the disposal of waste materials promptly and completely. Accumulation of effluent even for short periods of time, can attract insect and rodents, produce odours, and become a public nuisance.

Several factors, such as quantity, pollutant strength and nature of constituents of effluent have both economic and environmental consequences concerning treatability and disposal. Significant characteristics that determine the cost for effluent treatment are the relative strength of the effluent and the daily volume of discharge. Table 1 provides general characteristics of dairy plant effluent[(1)].

Table 1: Usual characteristics of untreated dairy effluent

Index	Average value
Specific quantity of effluent, (m^3/tonne[a])	1-2
Specific BOD_5, (kg/tonne[a])	0.8-2.5
BOD_5, (mg/l)	500-2000
COD / BOD_5	1.3-2.2
Phosphorous total, (mg/l)	10-100
Suspended solids total (SS), (mg/l)	100-1000
pH	2-12
Temperature, (^oC)	25-35

a. tonnes processed milk

Spent cleaning compounds and sanitizers are discharged into waste treatment facilities. The toxicity of sanitizers, if present in high concentration, can inhibit biodegradable process.

The major concerns for treatment of this effluent are pH fluctuations and possible long term exposure to trace heavy metals. However, these effects can be controlled and waste minimized through appropriate plant design and optimal concentration use of cleaning compounds and sanitizers.

An optimum waste management programme would include waste prevention techniques and utilization of waste products, pretreatment, primary treatment, secondary treatment, tertiary treatment, if necessary, and disposal of treated effluent.

This issue of Technews covers only some important aspects of dairy plant effluent and its treatment and does not detail the treatment processes and plants.

2. PRETREATMENT

Pretreatment may include coarse and fine screening, hydraulic and load balancing (flow equalization), skimming and pH control.

Screening: Screening is designed to remove suspended particles from the effluent, in order to protect the remainder of the treatment plant from damage by gross solids and to protect subsequent treatment stages from solids overload. Screening might be done in two stages: coarse screening, to remove solids of 20 mm size and above; and fine screening, to remove solids of size 0.25 mm and above.

Coarse screens could be either static or mechanically raked. In either case it is important that the velocity of the flow through the chamber is between 0.3 m per second to 0.8 m per second. Fine screens, installed after coarse ones, can be static, brushed or rotating drum screens (not used where there are high levels of fat). Provision should be made for the high-pressure or steam-cleaning of fine screens.

Flow Equalization: Biological treatment processes operate best under constant and consistent organic load. It is therefore essential that adequate provision is made for balancing both pollution load and flows. This is done in an equalization tank. This unit is characterized by a varying flow into and a constant flow from the tank. Equalization tanks can be lagoons, steel construction tanks, or concrete tanks, often without a cover. Consideration should be given to mixing and aerating the contents where the potential for biodegradation of the waste exists.

Skimming: This process is frequently incorporated if large floatable solids are present. These solids are collected and transferred into some disposal unit. Separation of solids is frequently increased by the addition of lime and alum, ferric chloride ($FeCL_3$), or a selected polymer. Paddle flocculation may follow the addition of flocculant.

pH Control: Control of pH is necessary to ensure that the effluent does not damage the structure, equipment or pipe work. pH values above 11 and below 5 may cause damage in some types of biological effluent treatment plants. Effluent with pH below 6 may attack concrete used in the system. Further, most biological processes operate best within the pH range 6.5 – 8.5 and with constant pH even outside this range. It is usually recommended to neutralize the effluent to pH values within the limits of 6-9 prior to treatment.

The pH is controlled by dosing hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3) or carbon dioxide. It should be remembered that a sulphate concentration in excess of 1000 mg/l will attack concrete unless it is sulphate resistant(2). Hence care must be taken during neutralization, especially if H_2SO_4 is used. For CO_2, flue gases can be used, or a separate CO_2 supply can be arranged. Using CO_2 in place of strong mineral acids has several benefits(3): it is cost saving, it is safer and easier to store, it allows precise control of pH, it is non-corrosive.

Nutrient Balancing: Biological treatment processes can be inhibited if the balance of available nutrients is insufficient for the microbes to break down the organic matter in an efficient manner. Dairy effluent may have an excess of phosphorous and a deficiency of nitrogen or potassium. Generally, the ratio between biochemical oxygen demand (BOD), nitrogen and phosphorous should be 100:5:1 to facilitate microbial breakdown(1).

Nutrient deficiency can be overcome by adding urea (or other source of nitrogen) and phosphoric acid. It is important that the available nitrogen and phosphorous are measured at the entry to the biological treatment and not prior to other physical/chemical processes.

3. PRIMARY TREATMENT

The main purpose of primary treatment is to remove particles from the effluent. Sedimentation and flotation techniques are commonly used.

