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An Appraisal of the Environmental Impacts of Food Processing Industrial Waste in Nigeria

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ABSTRACT
The food industry is now facing increasing pressure to ensure that their company's activities are environmentally sensitive, but there is also increased internal pressure to maintain or increase profitability in the face of fierce competition. In this study the environmental impacts of food processing industrial wastes and its remedy were examined. The study adopted a desk review of existing literatures on industrial waste in Nigeria. It was concluded that the food processing industries do have positive and negative impacts on the environment For all the identified negative environmental impacts, it is recommended that utilization of the best available technology; payment of optimal liability compensation to local communities and institutionalization of adequate abatement measures be adopted. The manufacturing processes should be designed to maximize recycling potential and minimize the generation of residuals.
Key words: Industrial wastes, Environmental impacts, Food processing, Positive and Negative impacts,

1. Introduction

Food processing includes the methods and techniques used to transform raw ingredients into food for human consumption. Food processing takes clean, harvested or slaughtered and butchered raw food materials and uses them to produce marketable food products. There are several different ways in which food can be produced (Levenstein, 2003).

One off Production: This method is used when customers make an order for something to be made to their own specifications, for example a wedding cake. The making of One off Products could take days depending on how intricate the design is and also the ability of the chef involved. Batch Production: This method is used when the size of the market for a product is not clear, and where there is a range within a product line. A certain number of the same goods will be produced to make up a batch or run, for example at Gregg's Bakery they will bake a certain number of chicken bakes. This method involves estimating the number of customers that will want to buy that product. Mass production: This method is used when there is a mass market for a large number of identical products, for example chocolate bars, ready meals and canned food. The product passes from one stage of production to another along a production line. Just In Time: This method of production is mainly used in sandwich bars such as in subway. All the components of the product are available in-house and the customer chooses what they want in their product. It is then prepared with fresh ingredients in front of the buyer (Levenstein, 2003).

2. Food Processing Industry In Nigeria

Food processing as an industry was introduced into Nigeria by the United African Company (UAC) in 1923 (Ojo 1998). Today, food industries in the country are so many that they could be sub-divided into thirteen (13) categories. These are flour and grain; soft drinks and carbonated water; breweries; starch and miscellaneous food products; meat, poultry and fish; tea, coffee and other beverages; fruit juices; animal feed; sugar; distilleries and blending of spirits; cocoa, chocolates and sugar confectioneries; agricultural and food chemicals and industrial packaging (Ojo 1998).

Food processing projects involve the processing and packaging of meat products, fish and shell fish, dairy products, fruits and vegetables, grains and beverages production. It includes refinement, preservation, and improvement of product; storage, handling, packaging and canning. The processing may involve receiving and storing raw or partially processed plant, animal or other food materials, processing the raw materials into finished products, and packaging and storing the finished products.

These processing industries exist in our environment and are the main generators of wastes. Since the existing environment within which they operate is the only one we have, and shared by both the consumers, and operators of other sectors of the economy, there is the need therefore, to ensure the preservation of the environment in as natural and as ecologically balanced a state as possible for the use of all. This must and should be made to be the motivating factor during the design, construction and operation of all industrial set up. Industrial waste is a major source of environmental pollution (Olessen *et al.,* 1996).

Environmental pollution is viewed as any condition or situation in which any substance or combination of substances present in the ecological system is detrimental to the health of humans, plants or animals or affects the welfare of humans now or at a later time .The food industries must be aware of the contents of the wastes they generate with the view to making them environmentally friendly .This is more so when it is realized that

waste from food industries has the potential of polluting the environment in all the three possible states – solid, liquid and gas (Olessen *et al.,* 1996).

3. Food Processing Waste and their Characteristics

Wastewater: Primary issues of concern are biochemical oxygen demand (BOD); total suspended solids (TSS); excessive nutrient loading, namely nitrogen and phosphorus compounds; pathogenic organisms, which are a result of animal processing; and residual chlorine and pesticide levels (FEPA, 1995).

