
UNIT 17 WASTE MANAGEMENT IN FOOD PROCESSING INDUSTRY

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17.1 INTRODUCTION

Food processing industry essentially uses biological material, which could be agricultural, animal or aquatic in origin as its raw material. It is also highly energy intensive and consumes significantly high quantities of water. The process of preparing the raw material for processing also generates significant amounts of solid and liquid wastes, e.g. stalks, shells, peels and cores of fruits and vegetables; trimmings, bones, hides, offals and shells in case of farm and aquatic animals and spillages, whey, etc. in case of dairy industry. It also uses significant quantities of cleaning and sanitizing agents which have to be discharged into the effluent lines. It is a big consumer of all types of packaging materials some of which find their way into the waste stream due to various reasons.

Waste materials generated from food processing and food service facilities can present difficult treatment problems since they contain large amounts of carbohydrates, proteins, fats and mineral salts. For example, the waste from dairy plants, food freezing and dehydration plants, and processing plants for red meats, poultry, and seafood can produce distinct odors and heavy pollution of water if the discharge is not properly treated. Organic matter of these wastes must be treated by biological stabilization before discharge into a body of water. A hazard to humans and aquatic forms of life results from improper waste disposal.

The problems of the treatment and disposal of wastes are similar for all food plants. These industries experience an increasing demand from the central (federal), state and local regulatory agencies and the public for the abatement of alleged nuisances such as water pollution.

Processors and regulatory agencies are charged with the prompt and complete disposal of waste materials. Accumulation of wastes, even for short periods of time, can create an unsanitary condition which may attract insects and rodents, produce odors, and lead to a public nuisance or an unsightly condition inside or outside the plant. In India, the air and water pollution issues are handled by the Central Pollution Control Board (CPCB) and the State Pollution Control Boards. Air pollution is dealt with by the Central Board but is administered by the respective State Boards while water pollution is a state subject. The

administrative ministry for the CPCB is the Ministry of Environment & Forests (MoEF).

Wastes from food plants generally present minimal public health concern because they are not a direct means of disease transmission. The major objection to these wastes is the presence of organic matter that provides a food source for microbial growth. With an abundant food supply, microorganisms multiply rapidly and subsequently reduce the dissolved oxygen contained in the water. Water normally contains approximately 8ppm of dissolved oxygen (DO). A minimum standard for fish life is 5ppm of dissolved oxygen, and values below this level can result in the death of fish by suffocation.

If dissolved oxygen is completely eliminated from water through high organic water content, a septic condition with foul odors and darkening of water occurs. Septic conditions with sulfur-containing proteins or water with a high content of natural content of sulfates can produce hydrogen sulfides, which causes an undesirable odor and blackening of painted buildings.

The large volume of waste water produced in food plants contains vast quantities of organic residues. The intermittent production schedule of most plants places greater demands on wastewater treatment systems.

In processing, water is an essential tool to help cleanse the product and serve as a cleaning medium to convey unwanted materials to the sewage system. In wastewater handling, water presents the problem of a diluter that flushes and dissolves organic soil and carries it to the sewer.

The table 17.1 below shows the typical composition of wastes from food and related industries.

Table 17.1: Average composition of waste from food industries

Type of waste	BOD 5 (parts per million)	Suspended solids (parts per million)
Packing house and stockyards	595	606
Meat products	1141	820
Glue and gelatin	431	307
Food products	796	505
Yeast and vinegar	1329	307
Vegetable oils	528	475
Dairy and mild products	674	387

Reduction, recycling and efficient processing of wastes forms the core of waste reduction management in food processing industry. To achieve this overall objective, the food processing plants have to take recourse to the following general principles:

1. Use raw materials of good quality;
2. Minimize wastage during handling, preparation and processing of raw materials and packaging of processed foods;
3. Use appropriate technology and process equipment to minimize energy consumption;
4. Minimize the wastage of water by reasonable care during preparation and processing without sacrificing quality;

5. Use recyclable or biodegradable packaging material as far as possible;
6. Recycle raw material and process waste as far as possible;
7. Use appropriate technology to process the non-recyclable wastes preferably into usable inputs, products or energy.

These principles, if adhered to religiously and implemented intelligently will bring down costs, improve product quality, improve the image of the company and pay rich dividends to the owners of the company.

17.2 ENERGY EFFICIENCY AND CONSERVATION

Energy efficiency was not always a priority in the industry especially when cheap power was in abundance globally till the early 1970`s. However, with the raise in demand for power and greater dependence on increasingly costlier petroleum fuels for power generation, energy conservation has become the *mantra* of the industry. Food processing industry is quite energy intensive and can benefit greatly from modern methods of energy conservation. Some of the steps in energy efficiency and conservation are:

- Having energy efficiency as a major criterion in the selection of technology and process equipment;
- Having in-built mechanism in the circuitry and processes for avoiding wastage of electricity;
- Heat recovery in process flows and multi-stage heating;
- High quality insulation in cold areas and cold processes;
- Modern methods of illumination;
- New high efficiency methods of heating and/or steam generation;
- Periodic review of the energy scenario by energy audits and follow up action;
- Review of preparation and process methodologies to keep the heating/cooling to minimum.

17.3 WATER CONSERVATION

Gone are the days when water was cheap and plentiful. As human population is growing in our planet, water is becoming a scarce commodity. Many developing nations including India are not able to ensure per capita water supply in conformity with globally accepted standards for water requirement for human hygiene and survival. In this scenario, it is vital for the food industry to ensure proper water management to bring down the costs as well as to meet its social obligations.

