# EFFECT OF FOOD PRESERVATIVES ON SOLID ORGANIC WASTE DEGRADATION PROCESS

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**Abstract**

Biodegradable wastes contains Food waste (FW) (both precooked and leftover) is discharged from various sources including food processing industries, households, and hospitality sector are waste materials easily degraded or broken down naturally by biotic factors (bacteria, fungi, plants, animals, etc.) This process enables complex substances to be broken down into simpler organic compounds which subsequently fade into the soil. This is a natural process that could be prolonged or rapid depends upon chemical composition waste, pH, temperature, oxygen, humidity and also depends upon any inhibitory chemical present in waste or not. One of that inhibitory chemical is food preservatives which are intentionally added to inhibit the growth of microorganism responsible for spoilage of that food product and ultimately for increase the shelf life of that food product. When that food product is leftover or expired, it will be part of solid waste .Preservatives added to packed food may inhibit the growth of microorganism active in natural degradation of waste. Due to this period of degradation, size of solid waste increased .This increase in solid waste generation poses numerous questions concerning the adequacy of conventional waste management systems and their environmental effects.

**Keywords**: Food preservatives, organic waste, degrading bacteria.

## 1. Introduction

The generation of solid waste has become a global issue because of a growth in world population and thus large increase in solid waste production .Solid waste and its accumulation are becoming a critical problem around the globe due to continuous increase of the population. The exponential growth in food waste is imposing serious threats to our society like environmental pollution, health, world risk, and scarcity of dump land. Solid waste categories as biodegradable and non-biodegradable, biodegradable solid waste are over ripen fruit and vegetable, fish, meat, poultry, processed packed food and left over processed packed food product .

According to FAO, nearly 1.3 billion tonnes of food including fresh vegetables, fruits, meat, bakery, and dairy products are lost along the food supply chain. The amount of FW has been projected to increase in the next 25 years due to economic and population growth, mainly in the Asian countries it has been reported that the annual amount of urban FW in Asian countries could rise from 278 to 416 million tonnes from 2005 to 2025. Approximately 1.4 billion hectares of fertile land (28% of the world’s agricultural area) is used annually to produce food that is lost or wasted. Apart from food and land resource wastage, the carbon foot print of food waste is estimated to contribute to the greenhouse gas (GHG) emissions by accumulating approximately 3.3 billion tonnes of CO2 into the atmosphere per year. Conventionally, this food waste, which is a component of municipal solid waste, is incinerated or dumped in open area which may cause severe health and environmental issues. (Bovin et. al., 1998).

The MSW (Municipal solid waste) is a serious problem, emerging at an alarming rate in the megacities of the world as a consequence of overpopulation, urbanization, industrialization and the indiscriminate disposal of waste. In today's world, solid waste generated by the rapidly surging population in the megacities is of very high magnitude, mandating the practicing of solid waste management (SWM) strategies including; collection, transportation, processing and disposal of the solid waste (Raju et al., 2018). The municipal solid waste generally includes household and commercial refuse, consisting of degradable (paper, food waste, straw and yard waste), partially degradable (wood, and sludge) and non-degradable materials (leather, plastics, metals, glass, electronics) (Jha et al., 2003). Among these, the degradable wastes that constitute the major fraction of MSW load in developing countries, typically characterized by high water content (>60%) requires greater operating cost and lesser chances of material recovery (Wei et al., 2017).

The Ministry of Environment has released the solid waste management rules in 2000, for effective collection and disposal of municipal solid waste in India. Although, the existing solid management system has emerged successful in the last decade, still the system could be tailored as per the variable characteristics of urban waste. The modern solid waste management practices advocate material recycling, reduction, stabilization of solid waste prior to landfill disposal and energy recovery (Bong et al., 2017). However, these practices require proper certifications from government and may differ in developing and developed nations, rural and urban areas, residential and industrial setup.

Bukola Margaret Popoola concluded that a Biodegradable waste contains wastes of plant or animal origin which can be degraded by microorganisms. Sources of municipal solid waste are green waste, food waste, paper waste, biodegradable plastics, etc. If this waste not properly managed they could become sources of environmental pollution, resulting in sicknesses and diseases and possibly death to humans and other living organisms. There are various steps for management of biodegradable waste could be the collection, transport, treatment, and eventually waste disposal. Biodegradable waste is non accumulated but is used up in a short time, they become part of biogeochemical cycles and used to produce renewable waste as a bio-energy resource (biogas), manure, fertilizers, compost.

