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Cracking of Cellulose from Ignorant Source - Animal Waste-Biomass Conversion and Utilization: A Review

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ABSTRACT: Waste-biomass consumption is a serious issue of concerning in developing countries. This review shows a comprehensive introduction to the biomass concept, covering the main biomass resources utilized commonly throughout the world under a category i.e. animal waste. Use as a simple illustration of potential sources of energy from biomass, including trees, agricultural crops, animal manure, the waste-biomass has been proved be field-harvested, preprocessed and transported to bio-refineries for treatment and processing. It has been converted to bio-fuel for transportation, industrial chemicals or power plants to supply electrical power for public consumption. From animal waste biomass cellulose is one of the abundant polysaccharide polymer which has been extracted and functionalized with many organic reaction. This present review explores cellulose history, structure, worldwide production, and extraction of cellulose from waste biomass mainly focused on animal dung. Present status of converting them into value-added products has been established. The materials based on cellulose and its derivatives have been used for a wide variety of applications, paper manufacturing, pharmaceuticals, or other chemical engineering uses, such as chromatography, paints, and explosives.

Keywords: Animal waste; cellulose; functionalization and waste-biomass.

INTRODUCTION: Waste is well-defined as any substantial, which has not yet been fully utilized. The waste contains three main constituents: Cellulose, hemicellulose, and lignin, and it can contain various compounds. Cellulose and hemicellulose are carbohydrates that can be broken down by enzymes and acids and then fermented to produce ethanol renewable electricity, fuels, and biomass-based products. However, waste is an expensive and generally unavoidable result of human activity. It includes plant materials, agricultural, industrial and municipal wastes, and residues. Food processing wastes food in spillage, spoilage, discarding substandard edible materials, or removing edible food parts in inefficient processing. Food waste significantly impacts environmental, economic, and community health. (Wang et al. 2016)

"What is biomass?," the word "biomass" consists of "bio" and "mass", and initially used in the field of natural science simply referring to amount of animal and plant. After the oil shocks, the meaning of the word was broadened beyond environmental field and came to include the meaning "biological resources as energy sources", since it was dynamically proposed that alternative energy sources should be encouraged. There is still no strict definition of biomass, and the definition differs from one field to another. From the perspective of energy resources, a common definition is "a general term for animal and plant resources and the wastes arising from them, which have accumulated in a certain amount (excluding fossil resources)". Accordingly, biomass encompasses a wide variety including not only agricultural crops, timber, marine plants, and other conventional agriculture, forestry, and fisheries resources, but also pulp sludge, black liquor, alcohol fermentation stillage, and other organic industrial waste, municipal waste such as kitchen garbage and paper waste, and sewage sludge. Because some countries do not classify municipal waste as biomass, care is needed in the use of statistical data. Generallybiomassisthematterthatcanbederiveddirectly orindirectlyfromplantwhichis utilized as energy or materials in a substantial amount. "Indirectly" refers to the products available via animal husbandry and the food industry. Biomass is called as "phytomass" and is often translated bio-resource or bio-derived-resource. The resource base includes hundreds of thousands of plant species, terrestrial and aquatic, various agricultural, forestry and industrial residues and process waste, sewage and animal wastes. Energy crops, which make the large scale energy plantation, will be one of the most promising biomass, though it is not yet commercialized at the present moment. Specifically biomass means wood, Napier grass, rape seed, water hyacinth, giant kelp, chlorella, sawdust, wood chip, rice straw, rice husk, kitchen garbage, pulp sludge, animal dung etc. As plantation type biomass, eucalyptus, hybrid poplar, oil palm, sugar cane, switch grass etc. are included in this category. According to Oxford English Dictionary, it was in 1934 that the term "biomass" appeared first in the literature. In Journal of Marine Biology Association, Russian scientist Bogorov used biomass as nomenclature. He measured the weight of marine plankton (*Calanus finmarchicus*) after drying which he collected in order to investigate the seasonal growth change of plankton. He named this dried plankton biomass. Biomass specifically means agricultural wastes such as rice straw and rice husk, forestry wastes such as sawdust and saw mill dust, MSW, excrement, animal dung, kitchen garbage, sewage sludge, etc. In the category of plantation type, biomass includes wood such as eucalyptus, hybrid poplar, palm tree, sugar cane, switch grass, kelp etc. Biomass is renewable resource and the energy derived from biomass is called renewable energy. However, biomass is designated as new energy in Japan and this naming is a legal term peculiar to our country. Biomass is quite various and different in its chemical property, physical property, moisture content, mechanical strength etc. and the conversion technologies to materials and energy are also diversified. Researches which make it possible to develop cost effective and environmentally friendly conversion technologies have been done to reduce the dependence on fossil fuels, to suppress CO_2 emission, and to activate rural economies (Reijnders, 2006).

Biomass Composition:

Overview of biomass composition: There is a wide variety of biomass, and composition is also diverse. Some primary components are cellulose, hemicellulose, lignin, starch, and proteins. Trees mainly consist of cellulose, hemicellulose, and lignin, and so herbaceous plants, although the component percentages differ. Different kinds of biomass have different components: grains have much starch, while livestock waste has many proteins. Because these components have different chemical structures, their reactivities are also different. From the standpoint of energy use, lignocellulose biomass, which consists mainly of cellulose and lignin such as trees, exist in large amounts and have great potential.

Typical biomass components:

Cellulose a polysaccharide: Three main polysaccharides related to the human nutrition include Cellulose - a structural polysaccharide in plants; when consumed, it acts as a dietary fiber, Glycogen - a storage form of glucose in the human liver and muscles and last one is Starch - an energy source obtained from plants. Polysaccharides mainly belong to two categories: Digestible polysaccharides, such as starch, are digested (broken down) in the mouth and small intestine in several steps that eventually yield glucose, which is absorbed. They are a source of energy; they provide about 4 Calories (kilocalories) per gram. They also provide carbon atoms for the synthesis of fats, proteins and other substances in your body. Non-digestible polysaccharides or dietary fiber, such as cellulose, promote the passage of food through the gut and thus help maintain bowel regularity. Some non-digestible polysaccharides, such as inulin, may also promote the growth of beneficial intestinal bacteria. None of the polysaccharides are essential nutrients; you do not need to consume them in order to be healthy.

