

**An overview of wastes discharges**  
**from dairy plants**  
**and Wastewater discharges form milk**  
**reception dock**

# INTRODUCTION

The dairy industry involves processing raw milk into products such as consumer milk, butter, cheese, yogurt, condensed milk, dried milk (milk powder), and ice cream, using processes such as chilling, pasteurization, and homogenization. Typical by-products include buttermilk, whey, and their derivatives. Dairy industries have shown tremendous growth in size and number in most countries of the world. These industries discharge wastewater which is characterized by high chemical oxygen demand, biological oxygen demand, nutrients, and organic and inorganic contents. Such wastewaters, if discharged without proper treatment, severely pollute receiving water bodies.

# DAIRY PROCESSING

**Dairy processing plants can be divided into two categories:**

- **Fluid milk processing involving the pasteurization and processing of raw milk into liquid milk for direct consumption, as well as cream, flavored milk, and fermented products such as buttermilk and yogurt.**
- **Industrial milk processing involving the pasteurization and processing of raw milk into value-added dairy products such as cheese and casein, butter and other milk fats, milk powder and condensed milk, whey powder and other dairy ingredients, and ice cream and other frozen dairy products.**

# DAIRY PROCESSING ACTIVITIES

- **Raw Milk Collection, Reception and Storage**
- **Separation and Standardization**
- **Homogenization**
- **Heat Treatment and Cooling of Milk Products**
- **Milk and Dairy Product Production**
  - **Milk production**
  - **Cheese production**
  - **Butter production**
  - **Milk powder production**
- **Packaging of Milk and Dairy Products**

# SOURCES OF WASTEWATER

## DAIRY PROCESS

### Preparation stages

- 1) Milk receiving/storage
- 2) Pasteurization/Ultra heat treatment

## SOURCES OF WASTE

- ⦿ Poor drainage of tankers
- ⦿ Spills and leaks from pipes
- ⦿ Foaming
- ⦿ Spills from storage tanks
- ⦿ Cleaning operations
- ⦿ Liquid losses
- ⦿ Foaming
- ⦿ Recovery of downgraded product
- ⦿ Cleaning operations
- ⦿ Deposits on surface of heating equipment.

### 3) Homogenisation

- ◉ Liquid losses/leaks
- ◉ Cleaning operations
- ◉ Foaming
- ◉ Pipe leaks

### 4) Separation/Clarification

## Product Processing Stage

### 5) Market milk

- ◉ Product washing
- ◉ Sludge removal from clarifier
- ◉ Damaged milk packages
- ◉ Overfilling
- ◉ Poor drainage
- ◉ Cleaning of filling machinery
- ◉ Leaks
- ◉ Cleaning operations

## 6) Cheese Making

- Overfilling vats
- Incomplete separation of whey from curd
- Using salt in cheese making
- Product washing
- Vacreation( reduced pressure pasteurization using steam) and salt use.

## 7) Butter Making

## 8) Milk powder manufacture

- Spills of powder handling
- Start up and shut down losses
- Plant malfunction
- Stack losses
- Cleaning of evaporators and driers
- Bagging losses

