UNIT 15 PLANT SANITATION AND EFFLUENT TREATMENT

Structure

15.0 OBJECTIVES

After studying this unit, you should be able to:

- know the importance of plant sanitation for a fruits and vegetables processing industry;
- know the properties of process water and different methods for treatment of process water as well as waste water;
- familiarise yourself with the methods for waste solids upgrading and methods to reduce the discharge volume from a fruits and vegetables processing plant; and
- acquaint yourself with the regulations relating to plant sanitation and waste disposal.

15.1 INTRODUCTION

Plant sanitation plays an important role in the overall work performance of any industry. In particular, in a fruit and vegetable processing industry as we are concerned with handling of food, plant sanitation plays a very vital role. It directly affects food safety. If the food produced by an industry is not safe, then the unit will ultimately loose customers, and may have to shut down. In this unit, we will discuss the various aspects of food processing plant sanitation and see how it affects food safety. Water is one of the major inputs in any fruit and vegetable processing plant as it is needed for a variety of operations such as cleaning, blanching, preparation of syrup or brine, as heat exchange medium or boiler feed, and many other uses. It also directly affects food safety and food plant sanitation. So we will discuss about the requirements of process water and its properties. Another important aspect for any type of industry is waste disposal, as it not only affects food safety, but also affects the surroundings and work environment. Hence, we will discuss about the waste disposal methods. Still more important are the methods that can be taken to reduce the discharge volumes and upgrade the waste solids for further uses, which are not only important for reducing environmental pollution, but also for the economy of operation in a plant. In addition, we will also discuss briefly about the waste and effluent disposal regulations.

15.2 IMPORTANCE OF PLANT SANITATION WITH RESPECT TO FOOD SAFETY, RISKS AND HAZARDS

The word "sanitation" derived from latin word '*Sanus*' means sound and healthy or clean and whole. Thus plant sanitation includes all possible activities to maintain a healthy environment.

Will you consume a food, which is very attractive in colour and aroma, but has a chance of some toxic or otherwise harmful material in it. Of course your answer will be 'No'; it means that the food plant sanitation principles are mandatory in the production of foods primarily for gaining public acceptance of the products. The processed food obtained from an industry should not only be attractive and nutritious, but also be wholesome and bacteriologically safe. The processed food, even though processed for killing pathogenic organism, is at a greater risk of contamination because it is prepared in large quantities and is handled by many people. Hence, along with proper control on the qualities of raw materials used in processing, proper hygiene at all the work places is very important for obtaining safe food. Since food sanitation has a direct effect on the health of individuals patronising the specific food processing industry, the management needs to lay down definite guidelines for implementation and maintenance of hygienic conditions. This is required even for the survival of the industry itself.

We must realise that sanitation affects every phase of food handling such as purchasing and receiving raw material, transportation and processing operations; and quality control should be maintained throughout. The major sources of contamination of food are air, water, plant, soil, food handler, machinery and equipment, sewage and trucks or cans during transport. The contamination can be in the form of visible contamination by insects, rodents, stones or other extraneous materials, or visible and invisible contamination by micro-organisms. The third type is potential chemical contamination. It means, if slight negligence is observed at any point that would directly bear a risk of food contamination. We should also bear in mind that all the above sources of contamination are directly related with many decisions as selection of a proper site, layout and orientation, ventilation, illumination, water supply and disposal of wastes.

Sanitation is every person's job in a food plant. It should be a part of everyday's policy of the food firm, as ultimately a good sanitation gives us a product free of risks and hazards. If properly practised, sanitation removes the concern about the spreading of communicable diseases or potential food poisoning. Further properly maintained sanitation gives us a product free of contamination and eliminates waste and spoilage. A food prepared under hygienic conditions commands respect in the market. From a legal obligation stand point also, it is important. If the food is prepared, packed, or held under unsanitary conditions, whereby it may become contaminated with filth, it invites legal action.

Sanitation is a responsibility that every person handling or working with food must constantly fulfill. The value of a planned sanitation programme utilising good manufacturing practice includes the following.

- A better product to meet the competition's demands and consumer's expectations.
- A more efficient food plant operation.
- Greater employee productivity.
- Fewer food plant employee accidents.
- Fewer consumer complaints.

Thus food plant sanitation is of prime importance, and several requirements such as adequate supply of potable water, proper sewage disposal facilities have to be fulfilled for maintaining sanitation. However, whatever may be the expense of maintaining a quality sanitation system, there is no point of compromise, as we are going to handle food and ultimately the health and life of the people.

15.3 PROPERTIES AND REQUIREMENTS OF PROCESSING WATER

Water is one of the major inputs in a fruit and vegetable processing plant. It is used in the preparation of brine or syrup, in blanching, in cleaning and washing of fruits and vegetables, different equipment and containers. The other important applications include its use as boiler feed and as heat exchange medium. More than 10,000 litres of water are required to process a tonne of fruits or vegetables.