Food preservatives are substances when added to food, retard, inhibit or arrest the activity of microorganisms such as fermentation, acidification and decomposition of foods. In India, the preservatives have been grouped into two classes – Class I and Class II preservatives. Class I contains natural preservatives like salt, sugar while class II contains following groups as

a) Sulphur dioxide, bisulphites and sulphites

b) Nitrates and nitrites.

c) Benzoic acid and salts

d) Sorbic acid and salts.

The common use of food preservatives in various food products as follows.

Sulphur dioxide, bisulphites and sulphites:

a) Sulphites, as a source of sulphur dioxide, has been extensively used as preservatives in foods. They are effective, versatile and economical additives which are used as antimicrobials in the preservation of a number of food items viz. jam, jelly, marmalade, fruit, fruit pulp and juices, syrups and sherbets, alcoholic beverages, confectionery, dry fruits and meat products.

They are also used as bleaching agents in the refining of sugar, as antimicrobial agents to control enzymatic and non-enzymatic browning reactions in dehydrated fruits and vegetables and to provide protection against oxidative reactions.

b) Nitrates and nitrites: These are added as preservatives to particularly meat products like ham, bacon and pickled meat. They are especially effective against bacteria like *Clostridium botulinum* and *Staphylococcus aureus* which have a long history of causing lethal food poisoning. Its preservative action is mainly due to the formation of nitric acid and other oxides of nitrogen and their action increases with decreasing pH value. Nitrates are more effective when they are used in combination with common salt. The presence of nitrites imparts the characteristic pink colour to meat apart from protecting its flavour. It also delays the development of off-flavours during storage

c) Benzoic acid and salts: These are mainly used to protect foods against yeasts and moulds. They are not very effective against bacteria and have to be used in combination with sulphur dioxide in foods prone to spoilage by bacteria. Benzoic acid is used in squashes, fruit syrups, cordials, juices, jams, marmalades, preserves, sweetened ready-to-serve beverages, pickles, chutneys, sauces, tomato puree and paste and fat spread. Its effectiveness increases with the lowering of pH and is most effective below of pH 4.5.

d) Sorbic acid and its salts: These are effective against moulds, yeasts and many bacteria. It is more effective as a preservative than propionates and benzoates at higher pH values and, therefore, it is widely used for bakery and confectionery products like cakes, fillings for Chocolates and various types of cheese, cheese spreads and fat spread, paneer and ready-to-eat preserved chapatis. These are also used in the preservation of fermented vegetable products and vegetables pickled in vinegar. Its presence inhibits lactic acid fermentation slightly but supresses the growth of film-forming yeasts and moulds. (Rastogi et. al., 2020)

**Role of Microorganism in Solid waste degradation**

The dynamics or succession of a microbial community within composting, reflects their degradative capacity for the compost mix (Ling et al., 2014). Along the process, variations produced in a microbiome depend extremely on composition of the raw materials and nutrient supplements, environmental conditions (ambient or trial) and interactions among all these factors. Here in, Bacteria and fungi are the most abundant and fastest emerging microorganisms during composting. The substrates utilized and the microbiota involved within the process have a great influence on the quality of the formed compost (Villar et al., 2016). They promote organic degradation within composting by releasing various substrate based hydrolytic enzymes (Echeverria et. al., 2012), that break the complicated structured molecules, forming water-soluble compounds (Lee, 2016). Besides metabolizing the organics, they produce simple usable compounds that enhance the agricultural possibilities and stabilize the natural ecosystem when added to soil.

The mapping of diverse physiological microbial profiles in composting can portray a good picture of compost_maturity events. An initial profiling showed an expected decrease in the microbial biomass, associated with changes in C/N ratio and temperature of the composting mass (Karak et al., 2014). At mid mesophilic stage of composting, bacterial population continued to proliferate with production of more enzymes that resulted in proper humification (Vargas-García et al., 2010). Finally, microbial mass underwent a gradual decline at the cooling or maturation phase of waste composting. Generally, the fungal abundance observed throughout the process was lower compared to the bacterial population (Chandna et al., 2013). Certain modifications in the process integrating, bulking agents as addons to the substrate (such as rice husk, saw dust, wood chips and others) can develop an efficient microbiota. This would further optimise the C/N ratio and retain quality of compost (Zhang et al., 2013).

**Food Waste**

There is rapidly increasing attention given to sustainable food and biodegradable waste management (FBWM) in the municipal solid waste management system, due to environmental challenges. The enormous amount of FBW generated in Japan, for instance, is a result of their preference for raw food; such as raw egg, raw vegetables, or raw fish or meat (sashimi, sushi, etc.). Fresh fruits in particular, as well as other food, population growth, and improvement in lifestyle and standards of living, have invariably introduced several logistical problems that result in massive amounts of FBW (Singh et. al., 1995). Over the years, food and biodegradable waste have become a serious challenge and concern for both the general public and the government (Singh et. al., 1993). However, this waste presents a great opportunity if it is put to better use.

