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FROM THE EDITOR'S DESK

Agriculture has not changed from being the main occupation in India and in many other countries around the world. The major inputs of GDP still gets driven by agriculture sector as its known to be the bread earner of our country. Paradoxically, more amount of waste is generated from agriculture than the product itself, though not toxic. Unfortunately, this waste is simply burnt to prepare the fields for the next crop, or subject to open dumping. These practices have negative effects on the environment and more importantly we end up wasting a large useful resource.

Little do we realize that this waste can be converted into a useful resource by using it for energy production and other constructive applications. As per one estimate, using agro wastes for energy production can help us to meet 80% of India's demand for fuel for the year 2012.

There are a few mature methods of making use of agricultural waste, like gobar gas production, composting, etc. Many new technologies are being developed to produce fuel or other utilities from this 'waste'. Large impetus is being given for Research and Development in this sector in India and all over the world to put into use these long neglected resources. In coming days, it is important to start looking at all these wastes as precious resource which will help our country's economy.

This news letter deals with ***"Agrowastes – Present Usages and Potential Applications"*** *and aims at creating awareness about this vast treasure that is being wasted.*

AGROWASTES – PRESENT USAGES AND POTENTIAL APPLICATIONS

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1. Introduction
2. Types and properties of agricultural residues
3. Agrowaste in India: Statistics
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1.0 INTRODUCTION:

Wastes generated from agricultural activities like farming of cereals and pulses, horticulture, floriculture, animal husbandry, dairy farming etc which may or may not be biodegradable is called agricultural waste or 'agrowaste'

Agrowastes are of two types:

1. Non-natural waste
2. Natural waste

Non natural wastes include plastics used for packaging silage and non-packaging plastics like horticultural films, animal health care products like discarded syringes, containers of agrochemicals like fertilizers, pesticides,

herbicides, weedicides etc., waste from agriculture machinery e.g. oil, tyres and batteries and building waste e.g. asbestos sheeting. Presently, most of the waste generated is subject to burning or landfilling (open or burying). Burning of non natural wastes like packaging plastics gives rise to emission of harmful green house gases and particulates into the atmosphere. Most of the farmers do not have the technology to control these emissions. Burying is carried out in simple pits, and not in secured landfills. This gives rise to problems like leaching and ground water pollution. Hence the best way to deal with non- natural waste is to recycle it.

Natural waste includes agricultural residues such as wastes from cultivation of vegetables, fruits, flowers, cereals and pulses, waste generated by farm animals etc. For eg. grain husks, corn cobs, vegetable peelings, discarded parts of crops like stems of flowers, vegetable peelings, fruit peelings, seeds, dry leaves, infected plants which have been discarded, cow dung etc.

2.0 TYPES AND PROPERTIES OF AGRICULTURAL RESIDUES:

Natural wastes include agricultural residues which are wet and dry. Dry residues include those parts of arable crops which are not to be used for the primary purpose of producing food, feed or fiber, used animal bedding and feathers. For eg. Straw, corn stover, poultry litter.

Wet residues are residues and wastes that have a high water content as collected. This makes them energetically inefficient to use for combustion or gasification, and financially and energetically costly to transport. It is therefore preferable to process them close to production, and to use processes that can make use of biomass in an aqueous environment. Typical wet residues include animal slurry and farmyard manure and grass silage.

Many agricultural crops and processes yield residues that can potentially be used for energy applications, in a number of ways. Sources can include:

- Arable crop residues such as straw or husks
- Animal manures and slurries
- Animal bedding such as poultry litter
- Most organic material from excess production or insufficient market, such as grass silage

Straw:

Most straw can be used for animal bedding and feed, or may be chopped and returned to the soil, or sold. Chopped straw can reduce phosphate and potassium needed for a following crop, and can help conserve soil moisture and structure. It can however give increased weed carry over, cause disease problems, and increased risk of slug damage.