The processing water must meet the health standards for potable (drinking) water and should be low in mineral salts (calcium, magnesium, sulphur and iron). Potable water is one, which is safe to drink, pleasant to taste and usable for domestic purposes. The water for food processing plants should also be chemically pure to prevent turbidity, off-colour, and off-flavour. The tap water may not be sufficiently pure for use in food products.

15.3.1 Water Hardness

Hardness of water is one of the major properties of water as regards to food processing industry. We all know that if water forms a lather with soap which lasts for at least five minutes, it is called **soft water**. If lather is not formed easily then it is termed as **hard water**. The compounds of calcium and magnesium ions dissolved in water mainly cause the hardness. These ions form precipitates with bicarbonates, sulphates or chlorides present in water instead of forming lather, which is known as hardness.

Hardness of water is further classified as **carbonate hardness** and **non-carbonate hardness**. The carbonate hardness is due to the presence of calcium and magnesium bicarbonate. This type of water is found in chalk and lime stone regions. Non-carbonate hardness is due to the presence of calcium and magnesium sulphates, chlorides, and nitrates. The water in areas having rocks containing these salts is of this type. The carbonate and non-carbonate hardness are also referred to as **temporary hardness** and **permanent hardness,** respectively.

Hardness of water is expressed in terms of milli-equivalents per litre (mEq/l). One mEq/l of hardness producing ion is equal to 50 mg calcium carbonate (50 ppm) in one litre of water.

Table 15.1: Types of hardness

Sl. No.	Degree of hardness	Amount of dissolved compounds	
		mEq/l	mg/l
1.	Soft water	Less than 1	Less than 50
2.	Moderately hard	1-3	50-150
3.	Hard	3-6	150-300
4.	Very hard	More than 6	Over 300

Disadvantages of hard water in processing industry

As hard water fails to give lather with soap, it creates a problem in cleaning operations.

Hardness causes scale on equipment, which acts as an insulating layer against efficient heat transfer and may eventually clog pipes and foul valves. When hard water is used as boiler feed, the growing layer of scale not only reduces boiler efficiency, but also tends to contaminate steam generated in the boilers. Such steam can become alkaline and corrosive to aluminium and tin cans. There is also danger of overheating of the boilers.

The life of pipes and fixtures is reduced as they may rust.

These deposits can harbour bacteria and add to the difficulty of equipment cleanup and may affect food products directly.

Calcium ions have firming effect on certain fruits and vegetables, which may be used to advantage under controlled conditions. But in excessive amounts, the calcium from hard water can cause various textural defects.

Advantages of hard water

As mentioned before, calcium ions have firming effect on certain fruits and vegetables.

The dissolved calcium salts in hard water increases the dietary intake of calcium.

Hard water is more suitable in brewing industries, as it produces better beer.

Methods of removing hardness in water

There are various ways to soften water, depending primarily on the nature of hardness.

Boiling: If water is boiled, temporary hardness only is removed. The bicarbonates are broken down into carbonates, water and carbon dioxide.

$$Ca(HCO_3)_2 \rightarrow CaCO_3\downarrow + H_2O + CO_2$$

The equation of magnesium bicarbonate is similar. The carbonates are precipitated and therefore have no action on soap, being out of solution.

Addition of slaked lime (Clark's process): Slaked lime also removes temporary hardness only. The lime must be added in calculated quantities so that it just neutralises the bicarbonate. Insoluble calcium carbonate is formed.

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2\ CaCO_3\downarrow + 2\ H_2O$$

Addition of washing soda: The method removes both temporary and permanent hardness. Washing soda (sodium carbonate) reacts with the calcium and magnesium salts in hard water forming soluble sodium salts and insoluble calcium and magnesium salts, which remain as a precipitate. The equations are as follows:

For temporary hardness: $Ca(HCO_3)_2 + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2\ NaHCO_3$

For permanent hardness: $CaSO_4 + Na_2CO_3 \rightarrow CaCO_3\downarrow + Na_2SO_4$

Ion exchange process: This method is used in domestic and industrial installations for removing both types of hardness. It involves the use of natural and synthetic resins such as '***permutit***' and '***zeolite***'. The hard water is passed through a column packed with resin and the calcium and magnesium ions in the water are exchanged for sodium ions in the resin. The resin is regenerated from time to time by flushing the column with a concentrated salt (sodium chloride) solution. This replenishes the sodium ions.

Use of sequestering agents: A sequestering agent such as '***Calgon***' (sodium hexametaphosphate), when added to hard water, encloses the calcium and magnesium ions in stable complexes, which are soluble but do not react with soap. *Calgon* is used extensively for domestic purposes, but has limited industrial use, as it is quite expensive.

15.3.2 Other Impurities

The water may have natural pollutants like suspended impurities (clay, silt, sand and mud), dissolved gases like carbon dioxide and ammonia, dissolved minerals like calcium and magnesium salts, lead and microscopic plants or animals. The artificial pollutants include sewage that contains decomposable organic matter and pathogenic agents, industrial wastes, agricultural pollutants, pesticides, fertilizers and physical pollutants such as radioactive substances. Occasionally, the well waters and municipal waters entering a plant will be contaminated with moderate numbers of proteolytic and lipolytic food spoilage organisms. Thus the water to be used for processing needs a critical analysis and remedial steps as required. The municipal water may have a pH as low as 5 or as high as 8.5. Higher pH corresponds to hard water. In-plant water softening or direct neutralisation rectifies it. Pure water has a pH of 7.