Cellulose: A polysaccharide in which D-glucose is linked uniformly by β-glucosidic bonds. Its molecular formula is $(C_6H_{12}O_6)_n$. The degree of polymerization, indicated by n, is broad, ranging from several thousand to several tens of thousands. Total hydrolysis of cellulose yields D-glucose (a monosaccharide), but partial hydrolysis yields a disaccharide (cellobiose) and polysaccharides in which is in the order of 3 to 10. Cellulose has a crystalline structure and great resistance to acids and alkalis. Fig.1 and 2a shows the structural formula of cellulose (Balaman, 2019).

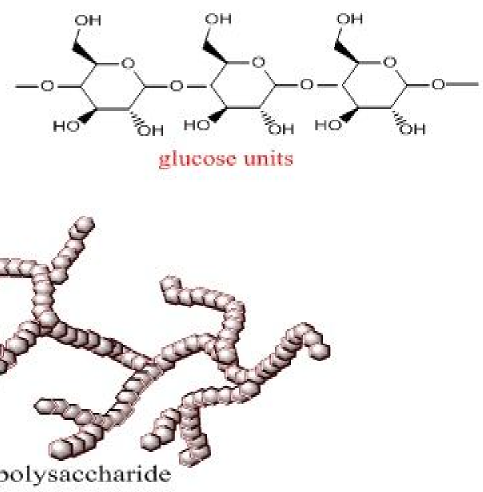

Figure 1: Cellulose as a polysaccharide.

Composition and characteristics of different types of animal waste to identify best source of cellulose: the quantity and quality of animal waste produced by animals varies between animal species. Within species, the exact proportion excreted varies according to a range of factors including diet composition, animal performance (e.g. amount of milk produced, live weight gain), size, age, sex and husbandry practices. The volume of manure per animal (liter/day) ranged from 5.4 - 45.3, 5.1 - 11.3, 0.08 - 0.14, 0.13 - 0.34, 0.71, 2.8 ewe and 28 for cattle, swine, chickens, turkey, rabbit, ewe sheep and horses, respectively.

Starch: Like cellulose, starch is a polysaccharide whose constituent units are D-glucose, but they are linked by α-glycosidic bonds. Owing to the difference in the bond structures, cellulose is not water-soluble, while part of starch(Fig.2b) is soluble in hot water (amylose, with a molecular weight of about 10,000 to 50,000, accounting for 10% - 20% of starch) and part is not soluble (amylopectin, with a molecular weight of about 50,000 to 100,000, accounting for 80% - 90% of starch). Starch is found in seeds, tubers (roots), and stems, and has a very high value as food.

Hemicellulose: A polysaccharide whose units are 5-carbon mono-saccharides including D-xylose and D-arabinose, and 6-carbon mono-saccharides including D-mannose, D-galactose, and D-glucose. The 5-carbon mono-saccharides outnumber the 6-carbon mono-saccharides, and the average molecular formula is $(C_5H_8O_4)_n$. Because the degree of polymerization "n" is 50 to 200, which is smaller than that of cellulose, it breaks down more easily than cellulose, and many hemicelluloses are soluble in alkaline solutions. A common hemicellulose is xylan, which consists of xylose with 1,4 bonds. Fig.2c shows the structural formula of xylan. Other hemicelluloses include glucomannan, but all hemicelluloses vary in amounts depending on tree species and the part of the plant**.**

Lignin: A compound whose constituent units, phenylpropane and its derivatives, are bonded 3-dimensionally. Its structure is complex and not yet fully understood. Fig. 2d shows a constituent unit. Its complex 3-dimensional structure is decomposed with difficulty by microorganisms and chemicals, and its function is therefore thought to be conferring mechanical strength and protection. Cellulose, hemicellulose, and lignin are universally found in many kinds of biomass, and are the most plentiful natural carbon resources on Earth.

Proteins: These are macromolecular compounds in which amino acids are polymerized to a high degree. Properties differ depending on the kinds and ratios of constituent amino acids, and the degree of polymerization. Proteins are not a primary component of biomass, and account for a lower proportion than do the previous three components.

Other components (organic and inorganic): The amount of the other organic components vary widely depending on specie, but there are also organic components with high value, such as glycerides (representative examples include rapeseed oil, palm oil, and other vegetable oils) and sucrose in sugar cane and sugar beet. Other examples are alkaloids, pigments, terpenes, and waxes. Although these are found in small amounts, they have very high added value as pharmaceutical ingredients. Biomass comprises organic macromolecular compounds, but it also contains inorganic substances (ash) in trace amounts. The primary metal elements include Ca, K, P, Mg, Si, Al, Fe, and Na. Substances and their amounts differ according to the feed stock type (Ogi, 2002).

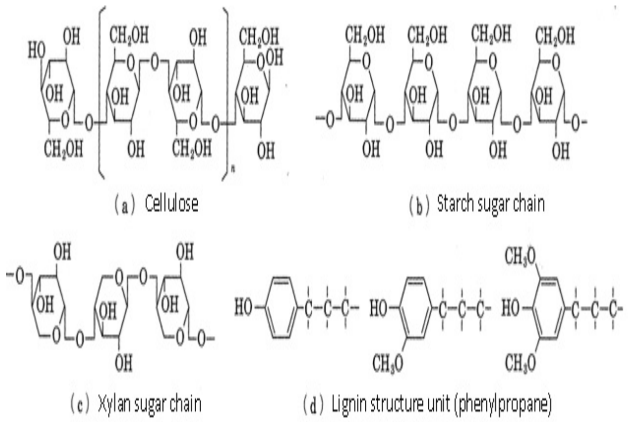

Figure 2: Chemical structures of major biomass components.