Straw is typically obtained at around 15-25% moisture content and has a lower heating value (LHV) (when dry) of around 18MJ/kg. It also tends to contain high levels of nutrients as a result of the timing of harvesting, and of silica, which gives a relatively high ash content (around 5%) and can lead to slagging and fouling problems in combustion. Oilseed rape straw has higher levels of calcium.

Straw can be used in a range of energy conversion technologies like **Ethanol production** (via cellulose process), combustion, and gasification.

Corn Stower:

Stover is the stalk and leaf residues from harvesting maize for grain, and it may be used as a biomass source to produce fuel in the same ways as straw. Handling and storage of corn stover is less well established than for cereal straw, and can be less efficient.

Poultry litter:

Poultry litter most commonly consists of the wood shavings or straw used as bedding in deep litter broiler houses, together with the accumulated droppings. Poultry litter contains higher levels of nitrogen, phosphate, potassium, sulphur and magnesium than the original wood shavings or straw, and may also contain zinc and/or copper from feed supplements. Although much poultry litter is spread on the land as a fertilizer, there has been evidence that when spread on land for cattle grazing or for hay or silage, this can cause botulism in cattle. Hence, incineration, deep ploughing or burial are better options. At present the most common energy application for poultry litter is combustion in dedicated power stations for electricity production, however it can also be burned on a smaller scale for heat or combined heat and power.

Animal slurry and farmyard manure:

Manures collected from animals such as cattle and pigs typically contain only 6-10% dry matter and so are not appropriate for combustion or gasification without energetically and financially costly drying. They are also inefficient to transport any distance or store owing to the high proportion of water. Cattle manure is one of the most important sources of sulphur that can be used as a soil fertilizer.

Figure 1: Animal slurry

Grass silage:

Silage is forage biomass harvested and fermented for use as winter fodder for cattle and sheep. Grass silage is harvested in the summer and stored anaerobically in a silage clamp under plastic sheeting, or in a silo.

Figure 2 : Silage

Although silage is primarily produced as a feed, excess production can also be suitable as a biomass. To use silage as biomass, moisture content is high, typically 60-75%, and so it is not efficient to burn it, however it may be used as feedstock for anaerobic digestion.

3.0 AGROWASTE IN INDIA: STATISTICS:

Agriculture being the main occupation in India, large amounts of agrowaste is generated, in the form of crop residue and animal residue. The total quantity of crop residue estimated is 99,754 Mt/year, besides cattle dung manure is 101,835 Mt/year, and rural compost is 104,025 Mt/year *(Source: Juwarkar et al. 1992)*.

4.0 WAYS TO DEAL WITH AGRICULTURAL RESIDUES:

Traditionally, dry leaves, cow dung cakes etc were burnt as fuel. For many years now, activities like composting, gobar gas production by anaerobic digestion of cellulosic wastes and animal slurry etc are being encouraged. Recently advances have been made on production of ethanol from agrowastes using microorganisms. This ethanol can be used as a source of energy. Thus agrowastes can be converted to fuel.

4.1 Agricultural residues for energy production:

A farm produces multiple crops which are sold in the market. Yet only 25-40% of the crop (grain, fruits etc.) generates income, whereas the rest of the produce (agricultural residues) which constitutes 60-75% of the product is totally wasted and most of the times has to be burnt it in the fields. This waste residue can be used for energy production. Three types of energy can be produced from these residues. Gaseous fuels like biogas (methane), Liquid fuels such as ethanol or pyrolysis oil and electricity.

Figure 3: A gobar gas production unit in a village in Dakshin Kanada

Production of Biogas:

Biogas or 'gobar' gas can be produced by anaerobic digestion of animal slurry and cellulosic wastes. Anaerobic digestion is a renewable energy source because the process produces a methane and carbon dioxide rich biogas suitable for energy production. Also, the nutrient-rich solids left after digestion can be used as fertiliser. Gobar gas contains 55-65% methane, 30-35% carbon di-oxide, with some hydrogen, nitrogen and other traces. Its heat value is about 600 B.T.U.'s per cubic foot. It can be burnt for the purposes of lighting, cooking, or generation of electricity. Previously, the technical expertise required to maintain anaerobic digesters coupled with high capital costs and low process efficiencies had limited the level of its application as a waste treatment technology. Anaerobic digestion facilities have, however, been recognised by the United Nations Development Programme as one of the most useful decentralised sources of energy supply, as they are less capital intensive than large power plants. Biogas production units are so environmentally friendly that they are often subsidized by government grants in India.