We know that chlorine disinfects water; but shall we like to consume water having a sharp chlorine smell? It implies, even though the water is safe from health point of view, still it may not be acceptable to food processing industries. A sharp detectable taste or odour of chlorine may be due to over-chlorination or due to the presence of traces of phenol in the water. Phenol reacts with chlorine to give a strong medicinal odour. Such type of odour can be removed by filtration of water through a bed of carbon or adsorbent clay. Materials such as hydrogen sulphide or organic impurities, if present in water, react with chlorine and inactivate it before chlorine can exert its germicidal effect. Therefore, the amount of chlorine required to disinfect water is dependent on other substances present in the water.

Decomposition of organic matter in water by non-pathogenic bacteria may produce off-flavours and off-odours. When water contains sulphates and reducing types of bacteria, production of sulphite odours may occur. These types of odours can be removed by filtering water through carbon. But prevention of formation of off-odour needs pipeline sanitation to destroy microorganisms.

Dissolved salts in water may impart some colour to the water. Iron salts, if present in water, can be oxidised to ferric hydroxide, which is red-brown in colour. Manganese hydroxides are gray-black in colour. The ion-exchange treatment removes the dissolved mineral impurities. Activated carbon or clay is used to adsorb the colouring pigments. Treatment with alum (aluminium and potassium sulphates) causes flocculation of suspended materials, which are then removed by filtration and centrifugation.

If the supplied water is not suitable for direct food processing applications due to one or more of the above reasons, they can still be used for other uses as heating canned food in a retort, in pre-chilling operations or as a heat exchange medium in evaporator. After the process water has been used, it can be recycled for cleaning of the processing plant and conveying of fruits and vegetables. However, if this recycled water poses threat to the overall sanitation and safety of food, then it is further purified or discarded depending upon the situation.

15.3.3 Disinfection of Water

Chlorination of water is done to kill or inhibit the growth of microorganisms. In addition, chlorinated water is used in the plant for disinfecting products and machinery. Effective chlorination must take into account the chlorine demand of water before a germicidal effect can be achieved. The **chlorine demand** is equal to the amount of chlorine added minus the amount of residual chlorine remaining at the end of 60 minutes of contact at a given temperature and pH. Therefore, it is the amount of chlorine required to destroy bacteria and oxidise organic matter. The break point is when the chlorine demand of water is met, after which further addition results in the formation of free residual chlorine.

For drinking purposes, the residual chlorine level should be less than 0.4 ppm. For cleaning of working equipment and conveyors water containing about 5 ppm of residual chlorine is used. Water to be used in general food plant cleanup may require a residual chlorine level as high as 25 ppm. This is because much of this chlorine will be used up in satisfying the chlorine demand of soil before it can have disinfecting properties. Chlorine is available in cylinders in the form of gas, which are discharged into the water. It may also be derived from hypochlorite preparations.

Ozone eliminates undesirable odour and taste, has a strong viricidal effect and is a powerful oxidising agent. The advantage is that it has no residual effect. **UV rays** are very effective against most viruses and microorganisms. However, the treatment is very expensive, and colour and turbidity of water reduces its effectiveness.

15.3.4 Water for Canning Industry

Chlorinated water should be used in a cannery to maintain hygienic conditions. As far as possible soft water should be used. The hardness of water, especially the temporary hardness, should be low for obtaining clear syrups (sugar solutions). The degree of hardness is still of greater importance in canning of vegetables, as the presence of lime in the blanching water or brine causes toughening of the skins of products such as peas and beans. The addition of sodium hexametaphosphate or sodium phosphate in desirable quantity overcomes the problems.

15.4 PROPERTIES OF WASTE WATER

The composition and contamination loads of the waste water obtained from a fruit and vegetable processing plant varies greatly as it may contain a wide variety of materials (e.g. pulp and peels, soil, detergents, etc.). The treatment of waste water is necessary for converting it into an acceptable final effluent and also to dispose off the solids removed in the process. The nature of the impurities and extent of pollution decide the suitable treatment methods and the degree of treatment, which will ultimately decide the design of the treatment plant.

15.4.1 Nature of Impurities in Waste Water

The wastewaters can be conveniently categorised according to their physical, chemical and biological natures of impurities.

The **physical characteristics** include appearance and odour. The materials in waste water from a fruit and vegetable processing plant are in solution and suspension, which are mostly organic with some inorganic matters. Water in-soluble liquids such as oils and certain solvents may also be present. The materials which remain as particles in the waste water must be removed before sending it to treatment plants or dumping, and should be treated separately. These materials, if discharged into streams and lakes, cause pollution and impart unaesthetic appearance. After removal of gross particulates, the wastewater may contain colloidal and dissolved impurities beyond the specified upper limit for discharge into streams or acceptable to sewage treatment plants. Therefore, further treatments depending upon the impurities are often required.