Water is used in the food processing industry for washing of raw materials, for cooking, blanching, etc., for steam generation, cooling purposes, maintaining plant sanitation and for use by the employees. Water management and conservation consists of a study of consumption pattern in each of these applications and use of innovative techniques and steps to ensure that water consumption is minimized without affecting product quality. Some of the principles and steps in water conservation are:

- Select technologies, processes and equipment that use less water
- Exercise supervision and develop systems whereby wasteful use of water can be curtailed

- Minimize water entering the effluent stream by recycling water at different stages e.g. steam condensate can be collected used as boiler feed; wash water in some food industries can be used for gardening purpose without much processing – remember, industry and domestic effluents are quite difficult and expensive to treat
- Have high tech water level controllers for sumps, overhead tanks, etc. and have spring-loaded hose guns for process plant washing applications to avoid overflows, unnecessary spillages, etc. due to human carelessness
- Have a good effluent treatment system which not only meets the legal requirements but also gives treated effluents which can be recycled for various industrial purposes

Good practices of water management and conservation, when implemented well, can save on water bills, money spent on energy for pumping water and costs of effluent treatment and disposal – remember, it costs money even to let off treated effluent into waterways or municipal lines.

17.4 BYPRODUCT UTILIZATION

Food Industry generates a huge volume of wastes especially at the pre-processing/raw material preparation phase. The quantities would vary, but could be as high as 50-60% in meat processing industry! Treating such quantities as waste would be counter-productive since it would not only add to the cost of waste management but also deprive the food industry of useful income that could be derived by utilization of much of the waste as saleable byproducts.

Type of wastes from the food industry would vary considerably depending upon the raw material consumed. However, almost all the wastes would be organic (biological) in nature except those from the packaging section. The concept of waste recycling, when implemented imaginatively, could make significant contributions to the profitability of the industry. The basic principle of recycling is to use as much of the wastes as raw material for conversion to some other product like animal feed, food/ feed ingredient, industrial chemicals, agricultural inputs and energy etc. Some of the wastes from major categories are listed below table 17.2.

Table 17.2: Types of Waste from the Industry

Type of industry	Waste description	Type of process	End product
Fruit & vegetable processing	stems, stalks, leaves, rotten fruit and vegetables	Composting. (Anaerobic treatment.) Landfill.	Bio-fertilizer. Bio-gas & Fertilizer. Fertilizer, Animal feed.
-do-	Seeds, pulp, peel, etc. (post-processing)	Extraction of pectin. Extraction of oleo-resins, antioxidants, colours, essential oils, Enzymes Fermentation of residual sugars & carbohydrates.	Pectin for jams, etc. Various food ingredients Alcohol, vinegar, residual dietary fibres, etc.

Meat & poultry processing	Skins & hides Blood	Salting, tanning, valorization	Leather, dresses Food ingredients, feeds, Industrial & pharma compounds, fertilizers
	Offals	Cleaning & processing.	Sausage casings, feeds, fertilizers.
	Bones	Crushing, processing.	Bone meal, mineral supplements, gelatine.
	Fat	Fat Extraction.	Cooking fats, Soaps
	Left over meats after prime cuts.	Cleaning, mincing.	Minced Meats, sausages, pet foods, etc.
Sea food processing	Skins, bones, heads, left over meat after filleting	Size reduction & steam cooking.	Fish meal & fish protein concentrate
		Oil extraction & refining Hydrolyzing	Fish Oil. Fish Protein hydrolyzate. Biofertilizer.
		Composting	
	Skins & bones	Cold water extraction Hot water extraction	Collagen. Gelatine
Shells, legs, etc. of crustaceans	Processing	Chitins & chitosans	
Dairy Industry	Whey from cheese making	Precipitation, concentration	Whey powder, whey proteins, lactose
	Cheese granules	Cleaning & processing	Cheese preparations, animal feeds
	Fat	Centrifugation, dehydration	Butter oil (ghee)
	Waste fat Buttermilk	Tray drying	Soap Buttermilk powder



Check Your Progress Exercise 1

- Note:** a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

- 1) List out the general principles of waste reduction, recycling & efficient processing for the food industry?

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2) What are the different types of wastes one encounters in the food industry?

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3) Why is water used in the food industry?

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4) Why is it important to invest in energy reduction measures industry?

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17.5 TREATMENT OF SOLID WASTES

Solid wastes after recycling to the extent possible has to be segregated into biodegradable and non-biodegradable wastes. Biodegradable wastes are those which are organic or biological in origin. Non-biodegradable materials will include metals, plastics, paper-poly composites which cannot be decomposed by naturally occurring micro-organisms.

Some years back, solid wastes were disposed off as land-fill materials by dumping them into designated land-fill areas. However, with increasing costs and environment consciousness, biodegradable solid wastes are now used as raw materials for composting.

What is compost?

Composting is the natural process of decomposition and recycling of organic material into a humus rich soil amendment known as *compost*. For any business or institution producing food waste, this organic material can be easily decomposed into high quality compost.

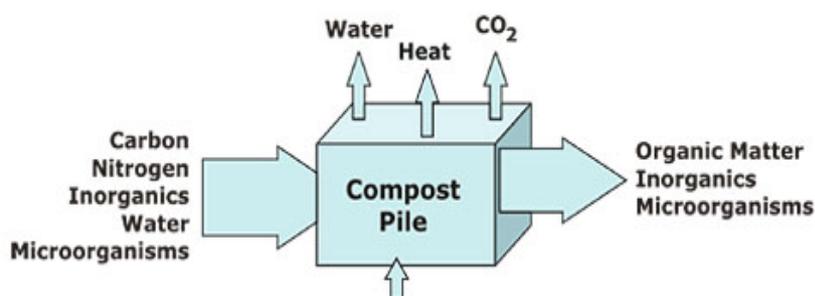


Fruits, vegetables, dairy products, grains, bread, unbleached paper napkins, coffee filters, eggshells, meats and newspaper can be composted. Any material which can be eaten or grown in a field or garden, it can be composted. Items that cannot be composted include plastics, grease, glass, and metals -- including plastic utensils, condiment packages, plastic wrap, plastic bags, foil, silverware, drinking straws, bottles, polystyrene or chemicals. Items such as red meat, bones and small amounts of paper are acceptable, but they take longer to decompose. Add red meat and bones to only a well-controlled compost pile to avoid attracting vermin, pests and insects to partially decomposed meat scraps.