India is a leader in gobar gas technology, and there are perhaps hundreds of thousands of gobar gas plants in India. A long-term goal for India could be to have one at each of our homes.

Production of Ethanol:

Ethanol fuel produced by conversion of agricultural residues can be used as transport fuel. Post harvest sugarcane residue can be used to produce fuel grade ethanol using yeast Saccharomyces cerevisiae ATCC strain 765. Hemicellulose hydrolysates of the agricultural residues bagasse, corn stover, and corn hulls plus fibers can be readily fermented to ethanol by recombinant *Escherichia coli* strain KO11. Extensive R&D is being done world over to optimize this technology. Few large scale plants in Canada, Japan and U.S. have already been set up on this technology. Theoretically the residues in India can produce 156 billion liters of ethanol, which can take care of 42% of India's oil demand for the year 2012.

Production of pyrolysis oil:

Pyrolysis oil is produced by rapid combustion of residue biomass and then condensing rapidly the ensuing vapors or smoke to yield oil which is nearly equivalent to diesel. Around 20% of charcoal is also produced as a by-product in the process. The charcoal can be used as cooking fuel for rural households. Nevertheless R&D is still needed in producing it economically, improving its keeping quality and making it suitable for use in existing internal combustion engines. Recent experiments in Sweden on running a 5 MW diesel

power plant on pyrolysis oil have been successful. India can produce about 400 billion kg of pyrolysis oil from its agricultural residues which is equivalent to 80% of India's total oil demand for 2012.

Biomass based power plants:

Biomass from agricultural residues can theoretically produce 80,000 MW of electric power year round through biomass-based power plants. This power is nearly 60% of the present installed capacity of India. The power plants could either be small scale (500 kW) running on producer gas from agricultural residues or medium scale (10-20 MW) running on direct combustion of these residues. The technology for this is very mature and there are thousands of such plants running all over the world.

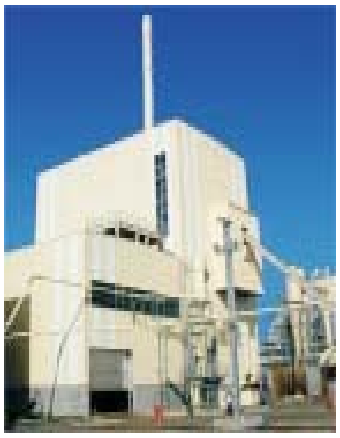

Figure 4: Biomass fired power plant

4.2 Production of manure:

Composting :

Composting recycles organic agricultural residue into an extremely useful humus-like, soil end-product called compost. Examples of residue used for composting are discarded fruits, vegetables and yard clippings. This permits the return of organic matter and nutrients into the foodchain and reduces the amount of "green" waste going into landfills. Carbonceous substrates in the composting process are first hydrolysed, then oxidised to produce CO_2 and heat, and finally transformed to stable composts. Composting is widely believed to considerably speed up the natural process of decomposition as a result of the higher temperatures generated during the process. This elevated temperature results from exothermic processes, and the heat in turn reduces the generational time of microorganisms, and thereby speeds up the energy and nutrient exchanges taking place. It is a popular misconception that composting is a "controlled" process; if the right environmental circumstances are present the process virtually runs itself. However, home (onsite) composting does not reach high temperatures necessary for sanitisation. Also, home (onsite) composting does not destroy weed seeds and segments of roots that can produce new plants.

