Impact of Agro-Industrial Wastes on Soil Properties and Agricultural Crop Yield

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Abstract

Agriculture-based industrial wastes are the rich in bioactive compounds. These wastes can be of use as an alternative source for the production of different products like bio-fuels, bio-gas, mushroom and tempeh as the raw material in different farming, industries and researches. The use of agro-industrial wastes as the raw materials can be helpful to lessen the cost of production and moreover reduces the environmental pollution load. The agro-industrial wastes are these days used for manufacturing of antibiotics, antioxidants, biofuels, enzymes, vitamins, animal feed and other chemicals through solid state fermentation (SSF) technique. The effects of agro-industrial wastes on soil bio-chemical properties and yield of various crops are reviewed and discussed.

Keywords: Agro-industrial wastes; Crop; Soil properties; Nutrient; Yields.

Introduction

Agricultural and Agricultural-based industries produce huge quantities of residues each year. The disposal of the generated wastes is a major problem for several industries. In India, the total waste generation is around 60-65 million tonnes per annum, of which only one-fifth is actually treated (Swaminathan, 2018). The approach towards solid waste management is still unscientific in our country. The collection efficiency of solid waste in India is around 70%, while it is almost 100% in the developed nations. Large portion of solid waste is dumped indiscriminately on outskirts of towns or cities without any prior treatment even today in the country (Nandan *et al*., 2017). These wastes, if released to the environment without proper disposal procedure, may cause environmental pollutions and harmful effects on soil, human and animal health (Kour and Arora, 2007). Several agro-industrial wastes are untreated and underutilized, therefore it is disposed of either by dumping, burning, or unplanned land filling as per reports. These untreated wastes create diverse problems with climate change by escalating a number of greenhouse gases (Bos and Hamelinck, 2014). Recycling of the industrial wastes is one way of disposal mechanism and another way of resource management. In India there is an immense scope for re-utilization of renewable agricultural wastes like farmyard manure (FYM), crop residues (Yadav and Arora, 2018), solid industrial wastes like pressmud, coir pith and industrial by-products like gypsum or phospho-gypsum. Utilization as such or value addition of these wastes as soil amendments for crop production with suitable technologies are

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the necessity of the day. Incorporation of FYM at the rate of 10-15 tonnes ha^{-1} along with optimal doses of NPK fertilizers increase the effectiveness of inorganic fertilizers resulting in enhanced crop productivity in diverse soil conditions. Apart from increase in crop yield, FYM also has significant effects on enhanced availability of soil organic carbon, macro and micro-nutrients (Nambiar and Abrol, 1989; Vats *et al*., 2001). Consequently, it helps in overall sustenance of the soil fertility. Pressmud, a waste generated from sugar mills have been reported in having positive characters like possessing considerable quantities of macro and micro nutrients, besides having soil ameliorating effects and can be used to improve the soil physical, chemical and biological properties of the degraded salt affected soils (Raman *et al*., 1999). Coir pith, a by-product of coir industry is available in ample quantities to the tune of 7.5 million tonnes per year in the country (Upadhyay *et al*., 1998). The raw coirpith can be composted with fungi such as *Pleurotus sajor caju, Trichoderma sp.* and *Aspergillus sp.* and can be converted to ideal manure with higher content of macro as well as micro nutrients (Savithri and Hameedkhan, 1994).

Waste Characteristics

In general terms, solid wastes can be defined as waste not transported by water; that has been discarded for further use. It includes industrial, agricultural wastes, mining, municipal wastes that mainly consists of a large organic matter, ash and fine earth, paper and plastic, glass and metals (Sharholy *et al*., 2007). Composition of solid waste however varies depending on various factors such as weather, field situations, living standards etc. Table1 presents the classified solid waste on basis of its sources.

Types of agro-industrial wastes

The agro-industrial wastes can be classified in many ways according to its source, composition, phase, treatment required, etc. Table 1 explains about the type of wastes on basis of its sources. It includes residential, municipal, mining, agricultural, industrial etc.