Solid Waste: Primary issues of concern include both organic and packaging waste. Organic waste, that is, the seeds, skin, and bones from raw materials, which results from processing operations. Inorganic wastes typically include excessive packaging items that are, plastic, glass, and metal. Organic wastes are finding ever-increasing markets for resale, and companies are slowly switching to more biodegradable and recyclable products for packaging. Excessive packaging has been reduced and recyclable products such as aluminum, glass, and high-density polyethylene (HDPE) are being used where applicable (FEPA, 1995).

Wastewater and solid wastes are the primary area of pollution control within the fruit and vegetable food-processing industry. Their wastewater is high in suspended solids, and organic sugars and starches and may contain residual pesticides. Solid wastes include organic materials from mechanical preparation processes that is, rinds, seeds, and skins from raw materials. For the most part, solid waste that is not resold as animal feed is handled by conventional biological treatment or composting (FEPA, 1995).

The total amount of material generated is a function of the amount of raw material moved through a facility, for example, for a given weight of apples processed comes a set amount of peel and seed waste. Attempts to decrease solid waste streams have not been an area of great development for pollution prevention opportunities and clean technologies. Pre-treatment opportunities intended to reduce the amount of raw materials lost to the waste stream have been an area of clean technology development. For the most part, the majority of clean technology advances and research have been in reducing the volume of wastewater generated in food processing operations (EEC, 1993).

4. Impacts of Food Processing Wastes on Air Quality

Carbon dioxide is one of the exhaust gases of food processing operations. An increase in the atmospheric carbon dioxide concentration can greatly affect living things. Green plants grow better when the air around them is enriched with carbon dioxide. Thus a worldwide increase in carbon dioxide might increase annual net vegetation production if no other environmental factor interferes to limit the growth. The increasing CO_2 concentration in the atmosphere could have other indirect effects. If the climate were to warm, some kinds of vegetation would increase and others would decrease. The effects of changes in weather patterns, including rainfall could become complicated and difficult to predict. Increased CO_2 in the atmosphere contributes to global warming via the greenhouse effect (Hart 2003; Zimmerman 2004; Chukwu 2005).

Pollutants in the air cause health defects ranging from unnoticeable chemical and biological changes to troubled breathing and coughing. The ill effects of air pollution primarily attack the cardiovascular and respiratory systems. The severity of a person's reaction to pollution depends on a number of factors, including the composition of the pollution, degree and length of exposure and genetics (Roder, 2004).

Sulphur dioxide (SO_2) (a by-product of processing activities gives rise to irritative reactions which cause pulmonary blood vessels (capillaries) to dilate and exude fluid. This leads to tissue fluid accumulation and swelling (edema), bronchial spasms, and shortness of breath. In a chronic situation the gas contributes and aggravates lung diseases like chronic bronchitis, pulmonary fibrosis via irritation leading to decreased pulmonary function and increasing stress on the heart (Kupchella and Hyland 1993; Zimmerman 2004; Chukwu 2005).

Nitrogen dioxide (NO_2), a by-product of processing activities, at concentrations higher than acceptable level is responsible for respiratory tract edema due to cell membrane disruption. In chronic cases, it causes cell membrane damage and acid-induced irritation leading to or contributing to diminished pulmonary function and right-heart stress (Schindler *et al*. 1985).

Dust and dusty environment are generated by the food processing industries. Inhalation of large doses of dust or accumulation of small doses of dust over a prolonged period may eventually help to bring about structural impairment and loss of lung function. Dust in the lungs causes a response in which fibrous tissue is deposited around dust particles, creating “macules”. The fibrotic reaction eventually decreases the function of the lungs; this in turn puts stress on the heart (Kupchella and Hyland 1993; Chukwu 2005).

5. Impacts of Food Processing Wastes on Water Quality

Sulphur dioxide and nitrogen dioxide are two of the important gaseous pollutants identified in food processing

industry whose end products are respectively sulphuric acid and nitric acid when they dissolve in rain water. As a result, acid rain precipitation occurs. An obvious mechanism by which acid rain influences aquatic systems is that involving pH itself. Living things have optimal pH levels and pH limits (tolerance limits). (Chukwu et al., 2007).

