CHAPTER III
REVIEW AND CONCEPTS

3.1 Introduction

The principal aim of this study is to trace waste management practices among the small-scale food processing units. Although no systematic and serious research had been carried out on these aspects in Madurai and Dindigul districts, however, there have been a few studies, which have tried to analyse some of the relevant aspects of waste management in food processing industry in several countries, including India. A review of these studies would be relevant to the present study as it would reveal the strategies adopted by various food processing units in managing their waste and also highlight the methods used by the earlier researchers in this field. This chapter provides a brief review of these early research works in the international and national studies in the area of waste management in food processing industry. The choices of the studies were being prompted by the availability of materials in this field. This chapter also includes various concepts used in this study.

3.1.1 Generation of Waste During Production Process

Food processing industries generates huge amount of both solid and liquid wastes during the production process. The possible generation of waste among the food processing industries has been attempted by many researchers in India and abroad. For instance studies on the generation of waste in fruit and vegetable processing industries was carried out by Wiegand (1947), Sanborn (1944, 1945), Morris (1946), Kelly (1958), Joslyn (1961), and Mercer (1965) have revealed that in the process of canning, drying and preserving of fruits and
vegetables lot of wastes are accumulated in the form of peels, cores, vines, cobs and other waste materials which have to be either utilised in some manner for by-products or can be fed to the live-stock. Cruess (1958) has listed out different types of waste generated from fruit and vegetable processing. Wastes in these industries are generated during the process of sorting, peeling, trimming and coring. The researcher had pointed out that large quantities of fruit and vegetable processing wastes are generally disposed of in garbage, instead of using it for manufacturing good quality vinegar.

Watkins (1967) has indicated that, among the various fruits processed in the United States, the most important processing wastes are derived from citrus fruits, apples, peaches, apricots, pears, pineapples and cherries. He also found that wastes from tropical and other fruits marketed fresh are probably greater.

Somayaji's (1992) study has indicated that among fruits, mango occupies a very important place as it is utilised for a variety of purposes. In recent years considerably large quantity of mango is processed annually for international consumption and export purposes. About 4.27 million tonnes of solid wastes mainly of peels and seeds emanate every year in the food processing industries in the country. They are largely wasted and disposed of and pose a serious health hazard. Mango seeds are generally assorted for grafting and other uses but peels are dumped outside creating problems of waste management. The study concluded that, the wastes are rich in carbon and other nutrients, which can become a valuable raw material for a number of fermentative processes. The study recommend the use of anaerobic digestion over the other methods of waste treatment.
Gandhirajan et al. (1995), revealed that some of the major food processing industries such as dairies, canneries, sugar industries and plants processing foods such as sea food, soft drinks, bakeries/biscuits, coffee, starch, and fast food, invariably generate waste water in their process operations. The main waste sources are spoiled raw materials, rinsing of raw materials, washing of food stuff manufacturing/mixing vats, and floor washing. The wastewater contains soluble and insoluble organics, which in turn exerts high BOD demand. The BOD value of these wastewater normally varies from 500 to 5000 mg./litre as against the prescribed tolerance limits of 30 mg./litre. When this wastewater is discharged into water course or into soil it putrifies rapidly leading to foul odour and contaminates the water course and ground water. The study recommend to prevent water pollution in food processing industries, and to treat the wastewater prior to disposal.

Sanjeev's (1999) study has found that the preference of the consumers towards alive chicken results in the generation of about 0.3 million tonnes of poultry waste throughout the country. The researcher further added that, in Delhi and Mumbai, 30 truckloads of poultry refuse is wasted everyday. In Mumbai it is thrown into the sea and in Delhi on the open land which cause severe environmental hazards. The researcher has recommended effective utilisation of waste by setting up dehydration units, chilling and processing units and centralised refuse disposal facilities, which will save at least 30 per cent of protein waste.
Beebi Khasim et al. (2004) have conducted a study to know the impact of grain dust in the vicinity of warehousing complex in Visakapatnam. According to the study huge quantities of dust is generated by the grain industrial pollution. 27 pounds of dust is emitted for every tonne of grain handled, resulting in 1.7 million tonnes of grain dust generation per year. Grain dust is a complex and variable mixture of particles from plants, insects, soil, micro organisms and other sources. It evokes a number of responses with in the respiratory tract, ranging from an acute inflammatory response as asthma to chronic obstructive pulmonary disease among the grain handlers who work with grain regularly such as grain elevator, workers or grain transporters. The study found that grain dust mainly affects air quality, human beings and vegetations.

Drawing important lesson from the earlier studies, the present study attempts to assess the production process and generation of waste in seven small-scale food processing industries namely grain milling, fruit and vegetable processing, milk processing, oil crushing/ extraction, soft drink (beverage), bakery and confectionery, and meat and poultry.

3.1.2 Waste Management Practices Adopted by the Food Processing Units

One of the objectives of the present study is to analyse the waste management practices adopted by the small-scale food processing industries. A number of studies have been conducted in this area, which are explored in this section.
Kalia (1997) in his study at the Centre for Biochemical Technology (CBT) in Delhi has developed an indigenous and eco-friendly technology to recycle vegetable wastes into bioenergy. According to the researcher a highly efficient technique will not only reduce the mounting garbage heaps that pollute the city but also will lead to the generation of energy rich fuel. It is an easy-to-operate technique in which vegetable wastes are first solubilised into slurry. The slurry is then subjected to fermentation and anaerobic digestion in the presence of methane producing bacteria, which convert the waste into gas and an effluent. In the process, nearly 70 per cent of the gas obtained is methane which can be used as bio-gas fuel. And the nutrient rich, odourless effluent can be used as fertiliser and as an animal feed.

