Uncovering mineral recycling: A new trend in the pulp and paper industry

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INTRODUCTION:

In the exploration of mineral recycling within the pulp and paper industry, this paper delves into the intricate web of waste streams and environmental challenges stemming from pulp and paper production. Omya, with over 50 years of expertise in supplying minerals to the paper industry, emerges as a crucial partner in the journey towards sustainability, actively seeking effective approaches to recover and re-utilize minerals from diverse waste streams. From comprehensive insights into waste composition to the utilization of fly ash for pH control, Omya's "thinking of tomorrow" commitment to a circular economic model aims to reduce environmental impact and propel the industry towards a sustainable future.

The pulp and paper industry is one of the largest in the world, with annual production exceeding 400 million tons (Figure 1). Its processes generate a vast amount of waste streams including wastewater treatment sludges, boiler and furnace ash, lime mud, lime slaker grits, green liquor dregs or wood processing residuals. The composition and quantity of waste generated is largely affected by the raw materials used in the process, the paper grades being produced, the production process and the available treatment technologies. Around 11 million tons of waste are estimated to be generated by the pulp and paper industry annually in Europe and this number is expected to grow. This waste represents a huge environmental burden and requires appropriate management. Nonetheless, the paper industry is considered one of the most sustainable industries in the world and has been a pioneer in the sustainability transition. Already in 1991, the European pulp and paper industry had a wastepaper recycling rate above 40 % and currently, it reaches more than 70%.

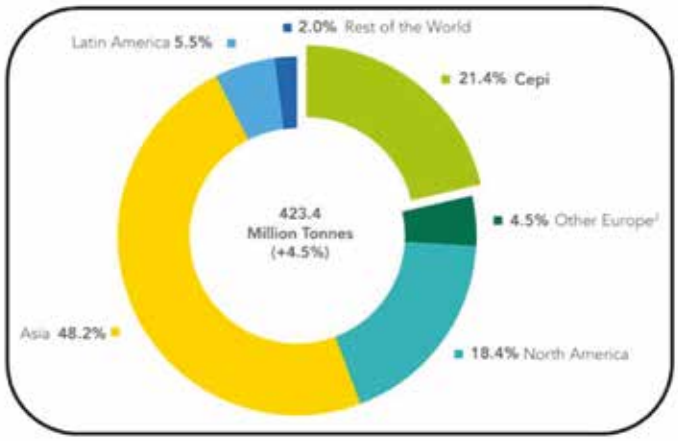

Figure 1: Paper and Board Production by region in 2021. Adapted from CEPI statistics 2022.

Over the years, the pulp and paper industry has conducted and sponsored most of the research on the identification and evaluation of management options for its waste. Due to the large quantities of waste generated, the high moisture content of the waste and the challenging composition, some recycling methods are simply too expensive and their environmental impact uncertain. Landfilling is the most common method worldwide for the final disposal of mill waste. However, environmental concerns, together with increasing costs regarding waste management and disposal, aligned with strong social and legislative pressure are forcing the pulp and paper industry to look for alternative ways to handle waste streams. The pulp and paper industry must, therefore, continue to make progress in the transition from a linear economic model, where "take, make, dispose" was standard practice, to a circular economic model, aiming to become a closed cycle with a zero-waste generation, where the utilization of virgin raw materials is reduced, and the use of recycled resources is favored. To successfully implement a circular economic model, where waste streams are converted into value-added products, a deep understanding of waste chemical and structural composition is necessary.

Omya, with more than 50 years of experience in supplying minerals to the paper industry, has been an active and important partner, looking for sustainable and effective approaches to recover and re-utilize minerals from diverse waste streams. Figure 2 represents the mineral life cycle in the paper industry.

Minerals are mined at Omya quarries (a) and then processed at Omya plants (b) into products suitable for the paper industry (c). Here, minerals are used to produce diverse paper products which are then sent to printing houses or converters (d). Final paper products will then end up at the supermarket (e) where regular daily customers can purchase them. The final customer will then decide whether the paper (and containing minerals) will be recycled (f) or not. The mineral stream coming from recycled paper will be partially reused for the production of new paper products. Nonetheless, a large amount of minerals is discarded in different waste streams generated in the paper mills. The amount of waste produced in the paper industry may be surprising for the average person. Nonetheless, in comparison to other waste streams, for example, sewage sludge, paper mill waste streams are almost free of pathogens making their handling and use safer and with lower health risks.