**Natural Biodegradation process**

a) Aerobic Biodegradation of Organic Wastes

The principle organic substances found in any domestic waste and in some of the animal wastes are proteins (40-60 per cent), carbohydrates (25-50 per cent), fats and oils (10 per cent). In most biological sewage treatment systems, the principle biochemical reactions that occur during the active waste stabilization process are: (a) Hydrolysis (b) Oxidation (c) Cell synthesis/biomass generation (d) Endogenous respiration. Hydrolytic reactions supply building blocks for biomass generation and substrate for cellular oxidation. Oxidation is carried out to obtain energy for the synthesis of new bacterial biomass (Ramana et.al., 1990). The rate of molecular synthesis and growth rate of bacteria is, therefore, a function of the ability of microorganisms to degrade the substrate. During endogenous respiration, the microorganisms begin to consume their own protoplasm due to depletion of nutrients in the medium.

b) Anaerobic Biodegradation of Organic Wastes

According to Zinder, the anaerobic bacteria of digesters have been grouped into:

(a) Hydrolytic bacteria

(b) Fermentative bacteria

(c) Acetogenic bacteria

(d) Aceloclastic methanogens.

The obligate anaerobes which convert organic acids to CH4 and CO2 (methanogens) are highly sensitive to low temperature and drop in pH levels(K.V. Ramana et.al ,1990). Microbial reactions that are expected to affect the pH in the anaerobic digesters include acetogenesis, methanogenesis, and autotrophic carbon fixation as in the case of homoacetogens, such as *Acetobacter woodii* and denitrification. While the facultative anaerobes are least affected by temperature, they produce fatty acids uninterruptedly, causing fatty acid accumulation. Higher volatile fatty acid levels, in turn, may suppress the methanogens, leading to the digester souring and failure. It has been noticed that the microbial growth and. CH4 production is very slow at sub-ambient temperature and the rate of methanogenesis is highly dependent on pH and temperature (Rastogi et.al., 2020).

C) Composting

Organic food waste composting is a type of natural food waste decomposition process under controlled aerobic conditions whereby food wastes are being broken down into their simplest components by microorganisms (Rastogi et.al., 2020). Composting eventually will be able to improve soil structure, texture and aeration and improve the water retention capacity of the soil .The simplest components would then be formed into humus which is known as compost (Beudet et. al., 1990). The process of composting includes majorly three phases (i) an initial mesophilic phase, where degradation of simple compounds like sugars, amino acids, etc. is carried out by mesophilic bacteria and fungi rapidly elevating the temperature; (ii) Second phase is thermophilic phase, where thermophilic microbes degrade the organic matter (fats, cellulose, hemicellulose and lignin). During this phase, organic carbon content is decreased in the feedstock ascribed to the metabolic activities of heat tolerant microbes. Lastly, (iii) cooling phase is characterized by a subsided microbial activity and decreased temperature (Gautam et. al., 2002). Within this, the compost mass is recolonized by mesophilic micro-organisms that degrade the residual sugars, cellulose and hemicellulose, materializing humic-like substances. This is followed by a declined rate of organic matter degradation and an increased rate of humification and polymerization of the organic compounds.

The mesophilic temperature and availability of carbon-rich substrate at the early stage of composting process favour the growth of mesophiles with mixture of bacteria, actinomycetes and fungi whereby they grow at the temperature between 15 °C to 45 °C and achieve optimum growth at the range of 30 °C to 39 °C (Gill et. al., 2014). At this stage, mesophilic fungi such as yeasts and molds as well as acid-producing bacteria like Lactobacillus spp. and Acetobacter spp. are the dominant species to decompose organic waste materials (B1ovin et. al., 1988). At the mesophilic stage, microbial activities during the degradation process will result in an increased in temperature owing to energy of the organic combinations (Palaniveloo. et. al., 2020)

**Table 1 Mesophilic Bacteria responsible for degradation of solid organic waste**

| Compost stage | Group | Genus | Species |
|---|---|---|---|
| Mesophilic | Bacteria | Amycolicicoccus | *Amycolicicoccus subflavus* |
| | | Bacillus | *Bacillus badius, Bacillus cereus, Bacillus flexus, Bacillus subtilis, Bacillus polymyxa* |
| | | Enterobacter | *Enterobacter sakazakii* |
| | | Mycobacterium | *Mycobacterium xenopi, Mycobacterium thermoresistibile* |
| | | Staphylococcus | *Staphylococcus aureus, Staphylococcus sciuri, Staphylococcus xyloseus, Staphylococcus sp.* |
| | | Klebsiella | *Klebsiella pneumonia* |
| | | Mycobacterium | *Mycobacterium xenopi, Mycobacterium thermoresistibile* |
| | | Brevibacillus | *Brevibacillus brevis* |