Agricultural wastes

The two different types of agro-industrial wastes *viz*. agriculture and another are industrial wastes. Agriculture wastes can be further divided into farm wastes and process wastes. The wastes that are present in the field after the process of crop harvesting or threshing are classed as Field wastes. These field wastes consist of leaf litter, stalks, seed

Table 1: Type of industrial wastes

Source	Typical waste generators	Type of solid wastes
Residential	Household activities	Food waste, paper, cardboard, plastics, wood, glass, metals, electronic items etc.
Commercial & Institutional	Hotels, restaurants, markets, office buildings, schools, hospitals, prisons etc.	Bio-medical waste, Food waste, glass, metals, plastic, paper, special wastes etc.
Construction & Demolition	New construction sites, demolition of existing structures, road repair etc.	Wood, steel, concrete, dust etc.
Industrial	Manufacturing units, power plants, process industries etc.	Housekeeping wastes, hazardous wastes, ashes, special wastes etc.
Municipal services	Street cleaning, landscaping, parks and other recreational areas, water and wastewater treatment plants	Tree trimmings, general wastes, sludge etc.
Mining	Open-cast mining, underground mining	Mainly inert materials such as ash
Agriculture	Crops, orchards, vineyards, dairies, farm etc.	Agricultural wastes, hazardous wastes such as chemical pesticides

Source: Nandan *et al*., 2017

Table 2: Types of Agro-industrial wastes

Agro-industrial wastes		
Agricultural wastes		Industrial wastes
Farm wastes	Processing wastes	
Leaves, stalks, seed pods and stems	Molasses, husks, seeds, leaves, stems, straws, stalks, shells, pulps, bagasse, stubbles, peels, roots etc.	Potato peel, orange peel, cassava peel, groundnut and coconut oil cake, soybean oil cake

pods, and stems, whereas the process wastes are wastes present even after the processing of crops into interchange important resources (Table 2). These wastes generally consist of molasses, husks, bagasse, seeds, leaves, stem, straw, stalk, shell, pulp, stubble, peel, roots, etc. and can be utilized for animal feed, soil improvement, organic compost, bio-fertilizers, manufacturing and many other processes. Enormous amount of field wastes are generated and the majority of them are underutilized. Controlled use of field remains can increase the ability of irrigation and control of erosion. In Middle East region, wheat and barley are the major crops. In addition to this, various other crops like rice, wheat, maize, chickpeas, lentils, fruits, vegetables and fodders are also produced across the globe. Agricultural wastes are differentiated on the basis of their availability as well as characteristics that can be different from other solid fuels like charcoal, wood and char briquette (Zafar, 2014).

Industrial wastes

Foremost organic residues and related effluents are produced every year through the food processing industries like juice, chips, meat, beverages, confectionary and fruit industries. These organic residues can be utilized for different energy sources. As the population increases continuously, the requirement of food and their uses also increased. So, in most of the countries, different industries of food and beverage have increased remarkably in that region for fulfillment of need of food. Table 3 shows different compositions of fruit industrial wastes that constitute the different compositions of cellulose, hemicellulose, lignin, moisture, ash, carbon, nitrogen, ash, etc. and these constituents have potential to biochemically digested to produce useful products like production of biogas, bio-ethanol, and other commercially useful examples. Approximately, 20% of the production of fruits and vegetables in India are going waste every year (Rudra *et al.,* 2015) because in India a huge amount of wheat, cotton, sugarcane, soybean and apple are produced. Consequently, the production increased in the country, it also increased the percentage of waste produced from them. Similarly, the waste produced from food industries contains high value of BOD, COD, and other suspended solids. Most of these wastes are left unutilized or untreated, which caused adverse effect on environment as well as human and animal health but the composition of these wastes contains a large number of organic compound that produced a variety of value-added products and also reduced the cost of production as described in Table 3. Especially in oil industries, vast amount of processed residues are produced after oil extraction from the seeds; these residues are known as oil cakes. These industries cause air, water, and solid waste pollution because these residues contain high concentration of fat, oil, grease, suspended solids, and dissolved solids. Oil cakes have variability's based on their substrate (Table 3). Oil cake is of different types like canola oil cake (CaOC), sunflower oil cake (SuOC), coconut oil cake (COC), sesame oil cake (SOC), mustard oil cake (MOC), palm kernel cake (PKC), soy bean cake (SBC), groundnut oil cake (GOC), cotton seed cake (CSC), olive oil cake (OOC), rapeseed cake (RSC) (Ramachandran *et al.*, 2007). These agro-industrial residues are relatively cheaper and contain high amount of constituents that have an unlimited prospective to be consumed as alternative substrates for fermentation.