Departure from near-optimal pH means sub-optimal reproduction, growth, and survival. Acid rain can change the pH of lakes directly and through the soil acids it mobilizes as it runs over and through soil on its way to streams and lakes. In aquatic systems, acidification can also cause toxic metals (e.g. aluminum and mercury) to be leached from sediment in a lakebed, for example, and from soil as acid water percolates through it (Sandler, 1996).

Schindler *et al*. (1985) reported dramatic changes in the food web of a poorly buffered, small lake in Ontario. They noted that there was elimination of key organisms at pH values as high as 5.8, changes in the phytoplankton species, cessation of reproduction, disappearance of bottom-dwelling crustaceans, and the appearance of filamentous algae (such as had been reported in dying lakes in high-acid-deposition areas). They concluded that the changes were caused by changes in acidity and not by secondary effects such as aluminum toxicity.

6. Impacts of Air Pollution on Plants And Animals

The air pollutants most responsible for plant damage are sulphur dioxide and acids derived from the oxides of both sulphur and nitrogen. Schindler *et al*. (1985) reported the effects of these pollutants on plants and animals. Plants that are susceptible to these kinds of pollutants include vegetables, fruits, and other kinds of agricultural crops, grasses, shrubs, trees, and commercial flowers. For example, sulphur dioxide at levels above permissible level causes bleached spots on leaf, chlorosis, suppression of growth, early abscission, and reduced yields in crops. Nitrogen dioxide at concentrations above optimal causes brown spots on leaf and suppression of growth in some crops (Chukwu, 2005).

The effects of acid rain on wildlife can be far-reaching. If a population of one plant or animal is adversely affected by acid rain, animals that feed on that organism may also suffer. Ultimately, an entire ecosystem may become endangered. Some species that live in water are very sensitive to acidity, some less so. Freshwater clams and mayfly young, for instance, begin dying when the water pH reaches 6.0. Frogs can generally survive more acidic water, but if their supply of mayflies is destroyed by acid rain, frog populations may also decline. Fish eggs of most species stop hatching at a pH of 5.0. Below a pH of 4.5, water is nearly sterile, unable to support any wildlife. Land animals dependent on aquatic organisms are also affected. It has been reported that populations of snails living in or near water polluted by acid rain are declining in some regions (Chukwu, 2005).

Acid pollution, however, has one surprising effect that may be beneficial. Sulphates in the upper atmosphere reflect some sunlight out into space, and thus tend to slow down global warming. It is believed that acid pollution may have delayed the onset of warming by several decades in the middle of the 20th century. The susceptibility of plants to pollutants is influenced by such variables as temperature, wind, light intensity, soil fertility and relative humidity. High soil moisture and atmospheric humidity actually intensify the damage (Partidario, 1996).

7. Impacts of Air Pollution on Climate

Impairment of visibility is perhaps the most noticeable effect of particulate matter. Smoke and haze distort visual range, the colour of the sky, and the ability to see stars at night (Uchendu, 2004). In socio-economic terms, reduced visibility has considerable impact on air travel and property values. Sulphur dioxide and nitrogen dioxide are involved in reactions that yield haze-generating plant particle atmosphere. The reactions and the hazes they form are influenced a great deal by meteorological conditions including wind, rain, sunlight, temperature, and humidity. These pollutants that reduce visibility may also affect climate via reduction of net solar radiation and enhanced cloud and fog formation. Actually, industrial emissions affect microclimate via reduced cloud formation as a result of net reduction in solar radiation (Zimmerman, 2004).

8. Mitigation of the Impacts

The food processing factories should follow the major technological innovations in the industry, including those in clean technologies and processes. Clean technologies include:

A. Advanced Wastewater Treatment Practices: Use of wastewater treatment technologies beyond conventional secondary treatment.

B. Improved Packaging: Use of less excessive and more environmentally friendly packaging products.

C. Improved Sensors and Process Control: Use of advanced techniques to control specific portions of the manufacturing process to reduce wastes and increase productivity.

D. Food Irradiation: Use of radiation to kill pathogenic microorganisms.

E. Water and Wastewater Reduction (Closed Loop/Zero Emission Systems): Reduction or total elimination of effluent from the manufacturing process.