Constituent analyses of representative biomass types: Table 1 presents representative compositions of major biomass types. Although there are exceptions, the main components of terrestrial biomass in order of amount from high to low are cellulose, hemicellulose, lignin, and proteins. Aquatic biomass has different compositions. While Table 1 shows plant biomass, Table 2 gives the compositions of sludge and other waste biomass types.

Animal Waste: Livestock feces and urine are the major animal waste products and the amounts of livestock feces and urine account for the greatest portion of domestic organic waste in Japan. The feces and urine contain many easily degradable organic materials and many nutrient materials, suchasnitrogenandphosphorus.Thequantityandqualityoffecesandurineareverydifferent depending on the kind of livestock, weight, feed, and amount of drinking water, breeding system, season, and livestock conditions. According to their characteristics, feces and urine are processed and stored or used by suitable methods. Other animal waste products include slaughterhouse residue and other by-products of meat processing.

Generally, cow manure has a high carbon content (C/N ratio: ratio of carbon and nitrogen contents), but there are many organic materials that are relatively difficult to degrade, and poultry manure includes high concentrations of nutrient chemicals, such as nitrogen, phosphorus and potassium, and also containsmanytypesoforganicmattersthatarerelativelyeasytodecompose.Thecategory "waste" in slaughterhouse residue includes substances that are not suitable as foods (inedible visceral, bone, fat, blood, skin, and feathers.

General treatment and usage of animal waste Javier et al. 2017 (National Agriculture and Food Research Organization, Rome) summarized the main systems used for treatment of major livestock waste in Japan. According to the results of an investigation by the Agricultural Production Bureau of the Livestock Industry Department, solid parts of manure were just piled or operated by a simple composting process and liquid parts of manure were stored and used on their own fields as fertilizer in most dairy cattle and beef cattle farms. In the case of pig breeding, composting with a forced aeration system was the main method used for processing of solid parts and wastewater purification systems were used on most farms for treatment of liquid parts. Moreover, after drying treatment, layer and broiler manure is sold and used in other farms in many cases. Generally, dairy and beef cattle farmer shave their own land for cultivation but pig and poultry farmers do not. This is thought to be the major reason for the differences in livestock waste treatments. The slaughterhouse residue and other by-products of meat processing are treated by a process called "rendering", and most of the mare used as edible fat and oil, feed, or an industrial source.

Table 1: Plant biomass compositions.

Polysaccharide	**Composition**	**K Cal/g**	**Food Source**
Digestible			
Starch	Glucose	4.2	Cereal grains (wheat, oats, barley, corn, rice) and their products (bread, pasta, pastries, cookies), potatoes, tapioca, yam, legumes
Dextrin (starch gum)	Glucose	3.8	An artificially produced food additive
Glycogen	Glucose	4	Shellfish, animal liver
Non-Digestible (Dietary Fiber**)**			
Cellulose	Glucose	0	Whole grains, green leafy vegetables, beans, peas, lentils
Hemicellulose	Arabinose + xylose	0	Cereals bran
Polydextrose	Glucose	1.2	A food additive
Inulin	Fructose+ glucose	1-2	Wheat, onions, chicory root, leeks; a food additive
Beta-glucan	Glucose	~2	Barley, whole oats, supplements
Pectin	Various monosaccharides	3.3	Fruits, carrots, sweet potatoes; a food additive
Psylliumhusk mucilage	Various monosaccharides		Psyllium seed husk
Galactomannansorgums: betamannan, carob**,** fenu greek**,** guar and tara gum	Galactose + mannose	1-4	A food additive derived from beans and seeds
Glucomannan or konjac gum	Glucose + mannose	0	A food additive extracted from konjac plant
Othernaturalgums: gumacacia(arabic), karaya, tragacanth	Various monosaccharides	1.7	Food additives
Artificially producedgums: arabinoxylan(soluble),gellan, xanthan	Various mono-saccharides	<2	Food additives
Seaweed polysaccharides: agaragar, alginate, carrageenan	Galactose		Food additives derived from marine algae
Chitin and chitosan	Glucosamin		Dietary supplements, derived from shells of crustaceans

Table 2: Typical chemical analyses of representative biomass (wt%).

Category of biomass	Marine	Freshwater	Herbaceous	Woody	Waste
	Giant brown kelp	Water hyacinth	Bermuda grass	Hybrid poplar	Refuse-derived fuel (RDF)
Cellulose	4.8	16.2	31.7	41.3	65.6
Hemicellulose	—	55.5	40.2	32.9	11.2
Lignin	—	6.1	4.1	25.6	3.1
Mannitol	18.7	—	—	—	—
Alginin	14.2	—	—	—	—
Crude protein	15.9	12.3	12.3	2.1	3.5
Ash	45.8	22.4	5.0	1.0	16.7
Total*	—	112.5	93.3	102.9	100.1

** Totals may not necessarily be 100 because each component was measured with a different method.*

Table 3: The annual production of livestock waste in Japan.

Dairy Cattle	1,683	21,206	6,261	27,467	3,424.2	134.9	18.8
Beef Cattle	2,805	18,990	6,872	25,862	3,452.5	130.9	15.9
Pig	9,724	7,857	14,586	22,443	1,644.3	151.5	32.3
Layer	174,550	7,698	-	7,698	1,154.6	154.0	29.3
Broiler	104,950	4,975	-	4,975	746.2	99.5	11.4
Total		60,725	27,719	88,444	10,421.9	670.8	107.6

Global waste problem to rise 70% by 2050: Around the world, waste generation rates are rising. In 2016, the worlds' cities generated 2.01 billion tonnes of solid waste, amounting to a footprint of 0.74 kilograms per person per day. With rapid population growth and urbanization, annual waste generation is expected to increase by 70% from 2016 levels to 3.40 billion tonnes in 2050.

