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A Review: Utilization of Agricultural Waste in India

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Abstract: ***Agriculture plays a vital role in India's economy. Over 58% rural households depends on the agriculture. In recent years agriculture and allied areas has been facing the challenges. Agricultural waste is non-product output of production and processing of agricultural products that may contain material that can be beneficial for human being. Generally, the agricultural wastes are generated from number of sources such as cultivation, livestock, Industrial means, etc. These types of wastes can be used for number of applications. Agricultural wastes produced by these number of ways are a great concern because of the problems of environmental pollution, rural sanitation, recycling and utilization. The present review aims to give the information on utilization of agricultural wastes into number of applications like biogas, bio-hydrogen, bioethanol, biofertilizers etc.***

Keywords: Agriculture, Agricultural waste, Pollution, Utilization

1. Introduction

Agricultural wastes are the wastes from the growing and processing of raw agricultural products such as fruits, crops, vegetables; as well as of animal wastes such as meat, poultry, dairy products, manure etc. These are the non-product outputs of production and processing of agricultural products. These types of products may contain materials that can benefit man. Agricultural waste has the less economic values than the cost of collection, transportation, and processing for beneficial use.

Agricultural residues are generally referred as agro-waste produced in huge quantities per year on farms of India. The amount of crop residues produced every year in India, of which about 50% finds applications in various agricultural and industrial purposes like animal feed, paper industry, roofing material and energy generation. The major quantity of the on-farm agro-wastes are burnt in field by farmers itself. Although this is very cheap, non-labor intensive, and easy way of agro-waste disposal, but in returns this has great negative impact on agro-ecosystem as it generates a lot of particulate matter in environment in the form of smog, smoke that cause air pollution, and disturbs soil physical, chemical and biological structure including microbial population, microflora and microfauna life forms [1].

Agricultural wastes are basically unusable substances which may be either liquid or solid. The agricultural wastes are produced as a results of cultivation process including fertilizers, crop residues, animal wastes etc. The accumulation of agro-waste may cause health, safety, environmental, and esthetic concern. Thus this represents a problem which requires safe disposal [2]. Agricultural waste management is a part of the ecological cycle in which everything is cycled and recycled such that an interdependent relationship is maintained in the ecosystem [3].

Agro-wastes contain insoluble chemical constituents (eg., Cellulose and lignin) and soluble constituents (sugars, amino acids, and organic acids). [4],[5]. Agricultural wastes are comprised of animal wastes (manure, animal carcasses), food processing wastes, crop wastes (corn stalks, sugar bagasse, peels of fruits etc), and hazardous agricultural wastes (pesticides, insecticides, herbicides).

2. Agricultural waste generation in India

As earlier noted, the agricultural wastes are generated by the cultivation processes, intensive farming methods, and abuse use of chemicals for cultivation which remarkably affects the rural environments in particular and global environmental in general.

The agricultural wastes are also called as biomass. The biomass is highly diverse in nature. Biomass can be classified on the basis of their site of origin such as plantation biomass, forest biomass, industrial biomass, aquatic biomass etc. the main source of biomass is wood waste and agricultural waste. In this review we have only focused on Waste Agricultural Biomass (WAB).

Ministry of New and Renewable Energy (MNRE 2009), Government of India estimated that about 500 Mt of crop residue is generated every year. The availability of biomass in India is estimated at about 500 million tons per year covering residues from agriculture, agro-industrial, forestry, and plantations [6]. There is a large variability in crop residues generation and their use depending on the cropping intensity, productivity, and crops grown in different states of India. The residue generation is highest in Uttar Pradesh (60 Mt) followed by Punjab(51 Mt) and Maharashtra(46 Mt) [7].

3. Waste Utilization Routes

Agricultural waste utilization technology must either use the residues rapidly, or store the residues under conditions that do not cause spoilage or render the residues unsuitable for processing to the desired end product [8]. These wastes can be utilized by number of ways for number of applications which includes:

3.1 Fuel

The fuel such as petrol, diesel, kerosene etc are non-renewable sources of energy as they are produced by the decomposition of fossils under the earth. These types of resources are being exhausted because of increase in population and rapid urbanization which will affects the earth's atmosphere by polluting the air by burning of fuels. Because of these there is a need to find the alternative source for the fossil fuels. The agricultural waste can be converted into the fuel to fulfill our daily requirements. The agro-wastes can be utilized for Biogas, Bioethanol, Bio-hydrogen, and Biobutanol.

3.1.1 Bioethanol

Increase on world's energy demand and the progressive depletion of oil reserves motivate the search for alternative energy resources, especially for those derived from renewable materials such as biomass [9]. In it's simplest form, bioethanol is the alcohol produced from the starchy material with the help of microorganisms by the process called fermentation. The ethanol is then concentrated and recovered in the process called distillation.

Ethanol production represents an effective method for conversion of biomass into liquid fuel, as a way to replace or supplement our reliance on fossil fuels. There are two types of microbes, one is aerobic and another is anaerobic. In ethanol production generally anaerobic microbes are used. Primarily the yeast namely *Saccharomyces cerevisae* is used for this purpose.