8.1 Environmental Protection

- Source reduction

The most effective method of environmental protection and reducing your disposal costs is to decrease the volume of waste material and by-products generated in the production process. If less waste is generated, then less material needs to be disposed of. Source reduction should be the most logical starting point for reducing disposal costs since the company is in business to produce a saleable product, not waste materials or by-products. Examples of source reduction include:

A. Use brooms and scrapers to clean floors and equipment while they are dry before washing them down with water.

B. Use high-pressure spray washes during cleanup to conserve water.

C. Dedicate mixing lines to certain products to reduce changeover cleanups.

D. Minimize spills and leaks on the production line to prevent raw materials from becoming wastes.

- Management Alternatives

If source reduction is not a viable solution, management alternatives exist, including:

A. Using the food by-product as an animal feed.

B. Composting or land spreading the food by- product.

1. Animal Feed

Feeding food by-products directly to livestock allows for former wastes to be useful again. In addition, the quantity of liquid and solid waste is reduced when by-products are fed to livestock rather than being disposed of in landfills or wastewater treatment plants.

2. Composting and Land spreading

When it is impractical to feed by-products to livestock, both composting and land spreading the food waste are viable alternatives. Both methods degrade food by-products into a useful soil additive called "humus." Composting degrades by-products above ground in a concentrated area, while land spreading degrades by-products beneath the soil in a cultivated field.

Composting: With proper management, food by-products can be kept out of the landfill and instead be composted and added to the soil at appropriate rates. Composting has the following benefits:

1. Low transportation costs: The by-products can be composted on site, and the resulting humus can have a volume and weight reduction of up to 40 percent.

2. Low capital investment. Composting is a batch process that can be done by using either a mound or a windrow system. In both systems all the by-products are managed to accelerate biological breakdown.

3. Good for seasonal processors: For a company (such as a cannery) that only processes food for several months a year, composting may be a suitable alternative to animal feeding or land filling. Livestock producers may be unwilling to switch to a livestock feed that is only available for a short period.

4. Long shelf life: Humus can be stored without spoiling and applied to enrich the soil as needed.

Land spreading: If a company has sufficient land, it is possible to incorporate food byproducts directly into the soil on site. A farmer can be paid to take the by-products to a suitable field. Again, with proper management, food is kept out of the landfill and is used to enhance the soil. Land spreading has the following benefits:

1. A separate compost facility is not necessary.

2. The finished product does not have to be stored.

3. The finished product does not have to be transported. It is left in the soil as a plant nutrient.

8.2 Clean Technology Developments

Because wastewater generation is the industry's biggest area of concern, the following clean technologies focus on source reduction, recycling, reuse, and treatment of wastewater. Clean technologies are defined as "manufacturing processes or product technologies that reduce pollution or waste, energy use, or material use in comparison to the technologies that they replace."

The food-processing industry has special concerns about the health and safety of the consumer. It should be noted that some of the technologies outlined in the report target both human health and environmental pollution issues. Common source reduction methods employed at most plants include improving good housekeeping practices, making process modifications, substituting more environmentally friendly raw materials, and segregating waste streams. Some simple cost-effective means of achieving source reduction include installing automatic shut-off valves, using low -flow or air injected faucets/spray cleaners, switching from chemical caustic peeling processes to mechanical peeling, and converting from water to mechanical conveyance of raw materials through a production line.

9. Conclusion

Food processing industry can have positive and negative impacts on the environment. The positive impacts are more of social services to their immediate community and jobs creation for the Nigerian people. But of greater significance to food processing industry are the negative impacts on climate and air quality. Acid rain resulting from unrestrained discharge of gaseous pollutants can impact negatively on quality of life of man, aquatic life, flora and fauna as well as materials that man cherishes.

In order to protect the environment from adverse effect of food processing industries, a number of mitigation measures and management options that should be implemented are hereby recommended. For all the identified negative environmental impacts, it is recommended that utilization of the best available technology; payment of optimal liability compensation to local communities and institutionalization of adequate abatement measures be adopted. The manufacturing processes should be designed to maximize recycling potential and minimize the generation of residuals. For example, new low and non-waste technologies (already in use in developed countries) which can reduce environmental impacts are to be adopted.

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