Food waste is unique as a compost agent

Food waste has unique properties as a raw compost agent. Because it has a high moisture content and low physical structure, it is important to mix fresh food waste with a bulking agent that will absorb some of the excess moisture as well as add structure to the mix. Bulking agents with a high C:N ratio, such as sawdust and yard waste, are good choices.

Food waste is highly susceptible to odour production -- mainly ammonia -- and large quantities of leachate. The best prevention for odour is a well-aerated pile that remains aerobic and free of standing water. Leachate can be reduced through aeration and sufficient amounts of a high carbon bulking agent. It is normal to have some odour and leachate production. Captured leachate can be reapplied to the compost.



A typical composting operation

Pre-consumer food wastes are particularly suitable (being devoid of the complexities of household wastes) for composting and the end product is an excellent bio-fertilizer in good demand and hence fetches a good price to the food processor.

Non-biodegradable wastes are sorted into ferrous and non-ferrous metallic, glass, plastic and paper wastes and sent separately for reuse through well established channels.

Some of the benefits of composting to environment and agriculture are listed below. (Table 17.3)

Table 17.3: Benefits of compost to the environment and agriculture

Environment:	Agriculture:
<ul style="list-style-type: none"> • Water and soil conservation • Protects groundwater quality. • Minimizes odours from agricultural areas. 	<ul style="list-style-type: none"> • Adds organic matter, humus and cation exchange capacity to regenerate poor soils. • Suppresses certain plant diseases

<ul style="list-style-type: none"> • Avoids methane production and leachate formation in landfills by diverting organics from landfills into compost. • Prevents erosion and turf loss on roadsides, hillsides, playing fields and golf courses. • Drastically reduces the need for pesticides and fertilizers. • Binds heavy metals and prevents them from migrating to water resources, being absorbed by plants, or being bioavailable to humans. • Off-farm materials can be brought in and added to manure to make compost. • Facilitates reforestation, wetlands restoration, and wildlife habitat revitalization efforts by amending contaminated, compacted and marginal soils. • Long-term stable organic matter source. • Buffers soil pH levels. • Off-farm materials can be brought in and added to manure to make compost. • Composted manure weights about one-fourth as much as raw manure per ton. 	<ul style="list-style-type: none"> and parasites and kills weed seeds. • Increases yield and size in some crops. • Increases length and concentration of roots in some crops. • Increases soil nutrient content and water holding capacity of sandy soils and water infiltration of clay soils. • Reduces fertilizer requirements. • Restores soil structure after natural soil microorganisms have been reduced by the use of chemical fertilizers; compost is a soil inoculant. • Increases earthworm populations in soil. • Provides slow, gradual release of nutrients, reducing loss from contaminated soils. • Reduces water requirements and irrigation. • Provides opportunity for extra income; high quality compost can be sold at a premium price in established markets. • Moves manure to non-traditional markets that do not exist for raw manure. • Brings higher prices for organically grown crops. • Minimizes odours from agricultural areas.
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Source: U.S. Environmental Protection Agency

17.6 TREATMENT OF LIQUID WASTES

Food industries generate large volumes of liquid wastes which after all possible recycling steps are finally led to a common sump called the effluent sump. Since food processing is a continuous activity usually going round the clock, the sump acts as a storage cum equilibrium tank since the characteristics of the effluent entering the sump could be quite varying at different times. Thus the equilibrium tank acts as a buffer against possible damage to the working of the effluent treatment plant (ETP), which in effect a delicate bioreactor, due to varying influent characteristics.

17.6.1 Need for ETP`s

The food plant effluents have several undesirable characteristics like high biological oxygen demand (BOD) and chemical oxygen demand (COD), apart from high suspended solids, etc. Every nation now has legislation regarding the quality parameters for effluents that can be let out into public waterways

like streams, ponds and rivers or into the municipal sewage lines. To meet these stringent criteria, the food processor has to go in for an ETP.

There are basically two types of ETP's in the food industry- those working on aerobic conditions (i.e. in the presence of oxygen) and those working under anaerobic conditions (i.e. in the absence of oxygen). The choice of the ETP would depend upon the influent characteristics, the required characteristics in the treated effluent, budgetary considerations and whether it would be viable to go in for systems that generate energy (combustible gases), etc.

Some of the terminology used in this chapter, including those in the earlier paragraphs are explained below:

(i) What is biochemical oxygen demand (BOD)?

-The BOD is an important measure of water quality. It is a measure of the amount of oxygen needed (in milligrams per liter or parts per million) by bacteria and other microorganisms to oxidize the organic matter present in a water sample over a period of 5 days. The BOD of drinking water should be less than 1. That of raw sewage may run to several hundred.

(ii) What is chemical oxygen demand (COD)?

- COD (chemical oxygen demand) is a measure of the oxygen required to oxidize all compounds in water, both organic and inorganic.

(iii) What is primary treatment?

-The simplest, and least effective method of treatment is to allow the undissolved (suspended) solids in raw sewage to settle out of suspension, forming sludge. Such primary treatment removes only one-third of the BOD and virtually none of the dissolved minerals.

Attempts to use digested sludge as a fertilizer have been hampered by its frequent contamination by toxic chemicals derived from industrial wastes.