The biomass is rich and renewable source of sugars or starch which is then converted into valuable product (Ethanol) by enzymatic action of yeast. When ethanol is produced by yeast fermentation of sugar containing biomass such as sugar molasses, sugar bagasses etc, yeast can directly consume simple sugars and convert them to ethanol with the help of enzyme called as zymase. However, starch and cellulosic biomass is a polymer of glucose and can not be directly converted to ethanol. They have to be converted to glucose prior to fermentation process by the means of acid, enzymes or combination of both.

The starch hydrolysis by enzyme includes two stages i.e liquefaction and saccharification. In liquefaction the starch is degraded or hydrolyzed into dextrins by the action of endo-acting enzyme namely α-amylase. The dextrins obtained after liquefaction, is further hydrolyzed to glucose by glucoamylase. Glucose is then converted to ethanol by yeast fermentation. By the end of fermentation, the obtained product is subjected to distillation to remove water, and other impurities, yielding pure ethanol.

Glycolysis is the normal pathway for breakdown of glucose in most of organisms. Under the aerobic conditions the end point of glycolysis is pyruvate, while under anaerobic conditions the end point is ethanol.

The ethanol can be used as fuel in many vehicles. It is eco-friendly as it can not produce any harmful gases when burning. As production of bioethanol, Butanol is also produced by using species of microorganism namely *Clostridium acetobutylicum*.

3.1.2 Biogas

Interest in biogas technology is increasing around the world due to the requirements for renewable energy production, reuse of materials and reduction of harmful emissions. It produces methane-rich biogas which can be utilised as renewable energy in various ways. Biogas technology is currently the most sustainable way to utilise the energy content of agro-waste while also recycling the nutrients and minimising the emissions.

Biogas is also known as anaerobic digestion which plays an important role in manure treatment processes. It includes number of biochemical processes by different microorganisms to degrade organic matter under anaerobic condition.

The byproduct of anaerobic digestion (Methane) is a rich source of renewable energy, which can replace fossil fuel. Biogas contains mainly methane (55-70%), while the rest is mostly carbon dioxide. Small quantities of other gaseous compounds such as hydrogen, hydrogen sulphide, ammonia, oxygen, nitrogen, silicon dioxide and particulates are also present depending on process technology and the raw materials digested. The degradation of organic matter to biogas is a very complex process which includes hydrolysis, acidogenesis, acetogenesis and methanogenesis.

In hydrolysis, the polymers (carbohydrates, proteins and lipids) are degraded into their monomers and dimers via hydrolytic enzymes excreted by acidogenic microbes. Once the raw materials are degraded into smaller molecules, i.e. long chain fatty acids (LCFA), alcohols, simple sugars and amino acids, during hydrolysis, the acidogenic bacteria are able to uptake them and facilitate further degradation into volatile fatty acids (VFA) [10]. The more specific intermediate products (e.g. propionic, butyric and valeric acid) depend on operational conditions, raw materials and microbial activity. This process is known as acidogenesis.

Acetogenesis then facilitates degradation of the intermediate VFAs into acetate, hydrogen and carbon dioxide [11]. These are the compounds the methane-producing microbes (methanogens) are able to utilize in their metabolism and convert them into biogas, a mixture of methane and carbon dioxide. Approximately 70% of methane is usually produced from acetate (acetoclastic methanogens) and 30% from hydrogen and carbon dioxide (hydrogenotrophic methanogens) [12].

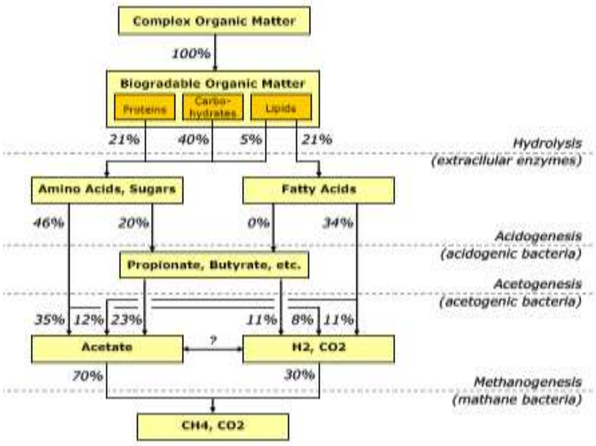

Figure 1: Degradation process of complex organic components to biogas [13]

3.1.3 Bio-hydogen

Hydrogen is a clean energy carrier which has a great potential to be an alternative fuel. Abundant biomass from various agro-industries could be a source for biohydrogen production. To date, global energy requirements are heavily dependent on fossil fuels such as oil, coal and natural gas. As the depletion of limited fossil fuels is inevitable, there is an urgency to search for replacement source of energy [14].