## 2. Material and Methods

### Materials

The various materials were used like Raw fruits and vegetables, Waste from kitchen, Waste from food industry, and Processed packed foods. In the processed packed foods food products like Jam, Jelly, Marmalade, Fruit based Beverages, Meat products, Oil and fats, Cereals and pulses, Milk and milk products, Fish products, Bakery and Confectionary.

### Methods

For this Firstly the food waste like pineapple waste, kitchen waste and leftover food was collected accordingly and then the collected food waste material was sterilized using the autoclave. The processed packed foods after the expiry date or left over foods was also collected such as pineapple jam, mango jam, meat sausages and bakery products. For checking the degradation the eco-friendly organisms (*Pseudomonas aeruginosa*, *Bacillus subtilis, staphylococcus aureus and Escherichia coli)* were used. This micro-organisms were inoculated into the organic disposable materials and the incubation was done at room temperature and moisture levels. The degradation rate of the organic disposal materials was monitored for the change. Finally the degradation rate was analysed by seeing the microbial growth and activity using techniques such as plate counting, spectroscopy and FTIR and the degradation and microbial growth rate was calculated and compared among the different treatment groups. The effects on environmental factors on the degradation process were analysed. For the growth of mirobes following environmental conditions were maintained

1. Temperature: 20-45°C (68-109°F)
2. pH: 5.0 -9.0
3. Moisture: 50-90%
4. Aeration:- aerobic or anaerobic conditions
5. Nutrient availability: presence or absence of nutrients

## 3. Results and Discussion

Degradation of Solid Organic Waste bacteria play an important role in the decomposition of organic waste. For decomposition of organic solid waste by using bacteria no bad smell was emitted after 60 days. It indicates the possible complete degradation of organic waste in plates that contained 50g organic waste.

This research focus on the effect of food preservatives contained in packed food product on waste degrading microorganism then after on natural degradation process of solid organic waste. There is an urgent need to take appropriate measures to reduce food waste burden by adopting standard management practice