Production of animal waste: Based on the data shown in Table 3, the annual production of livestock waste in Japan was calculated to be 60.7 million tons of feces and 27.7 million tons of urine (Table 3). Livestock waste in Japan contains 670 thousand tons of nitrogen and 108 thousand tons of phosphorus. Those amounts are very large considering that the amounts of nitrogen and phosphorus used as chemical fertilizer in Japan are 480 thousand tons and 250 thousand tons, respectively. Statistics for the total amount of slaughterhouse residue are not available, but the quantity (about 1.5 million tons) is less than 2% of the total amount of animal waste.

China: Traditionally, animal waste is used as organic manure in farming and as a source of phosphorus in the modern agricultural practices. Latest reports from China (2014) showed that beef cattle, dairy cattle, swine, and poultry on an average produce 4.9 MMTP (million metric tons of phosphorus per year) in animal manures (Liu et al. 2014). The 30% of the world's livestock population is held by China alone by 2014 in and the proportion has remained constant (FAO, 2013). The estimate of global production of 16-20 MMTP year^{-1} in animal wastes, applying an average concentration of 0.8–1% of phosphorus for both confined and unconfined animal wastes, is probably more accurate. United States: In US, the average amount of manure excreted accounts for 369 million tons which accounts for almost 13 times more waste in comparison to that of entire US population of 312 million. Phosphorus and nitrogen is among the main element present in the animal waste. The high content of phosphorus and nitrogen contaminate downstream waters (Charles et al. 2009). . Excessive amount of nitrogen leads to growth of algae that consumes all oxygen, which is required for growth of other life forms. There is one report in 2015 where manure in the running waters leads to creation of dead zones in the Gulf of Mexico and in the Mississippi floodplain by other agricultural fertilizer. These elements may lead to toxic algae blooms and increase the risk in humans for developing cancer. Animal waste contaminated water from concentrated animal feeding operations can also be a cause environmental heavy metal contamination such as lead, copper and zinc (Li et al. 2005).Netherlands: In 2016, a Dutch designer Jalila Essaïdi of the Netherlands has found a novel way to tackle the problem of exceeding the phosphate ceiling because of excess manure in the Netherlands by developing a technology with which manure can be immediately transformed into bioplastic, biopaper and bio textile. The new fabric called Mestic- a Dutch word combining the terms for manure, mest and plastic - was even featured in a fashion show organized by Essaïdi and her team at BioArt Laboratories in June this year. She makes dresses out of cow and elephant dung. the new fabric met with so much enthusiasm that Mestic is now being projected as a circular solution that will not only solve the current problem with cow manure which is causing excessive amounts of harmful phosphorus and nitrogen in surface and groundwater but will also provide a sustainable source of biomaterials to the manufacturing industry, including the textiles sector.

The invention relates to the separation of manure in fractions and the treatment of said fractions in order to retrieve useful components to produce manure-derived bioplastic and other manure-derived bioproducts. The invention further relates to a method for producing composite bioplastic, and to a method for producing fibre from regenerated manure-derived cellulose. The methods include the steps of: flocculation treatment and a filtration treatment; pulping the manure-derived solid fractions; acetylation of the manure-derived dissolving-grade cellulose pulp with acetic anhydride and a catalyst; extracting fermentable components from the different fractions of the manure to produce monocarboxylic acids for use in the monocarboxylic acid carrier solution. Furthermore methods are disclosed for forming composite bioplastics with resin binding agents; and for spinning yarn from cellulose pulp (Jalila Eaisaidi, 2019).A method for the treatment of spider silk filament for use as a thread or composition in the manufacture of cosmetic, medical, textile, and industrial applications, wherein the spider silk filament, derived from genetically modified organisms, is treated with at least one component selected from the group consisting of vitamins, hormones, antioxidants, chelating agents, antibiotics, preserving agents, fragrances, dyes, pigments, magnetic nanoparticles, nanocrystals, cell adhesion enhancers, thermal insulators, shrinkage agents and cosmetic, medical or dermatological active substances. Textile fabrics obtained by this method are stronger, bio-compatible, bio-degradable and have a higher thermal conductivity. Treated spider silk filament can also be applied in an oil-in-water or water-in-oil protective cream that is hypoallergenic and ensures a firmer skin (Jalila Eaisaidi, 2015).

The 255^{th} National Meeting & Exposition 2018, of the American Chemical Society (ACS) was held in New Orleans, emphasized the importance of Elephant and cow manure for making paper sustainably. Main highlights of the meeting were on benefits of using animal waste, as much less energy and fewer chemical treatments will be required to turn this partially digested material into cellulose. Prof Alexander Bismarck who is at the University of Vienna, Austria, his post doc Andreas Mautner, Ph.D. and graduate students Nurul Ain Kamal and Kathrin Weil and working on animals' dung. They treated the manure with alkali (NaOH) solution that partially removes lignin, which is used later as a fertilizer or fuel. The un-dissolved pulp material is bleached with sodium hypochlorite to fully remove lignin and to produce white pulp for making paper. Li et al (2018) has reported that the cow manure has been used for the production of activated carbon and which is further used to treat sewage from the cow farm for wastewater treatment. This treated water can be recycled or discharged which proved that the 'Zero' discharge from intensive dairy farm is possible. Further, there are numerous reports, which turn around issue of disposal of massive amount of animal waste, and various approaches to convert unutilised animal waste into different useful products.

The livestock sector contributes significantly to generating employment in rural India, especially for landless people and marginal farmers, providing nutritious food to millions of people. India is among the leading Asian countries (China & India) using biogas technology. Composting and vermicomposting of animal waste is also done which produce substrates that has better physical and chemical properties and can be used as an alternative to fertilizers.

According to National survey: About 16.44 million people are directly or indirectly involved in the livestock sector. According to the 19th Livestock census report, national livestock population stands at 512 million, comprising mainly of cows, buffaloes, sheep, goats, pigs, and other species including poultry and among them cows and buffaloes account for 191 million and 109 million respectively (Sorathiya et al. 2018). The annual generation of dung, (95% by large dairy animals) stands at around 2600 million tons (MT), out of which only 9% is used in biogas recovery. Solid waste disposal sites have been making headlines of Gazipur in Delhi, Mulund and Deonar in Mumbai, Belahalli in Bengaluru. And the story is no different elsewhere. The world today generates more than 2 billion tonnes of trash which, over the next three decades, is expected to grow 1.7 times. Venkatasubramanian et al., (2017) has been reported that the use of waste as construction materials at large scale using 2.5, 3 and 3.5 % by weight of the cow dung ash and 1% coconut fibers replacement of cement in concrete. Dried Coconut Fibres and cow dung ash were used as a shown in fig. 3. Addition of these materials marginally improves the structural properties of concrete.