(iv) What is secondary treatment?

-Many treatment plants pass the effluent from primary treatment to secondary treatment. Here the effluent is brought in contact with oxygen and aerobic microorganisms. They break down much of the organic matter to harmless substances such as carbon dioxide.

Primary and secondary treatment together can remove up 90% of the BOD. After chlorination to remove its content of bacteria, the effluent from secondary treatment is discharged to surface waterways.

(v) Advanced waste treatment or tertiary treatment

The combination of primary and secondary treatment removes most of the organic matter in sewage and thus lowers the BOD. However, most of the nitrogen and phosphorus in sewage remains in the effluent from secondary treatment. These inorganic nutrients can cause eutrophication of surface water receiving the effluent causing blooms of algae. To avoid this, a few add a third stage of treatment called tertiary treatment.

(vi) Biological treatment

Biological treatment is the process of utilizing naturally occurring living organisms to degrade, stabilize and destroy organic contaminants. These microorganisms use the waste as their source of energy and carbon. Biological treatment technologies are restricted to organic wastes, and therefore, are quite

suitable for food industry applications. It is appropriate at this point to review some principles of biological process.

All living organisms require a source of energy and carbon to be able to develop and reproduce. Many organisms (autotrophic) get their carbon from inorganic compounds (such as CO_2), while other organisms (heterotrophic) use organic compounds to get their carbon. Aerobic and anaerobic metabolic pathways are used by microorganisms to degrade organic waste. During aerobic respiration, the organism utilizes oxygen to break down complex organic compounds into simple inorganic salts, carbon dioxide and water. These microorganisms require an electron acceptor (oxygen in the case of aerobic), nutrients such as nitrogen (N) and phosphorous (P), and other trace elements.

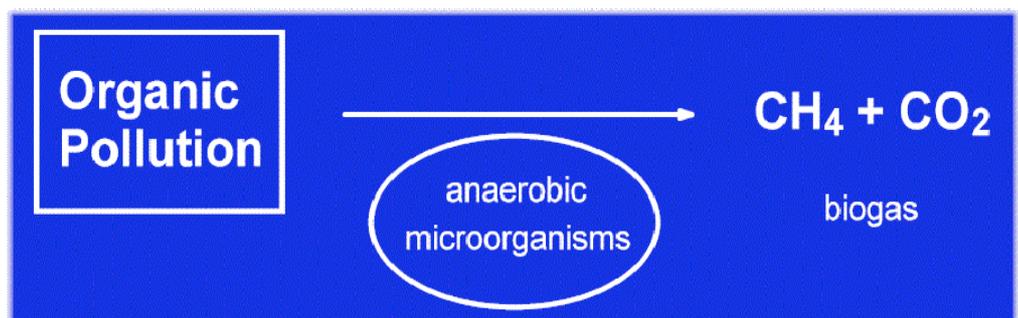
One of the most important characteristics of the food industry waste is its biodegradability. Microorganisms can either directly use the contaminated waste and gain energy and carbon from it; or, with the help of another substance they can co-metabolically break down the contaminated waste. The biodegradability of a waste can be measured in the laboratory through BOD 5 / COD tests. BOD (biological oxygen demand) is a test through which contaminants can be categorized according to their biodegradability. COD (chemical oxygen demand) is a measure of the oxygen required to oxidize all compounds in water, both organic and inorganic.

Aerobic process

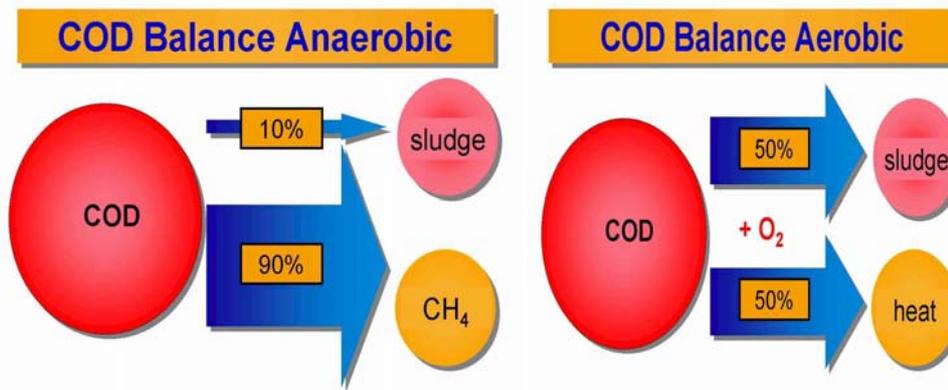
While the aerobic process is less capital intensive, it does not yield any useful end product. The biomass is converted mostly into heat and CO_2 and a significant portion into sludge. The energy required to run the aerobic plants is generally higher.

Anaerobic process

The cost of installing the plant is higher. However, operating costs are lower and we get methane as biogas which can be made use of in the food industry as a heating source. The quantum of sludge is also less and hence cost of disposal of sludge is higher.



Conversion of organic pollutants to biogas (methane) by anaerobic microorganisms



Comparison of the COD balance during anaerobic and aerobic treatment of wastewater containing organic pollution

Let us now examine in more detail how the liquid effluents can be effectively handled.

17.6.2 Wastewater Handling

Wastewater can be salvaged through recycling and reuse and the recovery of solids. The degree of conservation and salvage value of wastewater are based on factors such as (a) wastewater treatment facilities for recoverable materials, (b) operating costs of independent treatment, (c) market value of the recoverable materials, (d) local regulations regarding effluent quality, (e) surcharge cost for plants discharging into public sewers, and (f) anticipated discharge volume in the future. The economics of disposal of solids, concentrates, blood, and concentrated stick (in wet rendering) determine how much of these pollutional solids are kept out of the sewer. The design of a wastewater control plan is to remove and convey organic solids using “dry” methods, without discharging those solids to the sewer and by using a minimal amount of water in the cleaning operation.