Pap Nora et al. (2004) found that environmental best-practice technologies satisfy consumer demands, while the production process is optimised in order to have the least impact on the environment. The other features of the technology are reduced use of raw materials, less energy and water use, safety in the production process, and minimisation in generation of waste effluents.

The Indian Institute of Technology, New Delhi (1980) has developed a bio-gas operator capable of producing electricity for lighting rural homes, driving irrigation pumps and operating farm machinery through animal waste, farm waste and organic waste for producing bio-gas. A medium sized plant using nothing but agricultural waste or animal waste can produce enough gas to operate the generator for nearly eight hours a day.
The National Environmental Engineering Research Institute, Nagpur (1993) used microbes to produce methanol from spoilt vegetables and fruits. Spoilt vegetables and fruits have been found to emit methane gas, which can be used as a substance by some micro-organisms to produce methanol. Experiments have shown that about 100 mg. of methanol can be obtained per litre of the culture medium containing micro-organisms, a 1000 fold increase over earlier reports in literature.

The Solar Energy and Training Centre of Naresuan University in Thailand (1997) undertook a project which aimed at converting banana peels into energy using biogas technology. The centre is using the waste banana peels to produce biogas for basic rural energy requirements, besides cleaning up the local environment.

The scientists at the Centre for Biochemical Technology in Delhi (1997) have developed an indigenous and eco-friendly technology to recycle vegetable wastes into bio-energy. The highly efficient technique can not only reduce the mounting garbage heaps that pollute the city but also lead to the generation of energy rich fuel. In the easy-to-operate technique, vegetable wastes are first solubilised into slurry. The slurry is then subjected to fermentation and anaerobic digestion in the presence of methane producing bacteria, which convert the waste into gas and an effluent. Under this process 70 per cent of the gas obtained is methane, which can be used as bio-gas fuel. The nutrient - rich, odourless effluent can be used as fertiliser and as an animal feed.
Kakani's (1990) study investigated the recovery of aroma from fruit processing wastes. One of the primary objectives of the investigation was to develop a convenient and simple technique for recovering aroma from apple pomace and mango peel waste. Taking into account various operational aspects and ease of disposal or further utilisation of the spent fruit waste, direct steaming of the waste to recover aroma was found to be the best approach. Studies using the aroma generation assembly have shown that it is possible to recover more than 90 per cent of the aroma content by equilibration of pressure cooker vapor phase with the fruit aroma followed by \( N_2 \) flushing during steaming. The results of the study indicate that the pomace/peel waste aroma could be utilised as “flavour boosters” for the respective fruit beverages, synthetic beverages and other food products like dairy products. These fruit flavors may also find application in cosmetic industries.

Swadas's (1996) study on dairy industry recommends to use membrane technology. The researcher finally concluded that the liquid waste should be reduced as far as possible through economic alternatives such as anaerobic and the aerobic treatment and also should be recycled in the dairy for washing the containers before the final disposal.

Kadam et al. (1996) and Prajapati et al. (1999) in their study on dairy industry found that this industry creates pollution problems, if discharged without treatment. At the same time the dairy effluently have tremendous potential for recovering valuable products like fats, methane gas by subjecting effluents to anaerobic treatment, oxidation ponds, aerated lagoons and activated sludge process.
Puranik et al. (1995) have cited that in the treatment of both liquid and solid wastes in dairy industry there are significant opportunities for the use of bio-technology. Micro-organisms are the major tools of biotechnology for controlling pollution. Now, additional techniques are applied to use genetically manipulated micro-organisms or their products, which have greater potential for disposing of many of the persistent toxic chemical from the environment. The researchers have finally listed out the application of biotechnology in dairy waste treatment mainly i) Methane production from dairy waste which has an important utility, ii) Ethanol production from whey, iii) Single cell protein production, iv) Single cell oil production and v) Metal recovery from waste.

Shivayogimath et al. (2002) in their study have indicated that the high-rate anaerobic treatment process has emerged as a viable alternative for the treatment of milk processing industrial wastewaters. The study used laboratory scale anaerobic filter (AF) with polyurethane foam as packing material for the treatment of dairy effluent under ambient conditions. The study found that i) Anaerobically digested sludge from septic tank can be used as seed for the start-up of anaerobic filter for dairy effluent; ii) Dairy effluent of 2850 mg. COD/litre can be satisfactorily treated (83 per cent) at a short hydraulic retention time of 12 hours; and iii) Biogas rich in methane (80 per cent) can be generated at a rate of 2.3 under ambient conditions. The study concluded that anaerobic filter with polyurethane foam cubes as packing materials, can be used for stable and satisfactory treatment of dairy effluent.
The Australian Council for Scientific and Industrial Research Organisation’s Meat Research Laboratory in Brisbane (1993) has transformed abattoir waste into high-grade garden compost, which can be used as a soil conditioner, fertiliser and potting mix. Working with vast volumes of waste, the researchers turned various mixtures of meat scrap and cattle and sheep paunch content into a stabilised organic residue within 19 to 27 days. This material, after lying inert for several months, became mature, odour free, ready-for-sale compost.