Sedimentation: Grit particles like sand, gravels, clay etc. generally enter the waste stream from the truck– and tank–washing area or through the corrosion of concrete and paved surfaces. If allowed to pass through the process, it can cause serious damage to pumps and other equipment and, with sludge, can cause pipe clogging.

Flotation: In this process, fat, oil, grease (FOG) and other suspended matter are removed from effluent. This process is effective in removing FOG from effluent.

Many small plants still prefer static grease traps designed on the basis of flow. A retention time of about 30 minutes or more is provided and the accumulated FOG is removed manually. Biological dosing system can be used with good effect in degrading FOG, but may be inactivated on inhibited by cleaning chemicals. There are however Grease Digesters which combine the attributes of grease traps and dosing systems. The combined system separates FOG accumulation and biodegradation. The FOG – degrading bacteria are self-regenerating and are not inactivated by cleaning chemicals[4]. The main problem in this system is the possibility of accumulated FOG being subjected to higher temperature and becoming emulsified. Recently, dissolved air flotation (DAF), which removes suspended matter by using small air bubbles, has become more popular (Fig 1).

Fig 1: Dissolved air flotation (DAF)

Typical design parameters for a DAF unit are[1]:
* Upward flow velocity: upto 7.2 m per h
* volumetric retention time at maximum inflow: 20-30 minutes
* recycle rate: 20-35% of inflow
* air/solid ratio: 0.005-0.05 kg air per kg solid to be removed.

Flocculating agents are commonly used to pretreat effluent prior to treatment by a DAF unit. This system can remove more than 50% of the chemical oxygen demand (COD) load. The technique requires high investment and operating costs.

DAF systems maintain a concentration of bacteria that are kept alive within the system to biodegrade pollutants in the effluent.

The high costs of the system can be offset by selling the collected FOG to renderers for secondary applications, and reusing in some plant operations the treated effluent after it has been run through filtration and disinfecting processes.

4. SECONDARY TREATMENT

The primary purpose of secondary treatment is to continue the removal of organic matter and to produce an effluent low in BOD and suspended solids (SS). This may include biological treatment to degrade the dissolved organic matter and chemical treatment to remove phosphorous and nitrogen or to aid in the flocculation of solids.

Biological treatment processes can be aerobic (activated sludge and trickling filters or biological filtration) or anaerobic.

Activated Sludge: This process is widely used. Its operating principle is shown in Fig 2.

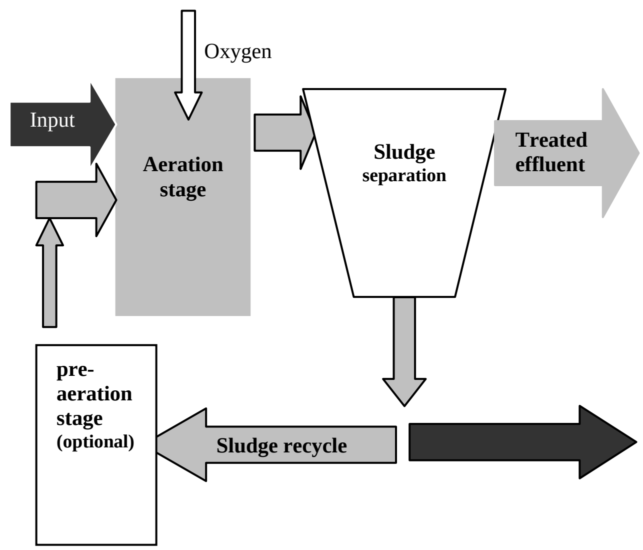

Fig 2 : Basic activated sludge process

Primary treatment is optional. It is very effective for the removal of all organic matters in the effluent. Several configurations of aeration tank have become popular in the treatment of dairy effluent. Some modified activated sludge plants have high BOD removal efficiency (95 to 98%). The sequencing batch reactor (SBR) is a relatively recent variation of the activated sludge system, that accommodates the entire process in a single tank but at different times, with steps including filling, aerating, settling, drawing off floating scum and removing treated effluent[5].

Biological Filtration: Biological or trickling filters reduce BOD and SS by bacterial action and biological oxidation as effluent passes in a thin layer over stationary media (usually rocks) arranged above an over-drain. Primary treatment should precede this process if the effluent suspended solids concentration exceeds 100 mg/l[6].

A very common form of biofilter used in the treatment of dairy effluent is the high-rate biofilter. The media, usually in the form of opern-textured plastic, can be either random pack or modular. High-rate biofilters are normally loaded above 0.6 kg BOD / cubic m and generally remove 50-70% of the applied BOD[1].

