Application of Bioremediation on Food Waste Management for Cleaner Environment

A. Punnagaiarasi, A. Elango, G. Rajarajan and S. Prakash

Abstract In the past few years, there has been a tremendous increase in food waste generation due to rapid urbanization and industrialization. These food wastages have put an emphasis to employ novel techniques for management of waste generated so that waste generation could be reduced to a minimum or these wastes could be converted into some valuable products. Food waste consists of high levels of sodium and moisture and is usually mixed with other types of waste during its collection. Amount of waste generated is largely determined by two factors—population in a given area and its consumption patterns. In order to cope with this huge waste production, advanced and effective waste management systems are to be adopted that can overcome the gap between production and management of waste disposal. Therefore, in this view much technological advancement has occurred in the recent past which has proved to be useful for combating this problem. In this review, a brief introduction to bioremediation for various food industry waste management and advantages and limitation of bioremediation has been discussed.

Keywords Bioremediation · Food waste management · Cleaner environment

1 Introduction

Food industry is a source of an untapped energy which is mostly dumped in landfills whereby it releases greenhouse gases into an atmosphere (Zafar 2012). It is very difficult to treat and recycle food waste due to its composition. Food waste consists of high levels of sodium and moisture and is usually mixed with other

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M. Prashanthi et al. (eds.), *Bioremediation and Sustainable Technologies for Cleaner Environment*, Environmental Science and Engineering,
DOI 10.1007/978-3-319-48439-6_5

types of waste during its collection. Amount of waste generated is largely determined by two factors- population in a given area and its consumption patterns (Mavropoulos 2011). In order to cope with this huge waste production, advanced and effective waste management systems are to be adopted that can overcome the gap between production and management of waste disposal. Bioremediation is a naturally occurring process in which microorganisms either immobilize or transform environmental contaminants to innocuous end products (Thassitou and Arvanitoyannis 2001). Biotreatment is well accepted by industry as it goes along with the current popularity of maintaining nature's harmony. Bioremediation has become a widely accepted option for the clean up of contaminated soils and aquifers although it does not have a fully credible reputation within the regulatory community (NRC 1993).

2 Characteristics and Treatment of Various Food Industries

2.1 Fruit and Vegetable Processing Industry

Industries that process fruits and vegetables are a very important part of the food industry especially in the Mediterranean countries where agriculture still remains one of the main sources of income. The fruit and vegetable canning industry, frozen vegetable industry, vegetable dehydration industry, fruit and vegetable drying industry, fruit pulping, tomato juice concentrate and fruit concentrate belong to this category. These industries may operate seasonally since operation time depends on the production of the fruits and vegetable that they process. That means that the environmental pollution from those industries' waste will also be seasonal. According to the processing stage, different types of waste may be produced thus contributing with different percentages to the formation of the final process waste. The wastes from fruit and vegetable processing industries generally contain large amounts of solid suspensions and a high biochemical oxygen demand (BOD). Some other parameters usually of interest to the waste treatment are pH, chemical oxygen demand (COD), dissolved oxygen and total solids. Indicative values for BOD, COD, suspended solids (SS) and pH for the processing of some fruit and vegetables are summarized. As has already been described, fruit and vegetable industry wastes consist of various by-products with an acidic pH (Riggle 1989), and a moisture content of 80–90% (Grobe 1994). The chemical composition of the wastes varies and depends on the processed fruit or vegetable. In general, the wastes consist of hydrocarbons and relatively small amounts of proteins and fat. The hydrocarbons are mainly sugars and nitrogen and cellulose fibers. The water wastes contain dissolved compounds, pesticides, herbicides and cleaning chemicals. These differences in the nature of the wastes require their separate treatment. Although the solid waste is mainly treated with composting, because of superior results slurry bioreactors and land farming may also constitute two further options. A pretreatment is necessary to remove the water and neutralize the pH to ensure the best conditions for microbial growth and development. Bulking agents are also added to improve the porosity of the sludge and decrease the bulk density (Schaub and Leonard 1996). The increased porosity may help in the drainage of water, which can be carried out either by gravity or by exerting pressure on the sludge. In some investigations the waste was left in open air so that the excess water is evaporated (Grobe 1994). Aerated piles are more frequently used for the treatment of solid waste from fruit and vegetable industries (Nakata 1994) because they allow the best mixing of the sludge while it is easy to add moisture, nutrients or more waste for processing if necessary. However, if static piles are initially used, then later the compost has to be moved to an aerated pile for further cure.

2.2 Fermentation Industry

The fermentation industry is divided into three main categories: brewing, distilling and wine manufacture. Each of these industries produces liquid waste with many common characteristics, such as high BODs and CODs, but differ in the concentration of the organic compounds that determine the biological treatment that will be selected. The difficulty in dealing with fermentation wastewaters is in the flows and loads of the waste. Since the fermentation industry's wastewater contains high concentrations of tannins, phenols and organic acid, anaerobic treatment results in higher performance. Mayer (1991) attempted to compare aerobic with anaerobic treatment of the wastewaters in a German brewery. Anaerobic treatment achieved 91% COD reduction at loading rates up to 20 g COD/L day, whereas the aerobic treatment resulted in a 76% reduction at a loading rate of 69 g COD/L day. In order to optimize the conditions of anaerobic treatment, Suzuki et al. (1997) conducted several experiments for the optimization of acidity and temperature of highly concentrated brewery wastewater by applying the upflow anaerobic sludge blanket. These experiments showed that the optimal conditions for the particular treatment were 40 °C and 5–6 pH. The amount and load of distillery waste varies according to the raw materials used. In winery, the treatment methods are based on principles similar to the previous fermentation industries. Experiments conducted both in the laboratory and on industrial scale showed that with the use of a full-scale, modular, multi-stage activated sludge treatment plant could reduce the COD level up to 98% when the influent COD varies between 2000 and 9000 mg/L (Fumi et al. 1995). One of the main problems in winery waste treatment is the presence of vinasse (It is like a molasses, a hone like dark brown syrup), which needs to be treated biologically for 4–8 days in order to reduce 90% of the COD (Boudouropoulos and Arvanitoyannis 2000).