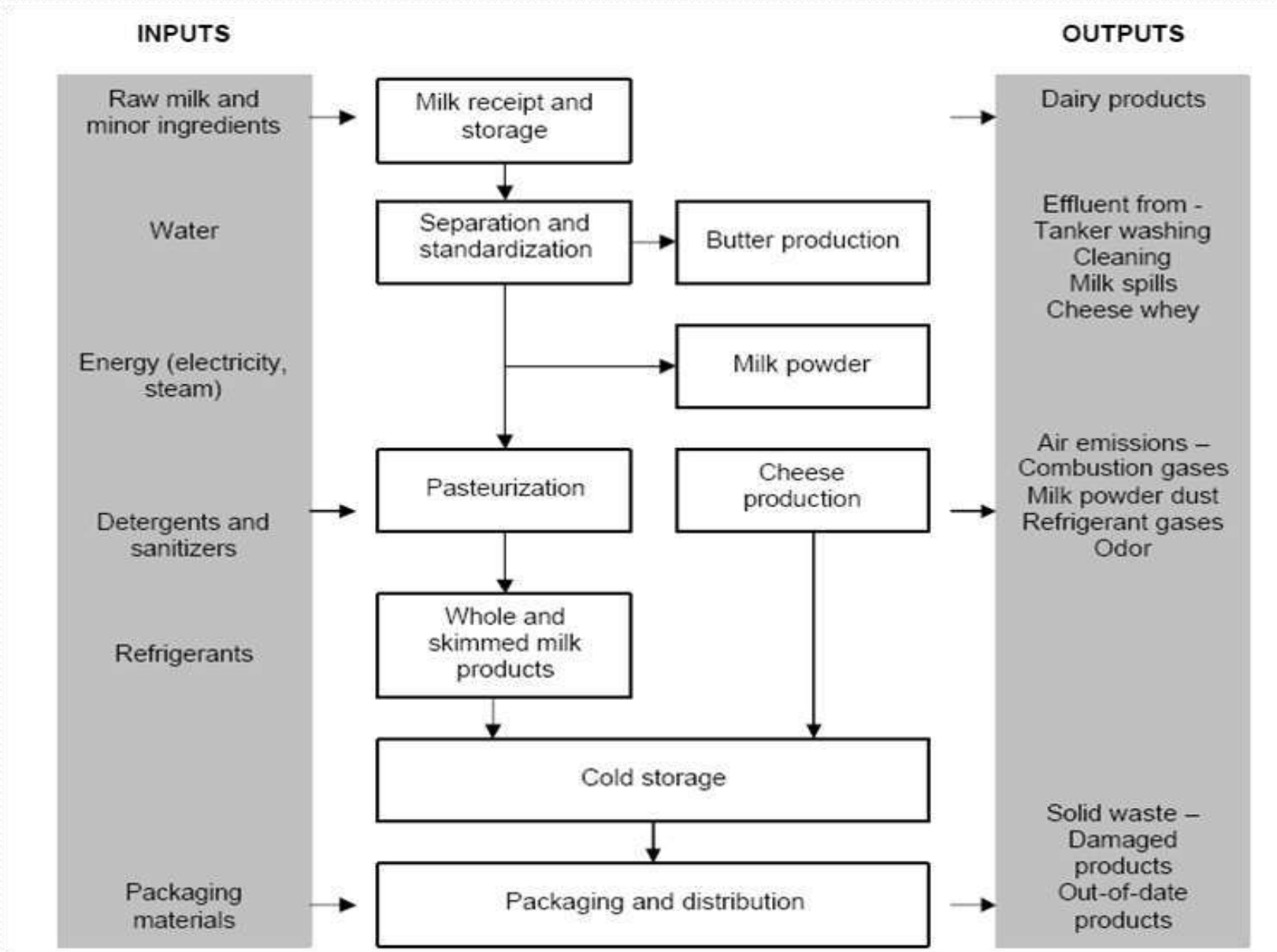
# PACKAGING OF MILK AND DAIRY PRODUCTS

- Packaging protects the product from bacteriological, light, and oxygencontamination.
- Liquid milk products may be packed in a beverage carton, which is mainly paperboard covered by a thin layer of food-grade polyethylene on eitherside.
- Milk cartons for long-life milk have an additional layer of aluminum foil.
- Many other packaging materials are also used, ranging from simple plastic pouches to glass bottles, PET laminates and PVC bottles.