Vermicomposting:

Vermicomposting is a simple biotechnological process of composting in which certain species of earthworms are used to enhance the process of waste conversion and produce a better product. Vermicomposting differs from composting in several ways. It is a mesophilic process, utilizing microorganisms and earthworms which are active at 10-32^{0}C. The process is faster than composting. As the material passes through the earthworm gut a significant but not yet fully understood transformation takes place, whereby the resulting earthworm castings (worm manure) are rich in microbial activity and plant growth regulators and are fortified with pest repellent properties as well. In short earthworms, through a biological alchemy are able to transform garbage into gold.

Figure 5 : Vermicomposting

4.3 Substitution of virgin wood fibres:

Using agricultural residues, wheat, rice, barley and other cereal grain straw, and corn stalks and stovers, as industrial feedstock for the construction material and pulp and paper industries will allow those industries to move away from the current reliance on virgin wood fibers.

To use agricultural residues as an industrial feedstock, accurate reports should be provided of how much residue is created each year, how much of that residue can safely be removed from fields without diminishing soil health, and which regions can support local mills to process locally produced residues.

Benefits of Using Residues:

The advantages to using agricultural residues are three-fold: environmental, economic and technological.

A. Environment

Burning of crop residues is believed to prepare fields for future crops and control diseases. However, burning yields smoke and other pollutants like CO. Paper industry can use agricultural residue instead of virgin wood fibre. Straw might prove to be an excellent pulp, but there are environmental restrictions to the amount of straw that can be harvested. Some straw is often left on fields to resupply nutrients to the soil and retain soil moisture.

To take all of the straw off of a field would cause erosion, poor soil nutrition and reduced crop yields, hence negating the net environmental benefits of reducing wood use. The relatively recent discovery that pulp and paper mills were releasing dioxins and furans directly into rivers, resulting in unprecedented fish kills. Paper produced from residue can be bleached using chemicals other than chlorine. Some processes are effluent-free, reflecting a previously unheard of efficiency in pulp production.

B. Economic

For the farmer, agricultural residues can be a cash crop. The heightened interest in making paper out of agricultural wastes means that farmers can reap a “second harvest” from grain plantings. In addition, because of the high cost of transporting agricultural residues to be processed into pulp, it is likely that mills will have to be built in rural areas, near the farms that supply the residues. This will boost local economies by providing jobs, services, and a higher tax base. In fact, a recent study shows that it is 15 percent cheaper to make newsprint from agricultural residue pulp than it is from conventional pulps.

C. Technology

Absence of chlorine or chlorine-based chemicals in the pulping and bleaching stages means that there is no production of adsorbable organic halides (AOX), the most famous and harmful of which are dioxins and furans. One method for manufacturing pulps from agricultural residues uses potassium chemicals, which can be recycled at the end of the process to make potassium-enriched fertilizer and natural fungicide products. Another process, called the Organosolv Process, uses water ethanol for pulping. Yet another process uses ammonium sulfite to pulp straw. This process fixes the ammonium to lignin, which can be returned to the soil in pelletized form. Agricultural fibers are much more porous than wood, and have much lower lignin levels. Both of these factors make straw easier to pulp. Most agricultural fibers are shorter than softwood fibers, and are therefore well suited for the manufacture of certain specialty papers.

Concerns About Using Agricultural Residues:

The high collection, transportation, and handling costs associated with agricultural residues are the foremost obstacles to the production of paper and building materials from these wastes. Whereas logs have high volume density, straw is hard to pack, has low volume density, and is difficult to store. Agricultural residues are also available only seasonally, and their cultivation is limited to certain geographic regions.

5.0 OTHER INNOVATIVE WAYS TO USE AGRICULTURAL RESIDUE:

5.1 Agricultural waste fired furnace:

This furnace has been developed for drying the farm crop, such as paddy, groundnut, bajra, sorghum and other grains, using agricultural waste. Cotton stalk, groundnut shell, rice husk, and empty maize cobs can be used as fuel for drying purposes.. The expected output is 5-10 quintals per day depending upon the crop and initial moisture content.