Figure 3: (a) coconut fibers, (b) Cow dung ash.

Since, the annual animal waste production is quite high in India and there is the technology gap from many more years for the production of textile by using animal waste as potential unexplored resource. So, there is need to innovate some green methods and technology to convert this unutilized animal waste to wealth, which will have a positive impact on society.

Cow dung is considered as an excellent fuel in India. There is a long history to our contribution in generating electricity from cow dung. When manure is to be converted to energy, this heating value is considered the input energy into the conversion process. To generate useful energy and fuel, manure could be converted through the action of microorganisms for the production of methane (biological process) or through the action of heat at high temperature with or without the presence of air or oxidant (a thermo-chemical process).Manure containing undigested and partially digested dietary nutrients is a resource that benefits plant growth and adds organic matter to improve soil structure. Nutrients in animal feed that are sources of energy include carbohydrates - comprised of carbon (C), hydrogen (H) and oxygen (O) - from forage and cereal grains, for example. Other nutrients are proteins (in the form of amino acids) and fats (or lipids), comprised primarily of C, H, O as well as phosphorus (P) and Nitrogen (N).The energy content of animal feed is expressed in calories. One calorie is the quantity of heat required to raise the temperature of one gram of water by 1 degree Celsius (°C) from a standard initial temperature and pressure at sea level. Not all of the energy in the feed is utilized by the animal. The energy in feed can be portioned into net energy and lost energy. Energy losses during the digestion process include the energy lost in manure (faeces and urine), in gases produced by fermentation in the gastrointestinal (digestive) tract of animals and through heat. Several processes have the potential to transform the energy in manure to usable bio-energy (Fig. 4). Despite its usefulness, major amount of it remain unutilized which results in environmental pollution. It is also estimated that just 9% of the total biomass generated by livestock is utilized for biogas recovery (Kaur et al. 2017).

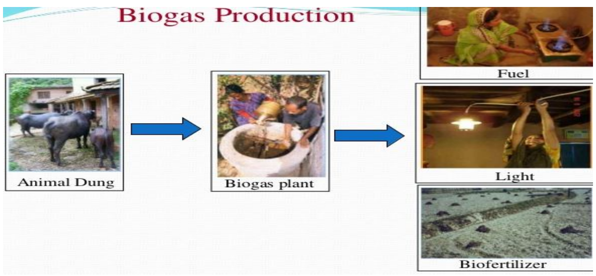

Figure 4: Utilization of animal dung in different fields.

Conversion and utilization: There are many conversion technologies available for changing the quality of biomass to match its utilization purposes. They are physical, chemical and biological techniques. Fig.5 illustrates typical conversion technologies. Biological conversion is mainly composed of fermentation processes such as ethanol fermentation, methane fermentation, acetone-butanol fermentation, hydrogen fermentation, and enzymatic treatments which will play more important role to bring the second-generation bioethanol on the practical stage. Application of photosynthesis and photolysis processes will be important to improve biomass systems Chemical conversion includes hydrolysis, partial oxidation, combustion, carbonization, and pyrolysis, hydrothermal reactions for decomposing biomass, and also synthesis, polymerization, hydrogenation for constructing new molecules or reforming biomass. Generation of electrons in oxidation process of biomass can be used for fuel cells to generate electricity. Physical conversion includes milling, grinding and steam explosion to decompose the biomass structure for increasing its surface areas to accelerate chemical, thermal or biological processes (Antony et al. 2018).. It also covers separation, extraction, distillation etc. for obtaining useful ingredients of biomass as well as densification, drying or moisture control for making biomass more suitablefortransportationandstorage.Physicalconversiontechnologiesarealsooftenusedfor the pretreatment to accelerate the main processes.

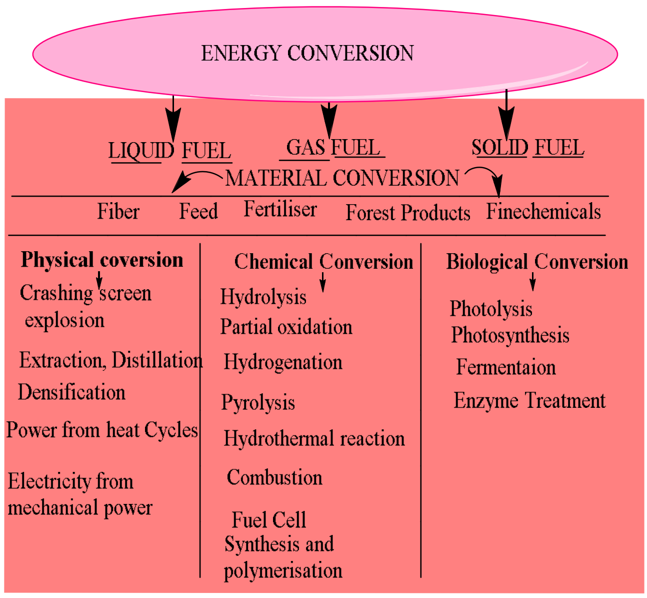

Figure 5: Illustration of typical conversion technologies of biomass.