Whenever food, regardless of form, is handled, processed, packaged, and stored, wastewater is generated. Quantity, pollutant strength, and nature of constituents of processing wastewater have both economic and environmental consequences concerning treatability and disposal. Economics of treatment are affected by the amount of product loss from the processing operations and the treatment costs of this waste material. Significant characteristics which determine the cost for wastewater treatment are the relative strength of the wastewater and the daily volume of discharge.

Ecological ramifications can result from inadequate removal of pollutants from effluent discharge. A eutrophic condition can develop within the aquatic environment due to the discharge of biodegradable, oxygen-consuming compounds if inadequately treated wastewater is discharged to a stream or other body of water. Maintenance of the eutrophic condition for an extended time can upset the ecological balance (i.e., aquatic microflora, plants and animals) of the receiving body of water. Also, development of undesirable odors and unattractive scenes can result from continual depletion of the oxygen in wastewater.

It is frequently more economical to invest in waste prevention technique and utilization of waste products than in waste treatment facilities. Yet, many food plants generate waste effluents that pollute. Insufficient treatment capacity of

many municipal waste treatment plants necessitates special waste treatment facilities in a large percentage of food plants.

I. Pretreatment

Most common pretreatment processes include flow equalization and the separation of floatable matter and settleable solids. Separation is frequently enhanced by addition of lime and alum, ferric chloride, or a selected polymer. Paddle flocculation may follow alum and lime and lime and ferric chloride additions to assist in coagulation of the suspended solids. Separation is usually accomplished by gravity or by air flotation. Screening by vibrating, rotary or static-type screens is a step that precedes the separation process and concentrates the separated floatable and settled solids. The various pretreatment processes are discussed under the following topics.

(a) Flow equalization

Flow equalization and neutralization are adopted to reduce hydraulic loading in the waste stream. Equalization facilities consist of a holding tank and pumping equipment designed to reduce the fluctuation of effluent discharge. This operation can be economically advantageous whether processing firms treat their own waste water or discharge into a municipal sewage treatment facility after pretreatment. The equalizing tank has the capacity to store wastewater for recycling and reuse, or to feed the flow uniformly to the treatment facility throughout the 24 hr day. The tank is characterized by a varying flow into the tank and a constant flow from the tank. Equalizing tanks can be lagoons, steel construction tanks, or concrete tanks, often without a cover.

(b) Screening

The most frequently used process for pretreatment is screening. Screening normally employs vibrating screens, static screens, or a rotary screen. Vibrating or rotary screens are more frequently used since they permit pretreatment of a larger quantity of wastewater that contains more organic matter. These screening devices are well adapted to a flow-away (water in forward flow and passes through with solids constantly removed from the screen) mode of operation and can vary widely in mechanical action and in mesh size. Mesh sizes used in pretreatment range from approximately 12.5mm in diameter in a static screen to approximately 0.15mm in diameter in high-speed circular vibratory polishing screens. Various screens are sometimes used in combination (i.e., prescreen-polish screen) to attain the desired efficiency of solids removal.

(c) Skimming

This process is frequently incorporated if large floatable solids are present. These solids are collected and transferred into some disposal unit or preceding equipment. Lime and alum, FeCl_3 , or a selected polymer may be added to enhance separation of solids, and paddle flocculation may follow to assist with coagulation of these solids.

II. Primary treatment

The principal purpose of primary treatment is to remove particles from the wastewater. The processes involved in primary treatment are discussed under the topics that follow.

(a) Sedimentation - This is the most common primary treatment technique used to remove solids from the wastewater influent because most sewage

contains a substantial amount of readily settleable solids. According to Green and Kramer (1979), as much as 40-60% of the solids, or about 25-35% of the BOD₅ load, can be removed by pretreatment screening and primary sedimentation. Some of the solids removed are refractory (inert) and are not measured by the BOD test.

A rectangular settling tank or a circular tank clarifier is most frequently used for the sedimentation process of primary treatment. Many settling tanks incorporate slowly rotating collectors with attached flights (paddles) which scrape settled sludge from the bottom of the tank and skim floating scum from the surface.

Design of a sedimentation system should incorporate sizing of the detention vessel and providing a quiescent state for the raw wastewater. Temperature variation of the wastewater also affects sedimentation because of the development of heat convection currents and the potential interference with marginal settling particles. Grease removal is also accomplished during this pretreatment process through removal of the surface scum.

(b) Flotation- This is a treatment process in which oil, grease and other suspended matter are removed from wastewater. A primary reason that this treatment process has been used in the food industry is because of the effectiveness that oil can be removed from the wastewater. This system is also beneficial in the removal of other contaminants from the waste streams of food processing plants.

Air bubbles can be created in the wastewater treatment process by (a) use of rotating impellers or air diffusers to form air bubbles at atmospheric pressure; (b) saturation of the liquid medium with air and subsequent combination of the mixture to a vacuum to create bubbles; and (c) saturation of air with liquid under high pressure with subsequent release of pressure to form bubbles. The latter is known as dissolved air flotation (DAF), which is widely used in flotation treatment. This technique normally involves air forced under pressure into a portion of the liquid held in a retention tank.

Flocculating agents are commonly used to pretreat waste water prior to treatment by a dissolved air flotation unit. Treatment by DAF is frequently used because of the relatively fast passage, and solids of nearly the same density or lighter than water can be removed. This treatment technique requires high investment and operating costs, especially for chemical additives and sludge handling.