Under **chemical classification** of impurities, the colloidal and dissolved impurities in waste waters are divided into organic and inorganic materials. The peels, pulps, etc., which form a major part of the waste, are organic in nature. The ratio of nitrogenous constituents to carbohydrate materials present in the organic materials are very important from sewage treatment point of view. The nitrogen rich wastes accelerate the decomposition process by helping growth and activity of the sewage microorganisms, and hence sewage treatment plants are designed to receive wastes rich in nitrogen. Many vegetable wastes have higher nitrogen:carbohydrate ratio. As the fruit wastes have a high carbohydrate-low nitrogen content, they need supplementation with nitrogenous material before treatment in a sewage plant.

Very high and low pH waste water require neutralisation to bring down the pH to about 6-9 before discharging as it may kill aquatic life and essential microorganisms in sewage treatment plants or natural waters. The synthetic detergents and surface-active materials cause operating problems in sewage treatment plants, which can be easily avoided by using biodegradable detergents. If there is any bad odour from the wastewater, it needs an additional treatment.

The **biological nature** of impurities is very important. As previously discussed, the food plant wastes are generally organic, which are biodegradable. Mostly aerobic organisms are responsible for the degradation. In this process, carbohydrates are transformed into carbon dioxide and water, and nitrogen residues are converted to nitrates. Intermediate products such as alcohols, acids, amines, and ammonia are also produced during the process if the oxidation/ decomposition is incomplete. These intermediates often impart bad odour, and may be toxic to plant and fish life. These intermediates will undergo further degradation in nature.

15.4.2 Biological Oxygen Demand

Oxygen is required in the process of decomposition of organic waste by microorganisms. The amount of oxygen required is directly proportional to the amount of organic pollutants. This amount of oxygen, which is consumed for oxidation of organic contaminants is termed the biological oxygen demand (BOD).

BOD is an important measure of the dissolved organic wastes in water, and is of essential importance for the improvement of sewage and water. The BOD test measures the quantity of oxygen in ppm (parts per million) required by aerobic microorganisms to stabilise waste or polluted water under specific conditions (generally 20°C for 5 days). For example, the BOD of tomato processing wastes and citrus processing wastes vary between 80-4000 and 1000-5000 ppm. The BOD of milk processing waste water varies between 20-650 ppm only. When the BOD of waste discharged into a stream is excessive, there is fast depletion of the stream's oxygen, which disturbs stream's ecology, kills aquatic wild life and destroys beneficial microorganisms. The higher the BOD values, costlier will be the treatment before it is discharged into municipal wastes.

Sewage and waste treatment plants can be rated in terms of their BOD-removing capacity. The result of the BOD test determines whether a simple primary sewage treatment plant is sufficient or a complete treatment plant is required. The classification of streams by regulatory agencies is also often based upon BOD standards. Antipollution regulations are written to include maximum permissible BOD loadings into natural waters.

15.4.3 Chemical Oxygen Demand

The chemical oxygen demand (COD) is another useful test, which measures chemically oxidisable material in a liquid sample. This test is based upon the fact that all organic compounds, with a few exceptions can be oxidised quantitatively by strong oxidising agents, such as potassium dichromate, potassium permanganate, etc. under acid conditions. Thus it also measures chemically oxidisable inorganic materials.

15.4.4 Other Chemicals

The food plant wastes may sometimes be contaminated with highly toxic materials such as pesticides and disinfectants. Such toxic substances may kill the plant's normal microbial flora essential to sewage and waste treatment. Under such cases, it is advisable store it separately before discharging it into a convenient location or to dilute the wastes substantially and then send it to the treatment plant in very small quantities at a time.

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. What are the disadvantages of hard water for a food processing industry?

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2. Name the different methods for removal of hardness of water?

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3. What are the major disinfecting agents of water?

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4. What will happen if a high BOD waste water is discharged into a sewage treatment plant?

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15.5 WASTE WATER TREATMENT

The extent to which the pollution load must be decreased before waste water leaves a food processing plant is highly variable. It depends on many factors such as whether the waste water will be discharged to a municipal sewage or commercial waste treatment plant, and if so what is the maximum pollution load this plant can treat; what will be the cost for such treatment and can it be done more economically by the food plant itself; what dumping privileges does the food plant have and what pollution laws apply, and so on. The waste water treatments may be classified under the following headings.

15.5.1 Primary Treatments

The primary treatments include screening, filtration, centrifugation and settling or sedimentation. Large solid matters and heavy sediments are removed by screening through vibrating sieves. This is essential to protect and safeguard the subsequent treatment units. Smaller particles may be removed by filtering or centrifuging. Mostly the slow sand or biological filters and rapid sand or mechanical filters are used for the purpose.