The effluent is distributed over the media surface at a minimum flow rate of 1.5 cubic m per sq. m plan area per hour. This ensures that no clogging of the media occurs and discourages insect life.

The important parameters in the operation of a biofilter are[1]:

- loading rate – is it essential to maintain the loading rate to ensure that the filter media do not get clogged.
- fats and grease – the presence of FOG in concentration above 50 mg/l can result in the coating of the biological film; this can lead to uncontrolled anaerobic activity and significant odours in extreme cases.
- BOD applied – excessive loading rates (shock loads) can result in clogging of the media; prolonged BOD loading can give rise to odour problems.
- pH – adequate control of pH is required to maintain the efficiency of the biofilter and to prevent damage to the media and support structure.
- temperature – reduced efficiency will occur if the temperature within the biofilter drops below 8^0C.

The outflow from high-rate biological filters is usually not of sufficiently high quality and needs further treatment, such as in activated sludge system.

5. REDUCING POLLUTION LOAD

Effluent treatment and disposal are both costly. Moreover, products, chemicals and other materials contributing to effluent pollution are also expensive. Hence, dairy plants should aim to minimize the pollution load in the raw effluent. Some measures to reduce products loss were suggested in Technews Issues 40 and 41 (Sept-Oct and Nov-Dec 2002). Additionally, following steps may help in reducing pollution of effluent.

Equipment

- Ensure that flow and transportation of raw materials and products is by as short a path as possible, in order to minimize the adherence of residues.
- All plants should be easy to clean. Avoid dead spaces, which require additional cleaning and disinfecting.
- Ensure, by automatic control of the flow paths, that there is no cross-contamination between the products and the cleaning and disinfection chemicals.

.**1 F Oxamyl**Ensure that raw materials, products, additives and
Production

- Ensure that raw materials, products, additives and auxiliary chemicals are not lost by splashing, leaking valves or pipe connections, or overflowing containers.
- Optimize operations with the aim of minimizing the residues deposited on product-contacting surfaces, e.g. preheating in the production of UHT and concentrated milk reduces the deposits on heat-exchange surfaces.
- Try to utilize whey, e.g. by producing dried whey powder for suitable uses.
- Never discharge centrifugal sludge into the effluent.

Hygienic operations

- Remove product residues from product-contacting surfaces, e.g. by blowing out with filtered compressed air or rinsing with a small volume of water or, for cream residues, rinsing with warmed skim milk, which makes it easier to regain and use the cream that is rinsed off.

- Avoid unnecessary dilution of chemical solutions with rinsing water, which increases the consumption of detergents or sanitizers.
- Use mixed detergents instead of pure chemicals. Suitable additives can markedly improve the efficiency of alkalis and acids in many cases. As a result, the chemical pollution of the effluent by solutions of no further use is decreased.
- Regenerate used cleaning solutions by sedimentation, centrifugation or membrane filtration techniques in order to extend their useful life whenever practical. The sludge may be disposed of or utilized for biogas production.
- Disinfect closed systems by heating instead of applying chemicals, if it is safe and the consumption of energy seems acceptable.
- Avoid using chemicals that are dangerous to aquatic systems or may disturb effluent treatment. If in doubt, consult the producer or the distributor of the detergent/sanitizer.

Conditioning of water and effluent

- Reduce the water hardness only as far as necessary for the intended use. Water-softening should be done by ion exchange or reverse osmosis. Other physical methods cannot be recommended since, to date, too little is known about their effectiveness.
- Use as much condensate from evaporators as possible in order to reduce water hardness, but do not overlook possible microbiological risks.
- Neutralize the surplus alkalis from cleaning agents by using carbon dioxide or boiler-flue gas but not mineral acids. This reduces inorganic pollution of the wastewater. Further advantages of utilizing boiler-flue gas are less sulphuric dioxide exhaust and low running costs. However, special installations are required.

With efficient pollution reduction measures, the aim should be to reduce the BOD of the raw effluent to less than 200 mg/l of milk.

	References:
1.	Byrne, R.J. (2003). Design and operation of dairy effluent treatment plants, in **Encyclopedia of Dairy Science**, Vol. 2, Eds. H. Roginski, J.W. Fuquay and P.F. Fox, Academic Press, London, 733-743
2.	Anonymous (1980). **Guide for Dairy Mangers on Wastage Prevention in Dairy Plants**, IDF Bulletin No.124, 5-6
3.	Anonymous (1998). Gas ends acid reign, **Dairy Industries International**, December, 39
4.	Burton, C. (1997). FOG clearance, **Dairy Industries International**, December, 41
5.	Gregerson, J. (2001). Waste not. **Food Engineering**, May, 46-50
6.	Marriott, N.G. (1999). **Principles of Food Sanitation**, Aspen Publishers, Maryland, 187-206

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