Dissolved air flotation involves a process for removing suspended matter from wastewater that uses small air bubbles. When discrete particles attach to tiny air bubbles, the effective specific gravity of the aggregate particle becomes less than that of water. Reduction of the specific gravity for the aggregate particle causes separation from the carrying liquid in an upward direction through attachment of the air bubble to the particle to induce the vertical rate of rise. The mechanism of operation involves a clarification vessel where the particles are floated to the surface and removed by a skimming device to a collection trough for removal from the wastewater. Further activity of this pretreatment process involves contact of the raw wastewater with a recycled, clarified effluent which has been pressurized through air injection in a pressure tank. The combined flow stream enters the clarification vessel and the release of pressure causes tiny air bubbles to form, which ascend to the surface of the water, carrying the suspended particles with them.

Flotation technology has also been adapted to sludge handling and to secondary and tertiary treatments. Food processors with substantial quantities of grease and oil in their wastewater use this treatment technique as part of their waste treatment system.

Collected sludge from primary treatment contains approximately 2-6% solids, which can and should be concentrated before final disposal. Sludge treatment and disposal costs are the major costs of sewage treatment if this product is not used as a fertilizer or some other practical use. Treatment system exists that biodegrade most of the organic matter and create little sludge. These systems can reduce treatment and disposal costs. If sludge is recovered as a by-product, disposal costs can be reduced and the value of the salvaged material can provide enough profit to defray other treatment costs. Recovered solids (sludge) can also be treated by biological oxidation methods as a means of ultimate disposal.

III. Secondary treatment

Treatment through biological (or bacterial) degradation of dissolved organic matter through biological oxidation is the most common technique for secondary treatment. However, secondary treatment can range from use of lagoons to sophisticated activated sludge processes. Secondary treatment may also include chemical treatment to remove phosphorus and nitrogen or to aid in the flocculation of solids.

Although primary treatment removes screenable and readily settleable solids, dissolved solids remain. The primary purpose of secondary treatment is to continue the removal of suspended solids. Microorganisms most frequently involved in biological oxidation of existing solids are those that naturally occur in water and organic matter. Microflora involved in biological oxidation can assimilate some of the dissolved solids and convert them into terminal oxidation products such as CO_2 and H_2O or into cellular material which can be removed as particulate matter. Microbial cellular matter and assimilated organic matter continue to undergo aerobic degradation.

Some of the dissolved solids and small suspended solid matter in the form of colloidal and supracolloidal particles escape secondary clarification. Secondary treatment involving bacterial degradation is needed for further oxidation of these particles. Further discussion of types of secondary treatment follows.

(a) Anaerobic Lagoons

Anaerobic lagoons and aerobic lagoons have frequently been referred to as stabilization ponds, and have been used for primary wastewater treatment or for sludge disposal. Use of this treatment technique has increased during the past three decades because of the relatively low capital investment, low operating costs, and ease of operation. Because of space requirements, anaerobic and aerobic lagoons are not well suited where land costs are extremely high or for extremely large waste loads.

The treatment principle involved with lagoons involves biological oxidation and solid sedimentation. This treatment system involves conversion of dissolved, suspended and settled solids to volatile gases such as O_2 , CO_2 , N_2 and CH_4 ; water; and biomass such as microflora, macroflora and fauna. Anaerobic and other lagoons also equalize the discharge flow to further treatment facilities or receiving waters.

The depth of anaerobic lagoons varies from 2.5 to 3.0m. Surface area to volume ratios should be minimal. Anaerobic conditions are created throughout the entire lagoon through heavy organic loads. Under anaerobic conditions, anaerobes digest the organic matter. Loading rates are expressed as BOD₅, COD, SS, etc., per unit volume of the lagoon. BOD₅ loadings range from 225 to 1120 kg/ha/day. Operating temperature of 22 degree C or above is required with 4-20 days of detention. BOD reduction efficiency is 60%- 80%. Anaerobic lagoons are used for primary treatment or for secondary treatment of primary effluents containing high organic loads, or as sludge treatment systems. Anaerobic lagoons are normally followed by aerobic lagoons or trickling filters.

(b) Aerobic Lagoons

These incorporate use of mechanical aerators to supply atmospheric oxygen for enhancing biological oxidation. Mechanical agitators maintain a dissolved oxygen environment of from 1 to 3 mg/liter and can handle up to 450 kg/ha/day of BOD₅ loading rate. Aerated lagoons have been frequently subdivided into aerated facultative lagoons, which have supplemental aeration applied to only part of the lagoon cell, thus leaving anaerobic areas and complete-mix aerated lagoons that use mechanical means to completely aerate the entire lagoon and keep solids in suspension.

Depth of aerobic lagoons varies with some of the complete-mix aerated lagoons as deep as 3m. Approximately 20% of the BOD sent to an aerobic lagoon is converted to sludge solids and BOD and is reduced by 70-90%. Since sludge solids are produced, a polishing pond usually follows the aerated lagoons for tertiary treatment of secondary effluents.

(c) Trickling Filters

These reduce BOD and SS by bacterial action and biological oxidation as wastewater passes by a thin layer over stationary media (usually rocks) arranged above an overdrain. Aeration is accomplished by exposing large surface areas of wastewater to the atmosphere. Use of this technique is responsible for growth and attachment of layers of zooglea on the media surface. Clarification of the reactor effluent is essential to remove bioflocculated organic matter and sloughed fragments of zooglea (filter sludge).

The efficiency of trickling filters is affected by factors such as temperature, waste characteristics, intensity of the hydraulic loading rate, characteristics of the filter media, and depth of the filter. Media characteristics such as size, void space, and surface area as well as hydraulic loading rates tend to affect the performance of trickling filters more than other factors. Removal efficiency, unlike activated sludge systems, is independent of organic loading within broad ranges. Incorporation of plastic with more surface area and void space than rock filter media has permitted improvements in design and efficiency.