The extensive use of fossil fuel has created an environmental issue. The emission of carbon dioxide during combustion of fossil fuels causes global warming effect. For these reasons, researches are looking at alternative fuels that combat such problems. Hydrogen is one of the most abundant elements in the universe in its ionic form. It is an odorless, colorless, tasteless and non-poisonous gas. When hydrogen is used as a fuel, it generates no pollutants.

Biomass is the most versatile non-petroleum based resource that is generated from various agro-industries as waste materials. Lignocellulosic materials such as wood and wood products, food and starch-based materials, organic industry wastewater and household wastewater waste could be potential resources for biohydrogen production [14].

Biohydrogen production could be achieved by either photosynthetic or anaerobic microorganism. Photosynthetic microorganism basically uses carbon dioxide and water for hydrogen gas production while Anaerobic or photoheterophic microorganism uses carbohydrates or organic acids to produce hydrogen and carbon dioxide. During anaerobic acidogenesis process, hydrogen is produced as by-product with organic acid production.

There are various types of microbes that are found to produce hydrogen in absence of oxygen. The anaerobic bacteria are the most common class of bacteria that produces hydrogen. Generally these types of bacteria produces hydrogen mesophilically or thermophilically within pH 4-7. However few bacteria in which hydrogenase enzyme was found (facultative bacteria) are also found to produce hydrogen from organic biomass. Clostridium sp. is a typical acid and hydrogen producer which ferments carbohydrate to acetate, butyrate, hydrogen, carbon dioxide and organic solvent.

Biohydrogen can also be produced by electrolysis of water and gasification of biomass or pyrolysis. Pyrolysis is the process in which, agricultural waste is heated up to a temperature of 400-600°C in the absence of oxygen to vaporize a portion of the material, leaving a char behind. This is considered to be a higher technology procedure for the utilization of agricultural wastes. Pyrolysis of agro-waste also yields oil and char.

3.2 Biofertilizer

“Biofertilizers” are those substances that contain living microorganisms and they colonize the rhizosphere of the plant and increases the supply or availability of primary nutrient and/or growth stimulus to the target crop [15].

The utilization of animal manures for fertilizer has a great impact on input energy requirements at the farm level. Manure could supply 19, 38 and 61% of nitrogen, phosphorus and potassium in fertilizer [16]. Addition of manure to soil increases its fertility because it increases the nutrient retention capacity, improves the physical condition of soil, the water-holding capacity and the structure stability of soil.

Biofertilizers are made from easily obtained organic materials such as rice husk, bamboo, vegetable wastes, molasses etc that can be found in even the most remote areas. Biofertilizers are environment friendly substitute for harmful chemical fertilizers. They transform organic matter into nutrients that can be used to make plants healthy and productive. They have a low production cost because it produced from easily obtained organic matter.

The agro-waste is used as a medium for growth and development of beneficial microorganisms which converts agro-waste into valuable products which promotes plant growth. The bacteria belonging to species of Bacillus, Pseudomonas, Lactobacillus, Rhizobium and fungi belonging to species of Aspergillus, Trichoderma, and yeast are generally used to convert agro-waste into biofertillizers. These types microorganisms were grown on agro-waste for 25-30 days. In this period microbes ferment the agro-waste the converts the agro-waste into two solid and liquid fractions. The liquid fraction is then diluted with water and sprayed on the roots of plants to enhance their growth while solid fraction is used as compost for enhancement of plant growth.

3.3 Animal Feed

In most developing countries, the problem with animal feed is in the limited availability of protein sources although great efforts are being made to find alternative supplements [17]. Crop residues have high fiber content and are low in protein, starch and fat.

Currently, livestock is one of the fastest growing agricultural sub-sector in developing countries. The demand for livestock products is rapidly increasing in most developing countries. However, many developing countries have feed difficulties.

New unconventional alternative feed resources could play an important role in meeting such difficulties.

A huge quantity of fruit and vegetable wastes and by-products from the fruit and vegetable processing industry are available throughout the world. For example fruit and vegetable processing, packing, distribution and consumption in the organized sector in India, the Philippines, China and the United States of America generates millions of tones of fruits and vegetables waste. A large proportion of these wastes are dumped in landfills or rivers, which causes environmental hazards. Such unconventional resources can act as an excellent source of nutrients and help to bridge the gap between demand and supply of feedstuffs for livestock. Alternatives to such disposal methods could be recycling through livestock as feed resources and/or further processing to extract or develop value-added products.

The agricultural waste, especially fruits and vegetables wastes are feeded to animals by addintion of some nutritional constituents to it to fulfill the nutrient requirements of livestock. Lime, Molasses, urea etc are added to the fruits and vegetable waste to increase its nutritional composition before feeding to livestock.

4. Conclusion

Agricultural wastes are residues from the growing and processing of raw agricultural products. These types of products are non-product outputs of production and processing which may contain material that can benefit human. These residues are generated from a number of agricultural activities such as cultivation, livestock production and industrialization. These wastes can be managed properly through the number of applications such as fuel, fertilizers, animal feed etc. Proper waste utilization will assist in developing our agricultural sector and provide viable biofertilizers and biofuel resource for many.

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