# FLOW CHART OF DAIRY PROCESSING ACTIVITIES

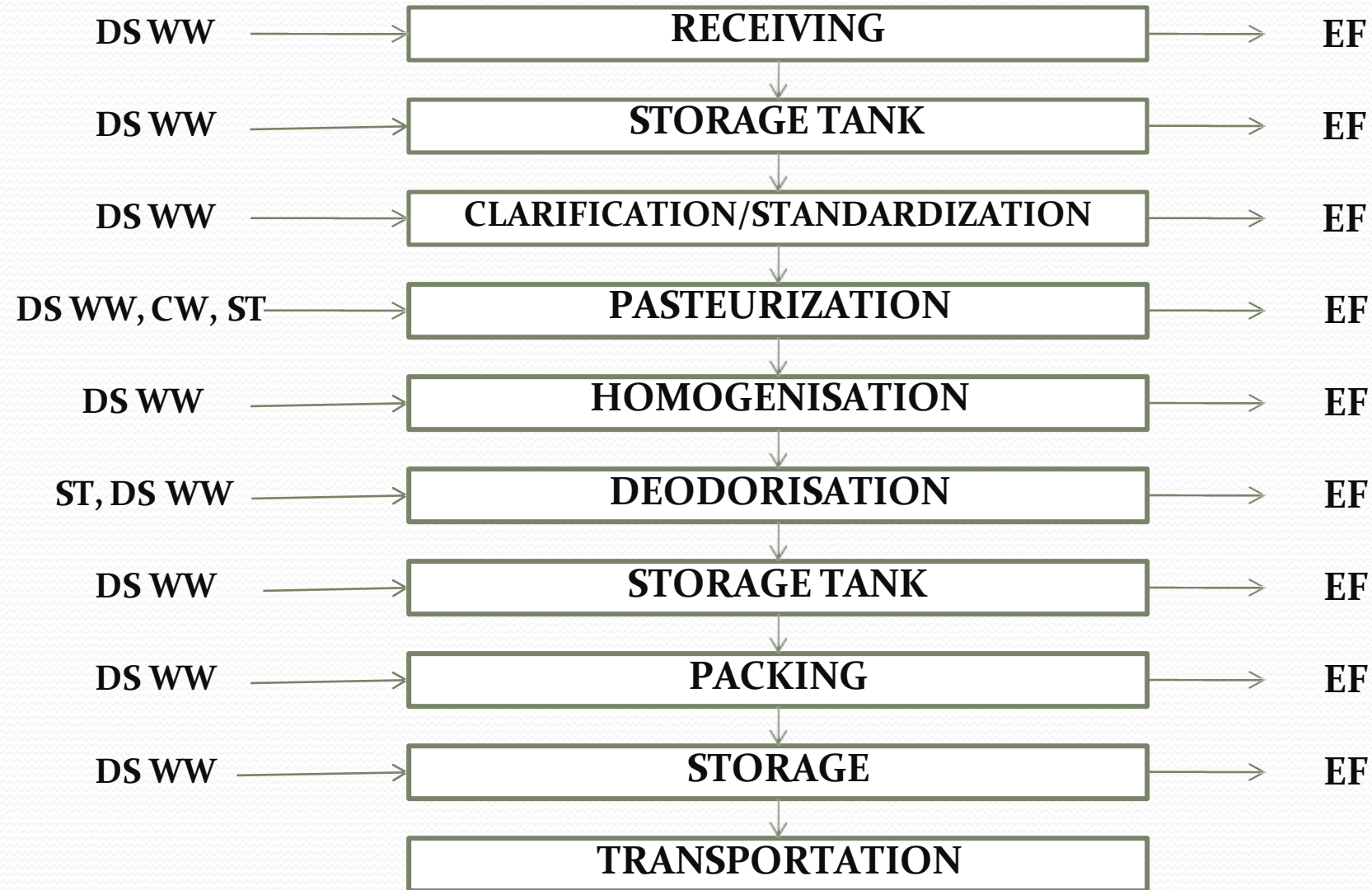


# WASTEWATER GENERATION

- **The dairy industry is one of the most polluting of industries, not only in terms of the volume of effluent generated, but also in terms of its characteristics as well.**
- **A chain of operations involving receiving and storing of raw materials, processing of raw materials into finished products, packaging and storing of finished products, and a group of other ancillary operations (e.g., heat transfer and cleaning) will produce wastewater.**

# EFFLUENT GENERATION FROM VARIOUS UNITS OF MILK PROCESSING.

## PROCESS



DS-Detergents and Sanitizing Agents, WW-Wash Water, ST-Steam, CW-Cooling Water.

# CHARACTERISTICS OF WASTEWATER

- **Dairy wastewater contains milk solids, detergents, sanitizers, milk wastes, and cleaning water.**
- **It is characterized by high concentrations of nutrients, and organic and inorganic contents.**
- **Salting activities during cheese production may result in high salinity levels.**
- **Wastewater may also contain acids, alkali with a number of active ingredients, and disinfectants, as well as a significant microbiological load, pathogenic viruses, and bacteria.**
- **Other wastewater streams include cooling water from utilities, storm water, and sanitary sewage.**

# CHARACTERISTICS OF WASTEWATER

Parameters	UNITS	GUIDELINE VALUE
pH	-	4-12
Suspended solids	mg/l	24-5700
BOD <sub>5</sub>	mg/l	450-4,790
COD	mg/l	80 - 95000
Total nitrogen	mg/l	15-180
Total phosphorus	mg/l	11-160
Oil and grease	mg/l	10
Total coliform bacteria	Mpn/100ml	400
Magnesium	mg/l	25-49
Potassium	mg/l	11-160
Chloride	mg/l	48-469
Calcium	mg/l	57-112