(d) Activated Sludge

The activated sludge process involves return of a portion of the clarifier-settled sludge to be mixed with wastewater entering the reactor. The term “activated sludge” applies since this returned sludge has viable microorganisms that actively decompose the waste being treated. The activated sludge process is frequently called the “fluid bed” biological oxidation system, whereas the trickling filter is referred to as a “fixed bed” system. The previously discussed process requires a reactor which is an aeration tank or basin, a clarifier, and a

pumping system for returning a portion of the settled sludge to the reactor and discharging the balance to waste disposal.

The conventional process of an activated sludge system has been designed as a continuous secondary treatment of domestic sewage. The conventional system is not effective in treating dissolved solids. This process normally incorporates surface aerators to achieve mixing. The influent solids are mixed with activated sludge and undergo a series of changes as they pass from the heavy end of the reactor to the discharge end in approximately 6 hr. When the activated sludge contacts the influent waste, there is a short period of less than 30min when influent particulate matter is rapidly absorbed onto the gelatinous matrix of the returned sludge. Absorption removes a large portion of the influent BOD.

(e) Oxidation Ditch

This treatment technique has been developed as a compact, efficient and economical process for treating wastewater. The process maintains waste material in contact with the sludge biomass for 20-30 hr under constant aeration. After the aeration step, the stabilized suspended solids enter a clarification step which removes the solids from the water by settling. An oxidation ditch can accommodate a BOD loading of from 200 to 500 g/day applied for each cubic meter of available aeration space. Sludge solids should have a 16- to 20-day turnover. For each kilogram of BOD applied, approximately 200-300 g of new sludge solids can be produced with an expected BOD reduction of 90-95%. Temperature can have a significant influence on the waste removal performance of the oxidation ditch since reported cases of developed pinpoint flocculae loss of biological activity will decrease the performance efficiency under cold weather operating conditions.

The typical oxidation ditch aeration basin design is either a single closed-loop channel or multiple closed-loop channels. An attractive feature of oxidation ditches is that a minimum of operator attention is required once a proper operation is established. Several food processing firms use oxidation ditches for wastewater treatment.



Check Your Progress Exercise 2

- Note:** a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1) Briefly describe the ways of treating solid wastes.

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2) What are the two principles of treating waste water (effluents) in the food industry? What are the relative merits & demerits of these processes?

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3) What is BOD?

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4) What is the purpose of flow equalization?

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5) Describe aerobic and anaerobic processes?

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6) Can you suggest some ways in which treated effluent can be utilized?

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7) What do you think would be the competitive advantage to companies that take corporate social responsibility seriously?

17.7 CORPORATE SOCIAL RESPONSIBILITY

Food processing industry is perhaps the largest industrial sector in the world. It is also one of the most polluting industry. Therefore while its contribution to the global economy & to food safety & security is laudable, the negative impact of the polluting nature has to be effectively countered by resorting to appropriate pollution control measures so as to protect the global environment. This is as important as food safety, conformance to standards, truthful labelling and ethical advertising.

An example of good CSR is an announcement by a Cola Drink company in India, in March 2008 that it would be a positive water balance company by 2009, which would be a global first. In other words, the company says it will save and replenish more water in its plants and communities than the total water it uses in India.

17.8 LET US SUM UP



Food processing is a capital intensive, high energy & water consuming and moderate to highly polluting industry. Though there are a small number of people who consider waste water treatment a wasteful and unnecessary activity, a large majority of human population considers it as an absolute necessity and a saviour of human race. However, the fact remains that food industry wastages in terms of raw materials, water and energy consumption can be minimized and a major source of environmental pollution can be avoided.

The modern food industry goes in for technology and equipments that are efficient, require minimal quantities of water and energy and create minimal wasted. Even in existing processing units of large food processors it is important to have specially designated officers who can periodically study the efficiencies of energy, water consumption and raw material wastages so that necessary remedial measures can be taken by investing in new technologies and/or equipments.

Most governments have prescribed standards for quality parameters of treated effluents of food industries so that the onus of conforming to them is on the managements of these processing units. In India, the central and state governments have their own pollution control boards which set standards for industry, monitor and guide them and if necessary, take punitive action.

Solid wastes of organic nature are best converted to manures which can be disposed off as a commercial product. The non-organic wastes which can be recycled also have an established market. The remaining solids would have to be used as landfills or incinerated.

Liquid wastes are collected and treated biologically using effluent treatment plants (ETP`s), which may be based on aerobic or anaerobic processes. While ETP`s using aerobic processes are less capital intensive, it does not generate any useful byproducts. Even though the ETP`s using anaerobic processes are more capital intensive, they generate energy as methane gas which can be used by the company or sold as a commercial product.

With the information technology age, more and more focus is on industries that pollute, waste water and energy. Therefore, most companies are now very conscious of their roles in the societies they exist in and try to take corporate social responsibility more seriously. Such affirmative action yields rich dividends in the long run and give them advantage in the fiercely competitive markets.

17.9 KEY WORDS

- Aerobic biological treatment** : Treatment processes that occur in the presence of oxygen are called Aerobic processes.
- Anaerobic biological treatment** : The decomposition by micro-organisms of organic matter in waste water in the absence of dissolved oxygen is called anaerobic treatment.
- Biological Oxygen Demand (BOD)** : A measure of oxygen requirements by micro-organisms when breaking down organic matter used as a measure of the polluting potential of material in water.
- Chemical Oxygen Demand (COD)** : A chemical method used to measure the polluting potential of material in water.
- Effluent** : Water that flows from a sewage treatment plant after it has been treated.
- Floatation** : Primary treatment process in which oils, grease and other suspended particles are removed from waste water.
- Percolating filter** : A percolating filters contains broken pieces of pumice or plastic materials especially made for the

growth of bacteria, yeasts, fungi, protozoan and nematodes.