Suspended impurities are allowed to settle or rise in large sedimentation tanks and removed. The rate of sedimentation can be enhanced by the use of alum or ammonium sulphite, which produces a sticky flocculant precipitate. Scum or oil is readily skimmed from such tanks, and settled solids are concentrated. These primary treatments may remove some 40% of the wastewater's BOD and about 75% of total solids, depending on the nature of the waste.

15.5.2 Secondary Treatments

The primarily treated sewage in small food processing industries is discharged into municipal treatment plants. But in large plants, some additional treatments similar to those carried out in municipal sewage installations are carried out after the primary treatments. The basic purpose of these treatments is to reduce the BOD level of the wastes. These secondary treatments commonly involve the use of trickling filters, activated sludge tanks, and ponds of various types. Sometimes these are preceded by use of anaerobic digesters.

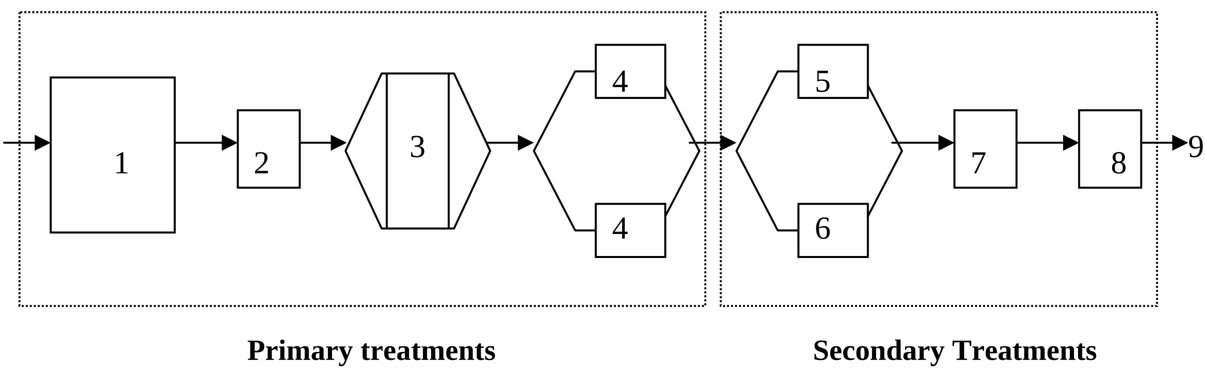

Figure 15.1: Waste water treatments: 1) Screen, 2) Shredder, 3) Grit chamber, 4) Primary sedimentation tank, 5) Trickling filter, 6) Activated sludge tank, 7) Secondary sedimentation tank, 8) Chlorination tank, and 9) final effluent.

15.5.3 Tertiary Treatments

The tertiary treatments or final treatments or advanced treatments applied to potable water for special food processing uses include water softening, ion exchange and carbon filtration. These treatments are also referred to as "polishing treatments". These are generally not needed or used to treat food plant wastewaters.

When a food plant has no means for disposing of treated waste waters, it may choose to discharge these waters into sewer lines for further handling by a municipal plant. The municipal plants usually chlorinate the waste waters before disposal into waterways or irrigation channels.

15.6 WASTE SOLIDS UPGRADING AND TREATMENT

You must have observed how a significant portion of the raw material is wasted during household processing of fruits and vegetables or cooking. Can you guess how much would be the amount of waste materials from a 10 tonne per day capacity fruit processing plant. If these wastes are not utilised properly, it affects the economic success of the industry. These wastes include crown, peel, core, seeds, pomace, trimmings, shells, stalks, etc. Table 15.2 gives an idea of the extent of waste during processing for different fruits and vegetables.

Table 15.2: Extent of wastes during processing for selected fruits and vegetables

Items	Waste as percent original raw material	Items	Waste as percent original raw material
Apples	30-35	Grapes	20-30
Mango	25-35	Peas	20-25
Guava	40-45	Beans	15-20
Pineapple	45-50	Carrots	5-7
Lemon	40-45	Tomato	8-10
Orange	50-55	Misc. vegetables	20-25

Most of the above wastes obtained from a fruit and vegetable processing industry are generally mixed with water. By suitable upgrading and treatment, they can be of several beneficial uses, as mentioned below.

- The by-products can be recovered from the waste water and spread out thinly on agricultural land for grazing of cattle. The unused material may be disposed off by burning.
- If the waste food are collected separately taking care that it does not mix with other refuse like broken glass, polythene pieces etc., they can be boiled, shredded, dried and enriched with minerals and can be used as poultry feed.
- Under favourable economic conditions most wastes can be processed or altered to a more useful and valuable material. Table 15.3 gives some beneficial uses of fruits and vegetables processing by-products. In fact, you will soon discover that no part is a waste during the processing of fruits and vegetables.
- Fruit and vegetable skins, pulp, and pits can be pressed to further remove water and be converted into compost for improving soils. Some wastes are ground into the plough as fill. Vermicomposting is one novel way for getting bio-fertiliser from bio-degradable wastes with the activities of earthworms.
- Sludge and residues remaining after waste water and sewage treatment have been dried and sold as fertilizer or used wet for this purpose. Sometimes they are incinerated, leaving only a small amount of ash, which can be disposed conveniently.
- Fruit and vegetable wastes are also used as a source of fermentable carbohydrate.
- All kinds of glass, solids, polythene, paper and metal can be recycled. Each of these materials should be collected separately for recycling.
- When none of these uses are feasible, then waste may be burned as garbage where law permits.