- Dairy generates 800 m<sup>3</sup>/day waste water effluent
- Waste water sources are spilled milk, spoiled milk, wash water from bottles/ equipment/ plant, spillage & leakage from pumps
- The waste water effluent & treated water characteristics from ETP at 27<sup>0</sup>C (Source: Ecosystem India; Primary Survey)



Parameters	pH	BOD	COD	TSS	TDS	Oil & Grease
Unit	-	[mg/ liter]	[mg/ liter]	[mg/ liter]	[mg/ liter]	[mg/ liter]
Effluent	5.9 to 7.5	1200-1600	3500-4500	300-600	800-1200	150-400
Treated water	6.5 - 8.5	< 30	< 100	< 100	< 800	< 10
Efficiency [%]	-	97.85	97.5	77.8	-	93.3

**Comments:** (i) Effluent COD is high (~COD 2400 mg/l)  
(ii) Disposal of oil & grease from Fat Separation Tank is a limitation

## **EFFECTS WHEN WASTEWATER DISCHARGED TO LAND**

- **Dissolved salts contained in dairy plant wastewater can adversely affect soil structure if wastewater is used to irrigate land.**
- **Wastewater can also leach into underlying groundwater and affect its quality.**
- **High salt levels affect the type of vegetation that grow.**
- **Over-irrigation may cause the underlying water table to rise, resulting in further deterioration of surface soils and vegetation.**

# EFFECTS WHEN WASTEWATER DISCHARGED TO SEWER

- The volume and organic load of wastewater from just one dairy factory during peak season may well exceed the township's domestic waste.
- This may overload the sewage treatment plant, cause odors and give rise to poor effluent quality.
- Domestic wastewaters have a BOD<sub>5</sub> concentration of about 250 to 300 mg/L but in peak season a large dairy factory could be discharging two mega liters of wastewater at BOD<sub>5</sub> of 2,000 mg/L each day – the additional load on a sewerage plant is equivalent to an extra 16,000 persons which is very difficult to treat.



# WASTE MINIMIZATION

Waste minimization measures may include:

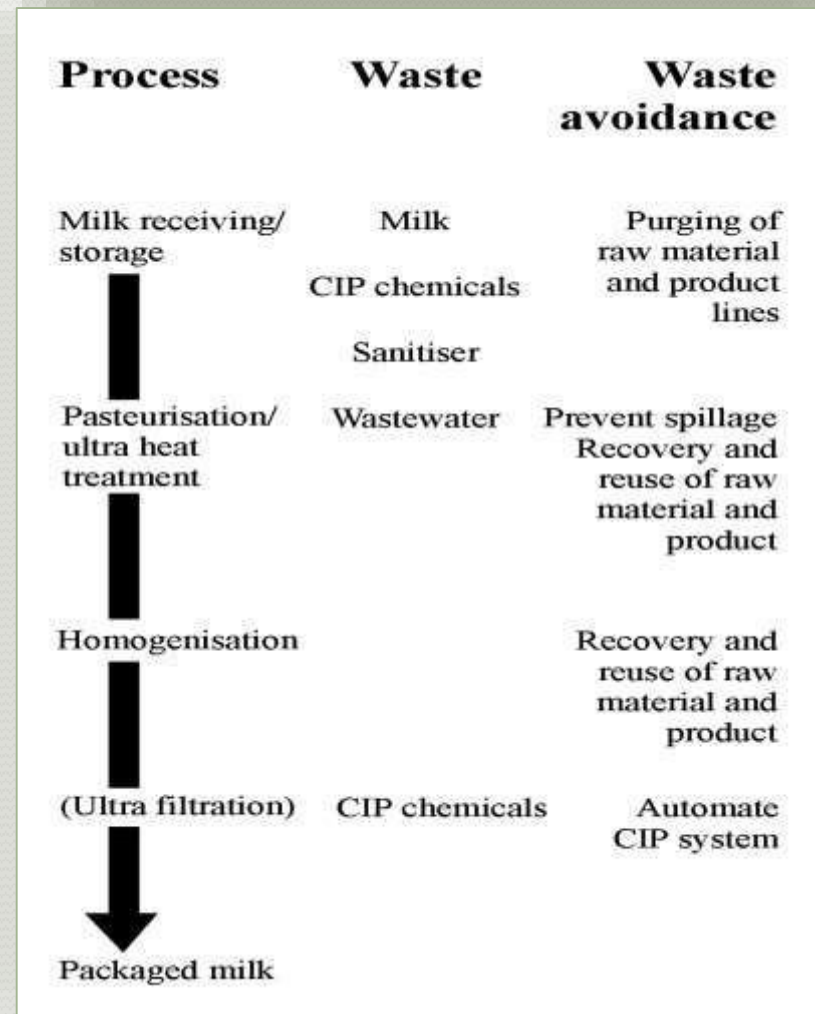
- reducing use of water
- reducing use of chemicals or substitution of mineral salts – for example, potassium in place of sodium compounds
- recycling water and chemicals
- recovery and reuse of product from first reuse
- recovering and reusing spilled raw materials and products.