2.3 Dairy Industry

Dairy industries contribute substantially to the pollution of surface water and soil. The main wastes from these industries are chemically modified liquid wastes. The main characteristics of dairy waste can be summarized as follows: high organic load (fatty substances, etc.), large variations in waste supply, considerable variations in pH (4.2–9.4), relatively large load of suspended solids (SS) (400–2000 mg/L). The dairy wastewater may contain proteins, salts, fatty substances, lactose and various kinds of cleaning chemicals. Detergents represent the biggest portion of chemicals used in dairies. The detergents may be alkaline or acid and are used for different purposes. Hydroxides or alkaline salts are responsible for the alkalinity of the detergent. They are mainly added to dissolve and remove proteins, but they also help to eliminate fats through saponification. Sodium hydroxide is the most widely applied alkaline detergent but for special applications it may be replaced or mixed with other strong bases. Acids are used to remove the inorganic deposits or so-called milkstone. For that purpose, nitric acid or phosphoric acid are used separately or in combination. Both alkaline and acid detergents often contain additives to improve their cleaning capability. These are phosphates, sequestering agents, surfactants and some minor components like dispersing agents, anti-foaming agents and inhibitors (Romney 1990). The presence of detergents and their additives in dairy waste water hardly influences the total COD in contrast to milk, cream or whey. However, detergents also present difficulties in their treatment. Wildbrett (1990) reported that sodium carbonate passed a two-stage effluent unchanged and was discharged into the river.

2.4 Meat and Poultry Industry

Meat, poultry and fish industries produce the highest loads of waste within the food industry. The meat industry contains slaughterhouses and processing units where meat is prepared, cut in pieces and is either frozen, cooked, cured, smoked or made into sausages. Slaughterhouses are more important than the other units in terms of environmental pollution. The wastes coming from these units contain various quantities of blood, fats and residues from the intestine, paunch grass and manure (Cournoyer 1996). The wastes are best separated into wastewater and solid waste. Solid waste, like intestines, pieces of meat or bones have been used as animal feed after further processing. Slaughterhouse wastewater is typically high in both moisture (90–95%) and nitrogen, has a high BOD and is odorous. Pretreatment is also necessary because the sludge derived from processing of wastewater contains pathogens. Therefore proper management is a prerequisite to ensure that potentially high levels of pathogens are eliminated (Cournoyer 1996). Poultry wastes are equally problematic to meat wastes because the main source of wastewaters is the slaughtering process. Starkey (1992) reviewed the considerations for selection of a treatment system for poultry processing wastewater, including land availability, previous site history, conventional waste treatment systems, and land application systems. The performance of anaerobic treatment systems, including lagoons, contact processes, sludge beds, filters, packed beds, and hybrid reactors were out lined (Ross and Valentine 1992). Pretreatment is also regarded as necessary for poultry waste to reduce the moisture and increase the porosity with the addition of bulking agents, which also increase the aeration and carbon level in wastewater. Proper treatment is needed to eliminate the pathogens.

3 Advantages of Bioremediation

- It conserves financial resources by the virtue of reduced cleanup times
- Capital expenditure is also less as compared to other remediation technologies (Geo Environmental 1998)
- This technology is widely accepted by industry as it maintains nature's harmony
- It destroys contaminants rather than transferring them from one medium into another (Thassitou and Arvanitoyannis 2001).

4 Limitation of Bioremediation

- If the process is not controlled it is possible the organic contaminants may not be broken down fully resulting in toxic by-products that could be more mobile than the initial contamination.
- In the great majority of cases, an inoculation with specific microorganisms is neither necessary nor useful. Besides all these some other factors are also effect the bioremediation such as solubility of waste, nature and chemical composition of waste, oxidation—reduction potential of waste and microbial interaction with this. Hence the researchers should search genetically different type of microbes which can also work on slightly adverse condition. Therefore, bioremediation is still considered as a developing technology to regulate the day to day environmental problems faced by man residing in an area.

5 Conclusion

Increase in the production of waste disposal has resulted in massive land degradation. This may lead to an increase in the demand for most promising techniques which will result in reducing the pollution level. Much of the technological advances occurred in the field of waste management have proven to be a great asset for managing food waste. Despite several benefits which they offer, they have their downsides too, which needs to be looked into or find some alternative technologies to overcome the problem of land degradation. Although researcher had found the variety of the ways by which we can degrade the food waste. But bioremediation also making its leap to tackle the problem associated with different categories of waste with the help of microorganism. Even with the obstacles discussed above, there are tremendous market opportunities for bioremediation and also the trend is slowly changing by using bioremediation in order to reduce the food wastage.

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