Carawan (1987) has carried out a study on pollution prevention in eight food processors, which includes two dairy plants, two poultry processors, a beef slaughtering facility, a breaded foods plant, a snack foods plant and a seafood processing plant. The researcher has indicated that pollution prevention provides technological, economic and environmental advantages over traditional methods. The ‘end-of-the-pipe’ and land fill approaches are expensive to industry and create regulatory costs and problems for government. The study has concluded that; i) Food processors can reduce pollution. In many cases this activity can pay with savings greater than the costs to implement necessary changes; ii) The management of food processing plants can often reduce water use and pollutants without expending capital. Capital expenditures can further decrease water use and pollutants. The study recommended that the disposal of residues, by-products and sludge from food processing plants need efficient and effective methodologies, and the food processing plant employees should be trained to minimise water use and wastes.
The present study is an improvement over the other studies as it is not partial in approach dealing with one or two food processing industries, but gives bird's eye view on the waste management practices adopted by seven small-scale food processing units in the select districts of Tamil Nadu, India.

3.1.3 Linkage of Wastage through Waste Utilisation and Exchange

Another area of interest of the present study is to trace the existing linkages between waste generation and waste recycling among the small-scale food processing units. A number of studies have been carried out with regard to the above said objective. The findings of these studies are listed below.

Many studies have been conducted on the waste generated from sweet potato processing industries. Grimes (1941), Southwell et al. (1948) and Bond et al. (1967) in their studies have come out with the conclusion that the waste, which are generated during the processing of sweet potato has a nutritive value if it is dehydrated and can be a good source of feed to beef cattle. On the other hand Matsumura et al. (1963) have reported that citric acid can be produced from the sweet potato pulp waste. Sweet potato pulp obtained as a by-product during starch manufacture can be a raw material to form calcium citrate with the help of fermentation process, whereas Janioki et al. (1966) in their study have highlighted that the solid waste from potato processing can be effectively used as a culture medium for yeast growth and also gave satisfactory utilisation of potatoes. It was also estimated that the protein content was also higher to the extent of four to five times more than the raw material. Similarly, Fremel et al. (1962) analysed the utilisation of potato waste and reported that production of antibiotics can be possible from potato waste.
Similarly some studies were carried out on the utilisation of citrus fruits waste. For instance Nolte et al. (1942) have demonstrated in their investigation the economic feasibility of the process to convert the waste citrus peel juice into high quality industrial alcohol. Long et al. (1961) have investigated the economic conversion of waste peel juice into 2,3 butylene glycol through fermentation process. Me Nary et al. (1960) have studied the possibilities of vinegar making from the waste orange peel juice through acetic fermentation. The researchers have found that elimination of peel oil from the fermentation medium resulted in a satisfactory product.

The scientist at Bhaba Atomic Research Centre (BARC), Mumbai, (1997) have developed an indigenous technology to produce pectin from lemon peels, an essential ingredient for food industry that is currently being imported to meet the requirements. The BARC technology for pectin will not only help satisfy the ever increasing market demand for the product but also save precious foreign exchange spent on its import. Pectin, a purified carbohydrate that consists chiefly of partially methoxylated polygalacturonic acid is required as a thickening agent in the preparation of jams, jellies, marmalades and salad dressings. It is also used in pharmaceutical preparations and as a replacement for fat.

Some of the researchers have tried to study the avenues for utilising the waste generated from pineapple processing industry. Collins's (1960) study has reported that the pineapple processing waste can be economically utilised to produce sugar syrup for canning, alcohol, cattle feed and organic acids. The
researchers have also discussed other possible products such as, feed yeasts, citric acid, malic acid from mill juice and starch proteases and fibre production from the plant residue. Henke (1931 and 1945) and Henke et al. (1945) have studied the feed value of pineapple waste. Pineapple bran, a product obtained by drying pressed fruit, shells and pressed pulp is suitable for feeding cattle, pigs, and chickens. It is estimated that one tonne of processed pineapple yields about 60 to 70 Lbs. of dry pineapple bran. On the other hand Richardson (1967) has conducted a study on the production of vinegar from pineapple waste. Submerged acetification experiments were performed to determine conditions necessary for the production of satisfactory vinegar from waste pineapple juice using a pure culture inoculum. Vinegar containing upto 7 per cent weight of acetic acid could be procured in less than 24 hours with a conversion efficiency of greater than 90 per cent in both laboratory and pilot plant equipment. None of the bacterial nutrients added to the juice improved either the rate of production or the yield of acetic acid.