# AVOIDING WASTE DURING LIQUID MILK PRODUCTION

Liquid milk production may lead to the generation of odour, wastewater, noise and solid waste.

Suggestions for avoiding wastes during liquid milk production are given in Figure.



# AVOIDING WASTE DURING BUTTER PRODUCTION

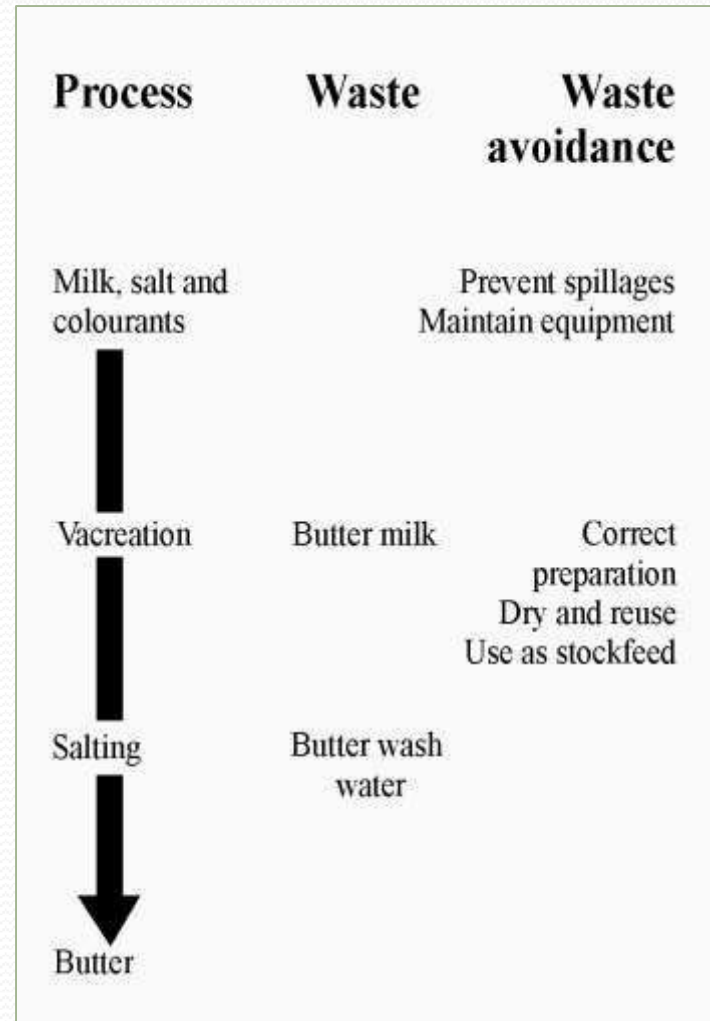
➤ Ways to prevent the build up of surface deposits

include:

- minimisation of surface area
- prevention of build-up of milk stone deposits
- maintenance of butter churns
- correct preparation before filling
- not over-working the batch