Combustion heat of biomass is converted to mechanical power by mean of such heat cycles as Otto cycle (for gasoline engine), Diesel cycle (Diesel engine), Rankine cycle (steam engine), Brayton cycle (gas turbine) and others. Electric generator with electromagnetic induction is used to convert mechanical power into electricity. Such pretreatments as separation, extraction, milling, grinding, moisture regulation etc. are often performed before the main conversion processes. Fig51 illustrates so-called a magic box in which biomass is put on the bottom and converted by using various techniques to match its utilization purpose. Evaluation of the conversion processes is done in terms of product quality, energy efficiency and yield and system economy. Planning of conversion and utilization system should take the following items into consideration: fluctuation of biomass supply, means and cost of transportation & storage, managing organization and rules which are in harmony with the relevant regulations, as well as the economy of the total system (Ogi, 2002).

Preference to chemical modification of cellulose (A greener approach to isolate and modified cellulose from animal waste:

Process for cellulose isolation from animal waste and functionalization of cellulose: The isolation of highly pure cellulose has been the subject of extensive studies for many years because of the complexity of plants' cell wall structure but in animal waste it is quite critical to isolate the cellulose content due to the composition of many other substances present. So, the combination of the chemical and the mechanical treatments is necessary for the dissolution of substances present in the manure like lignin, hemicelluloses, and other non-cellulosic substances. A protocol based on acidified sodium chlorite is frequently applied to delignify waste materials as an initial step in the extraction of cellulose. Alkali extraction to dissolve hemicelluloses before or after delignification is the common method. In the paper industry, pulping and bleaching is used to remove lignins, hemicelluloses, and other non-cellulosic substances and obtain pulp fibre with high cellulose purity and brightness via chemical and mechanical processes. Chemical pulping including either soda, sulfate, or sulfite are the main methods to isolate cellulose fibers from lignocellulosic materials. In these procedures, NaOH, Na_2S, H_2SO_4, Na_2SO_3, $NaHSO_3$ and SO_2 are present as the major active chemicals for impregnation and delignification. Alkali treatment could extract hemicellulose-lignin complexes that are soluble in alkaline solution. Thereafter, the obtained samples undergo delignification and/or alkali extraction to extract cellulose with relatively high purity. All cellulose derivatives are based on the substitution of hydroxyl groups of cellulose by other functional groups. Thus, a definition term Degree of substitution needs to be introduced here: The degree of substitution (DS) of a polymer is the (average) number of substituent groups attached per base unit (in the case of condensation polymers) or per monomeric unit (in the case of addition polymers). The term has been used mainly in cellulose chemistry where each anhydroglucose (E-glucopyranose) unit has three reactive (hydroxyl) groups; degrees of substitution may therefore range from zero (cellulose itself) to three (fully substituted cellulose). In the case of cellulose acetate, DS is the average number of acetyl groups attached per anhydroglucose unit (Patchiya et al. 2018).

Process of extraction and isolation of cellulose from animal waste is discussed below: ***Collection of sample:*** Sample was collected from different sources in village areas. Collected sample was dried under sunlight to avoid fungal growth and kept in hot air oven at 105°C for 30 minutes to disinfect the cow dung. The dried sample was then powdered and sieved to remove sand particles. ***Moisture content:*** TAPPI test method (T 210 cm-03, 2003) was used to determine the moisture content of the cow dung sample. ***Pulping of animal waste sample:*** Cooking of dried sample was performedin closed revolving digester by Kraft process at 160°C for 1hr. Then, digested sample was washed and dried for bleaching. ***Bleaching of pulp:*** The dried sample was bleached using several bleaching agents to get white cellulose pulp (Fig.6).

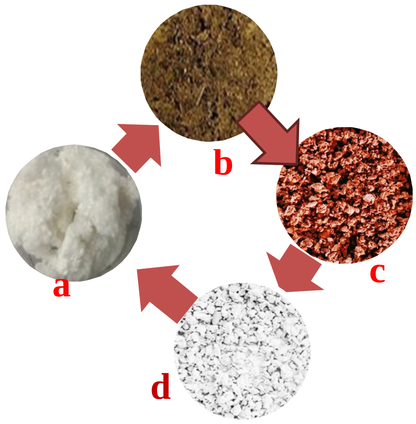

Figure 6: (a) Animal waste, (b) Digested animal waste by Kraft method, (c) Bleached cellulose (d) Isolated cellulose.

Wastewater: The term "wastewater" is basically used for "waste of all types of used water from residential, industrial, business, and agricultural areas." The area that water is obtained from also specifies the type of waste water, that is, agricultural wastewater, municipal wastewater, industrial wastewater. The main types of wastewater used as feedstock in biomass-based production systems include domestic grey water (wastewater from baths and kitchens), black water (wastewater from toilets), residual water from industrial processes, residual water from commercial or municipal institutions, rainwater, and residual water from agricultural and husbandry processes. A mixture of these types can be utilized as well. Besides procurement in biomass-based production plants, wastewater can be used for irrigation, aquaculture, forestry, and industrial activities, generally after some treatment processes. The application area is changed according to the level and type of treatment process (Mohan et al. 2007

Functionalized cellulose application for paper making and water purification: Wastes as Substrates for Paper Making Cereal straw is one of the most abundant, annually renewable resources in the world. According to a valid data, there are as many as 2.9 billion tons of cereal straw produced per year all over the world, and only in China there is 0.7 billion tons cereal straw produced per year (Chen, 2005). However, such abundant resource has not attracted enough attentions and thus has not been utilized reasonably. In fact, cereal straw is a product of plants' photosynthesis, which is constituted by high percentage of macromolecule or compounds such as cellulose, hemicellulose and lignin. Both cellulose and hemicellulose are polymers made up of fermentable sugar which can be fermented into chemical materials and liquid fuel such as ethanol, acetone, acetic acid, as well as be used as the fermenting materials of antibiotics, organic acid and enzyme after hydrolysis (Kamm et al. 2005). Lignin, comprised of phenylpropane derivatives, can be further transformed to other chemicals used as the raw material in organic chemistry industry. The utilization history of lignocellulose and fiber material has much to do with paper making industry which can date back to 3rd Century BC. Plant fiber is the raw material in the pulp and paper industry. Nowadays, wood fiber accounts for more than 90% of the world paper; nevertheless, to those countries which lack in wood fiber, fiber material such as straw is a good substitute. China is the largest straw pulp -producing country in the world, providing more than 75% of the world's non-wood pulp (Chen, 2008). Pulp and paper industry all focus on the utilization of the cellulose component in the fiber material and removal of both the hemi-cellulose and lignin components which accounts for the formation of black liquor. This process not only wastes the hemi-cellulose and lignin components, but the removal step dramatically generates the increment of the cost, and the black liquor pollutes the nearby environment especially the water resources. Obviously, it is urgent to develop new technology for straw utilization in solving the problems mentioned above. Fortunately, there are researchers who bring out biotechnologies such as bio-pulping (Chen et al. 2002) bio-bleaching and enzymatic deinking to tackle the pollution problem.