5.2 Agricultural waste fueled thermal power plant:

The Malwa Thermal Plant in Punjab uses 2,500 quintals of agricultural waste every day to generate electricity. This mini 6-megawatt thermal power plant generates 160,000 units of electricity everyday which is bought by Punjab State Electricity Board for further distribution. Major fuels that we are using in this plant are cotton sticks.

5.3 Compost palletizer:

The function of this machine is to make pellets from compost. The compost mixture is fed into the barrel housing the screw auger. The screw conveys the compost against the die assembly and extrudes it as pellets. A rotating knife cuts the pellets into small pieces. The pellets are passed over an oscillating tray and collected at the bottom as globules.

5.4. Briquetting machine:

This machine makes briquettes from coir pith. The screw shaft is mounted at one end by ball bearings and the other end is over hanging freely. It is coupled directly to a reduction gear unit (10:1) and is driven by a 5 hp electric motor. Fiber free coir pith and cow dung are mixed at 6:1 ratio with required quantity of water so that it will form briquettes during operation.

5.5 Adhesive from tamarind kernel powder (TKP):

The tamarind kernel is extracted during the pulping process of tamarind. The kernels have no use at the industry level, and are used as adulterants in the foods. The rich content of carbohydrate and protein makes it suitable for the production of adhesives. In the process of manufacture of adhesive, the tamarind kernel powder is mixed with hot water 200%, glucose 5%, formalin 4% and sodium carbonate 12% by weight.

5.6 Production of particle board from coirpith:

Coir pith is disposed from the coir industries. Being a ligno-cellulosic material, coir pith can be utilized for the production of particle board. The process involves drying of the coirpith and resalination using phenol formaldehyde (16%) or urea formaldehyde (20%). The resinated pith is formed into a mat of desired thickness and hot pressed at 120°C for 15-20 minutes. This board after the formation is suitable for use as table top and providing partition. The laminated boards will be suitable for exterior use, as the water absorption and swelling characteristics are good.

6.0 CONCLUSION:

Agriculture is an industry which produces the maximum amount of waste. About 60 % of the crop produced is discarded. This residue can be put to a better use by using it for energy production, substituting it for wood in industries, or producing manure from it, which can replace harmful chemical fertilizers. Thus we can put into practice the age old dictum **"Best out of Waste".**

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Waste Management and Research Journal

We would appreciate your feedback on this newsletter and welcome you all to contribute articles, news or in any other form pertaining to the Waste Management issues, for publishing in our subsequent newsletters.

Upcoming Events

Managing Waste in a Changing Climate Conference & Exhibition
March 4-6, 2009
Launceston, Tasmania, Australia
Website: http://www.taswasteandclimatechange.com.au/

Pragyaa 2009
March 6-8, 2009
Vishnupuri Nanded, Maharashtra, India
Website: http://www.pragyaa.in

International Symposium on Animal Waste Management
March 11-13, 2009
Florianopolis - SC – Brazil
Website: http://www.cnpsa.embrapa.br/sigera/ing/

Solid and Hazardous Wastes Management for Safety, Health and Environment
March 16-17, 2009
Andhra University, Andhra Pradesh, India
Email: audensem2009@gmail.com

The 2nd Kuwait Waste Management Conference
April 14-16, 2009
Kuwait City, Kuwait
Website: http://www.kuwaitwaste.com/

Identiplast 2009
April 20-21, 2009
Concert Noble Brussels, Belgium
Website: http://www2.plasticseurope.org/en/node/74

Innovative Practices for Sustainable Energy and Waste Management
April 24-25, 2009
SRIT, Coimbatore, Tamil Nadu, India
Email: srit02@rediffmail.com

Tenth International In Situ and On-Site Bioremediation Symposium
May 5-8, 2009
Baltimore, Maryland, United States
Website: http://www.battelle.org/biosymp

Sustainable Development 2009
May 13-15, 2009
Cyprus, Cyprus
Website: http://www.wessex.ac.uk/conferences/2009/sdp09/index.html

IAIA09: Impact Assessment and Human Well-being
May 16-22, 2009
Accra, Ghana
Website: http://www.iaia.org

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