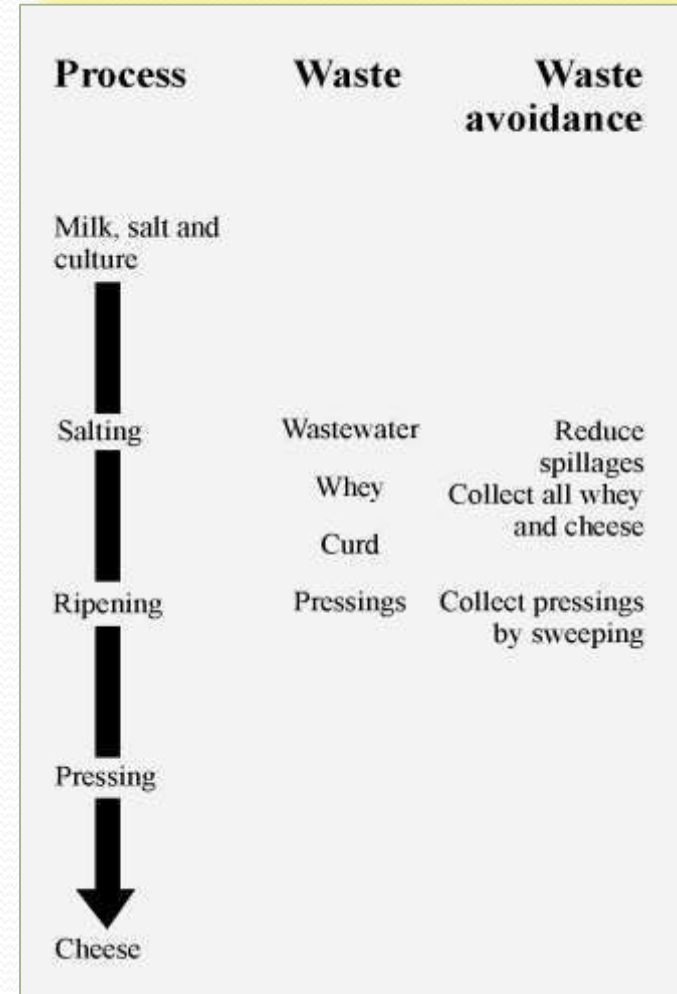
➤ To avoid spills, buttermilk collection facilities should be large enough to hold all buttermilk discharged. Buttermilk should be dried or used as animal feed and solids recovered from butter wash water also may be sold as stock feed.

➤ Suggestions for avoiding wastes during butter production are summarised in Figure .



# AVOIDING WASTE DURING CHEESE PRODUCTION

- Making cheese generates a large volume of by-products such as whey.
- Waste reduction can be achieved by:
  - not overfilling cheese vats to stop curd loss
  - completely removing whey and curds from vats before rinsing
  - segregating all whey drained from cheese
  - sweeping up pressings (particles)
  - screening all liquid streams to collect fines.
- These suggestions are summarised in Figure

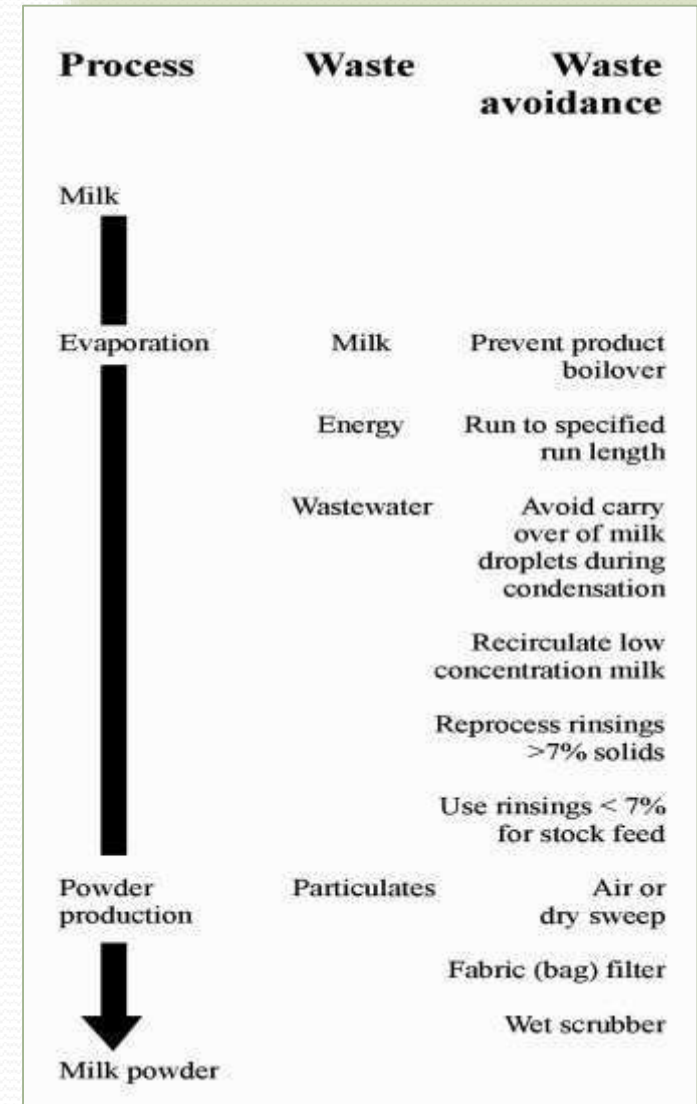




# AVOIDING WASTE DURING MILK POWDER PRODUCTION

It is suggested that evaporators be operated to:

- ❖ maintain a liquid level low enough to stop product boil-over
- ❖ run to specified length – excessively long runs with higher than specified running rates lead to blocked tubes which not only produce high pollution, but are difficult and time consuming to clean
- ❖ Use effluent entrainment separators to avoid carry-over of milk droplets during condensation of evaporated water
- ❖ minimize air emissions by using fabric filters or wet scrubbers.
- ❖ These suggestions are summarized in Figure



# REUSE AND RECYCLE

- Many dairy plants have technologies in place for recovering wastewater and/or for reuse in the dairy plant.
- Reuse and recycling can considerably decrease the volume of mains water required to operate the plant.
- Reuse and recycling reduce the cost of both mains water and wastewater disposal.
- Fats, milk solids and minerals can also be recovered from wastewater and recycled – either at the dairy plant or offsite.
- Cleaning chemicals can also be recovered and reused on site.

# **BY-PRODUCT RECOVERY**

- **A dairy by-product may be defined as a product of commercial value produced today the manufacture of a main product.**
- **In recent years there has been wide spread and increasing interest through out the world in creating newer channels of utilization for the by-products of the dairy industry.**
- **Conversion of edible substances into non-food items is not ordinarily justifiable especially in countries where there is an overall shortage of milk supplies.**
- **It has always been realized that economic disposal of by-products is an essential prerequisite to profitable dairying.**

# DAIRY BY-PRODUCTS

MAIN PRODUCT	BY PRODUCT	PRODUCTS MADE
CREAM	SKIM MILK	Flavored milk
		Sterilized flavored milk
		Cultured Buttermilk
		Concentrated sour skim milk
		Plain and Sweetened Condensed skim milk
		Dried skim milk or Skimmilk powder or Non Fat Dry Milk (NFDM)
		Cottage cheese, edible casein
BUTTER	BUTTER MILK	Condensed buttermilk
		Dried buttermilk
		Soft cheese





# DAIRY BY-PRODUCTS

MAIN PRODUCT	BY PRODUCT	PRODUCTS MADE
CHEESE, CASIN, PANEER	WHEY	Whey beverage, Yeast whey
		Plain and sweetened condensed whey
		whey protein concentrate, lactose
		whey protein concentrate, whey paste, lactose
		Ricotta cheese
GHEE	GHEE RESIDUE	Sweetmeat, Toffee, Sweet paste



# UTILIZATION OF DAIRY WASTE FROM MILK INDUSTRY IN PRODUCTION OF GLYCERINE AND BIODIESEL

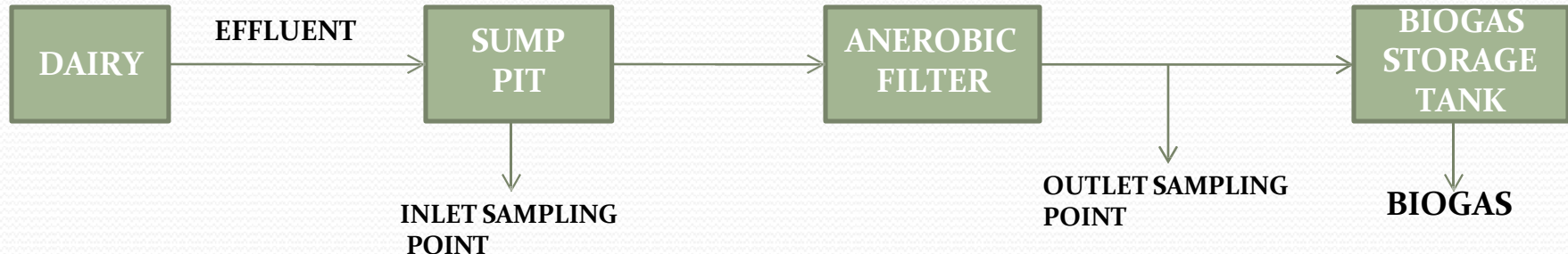
- **Part 1. Preparation of oil from dairy waste product**
  1. Batch extraction
  2. Continuous extraction
- **Part 2. Preparation of biodiesel and glycerin by trans esterification reaction.**
  1. Analysis of residue free fatty acid content in extracted dairy waste oil.
  2. Study the effect of catalysts on trans esterification reaction
- **Part 3. Purification of crude biodiesel and glycerin.**
  1. The purification of crude biodiesel
  2. The purification of crude glycerin
- **Part 4 Quality check of biodiesel and glycerin**
  1. Purity check of biodiesel
  2. Analysis an impurity in glycerin