Table 15.3: Beneficial uses of fruits and vegetable wastes

Fruit	Nature of waste	Uses
Mango	peels, stones, pulping waste	starch, fat, pectin, vinegar, syrup, alcoholic beverage
Pineapple	peels, cores, trimmings	vinegar, syrup, citric acid, candied cores
Grapes	stem, seeds, seed hulls	cream of tartar, seed oil, tannin, vinegar, pectins, wines, stock seed
Apple	pomace, Cores cull	Pectin, cider, vinegar, soft drink, jelly base, Ingredient in cattle feed
Citrus	peels, pomace, seeds	pectin, essential oil and seed oil
Peaches, apricots and cherries	piths, kernels	oil, stock feed
Tomato	seeds, peels, and cores	animal feed, fertiliser, resin from peels, oil from seeds for soap making and edible use, peels

15.7 LOWERING DISCHARGE VOLUMES

Even though there are several ways to treat waste water, but you will agree that for minimising costs involved with waste water treatment and reducing the size of treatment plant, it is better to try to lower the discharge volume. The first step in lowering the discharge volume from a food plant is to reduce the amount of water used in the plant, which can be achieved by some modification in processing methods. Other means are recycling of the used water or treated waste water for some other non-priority areas.

15.7.1 Waste Water Treatment

For very large quantities of waste disposal, land treatment is the cheapest and best. The recovery of by-products from the wastes not only offers good economy, but also reduces pollution. However, these practices are viable only for big processing plants.

It is better to separate the solid wastes from the liquid. The coarse particulates and fine solids can be separated with different types of screens and settling tanks, as discussed in the previous section. The clear and problem free effluent can be drained.

Instead of segregating the different waste streams from a particular plant, the concentrated and high BOD wastes need to be handled separately. Thus large volumes of dilute waste water can be saved from high contamination. Some pre-processing ingredients are available which can reduce waste loads needing treatment.

15.7.2 Recycling and Modified Processing Methods

There are many modified processing operations, which can give lesser volumes of waste water as compared to conventional processing methods.

Reuse of water for less demanding operations is the most suitable one. The water obtained from heat exchangers or the boiler feed can be used for cleaning and conveying of fruits and vegetables. This decreases waste load to a considerable extent.

Recovery of salt by evaporation of the brine and crystallisation is possible. In addition to a potential saving in salt costs, it also avoids pollution that might have been caused due to discharge of the brine. However, the crystallised salt slurry may contain some organic matter, which has to be separated before the salt can be reused. This is done by incineration of the slurry, which leaves a trace of carbon. The salt can be reused after certain modifications such as adjusting the pH, and filtering to remove the carbon. Such processes, however, must also be considered in terms of benefit-cost ratio.

Loosening the skins of fruits and vegetables for peeling is usually done in dilute caustic solution. This method consumes a lot of water, which is ultimately wasted after peeling. Instead, we can achieve a considerable saving in water by peeling using concentrated sodium hydroxide (NaOH) solution combined with vigorous mechanical action. The BOD of the wastewater per weight of raw material obtained by this ‘dry caustic method’ is only about one-third that generated by the dilute caustic solution.

Similarly, steam blanching of vegetables saves considerable water from being polluted as compared to conventional hot water blanching. Further, as less amount of solids are dissolved in the blanching medium, the effluent has low BOD level. It is also reported to give better texture of the vegetables after freezing, thawing, and cooking as compared to the hot water blanching method.

Check Your Progress Exercise 2

Note: a) Compare your answers with those given at the end of the unit.

1. State True / False:

   a) The primary treatment of wastewater involves the use of activated sludge tanks.

   b) The secondary treatments of wastewater are also known as “Polishing treatment”.

   c) In small food processing plants the secondary treatment of wastewater is not carried out.

   d) The amount of wastes from mango fruits is in the range of 5-10 percent of the raw material.

   e) Recycling of water in food processing plant reduces considerable wastewater.

15.8 PLANT SANITATION AND EFFLUENT TREATMENT AS A CONTINUOUS RESPONSIBILITY

The ever increasing population, increase in number of industries and vehicles, migration of the people from rural areas to cities and towns, and several other factors have added to the amount of wastes. Now there is more concentration of people in areas of processing than the areas of production. This has added to a growing problem of waste disposal, which has always meant expense to food processors. In particular, in fruit and vegetable processing industry huge amount of waste and effluents are released. Most often the wastes are more than the preserved edible materials. It must be disposed off regularly and efficiently to prevent contamination of any food product. In addition, it is very important to prevent pollution of atmosphere and water supplies by proper disposal of the waste and effluents from such plants.