The Cottage and Small-Scale Industries Department of the West Bengal Government (1978) has developed pineapple fibre for making furnishing material and garments. The fibre is stronger than cotton or jute. The yam developed is soft and can be used for making shirts and coats. The twisted yarn obtained from pineapple fibre can be used for manufacturing furnishing materials. Experiments are being made to get better quality of fibre by chemical treatment. It is estimated that a minimum of two tonnes of pineapple fibre is needed to manufacture textiles on a commercial scale.
Joseph's (1985) research found that from the waste materials obtained in pineapple processing industry valuable by-products such as bromelian, wine, oleoresin hamicellulose, vinegar and biogas may be manufactured. Among them bromelian and vinegar can be produced on commercial scale. Commercial production of bromelian has been developed by China Technical Consultancy Inc., Taiwan and that of vinegar has been developed at the Central Food Technological Research Institute (CFTRI) Experimental station, Trichur in Kerala. Other products such as single cell protein and biogas can be produced if sufficient waste materials are available. The researcher concluded that in Indian pineapple canning factories, the quantity of waste materials obtained is not sufficient for economical utilisation, producing valuable by-products. As per the researcher the following alternatives can be tried, i) The waste materials obtained from canning units situated in the nearby places may be collected and useful by-products can be produced; ii) Brewed vinegar can be manufactured from pineapple waste by individual factories; iii) The waste materials can be used to produce biogas, which may be utilised for producing steam in individual factories and iv) The waste materials can be used as cattle feed.

Studies pertaining to the usage of waste from other fruit processing industries such as peaches, apricots, cherries, guava, jack fruit, grape, banana and apple were also undertaken by the researchers. For instance, Girdharilal et al. (1967) have reported that, in the canning of peaches, apricots and cherries, a large quantity of waste pits are obtained. These have been utilised
successfully in Germany and the United States for the manufacture of fixed oil, bitter almond oil and macaroon paste. The researchers have also indicated that the core with the seed and the peelings of guava can be utilised for making guava cheese. They have found that the waste of jack fruit, namely the thick rind with innards perigones, to be a good raw material for high class jellies. Pectin can also be prepared from it. The starchy seeds can be roasted or cooked and eaten as a delicacy. Like wise, Nolte et al. (1940) in their study have described the commercial preparation of grape fruit seed oil as practiced in Florida, US. The crude oil has an extremely bitter taste, which is probably due to limonin \((C_{26}H_{30}O_{10})\). The oil can be easily refined. The refined oil has a blend taste.

Rajendrudu et al. (1996) have designed bio-batteries using ripe banana and orange peels, vegetable wastes and metal scrap, which can be used as an alternative to contentional low power dry cells for use in low voltage appliances like calculators, wall clocks and video game toys.

The National Research Centre for Banana, (2004) had reported that they have tested the fuel efficiency of Banana peel. The centre has been able to produce alcohol from banana peel and is willing to transfer its know how to the industry. Banana peels contains 11 per cent alcohol. In certain varieties like plantain AAB and Nendran, the alcohol content amounted to 30 per cent of the total weight of the fruit.

Modi's (1998) study at the Ram Manohar Lohia Avadh University, Faizabad, has developed a new method to produce ethyl alcohol, a chemical
required for various commercial applications, using damaged, low grade and inferior quality waste apples. Each year a large amount of apples perish in orchards due to inadequate storage and transportation facilities as well as diseases. These fruits can be used for manufacturing ethyl alcohol. Mature apples are highly susceptible to damage even on slight pressure. Seasonal diseases also add to the fruit loss causing not only economic loss but also environmental pollution. The researcher used two yeast strains, sugar in the form of molasses and trace amount of urea to produce the alcohol from culled apples. They yield maximum when the sugar concentration varies from ten to 20 per cent.

The Commonwealth Scientific and Industrial Organisation’s Food Research Division at Australia, (1977) have formulated a flavoursome new citrus drink from discarded peel of citrus fruits such as lemons and oranges. The drink is prepared as a powder which mixes readily with water to produce a lemon or orange beverage with full natural flavour and high vitamin C content.

Doedens (1984) has pointed out that dairy effluent sludge contains valuable nitrogen (about 15 per cent) and phosphorous (85 per cent) and lower potassium as compared to mineral fertilizers. This shows that such sludge has important fertilizer properties. In order to avoid poisoning or over fertility of soils, sludge application may be limited to 1 to 3 tonnes of dry solids per hectare per year, average over three years.

Murdia et al. (2005) have given an account of waste produced in dairy industry and its management practices. According to the researchers each product in dairy industry produces waste of different quality and quantity.
Dairy effluents, whey, buttermilk, and water are obtained either as waste or by-product. Most of the solid waste can be processed into other products and by-products. For example the whey can be utilised through the production of whey protein concentrates, whey beverages, ethanol production from whey, baker’s yeast from whey fermentation, fermentation of whey to methane (Biogas). The study recommends that there is a need for effective utilisation, treatment and management of wastes from dairy industry.

Prabhu's (1994) study indicated that the dairy industry releases between six and twelve litres of effluent for every litre of milk processed. Normally effluents is treated and released into water courses and ground water. According to the researcher, the utilisation of dairy effluent in forestry can be an economically viable, environmentally friendly and technically feasible proposition. It also conforms to the directives of the pollution control authorities.

The Punjab Agricultural University’s (1987) food technologists have found a way to turn the liquid whey (a by-product formed during the manufacture of paneer which is usually thrown away as waste) into an Italian-type cheese. The cheese, called Ricotta, is soft, fresh and unripened when manufactured from whey and costs much less than other cheeses.

