

Pulp and Paper Industries Residues as Valuable Biopolymer by-products

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Production Phases in Pulp and Paper Industries

The industry of pulp and paper is a well-established bio-refinery model focally due to the high availability of cellulose and lignin (Silvio, 2015). It has a long chain production process comprises of a few phases as stated in Figure 1. Certain residues for each phase will be wisely employed by the pulp and paper mills that are not for landfills dump but as secondary raw materials or also called as by-products mainly for composting, energy production, bio-fertilisers and more renewable chemicals (Vaz, 2014).

Wood Logging, Chipping and Virgin Pulp Production

Wood logging are carried out in the forest by leaving the residues. However, recently the wood logs residues are being collected and converted into biofuels. Wood chipping involves the debarking of the wood followed by chipping process. These processes produce barks and small segments of wood that are useful as biofuel and gardening or composting purpose accordingly. The residues are incalculable which proved by Hu et al. (2008) whom applied feedstock pre-treatment strategies to produce ethanol from wood, bark, and forest residues. Virgin pulp production is a process to transform the wood chip shape into individual fibres that is suitable for papermaking production. Subject to the manufacturing of paper, kraft pulping is the foremost chemical pulping method practised by majority pulp and paper producers. During kraft pulping, wood chips are cooked with chemicals in order to break and dilute the lignin that holds the fibres together. Hence, fibres in terms of unbleached pulp derived from woods are finally obtained and at one fell swoop, black liquor is also been collected during the washing of pulps. The black liquor as shown in Figure 2 is a black solution that contains organic and inorganic compounds refers as lignin and spent cooking liquor respectively (Anonymous, 2004). The inorganic compounds namely spent cooking liquor

can be regenerated and reused. The residues from chemical pulping are recognised as green liquor dregs, lime mud and lime sludge (Anonymous, 2004). Whereas in mechanical pulping, separation of fibres is obtained via grinding logs against rotating stone or via refining the chips between a rotating disc and a fixed plate. The residues in such pulping are mixture of fibres and wood components. Most research has proved that black liquor which was understood as hazardous substance due to the presence of lignin has shifted to excellent and potential raw material. In instance, Wang et al. (2017) reused black liquor for enzymatic hydrolysis and ethanol fermentation which indicated water consumption saving of alkaline pre-treatment.

Recovery Paper Processing and Paper Production

Recovery paper processing is related to the process of re-pulping the under-sized paper into pulps to be inserted in the papermaking system. Several pulp treatments like deinking, removal of coating materials and discharging the fillers from pulp systems are needed in order to fulfil the requirements for identified paper products. For instance, the production of soft, thin and absorbent tissue paper needs less non-fibre elements in the paper formation. Therefore, higher residue levels come from coating materials, inks and various inorganic fillers as well. Paper production requires virgin pulps and/or recycled pulps and minerals. The minerals comprise of fillers, coaters and binders. The blending of pulps and non-pulps is crucial in order to gain better formation of paper. In this phase, the residues are both either under or over-sized paper and minerals.

Effluent Treatment and Energy Production

Effluent treatment involved the treatment of used process water that comes out from each stage in the pulp and paper production. This industry utilizes a huge amount of water along the processes. Waste water

treatment plants are one of the mandatory facilities to treat the used water which combining mechanical, chemical and biological aspects which finally resulted in effluent treatment sludge as its residue. Hence, Simão et al. (2017) studied new alternative materials for clinkerization by using lime mud, biomass ashes and waste water treatment plants sludge and proved that these residues are potential use as alternative materials for clinker production. In addition, Jaria et al. (2017) applied sludge as raw materials to produce carbon adsorbents which benefit the strategy in waste management system of pulp and paper industry. Another interesting finding is obtained by Patel et al. (2017) whom applied biological treatment to the industry effluent by oleaginous yeast that was integrated with production of biodiesel. The biodiesel can be used as sustainable transportation fuel.

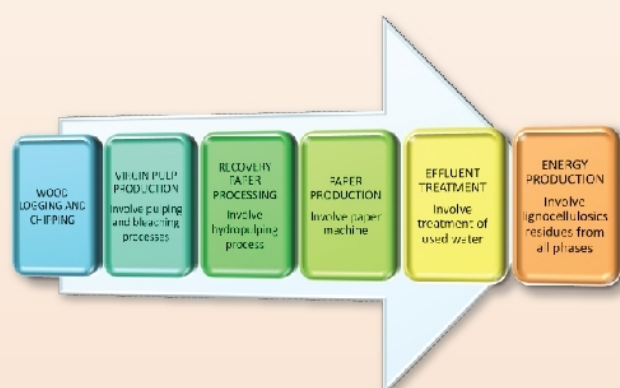


Fig. 1. The production phases in a pulp and paper industries.

Most of the pulp and paper residues from all stages of production are used as biofuels. Therefore, the mills can self-support its needs or even sold externally in terms of electricity and heat. The residue appears in this stage is ash resulted from the combustion of biofuels.

Value-able Residues Benefit Pulp and Paper Industries

By applying these value-able residues, the industries can assist the reduction of negative impacts on the environment and also to promote the global bio-economy as well (Silvio, 2015). Koutinas et al. (2014) focused on the potential in utilizing residues such as from pulp and paper industry in order to produce chemicals and biopolymers via microbial bioconversion.

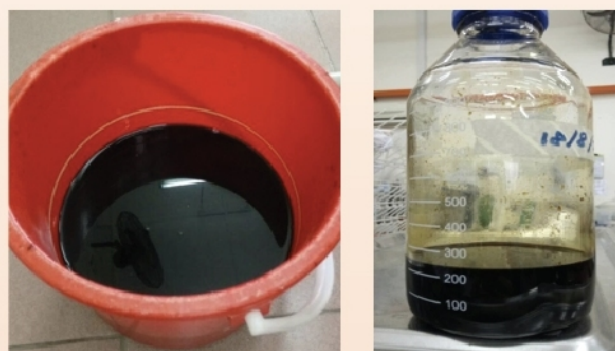


Fig. 2. The black liquor extracted after chemical pulping process which has high lignin content, potential for various bio-products.

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