**Results of Organic Solid Degradation Process**


**Fig. 1 Degradation of solid organic waste**

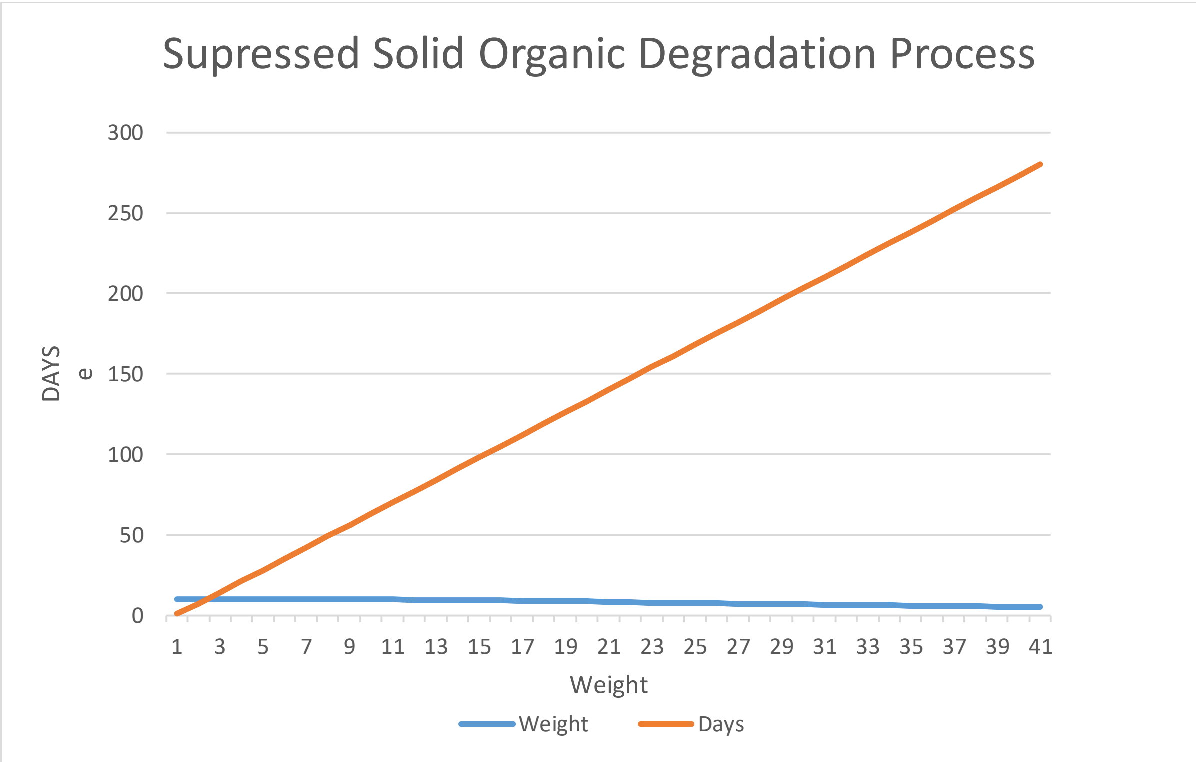


Fig-2 Supressed Solid Organic Degradation Process.

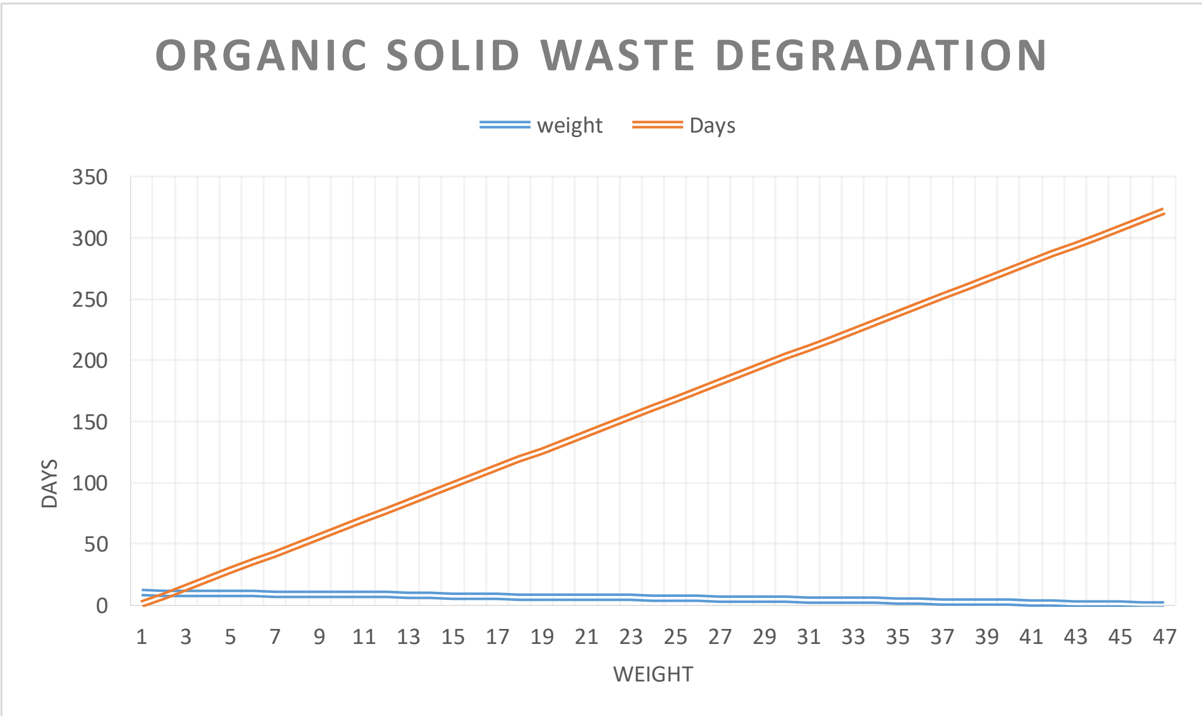


**Fig -3 Natural Solid Organic Degradation Process.**

## 4. Conclusion

Degradation of Solid Organic Waste bacteria play an important role in the decomposition of organic waste. For decomposition of organic solid waste by using bacteria no bad smell was emitted after 182 days. It indicates the complete degradation of solid organic waste (50g ) by using eco-friendly bacteria but if food preservatives are present in the solid waste ,it supressed the natural process of solid organic degradation process that plate requires 280 days for half degradation solid organic waste.

This research focus on the effect of food preservatives contained in packed food product on waste degrading microorganism then after on natural degradation process of solid organic waste. There is an urgent need to take appropriate measures to reduce food waste burden by adopting standard management practice.

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