Anon (1978) has cited that the protein blood from slaughtered animals can be recovered in the form of white powder that is 95 per cent pure protein. The powder is odorless and tasteless and blends easily with many foods. There are two major types of protein in blood, plasma protein and heme protein.
Presently, only the plasma protein is economically viable. The protein concentrate, which is merely isolated and spray-dried, has very desirable characteristics of solubility, whipping ability and emulsification. One major use for the blood plasma protein is as a food binder in ground meat products.

The Central Drug Research Institute, Lucknow (1977) has developed a process for preparing pepsin from slaughter house waste. In the process, buffalo and goat stomach are transported under chilled conditions from the slaughter house. Residual food and unwanted material are removed by washing with running tap water. Inner muscosal linings are scraped under cold conditions, homogenised and incubated after adjustment of pH, the homogenate is filtered and the filtrate is dried under vacuum to a light yellow powder. The study concluded that about 300g of pepsin have been prepared from buffalo stomach and 20g from goat stomach.

Dalev Pencho's (1994) investigation found that the waste feathers from poultry slaughter houses can be processed into a protein supplement. According to the researcher feathers account for five per cent of the body weight of poultry. Although feathers are known as a protein source, the use as feed requires the complete destruction of the rigid Keratin structure. The study had concluded that the complete amino acid composition of feather protein concentrate characterizes the product as a good source for preparation of mixed feed in combination with other protein products.

Cook (1980) has indicated that rice husk can be used to make cement like material. According to the researcher concrete and cement based products
are widely used in the developing world. The capital and running costs in the production of cement, however, are high and cement is not cheap. Also in many countries there is a shortage in the production of cement, which has to be imported at the cost of foreign reserves, if building construction programmes are to be maintained. Accordingly, it is hoped that the development of rice husk and cements, which could produce up to five million tonnes of cement per annum from the available rice husk in India, will provide a suitable alternative, particularly in rural areas. He pointed out that for every tonne of rice produced, complete combustion of the husks produces about 40 kg of ash. The ash cement could work out to be 30 to 50 per cent cheaper than the conventional cement. It also would require less capital investment than required in the manufacture of conventional cement.

The Central Glass and Ceramic Research Institute (1995) have developed new technologies to convert food units wastes into utility products. The wastes of rice mills, rice husk ash which causes pollution and problems of disposal, has been used to prepare a high quality insulation material, which finds extensive use in refractory kilns and steel plants. Fertilizer plants produce a waste, phosphogypsum, which makes ground water non-potable. Phosphogypsum has been converted into a high quality material to produce supreme quality plaster of paris for use in cement building, ceramic and medicare industries.

The Indian Institute of Technology, Kharagpur (2001) has developed light weight heat insulating tiles using agricultural waste materials like rice
husk and rice husk ash as binder. There are other uses to which rice husk and rice husk ash can be put. Rice husk ash can be used to manufacture a good and inexpensive substitute for the presently available acid-resistant material. Our country anticipates wide growth of Industries producing and discharging acidic end products /wastes and there is a strong need for acid proof cement. Other products which could be manufactured using acid proof cement so prepared from rice husk are: acid resistant tiles/bricks, heat insulating tiles for roof walls facing sun to reduce the flow of heat, cleaning powder - a cost effective cleaning powder, which can be used in industries, railways, and hotels. It can also been used for cleaning of utensils at home and acid proof concrete.

Kerr Thomas (1985) has indicated that groundnut shells, discarded as useless till now can be converted into a valuable animal feed using a simple biological conversion process. He has identified the right kind of microbial species of arthobacter that can do the job effectively. The bacteria has the ability to use the shells as a source of food. When a few more nutrients are added and finally reduce the shells to a crumbling powder resembling ground coffee. Instead of acid treatments the shells can be retted and fermentation could be done at the farm level.

The Indian Institute of Technology, New Delhi (1987) has developed a process for the conversion of food processing waste into a cheap and useful alternative source of energy. The process is based on conversion of biomass like paddy husk and groundnut shell, waste materials of low colorific value into highly efficient sources of energy called briqueted fuel. The cost of one kilogram of the fuel, which gives about 5,500 kilo calories of heat energy, is
expected to be less than Rs.1.50. Briqueted fuel an ideal alternative to firewood coal can be used in boilers, hostels, bakery and also in the household.

The Indian Plywood Industrial Research Institute, Bangalore (1980) has developed durable and low cost veneer and rice husk boards for roofing houses. According to the Director of the Institute, 1.7 crore tonnes of rice husk is available annually as an agro by product in the country and even if 10 per cent of it is utilised from making roof boards, it could provide roofs for 30 lakh houses. The veneer roofed houses would cost about Rs.10 per sq.meter of plinth area. A housing factory to manufacture veneer and components for 10-12 houses a day would require an investment of about Rs.3 lakhs.

The Central Glass and Ceramic Research Institute (CGCRI), Calcutta, (1980) has developed a process for the manufacture of sodium silicate from rice husk ash furnishing yet another example of making effective use of wastes. Sodium silicate is a chemical used in the production of soaps, detergents and silica gel (desiccant). Compared to the exiting conventional process for the manufacture of the chemical the CGCRI process requires low capital investment and is quite suitable for the small scale society run in rural areas.