Activated Sludge process Activated sludge refers to the brownish flocculent culture of organisms developed in an aeration tank under controlled conditions.

Aerated Lagoon : An aerated lagoon consists of a large pond or tank equipped with mechanical aerators to maintain an aerobic environment.

Sedimentation : Primary treatment technique used to remove solids from the waste water effluent.

Mechanical Treatment: Screening, filtration, sedimentation and floatation operations.

Upflow Anaerobic Sludge Blanket (USAB) : Anaerobic treatment system.

17.10 SOME USEFUL BOOKS

- Birdie G.S and Birdie J.S. (2003). Water Supply and Sanitary Engineering” Dhanpat Rai, Publishing Company, New Delhi.
- Gina Cybulska; (2000). Waste Management in the Food Industry; Publisher: Campden & Chorleywood Food Research Association
- Green, J.H. & Kramer A. (1979): Food Processing Waste Management ; AVI Publishing
- Ioannis S. Arvanitoyannis; (2007). Waste management for the Food Industry; Publisher: Academic Press
- Jha S. N. (2004). Dairy and Food Processing Plant Maintenance: Theory and Practice” By International Book Distribution (Publication Division) Company, Lucknow.
- K Waldron (Ed); (2007). Handbook of waste management and co-product recovery in food processing (Volume 1) ; Institute of Food Research, UK
- Wastewater Engineering: Treatment, Disposal and Reuse” by Metcalf and Eddy, (1995). Tata McGraw Hill Publishing Company Ltd., New Delhi
- Robert R. Zall; (2004). Managing Food Industry Waste: Common Sense Methods for Food Processors; 1st edition Publisher: Wiley-Blackwell;
- **Websites**
 - FDA/USDA website
 - FAO/CODEX ALIMENTARIUS website
 - Ministry of Food Processing Industries, Govt of India, website

17.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress Exercise 1

Your answer should include following points:

1. Some of the cardinal principles of running a food processing industry efficiently and with minimal wastage are listed below:
 - Use raw materials of good quality;

- Minimize wastage during handling, preparation & processing of raw materials and packaging of processed foods;
 - Use appropriate technology and process equipment to minimize energy consumption;
 - Minimize the wastage of water by reasonable care during preparation & processing without sacrificing quality;
 - Use recyclable or biodegradable packaging material as far as possible;
 - Recycle raw material & process waste as far as possible;
 - Use appropriate technology to process the non-recyclable wastes preferably into usable inputs, products or energy.
2. Food industry generates a wide variety of wastes depending upon the raw materials used for processing. It could be solids like peels, stalks, seeds etc of fruits & vegetables, bones & nails, fats, hair & skins from meat & fish and husk, pods and bran from cereals and oilseeds; liquids (suspension of fine solids in water) which can be pumped and even gases from burning of fuels for steam generation etc. These have to be treated appropriately and disposed off.
 3. Water is one of the most useful utilities for the food industry. It is used for a variety of purposes – as a solvent, as a washing medium, as a coolant in refrigeration systems and as the raw material for steam generation in boilers. As water is getting more scarce and expensive, it is becoming an important cost factor demanding economy in usage and requiring recycling.
 4. In an energy-starved nation like India, a unit of power saved is as good as a unit of power generated. Energy is becoming more expensive all over the world and such saving of power makes economic sense by directly resulting in lower energy bills. Power generation (by burning coal/petroleum products) is also a major source of global warming due to production of greenhouse gases like carbon dioxide. Therefore lower consumption of power also makes sense from environmental point of view as well.

Check Your Progress Exercise 2

Your answer should include following points:

1. Solid food wastes which are biodegradable are best utilized for composting. With organic/sustainable agriculture gaining momentum globally, compost has excellent economic value. Non- biodegradable wastes should be sorted to separate ferrous & non-ferrous metals, plastics, papers etc which can be sold to specialized companies recycling such wastes. What cannot be recycled, will have to be used as land-fills.
2. Liquid wastes can be treated using two basic principles / processes. One is an aerobic process and the other an anaerobic process. The idea is to convert waste water containing high BOD / COD into less toxic (less harmful) water conforming to the specifications prescribed in the law of the land. Such treated water can be reused for certain non-potable purposes like gardening or in washrooms for flushing etc. The by-

products of these processes can also be useful as fuel (methane gas produced in anaerobic processes) and the residues as agricultural inputs.

3. BOD is the milligrams of oxygen required by bacteria in 5 days at 20°C to aerobically degrade the organic matter present in a wastewater sample.
4. To reduce the variations in flow rates and variations in concentration of organic matter or BOD.
5. Aerobic–presence of oxygen; anaerobic–absence of oxygen in the process.
6. Treated effluent can be used for a number of purposes, depending upon the degree to which it has been treated. In fact well treated and clarified waste water can be used for any purpose other than for potable purposes. Some of the uses are – gardening, irrigation, cleaning of floors in the factory areas and for cleaning and flushing in washrooms
7. Companies taking up CSR measures stand to benefit in many ways. We are in an era where consumer is the king and the consumers are also a very aware lot who are concerned about their environment and the state of planet earth we will be leaving for the coming generations. Therefore brands of companies that are concerned about environment and take positive steps to prevent damage to environment, society and people are held in high regard by the consumers. Market surveys have indicated that in several markets, the consumer has shown distinct preference for products of such enlightened organizations and are willing to pay a premium price for their products. This trend is expected to strengthen further in the years to come. Such organizations also have a better relationship with the people in the neighborhood and are more likely to succeed as business ventures. Needless to add that such passion for environment must also be accompanied by sound business judgments and decisions and management practices.