Effects of agro-industrial wastes on soil and crops

Agro-industrial wastes having good value of nutrients and can be used as an amendments in soil. These wastes significantly improve soil health and crop yields.

Effects on soils

Agro-industrial wastes affect the physical, chemical properties of soils. Use of tannery effluents decrease the total porosity and hydraulic conductivity while, bulk density increased. The availability of macro-nutrients in soils is also increased (Chhonkar *et al.*, 2000). Use of pressmud or filter cake, bagasse, rice milling industry wastes, by-products from distillery and spent wash affects the physical, biological and chemical properties of soil.

Effects on Crops

Indian farming has an enormous scope for re-utilization of agricultural wastes like farmyard manure (FYM), industrial wastes like pressmud, coir-pith and industrial by-products like gypsum. Value addition and utilization of wastes as raw materials for crop production with suitable technologies is the need of the day. FYM incorporation at the rate of 10 to 15 tonnes ha^{-1} in conjunction with optimal NPK fertilizer increase the efficiency of inorganic fertilizers leading to improved crop productivity in various soil conditions. It has been reported that long-term

Table 3: Composition of agro-industrial wastes

Agro-industrial wastes	Chemical composition (% w/w)												
Crop wastes	**Cellulose**	**Hemi-cellulose**	**Lignin**	**Ash**	**Total solids**	**Moisture**	**Total C**	**Total N**	**D.M.**	**Crude protein**	**Crude fiber**	**Ca**	**P**
Rice straw	39.2	23.5	36.1	12.4	98.6	6.6	-	-	-	-	-	-	-
Wheat straw	32.9	24.0	8.9	6.7	95.6	7.0	-	-	-	-	-	-	-
Barley straw	33.8	33.8	13.8	11.0	-	-	-	-	-	-	-	-	-
Oat straw	39.4	27.1	17.5	8.0	-	-	-	-	-	-	-	-	-
Sugarcane bagasse	30.2	56.7	13.4	1.9	91.7	4.8	-	-	-	-	-	-	-
Corn stalks	61.2	19.3	6.9	10.8	97.8	6.4	-	-	-	-	-	-	-
Sawdust	45.1	28.1	24.2	1.2	98.5	1.1	-	-	-	-	-	-	-
Sugar beet waste	26.3	18.5	2.5	4.8	87.5	12.4	-	-	-	-	-	-	-
Cotton stalks	58.5	14.4	21.5	10.0	-	7.4	-	-	-	-	-	-	-
Soya stalks	34.5	24.8	19.8	10.4	-	11.4	-	-	-	-	-	-	-
Sunflower stalks	42.1	29.7	13.4	11.2	-	-	-	-	-	-	-	-	-
Fruit wastes													
Potato peel waste	2.2	-	-	7.7	-	9.9	1.3	-	-	-	-	-	-
Orange peel	9.2	10.5	0.8	3.5	-	11.9	-	-	-	-	-	-	-
Coffee skin (g/100g)	23.8	16.7	28.6	5.4	-	-	C/N 14.1	-	-	-	-	-	-
Pineapple peel	18.1	-	1.4	-	93.6	91.0	40.8	1.0	-	-	-	-	-
Oil cakes													
Canola oil cake	-	-	-	6.2	-	-	-	-	90.0	33.9	9.7	0.79	1.06
Coconut oil cake	-	-	-	6.0	-	-	-	-	88.8	25.2	10.8	0.08	0.67
Cotton seed cake	-	-	-	6.8	-	-	-	-	94.3	40.3	15.7	0.31	0.11
Groundnut oil cake	-	-	-	4.5	-	-	-	-	92.6	49.5	5.3	0.11	0.74
Mustard oil cake	-	-	-	9.9	-	-	-	-	89.8	38.5	3.5	0.05	1.11
Olive oil cake	-	-	-	4.2	-	-	-	-	85.2	6.3	40.0	-	-
Palm kernel cake	-	-	-	4.5	-	-	-	-	90.8	18.6	37.0	0.31	0.85
Sunflower oil cake	-	-	-	6.6	-	-	-	-	91.0	34.1	13.2	0.30	1.30