Remediation of heavy metals is commonly done by electrolytic deposition, electrodialysis, electrochemical, evaporation, precipitation, ion exchange, reduction, reverse osmosis, filtration, adsorption, chemical precipitation and distillation All these methods are expensive and not environment friendly; hence, there is a need of cleaner and greener methods. Cow dung and its microorganisms have recently been tapped for the remediation of heavy metals like chromium, strontium and arsenic. Arsenic can be detoxified by methylation process. The ability of bacteria to methylate arsenic into volatile products mainly arsine, in the form of dimethylarsine, is already known. Kartikey et al.(2016) have shown that cow dung can act as a major substrate for bacterial growth during removal of arsenic from arsenic-rich sludge by means of volatilization. It was detected that methanogenic bacteria at substrate, i.e., cow dung concentration of 25 mg/l, could effectively volatilise around 35 % arsenic. Dry cow dung powder has recently been used as a source of adsorption for the removal of chromium from aqueous solution and achieved 73.8 % removal of chromium. Another heavy metal, i.e., radiotoxic strontium which is very hazardous due to half-life of 29 years, imitates calcium in the body and increases the risk of bone cancer and leukaemia detected biosorption of a radiotoxic strontium (90Sr) by dry cow dung powder. 350 mg of dry cow dung powder along with certain laboratory conditions such as pH 6, contact time of 10 min and agitation speed of 4000 rpm resulted in 85–90 % adsorption of strontium. Thus, dry cow dung powder may be preferred over other synthetic adsorbents because of their production cost, time and energy requirements. Cow dung is a cheap and economically viable resource which is easily available. According to the above-discussed data, cow dung can be employed with or without pre- or post-treatment as an excellent measure to bioremediate non-biodegradable and of 11 potentially toxic pollutants. Using cow dung for bioremediation is a simple and eco-friendly method as it does not produce any harmful by products. However, much more comprehensive studies are required to be done in this field.

Cellulose derivatives as adsorbents for removal of heavy metal contaminants: Industrialization and human activities have led to an increasing number of pollutant mixtures entering water supply, so we need a universal and sustainable water purification technology. Water pollution is not only hindering the further development of the economy, but is also affecting people's health and survival. The United Nations have declared that a water crisis would be the first global crisis in the 21st century and second effective control of water pollution is an urgent matter. Adsorption, ion-exchange, electrochemical, and chemical deposition are common methods to treat wastewater. Recently, there is much attention on utilizing renewable, biodegradable and sustainable materials for wastewater treatment. Natural polymers such as cellulose, chitosan, gaur gum, and starch are good examples. Among these, nano crystalline cellulose (NCC) has been found to be cost-effective in water treatment (Fig 7). So, the extracted cellulose after modifications can be used as an effective adsorbent for water contamination. Cellulose nanofibers (CNF) are interesting for that purpose since: They have hydroxyl groups on their surface permitting chemical functionalization to target specific contaminants. They have a large surface area that could interact with contaminants. Their structure can be tuned permitting retention of particles via size exclusion and adsorption (Zang et al. 2014). Arsenicis one of the most toxic and carcinogenic chemical elements in natural environment Contamination of ground water with arsenic is a serious problem all over the world as chronic exposure to arsenic can induce cardiovascular, immunological, neurological and endocrine disorders, and is also a major cause of cancer (Prem et al. 2016). In 2006, the World Health Organization (WHO) has declared a concentration of 10 ppb as the maximum contamination level of arsenic in drinking water. The arsenic concentration in drinking ground water is reported to be higher than 10 ppb in various states of India and in different parts of the world including China, Bangladesh, Pakistan, Australia and USA [WHO, 2011; Fendorf et al. 2010). The increasing concentration of arsenic in ground water is a foremost concern these days as the ground water is the major source of drinking water in many developing countries such as India. There are numbers of arsenic decontamination techniques such as oxidation, adsorption, coagulation, membrane separation, ion exchange and chemisorption filtration. Among them adsorption is considered as the most promising approach for comprehensive treatment of natural water with low concentration of arsenic (Rodriguez et al. 2013; Kumar et al. 2009). Most of the conventional arsenic sorbents which include aluminium, manganese, titanium, silica, zirconium and iron-based materials are not sustainable due to multiple limitations such as insufficient removal of arsenic from water, operational complexity issues regarding complexity of pre and post treatment step, cost of the technology and their indiscriminate disposal resulting in environment degradation (Amini et al. 2008; Choong et al. 2007; Ali et al. 2012). Therefore, an urgent need is being felt to develop a highly effective and extremely capable sorbent material for the removal of arsenic, As(III) and As(V) from the contaminated water(Guo et al. 2005) . So, in this context the cellulose extracted from cow dung can be derivatized into the green cellulose thiomers which may possess high density of strong arsenic chelation (by –SH) groups by using thiourea reagent under different conditions. The derivatized cellulose thiomer can be tested for their efficiency in removal of As(III) and As(V) by various sorption studies. Therefore, it may be concluded that the proposed green material derivatized from cellulose extracted from animal waste can be a promising candidate in a practical viewpoint for arsenic removal from natural water. Hence this proposed solution for arsenic removal is green, promising and economical with zero post operational complexity and stands out as a potential solution to the animal waste menace and personifies the idiom "waste to wealth". For paper making there is a process to be followed for the production of paper on large scale. Bleached or unbleached pulp may be further refined to cut the fibers and roughen the surface of the fibers to enhance formation and bonding of the fibers as they enter the paper machine. Water is added to the pulp slurry to make a thin mixture normally containing less than 1 percent fiber. The dilute slurry is then cleaned in cyclone cleaners and screened in centrifugal screens before being fed into the 'wet end' of the paper-forming machine. The dilute stock passes through a head-box that distributes the fiber slurry uniformly over the width of the paper sheet to be formed.