The Regional Research Laboratory, Trivandram (1980) has produced good quality cement with the help of rice husk, a waste product. The laboratory which is engaged in work relating to the utilisation of agricultural and industrial wastes, has found that fine silica particles, produced from controlled burning of rice husk yield good quality cement when mixed with lime shell.
Laboratory scale trials on the cement made out of rice husk, as hand lime shell have yielded extremely satisfactory results.

James's (1986) research on wastes in food processing industry, suggested that the rich organics present in them would help in production of energy. This kind of attitude will partly reduce the pressure on energy consumption by the industries. The utilisation of slurry and effluents for animal food and agriculture purposes respectively will certainly reduce the cost of production of biogas. The integrated approach to the problem will help to popularise the use of biogas and it would be also cost competitive to other sources of energy such as LPG.

The Oil Technology Research Institute (OTRI), Anantpur (1993) has claimed that the researchers at their institute have extracted valuable edible fat from the mango stones that are invariably thrown away as waste. The OTRI researcher has designed a novel mechanical device for decortications that works efficiently on both fresh and dry stones. The extracted mango kernel fat finds application in bakery, confectionary and pharmaceutical products. The defatted seed is rich in starch and can be used in jute, textile and paper industries, along with powder, which is an effective plant manure. In another related development, the OTRI scientist has shown that the mango peel yields good quality wax that can be used in many industries.

The above studies show that the waste generated from the food processing industries has a high economic value, if it is utilised in a proper way. It is also established that the waste of one industry can be a raw material for the other industry, if there is proper linkages are developed between them.
The present study also tries to establish such a linkages between the small-scale food processing units in the study area.

### 3.1.4 Impact of Cost on the Implementation of Waste Management

Cost plays an important role in the adoption of waste management technology in an industry. Some of the researchers have highlighted the impact of cost on the implementation of waste management programmes.

Upadhyay *et al.* (2002) in their study have pointed out that the organic load of the dairy effluent normally varies as high as 3500 mg./litre depending on cost of effluent treatment and disposal. Means of improving wastage control including monitoring of turbidity, COD and BOD, the use of wastage audits, and value engineering reduce the overall cost of a project without compromising on quality. Among the various techniques of effluent treatment anaerobic treatment proves to be a very attractive alternative. Because dairy sludge can produce biogas of approximately 700 litres/kg. with an average decomposition rate of 85 per cent. The study that anaerobic treatment of dairy waste will reduce both treatment and running cost.

Carawan's (1988) survey has pointed out that process and management changes can be used to reduce the water use and waste load from food processing plants. Process waste load reductions are more economical than pre-treatment processes. Pre-treatment at food processing plants often costs more, may present health and safety concerns with microbial pathogens and perhaps viruses, and generates sludge which is difficult and expensive to dispose in environmentally sound manner. The researcher cautioned that the small-scale food plants not to venture into pre-treatment without serious
consideration of operational problems and sludge disposal. On the other hand
the study suggested that the large scale food plants to go for pre-treatment. The
municipal officials and food processors need to communicate mutual concerns
about pretreatment so that society receives maximum waste reduction with a
minimum of resources. Finally the study concludes that the least expensive
and most effective way to protect wastes is to implement management and
process changes that prevent pollution by reducing water use and waste
generation.

A very few studies has been carried out to understand the costing
problem associated with waste management. The present study tries to examine
the relationship between the cost of waste management, output, and
profitability of the selected small-scale food processing units in the study area.

3.1.5 Waste Management Policies and Regulations

The waste management policies and regulations have an important
bearing on the environment and hence it has attracted the attention of
researchers.

Kailaschandra's (1989) analysis found that large quantities of solid and
liquid wastes are generated during the processing of fruits and vegetables. This
poses serious disposal problems and health hazards. According to the study it
is more important to enforce these laws effectively to achieve desirable results.
The researcher finally concluded that recent developments have shown newer
approaches like pollutionless cyclic process, zero discharge system and so on
aimed at almost complete elimination of waste discharge from the processing
plants. With the present trend of steep increase in processing of fruit and
vegetable in India, there is an urgent need to resort to such system and reduce
the environmental pollution.
Eldon and Smith (1991) have viewed that, laws and regulations dealing with waste disposal are beginning to drive industrial behaviour towards pollution prevention. In addition, because the costs of safe disposal are mounting, waste handling firms - both private and public are looking for better and cheaper ways to treat and dispose of the waters. Strong enforceable laws have eliminated the economic incentives that were unable or, more likely, unwilling to properly dispose of their wastes have turned to illegal right - time dumping. The environmental costs of not managing wastes, as witnessed in virtually every industrialised country, are astronomical. And because major generators of waters remain liable for past mistakes, economic and regulatory incentives for complying with waste regulations should continue to encourage responsible management.

Panneer Selvam (1994) has reviewed the existing industrial and environmental policies and discussed the opportunities and the enabling measures in order to push the on going reform process towards an environmentally sustainable industrial development. According to the researcher economic efficiency and environmental management policies are complementary to each other. Experiences in the past have proved that the industrial output could be increased several times with reduced wastes. This required accelerated investments for development and adoption of cleaner production technologies, storage environmental institutions, supported by innovative environment policies and open trade and capital flows.
Turner et al. (1998) have reviewed recent developments in the context of waste management policy and the emergence of policy instruments such as recycling credits and the landfill tax. The study concluded that there is an important role that economic instruments can play in this policy area. The waste management policy area is one in which the use of economic instruments could prove effective and the combination of land fill tax and recycling credits is a first tentative step in this direction.