The wastes obtained from a fruit and vegetable processing plant are mostly organic and biodegradable. Large quantities of inorganic impurities from fruit / vegetable washing process may also be obtained. Small doses of pesticide residues, nitrates and nitrites formed out of residual protein and ammonical compounds during processing may also occur. All of these, if disposed as such to the surrounding, will pollute the surface and ground waters used for drinking purposes. This will ultimately add to the ever-growing problems of the human being. Therefore, every necessary step should be taken for effluent treatment of a food processing plant to protect the environment. All of these are moral obligations also.

The major source of air pollution in a fruit and vegetable processing industry is fuel burning in boiler for steam raising and heating which mainly emits smoke/ particles/dust, sulphur oxides and oxides of nitrogen. The intensity of emission varies with the type of fuel and boiler used, and the boiler-firing practice adopted. Minor discharge of benzpyrenes and trace metals contained in coal may also be present. Provision of inadequate smoke stack (lower height) and / or existence of unfavourable meteorological conditions may result in increased ground level concentration of pollutions which can result in discomfort and respiratory complaints initially and impairment of lung functions in the long run.

Therefore, it is our responsibility to take a holistic approach of production and processing as well as for the minimisation of wastes disposed from a food plant. Besides, if a food plant pollutes the surrounding atmosphere, it ultimately earns bad reputation and looses customers.

15.9 WASTE / EFFLUENT DISPOSAL REGULATIONS

Setting of the project has a very important role to play in the control of pollution. While deciding the location of the project, the weightage has to be given to the availability of power and water. It is also necessary to know in advance whether no objection certificate from the pollution control angle would be admissible for the proposed industry.

There are several pollution control acts to protect and improve the natural environment including forests, lakes, rivers and wild life and have compassion for leaving creatures. The Pollution Control Law Series: PCLS/02/1992 has the details of these regulations. It also contains standards notified with respect to the important pollutants as well as rules governing hazardous wastes, hazardous chemicals, etc. notified under Environment (Protection) Act, 1986. The Environment Ministry / Department and the State Pollution Control Boards are responsible for giving clearance on these aspects to any industry.

The Act specifies the wastewater discharge standards for any food and fruit processing industry, as given in Table 15.4. Table 15.5 gives the specified emission levels from boilers as covered under the Act.

Table 15.4: Wastewater discharge standards for food and fruit processing industry

Category	Concentration not to exceed				Quantum
	pH	Suspended solids (mg/l)	Oil and grease (mg/l)	BOD at 27°C for 3 days (mg/l)	g/tonne of product
a) Above 0.4 tonnes/day	6.5-8.5	50	10	30	-
b) 0.1-0.4 tonne/day	6.5-8.5	-	-	300	-

Table 15.5: Limits of emission from boiler houses

Capacity of Boilers	Particulate matters emission (mg/Nm³)
Less than 2 ton/h	1200*
2 to less than 10 ton/h	800*
10 to less than 15 tons/h	600*
15 tons/hr and above	150**

(* To meet the respective standards, cyclone / multicycle is recommended as control equipment with the boiler. ** Bag filter/ESP is recommended as control equipment. In the above table, 12% of carbon dioxide correction shall be the reference value for particulate matter emission standards for all categories of boilers.)

There are several other schedules in the Pollution Control Act dealing with discharge of effluents, ambient air quality standards, standards for control of noise pollution, etc. The Bureau of Indian Standards (BIS) has also specified regulations for manner, condition and fees for grant and renewal license for environmental management system.

The Factory Act, 1948 has several clauses relating to health measures and waste disposal aspects in any type of factory. Under the Act, the occupier is required to keep the factory premises clean and free from waste and effluvia. He shall make arrangements for sweeping and removing dirt and refuse daily, cleaning with disinfectant, painting the walls, doors and windows at specified time intervals. Effective arrangement shall be made for treatment of wastes and effluents due to the manufacturing process carried on therein, so as to render them innocuous and for their disposal.

If any process or machine gives off dust/fumes or other impurity which are likely to be injurious or offensive to the workers, effective measures should be taken to prevent its inhalation and accumulation in any workroom. The exhaust appliance, if used, shall be applied as near as possible to the point of origin of the dust, fume or other impurity. Besides, such points shall be enclosed as far as possible. The factory premises should be adequately ventilated by circulation of fresh air and comfortable temperature should be maintained in every workroom.

15.10 ENVIRONMENT IMPACT

Now-a-days we have become very conscious of the environmental pollution and degradation aspects at all levels. Therefore possible environmental impacts are taken into serious consideration before and after setting up an industry in a particular location. For example, the discharge of solid and liquid wastes, smoke and polluted air will change the physical and chemical characteristics of surrounding environment and water body. Sometimes, it has so happened that due to deposition of solids and/or discharge of harmful chemicals, streams have become unfit for drinking water purpose, or even for bathing. Similarly you must have observed how the surroundings near a thermal power plant or stone crushers are heavily polluted, which affect the normal life of the people. Hence, preparation of environmental management plan is required for formulation, implementation and monitoring of environment protection measures during and after commissioning of the projects.