Animal waste extracted cellulose conversion into textiles and Nano cellulose: Nowadays, there is increased demand of biomass resources and naturally occurring polymer products due to threats of limiting non-renewable resources, and increasing energy demands (Zang et al. 2014). Excessive usage of petroleum based polymer materials is resulting in increased global warming. Due to alarming increase of environmental pollution US department of energy is aiming to replace 25% of the industrial chemicals with biomass derived chemicals. Cellulose, as the most abundant natural polymer on earth, has attracted greater attention due to its wide availability, low cost, renewability, biodegradability as well as biocompatibility (Kunkun et al. 2018; Lin et al. 2016). Although cellulose various advantages over the petroleum based polymers but it has solubility limitations due to its fibril structure and intramolecular and intermolecular hydrogen bonding.

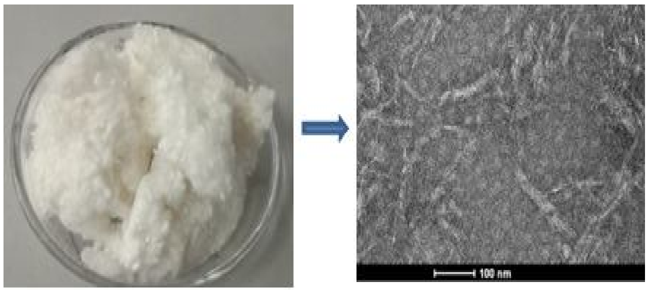

Figure 7: Conversion of extracted cow dung cellulose into nano cellulose.

Due to this limitation, a multistep viscose process is being utilized in the cellulose industries since 1892(Pichon, 2012). Viscose process has its own limitations as it leads to liberation of various hazardous chemicals such as CS_2, H_2S and heavy metals (Beer, 1962; Klemm et al. 2005; Rose et al. 2011). This method has led to several environmental hazards in India and China. The new solvent, that is, N-methlymorpholine-N-oxide (NMMO) was also commercialized which led to formulation of regenerated cellulose fibers with the generic name of lyocell (Wooding, 2001). Nowadays, the use of ionic solvents, as a substitute for viscose and lyocell process, has attracted the greater attention in fabrication of regenerated cellulose fibres (Zang et al. 2007; Wan et al 2017; Zhu et al. 2016). There is growing urgency for development of a novel environment friendly method for fabrication of cellulose fibres with desired properties.

In this context, chemical modification by carbamation and thiolation animal waste derived cellulose such that it may lead to conversion of cellulose fibres to regenerated cellulose fibres by environment friendly method of dope preparation for fibre spinning which can also prevent the liberation of any hazardous chemicals. Apart from cellulose fibres, we will also try to formulate Nano cellulose which can be further utilised in preparation of emulsions, Nano composite films and other pharmaceutical preparations (Mi et al 2016).

Animal Wastes as Substrates for Microbial Biomass (Single Cell Protein): A slightly different approach to the valorisation of animal and fishery waste is the hydrolysis and conversion of wastes to single cell protein. Horn et al., used hydrolysate of cord viscera which constitutes about 17% of the fish biomass to grow Lactobacillus spp. and demonstrated that the medium so formulated was as effective as commercial peptone based media used in the cultivation of the organism. This underscores the potential for the use of fishery waste of this kind for the cultivation of even fastidious organisms for the production of microbial biomass. Kuhn et al. fed microbial biomass produced from fish effluent to shrimps and demonstrated that the process improved the economics of shrimp production. In addition, the process led to the effective treatment of the resulting effluent. Single cell protein production for feed use has been achieved by cultivation of organisms on ram horn hydrolysate poultry process waste (Najafpour et al. 1994) and acid hydrolysed shrimp waste (Ferrer et al. 1996). Composted fish waste has been used for the production of Scytalidium aciabphilum biomass in submerged fermentation with good protein yield for animal feeding. Amar et al. (2006) also employed bacterial digestion of fish waste to produce feed for the production of Indian white prawn and in the process achieved both treatment and reuse of the fish waste. Schneider et al. (2006) produced protein enriched bacterial biomass for animal feed use from a suspended growth process using aquaculture waste and in the process achieved treatment of a particularly recalcitrant waste stream. Viera et al. (2005) used microalgae to treat fish pond waste water effluent, and demonstrated that the protein rich algal biomass could be used as feed for the production of abalone.

CONCLUSION: Undeniably, generation of wastes remains major fallout of almost every activity of man including ware biomass, agro-food production and processing activities. Unfortunately, most waste management options adopted over time had tended to see waste as useless entity that must be disposed off wholesomely. However, a close look at most natural systems gives outcome that invincible and all-knowing creator despises wastages of any kind, since nature has a way of recycling every bit of its resources into usefulness. Entering into this, chemical, biological and physical concepts have been included for the use of cellulose from waste biomass. With respect to these, the role of modern technology, particularly chemical modification and biological studies are the vision of researchers as evident in the wide range of useful resources: animal foods and feeds, bio-fertilizers, industrial chemicals/raw materials, biofuels, biogas and other energy renewable alternatives, etc. derived out of the so-called waste, using the tool of all fields of science, this paper has convincingly and conclusively shown that extracted cellulose and other biopolymers from wastes are veritable resources for wealth creation, and economic prosperity and most versatile cellulose can also extracted from nettle and lemon grass from which fibre can be converted into spun, since these products serves various purposes ranging from being consumer products in themselves or raw materials for production of various other products with various optional uses or applicability in different sectors of the economy.

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