Stafford (2000) has examined the relationship between environmental regulations and the location decisions of hazardous waste management firms. Unlike many other studies of the effect of environmental regulation on firm location choice, this analysis finds that a number of different measures of environmental regulations can explain some of the differences in location choice for hazardous waste management facilities. While other variables such as the level of manufacturing activity and energy cost may be more significant determinants of location choice, environmental regulations are not insignificant. Environmental regulations appear to have larger effects on the location decision than some other more traditional factors such as wages and taxes.

Angels and Sulaiman (2003) have viewed that the British environmentalist Pigou (1920) idea of a pollution tax can be implemented in India. Pigou suggested that polluters should pay a tax, based upon the estimated damage caused by their pollution emission. The ideal Pigovian tax on efficiency grounds must exactly reflect the costs of pollution of the margin. It is impractical to tax the polluters precisely and therefore a number of proxy
solutions are often adopted. Hence, the researchers have suggested that the pollution taxes would be administrated via the Government through existing tax framework. Under Indian conditions the best way of reducing the pollution is by taxation. When the taxes on polluting goods increases then the consumption of such goods for will decrease so the subsidies on such goods should be removed and taxes should be increased selectively based on the extent of pollution created by such goods.

Sulaiman Hameed and Satish Kumar (2003) have stated that, the two principal approaches to pollution control and waste management are the command - and - control and economic strategies. Since the inception of environmental policy in many countries, governments have tended to use command and control (that is, direct regulation along with monitoring and enforcement system) as the predominant strategy in pollution control and waste management. Theoretically, economic instruments have the capability to control pollution according to market mechanisms and thus facilitate deregulation practice; however, they have not eliminated the need for government participation. Nevertheless, economic instrument supplement direct environmental regulations to raise revenues for financing pollution control activities, provide incentives to better implement regulations contributing to the achievement of environmental policy objectives.

Jost Frank and George Muller (1996) have viewed that a major problem of environmental policy making is the evaluation of negative effects of economic activity on the natural environment. Two approaches to such evaluation can be discerned; the economic and the ecological. At the first sight, there is an unbridgeable gulf between these two approaches. They suggest that
this gulf can be bridged, or at least greatly reduced. If we take a joint production approach to the production process, not only is such an approach realistic for many manufacturing processes, but it also provides many useful insights into the management of negative environmental effects from economic activity. In particular, considerations of possible technical change, combined with the influences of environmental legislation are likely to allow the simultaneous reduction of the emission of polluting by-products and improvements in economic efficiency and profitability.

The above studies have shown the importance of waste management policies for effective environmental protection. The present study not only analyses the existing environmental policies and regulations in India for waste management but also tries to assess the knowledge of these policies by the owners of the small-scale food processing units in the study area.

3.2 Concepts

3.2.1 Aerobic Treatment

The United States Environmental Protection Agency defines aerobic treatment as “a process by which microbes decompose complex organic compounds in the presence of oxygen and use the liberated energy for reproduction and growth. Types of aerobic processes include extended aeration, trickling filtration, and rotating biological contactors.”

3.2.2 Air Pollution

The United States Environment Protection Agency has defined Air Pollution as “the presence of contaminant or pollutant substances in the air that do not disperse properly and interfere with human health or welfare or produce other harmful environmental effects”.

65
3.2.3 Anaerobic Digestion

Anaerobic digestion is defined by Johri and Rajeswari (2005:153-154) as “the process which involves the breakdown of organic compounds by microorganisms in the absence of oxygen to produce biogas, which is a mixture of methane and carbon dioxide. The optimum temperature for anaerobic digestion is 37 degree celcius and the pH is 7.”

3.2.4 Biochemical Oxygen Demand (BOD)

The United States Environment Protection Agency has defined BOD as “a measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution”.

3.2.5 Biodegradable

The United States Environmental Protection Agency defines biodegradable as “the ability to break down or decompose rapidly under natural conditions and processes”.

3.2.6 By-Product

United States Environmental Protection Agency defines by-product as “materials, other than the principal product, that is generated as a consequence of an industrial process”.

3.2.7 Chemical Oxygen Demand (COD)

The United States Environmental Protection Agency defines COD as “a measure of oxygen required to oxidise all compounds in water, both organic and inorganic
3.2.8 Cleaner Production

United Nations Environment Program (1989) defines Cleaner Production as “a continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment”.

3.2.9 Composting

Johri and Rajeswari (2005:149) defined it as “a process that involves the breakdown of organic waste in the presence of micro organisms, heat, and moisture.”

3.2.10 Conversion Rate

It is the rate at which the raw materials are converted into finished products. In other words, it is the percentage conversion of raw materials into final products.

3.2.11 Disposal

United States Environmental Protection Agency defines disposal as “the final placement or destruction of toxic, radioactive or other wastes, surplus or banned pesticides or other chemicals, polluted soils and drums containing hazardous materials from removal actions or accidental releases. Disposal may be accomplished through use of approved secure landfills, surface improvements, land farming, deep well injection, ocean dumping, or incineration.”