The environmental impact not only considers the changes in air or water qualities in the area, but it also considers the biological, cultural and socio-economic components of the environment. It is essential to assess these environmental impacts and the tool used for the purpose is known as **Environmental Impact Assessment** (EIA).

In recognition of the role that EIA could play, Ministry of Environment and Forests, has published a list of 29 industries, which are required to obtain environmental clearance from competent authority in addition to a NOC from Pollution Control Board. Even though, the food and fruit processing industry, at present, is not included in the list, still the environmental impact for such industry can not be ignored.

Environmental impact has a very wide scope in the formulation of a project. Even for site selection, the environmental attributes such as topography, geology, water resources (quantity and quality), soil characteristics, land productivity, flora and fauna, socio-economic conditions are considered. The proximity to water resources, raw materials, markets, availability of land and human resources etc. are other project attributes. An environmental management plan is formulated to ensure that the resources are used with maximum efficiency, waste generation is minimised, residuals are treated adequately and products are recovered and recycled to the maximum possible extent.

EIA consists of establishing quantitative values for selected parameters, which indicate the quality of the environment before, during and after the proposed development activity. EIA involves three steps, viz. identification, prediction and evaluation of impacts. First the environmental parameters to be investigated for possible impacts are listed. Then with the help of suitable models real impacts for proposed development are assessed. Though fairly good models are available for prediction with respect to air and water components, predictions of biological, socio-economic and cultural impacts are often subject to uncertainty. The degree of uncertainty could however be ascertained mathematically or indicated in qualitative terms while presenting prediction results. The evaluation step calls for conversion of predicted values for various environmental parameters to a comparable set of units using some system of normalisation. At present many consultancy firms are also doing EIA studies, which can be hired for the purpose.

Check Your Progress Exercise 3

Note: a) Compare your answers with those given at the end of the unit.

1. Fill in the blanks:

   a) The major source of air pollution in a fruits and vegetables processing industry is _________________.

   b) The extended form of EIA is _________________________________.

15.11 LET US SUM UP

In this unit we studied about the importance of plant sanitation for a fruits and vegetables processing plant and we observed that sanitation is very important for the safety of food and overall performance of the industry. We discussed about the different properties of process water and steps for removal of hardness and disinfection of water so as to make it fit to be used as process water. We also discussed about the methods for waste water treatment and water solids upgrading and treatment. The different methods for lowering discharge volumes such as waste water treatment and recycling and modified processing methods are also covered in the unit. Thus we are now familiar with the general sanitation and waste disposal aspects of a fruits and vegetables processing plant.

15.12 KEY WORDS

Carbonate hardness : Hardness due to presence of calcium and magnesium bicarbonates; also known as temporary hardness.

Non-carbonate Hardness : Hardness due to the presence of calcium and magnesium sulphates, chlorides and nitrates; also known as permanent hardness.

Chlorine demand : It is the amount of chlorine required to destroy bacteria and oxidise organic matter.

BOD : The amount of oxygen consumed for oxidation of organic contaminants in water.

15.13 SELF TEST FOR THE COMPLETE UNIT/ ASSIGNMENT

1. Explain the different methods for disinfection of water?

2. Explain the importance of waste solids upgrading and treatment?

3. Explain the requirement of process water?

15.14 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Hard water creates a problem in cleaning operations. Hardness causes scale on equipment, which reduces heat transfer and contaminates steam produced in boilers. The life of pipes and fixtures is reduced as they may rust. The scales house bacteria and affect food products directly. Calcium present in hard water in excess amounts can cause various textural defects.

2. The methods for removal of hardness of water are boiling, addition of slaked lime, addition of washing soda, ion exchange process, and use of sequestering agents.

3. Chlorine, Ozone, UV rays

4. There will be fast depletion of the stream's oxygen, which disturbs stream's ecology, kills aquatic life, and beneficial micro-organisms for sewage conversion.

Check Your Progress Exercise 2

1. a) False
   b) False
   c) True
   d) False
   e) True

Check Your Progress Exercise 3

1. a) Boiler
   b) Environmental Impact Assessment (EIA)

15.15 SOME USEFUL BOOKS

1. Bhatia, S.C. (2001). Environmental Pollution and Control in Chemical process Industries. Khanna Publication, New Delhi.

2. Central Pollution Control Board (1992). Pollution Control Acts, Rules and Notifications Isued thereunder. Pollution Control Law Series, PCLS/02/1992, CPCB, Delhi.

3. Chatterjee, A.K. (1996). Water supply, Waste Disposal and Environmental Pollution Engineering. 5th Edition. Khanna Publication, New Delhi.

4. Gould, W.A. (1990) CGMP's/Food Plant Sanitation. CTI Publication, Inc., Baltimore.

5. Potter, N.N., Hotchkiss, J.H. (1996). Food Science. 5th Edition. CBS Publishers and Distributors, New Delhi.

6. Roday, S. (1999). Hygiene and Sanitation in Food Industry. 1st Edition. Tata McGraw Hill, New Delhi.