SOXHLET APPARATUS

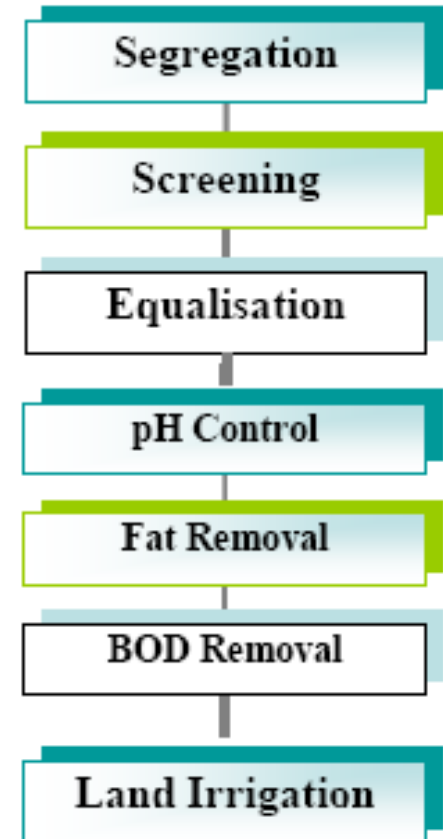
# UTILIZATION AND TREATMENT OF DAIRY EFFLUENT THROUGH BIOGAS GENERATION

- Biogas generation from dairy effluent has been viewed with the aim of control of water pollution through treatment of dairy waste as well as generation of biogas.
- Biogas, a mixture consisting primarily of methane and carbon dioxide, is produced from dairy wastes through anaerobic digestion.
- Anaerobic digestion not only reduce the COD of an effluent, but also little microbial biomass is produced by the process.
- The gas generation fluctuated between  $0.5\text{m}^3$  /day to maximum of  $4.5\text{m}^3$  /day with an average of  $3\text{m}^3$  /day.
- The biggest advantage is energy recovery in the form of methane and up to 95 percent of the organic matter in a waste stream can be converted in to biogas.



# TREATMENT OF DAIRY EFFLUENT

- ❑ The highly variable nature of dairy wastewaters in terms of volumes and flow rates and in terms of pH and suspended solid (SS) content makes the choice of an effective wastewater treatment regime difficult. Because dairy wastewaters are highly biodegradable, they can be effectively treated with biological wastewater treatment systems, but can pose a potential environmental hazard if not treated properly.





# BIOLOGICAL TREATMENT SYSTEMS USED TO TREAT DAIRY EFFLUENT

**Table 4** Some of biological treatment systems used to treat dairy effluents

Biological Treatment	Treatment Method	Wastewater Resource	COD Removal %	BOD Removal %	Notices
<i>Aerobic</i>	Activated sludge	Milk powder/butter	90		
	Trickling filters	Dairy wastewater	-	92	
	Sequence batch reactor	Dairy wastewater	91-97		
		Cheese-making wastewater	> 97		OLR = 0.5 kg COD / $m^3$ .day
		Dairy wastes	80		OLR = 10 g COD / l
	Rotation biological contactors	Dairy wastewater	85		0.5 kg COD / $m^3$ .hour
	Aerated ponds	Milk wastes	-	85	5 days of aeration
<i>Anaerobic</i>	Completely stirred reactors	Cheese factory wastewater (80 % water + 20 % whey) (17000 mg/l COD)	90		HRT > 9 days
	The fluidized-bed reactor	Dairy wastewater	80		
	UASB reactor	Synthetic ice cream wastewater	86		HRT = 18.4 h 3 kg TOC / $m^3$ .day
		Cheese effluent	86		HRT = 16 h 49.5 kg COD / $m^3$ .day
		Dairy wastewater	70-90		
	Fixed-bed digester	Cheese whey (59000 mg/l)	90-95		HRT = 2-2.5 days 12.5 kg COD / $m^3$ .day
	Membrane anaerobic reactor + Microfiltration membrane	Cheese whey (62000 mg/l)	99.5		HRT = 7.5 days
	Separated phase digester	Dairy wastewater (COD 50000 mg/l)	72		