3.2.12 Effluent

Bhatia (2003:575) defines it as “anything which flows out or is discharged. Usually applied to the discharge of a waste material into a water body or the atmosphere”.

67
3.2.13 Food Processing Industries

Mani and Dawood (1995) have defined food processing industries as “those industries whose main concern is the production of edible goods for human or animal consumption. Processing plants include canneries, dairies, breweries and distilleries, meat-packing and rendering plants (including poultry plant and animal feed lot), beet-sugar refineries, pharmaceutical plants, yeast plants and miscellaneous plants producing such goods as pickles, coffee, fish, rice, soft drinks, bakery and water production”.

3.2.14 Hazardous Waste

As per the definition of the Resource Conservation and Recovery Act (RCRA) of USA, hazardous waste is a solid, liquid or gaseous waste, or combination of wastes, that because of its quantity, concentration or characteristics may cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness and pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed. (Abbasi et al. 1999:102-103).

3.2.15 Incineration

United States Environmental Protection Agency defines incineration as “a treatment technology involving destruction of waste by controlled burning at high temperature.”
3.2.16 Industrial Waste

Industrial waste is a major component of the waste stream. Boland (1993) defines industrial waste as solid residues from industrial processes. Industrial wastes may be in the form of solid waste, liquid waste and gaseous waste. Based on the toxicity, industrial waste are classified as hazardous and non-hazardous.

3.2.17 Pollution Prevention

United States Environmental Protection Agency defines pollution prevention as “measures taken to minimise the release of wastes to the environment”.

3.2.18 Primary Treatment

United States Environmental Protection Agency defines primary treatment as “the first step in waste water treatment, where screens and sedimentation tanks are used to remove most materials that float or will settle. Primary treatment results in the removal of about 30 per cent of carbonaceous BOD from domestic sewage.”

3.2.19 Recycling

According to Kumar (1998: 331) recycling refers to the "collection of post-use materials and further processing for transformation into new products.

3.2.20 Resource Recovery

United States Environmental Protection Agency defines Resource Recovery as “the process of obtaining matter or energy from materials formerly discarded.”
3.2.21 Reuse

According to Kumar (1998: 330) "it is the direct reapplication or repeated use of a product for the same or different purposes in its original form."

3.2.22 Secondary Treatment

United States Environmental Protection Agency defines secondary treatment as “the second step in waste water treatment, in which bacteria consume the organic parts of the waste. It is accomplished by bringing together waste, bacteria, and oxygen in trickling filters or in the activated sludge process. This treatment removes floating and settle able solids and about 90 per cent of the oxygen - demand substances and suspended solids, disinfection is the final stage of secondary treatment.”

3.2.23 Sludge

The United States Environment Protection Agency has defined sludge as “a semisolid residue from any of a number of air or water treatment process. Sludge can be a hazardous waste”.

3.2.24 Small - Scale Industries

Third All India census of Small-Scale-Industries has defined it as “an industrial undertaking in which the investment in fixed assets in plant and machinery, whether held on ownership term, or on lease, or by hire purchase, does not exceed Rs. 100 lakhs as on 31.3.2001 is to be treated as a Small Scale Industries Unit".
3.2.25 Source Reduction

Robert (1995:3-4) has defined it as “the reduction or elimination of hazardous waste at the source, usually within a process. Source reduction measures include product modifications, feed stock substitutions, improvements in feed-stock purity, housekeeping and management in practice changes, increase in the efficiency of equipment, and recycling within a process.”

3.2.26 Suspended Solids

United States Environmental Protection Agency defines suspended solids as “small particles of solid pollutants that float on the surface of or are suspended in sewage or other liquids. They resist removal by conventional means.”

3.2.27 Waste

Collins Cobuilt Dictionary (1993) defines "waste as materials which has been used and is no longer wanted because the valuable or useful part of it has been taken out." In India, there is no legal definition for waste but similar terms like ‘hazardous waste’ also ‘sewage effluent’, ‘trade effluent’, ‘air pollutant’, ‘emission’, and ‘environmental pollutant’ are used to define waste.

3.2.28 Waste Management

Wikipedia (2007) defines waste management as “the collection, transport, processing (Waste treatment), recycling or disposal of waste materials, usually ones produced by human activity in an effort to reduce their effect on human health or local aesthetics or amenity”.

71
3.2.29 Waste Minimisation

The National Productivity Council of India has defined waste minimisation as “a new and creative way of thinking about products and the processes which make them. It is achieved by the continuous application of strategies to minimise the generation of wastes and emissions.

3.2.30 Water Pollution

Sharma and Kaur (1997:216) have defined water pollution as "alternation in physical, chemical and biological characteristics of water, which may cause harmful effects on human and aquatic biota."

3.3 Conclusion

The food processing industry covers a wide range of industrial units generating varied amounts of solid and liquid wastes. Many of the earlier researchers have taken only one or two categories of industries for their analysis. On the contrary, the present investigation has selected seven categories of small-scale food processing units for thorough understanding on the selected issues. The units selected for the present research are, grain milling, fruit and vegetable processing, milk processing, oil crushing / extraction, soft drink (beverages), bakery and confectionery, and meat and poultry.