Source: Sadh *et al.* (2018)

Table 4: Effects of agro-industrial wastes on soils

Effects	References
Improved significantly soil organic carbon, pH, EC and soil bacteria, fungus and actinomycetes population and enhanced the soil fertility status (N,P,K and Zn, Cu, Mn, Fe).	Rangaraj *et al.*, 2007
Organic matter, soil pH and total nitrogen increased in soils treated with poultry manure. But saw dust and cassava mill and palm oil mill effluent had no effect on total nitrogen.	Eneje and Ifenkwe, 2012
Maximum water holding capacity, porosity and bulk density (lowest); and availability of primary, secondary and micro nutrients contents are recorded under application of 25%RDF+75% effluents (spent wash).	Sharma, 2014
It was found that microbial biomass carbon increased up to 100% using high-rate compost treatments, and enzymatic activity increased by 30% with sludge addition. Application of organic amendments increased organic carbon by up to 90% versus unfertilized soil, and up to 100% versus chemical fertilizer treatments. Improving aggregate stability and decreasing soil bulk density. Application of composted materials enhances soil organic nitrogen content by up to 90%, storing it for mineralization in future cropping seasons, often without inducing nitrate leaching to ground water.	Mariangela Diacono and Francesco Montemurro, 2011
Application of pressmud 2-20 tonnes/ha increased the total porosity and decreased the bulk density.	Wani *et al.*, 2017

Table 5: Effects of agro-industrial wastes on crops

Crop	Effects	References
Finger millet	Pressmud @12.5 t ha^{-1} recorded better growth and yield, followed by composted coirpith @12.5 t ha^{-1}.	Rangaraj *et al.*, 2007
Tomato	Amendment of spent grain and cocoa husk at 2.5 t ha^{-1} with animal droppings at 2.5 t ha^{-1} increased effectiveness of the wastes in improving yield.	Odedina *et al.*, 2007
Okra	The industrial effluents had little effects on yield of okra, however, the use of poultry manure as an agricultural amendment, gave better boost in the yield of okra than the effluents from the industrial waste.	Eneje and Ifenkwe, 2012
Lentil	The highest number of branches per plant (11.8–12.0), pods per plant (44.0–45.2), grains per pod (1.7–1.8), grain yield (768–799 kg ha^{-1}), dry matter yield (1168–1250 kg ha^{-1}) and root length (12.0–12.6 cm) of lentil were recorded in treatments receiving NPK or pressmud at the rate of 10 tonnes ha^{-1}.	Ghulam *et al.*, 2012
Maize	Sugarcane pressmud biocompost substantially improved the plant height, leaf area and shoots and root fresh and dry weights.	Korai *et al.*, 2014

application of high rates of municipal solid waste compost increased the crop yield by 250% (Diacono and Montemurro, 2011). Also in sodic lands, application of municipal solid waste compost enhanced crop yields and improved soil properties (Singh *et al.*, 2018).

Conclusion

Agro-industrial wastes are rich in bioactive compounds and nutrients composition. Such waste comprises variability in compositions such as minerals, sugars and proteins; consequently, they should be considered as "raw material" instead of "wastes" for other industrial processes. The occurrence of such nutrients in these residues offers suitable conditions for the productive growth of micro-organisms. The micro-organisms have enormous potential to reuse the waste as raw materials for their growth through fermentation processes. The agro-industrial wastes can be used as solid support in SSF processes for the production of a range of significant beneficial compounds. The use of agricultural and agro-based industry wastes as raw materials can help to reduce the production cost, bio-multiplication of microorganism and contributed in recycling of waste as well to make the environment eco-friendly.

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