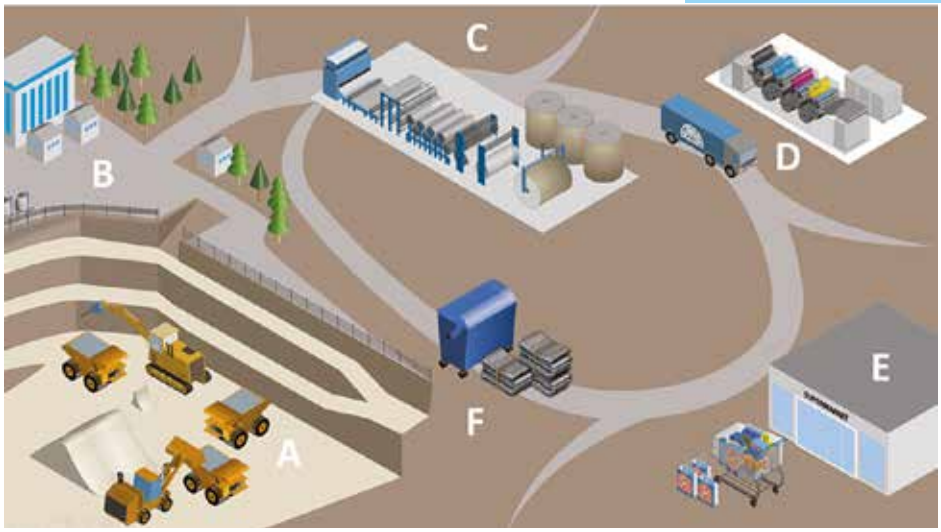

Figure 2: Mineral life cycle. a) Mineral quarry; b) Omya plant; c) Paper industry; d) Printing house/converter; e) Supermarket and f) Municipal recycling.

As a mineral supplier, Omya is especially interested in the mineral content present in the different waste streams. Waste quantities, respective estimated mineral percentages and main mineral sources can be found in Table 1. The recycling of white fibers (tissue and paper) generates the largest volumes of by-products, followed by kraft pulping. According to these numbers, a very large percentage of minerals is discarded in the different waste streams. Omya has a long history in mineral recycling, partnering with various start-ups and academic partners, and working on different technologies to valorize different waste streams. However, mineral recycling is not straightforward. There is a direct correlation between the quality requirements and the cost of the product. Therefore, when looking into mineral recycling approaches, the right balance between mineral availability, cost of the recycling process and final application must be considered. Furthermore, every approach has to be tailored to the specific conditions at the mills, including waste type, amount, and the quality and variation in waste composition.

From Table 1, it can be observed that the waste stream containing the highest amount of minerals is deinking sludge. In paper recycling, ink and fillers are removed by deinking the recycled paper, generating a waste stream of deinking paper sludge. Deinking sludge consists of printing inks (black and colored pigments), fillers and coating pigments, fibers, fiber fines and adhesive components. More than 55% of the solids removed by flotation deinking are inorganic compounds. They are primarily fillers and coating pigments such as clay and calcium carbonate. The concentrations of heavy metals in deinking sludge are generally low and, overall, they contain fewer contaminants than, for example, sludges of municipal wastewater treatment.

Deinking sludge is often incinerated to generate electricity used at the plant. Also, by incinerating waste, paper producers reduce the waste volume making it more suitable for landfilling. Landfill sites can be owned and operated by the industry itself or can be independently maintained, requiring payment from the mills. Nevertheless, landfilling is not recommended, and stricter rules are being implemented since landfilling causes environmental problems related to leaching and greenhouse gas production (US Environmental Protection Agency Resource Conservation and Recovery Act; European Union Waste Framework Directive; People's Republic of China law on the prevention and control of environmental pollution by solid wastes). Therefore, sustainable practices must be developed focusing on waste valorization by using it as raw material for distinct applications.

Over the years, Omya has spent a lot of effort in assessing technologies for an effective recovery of minerals from deinking sludges. Omya is currently proposing the utilization of fly ash originating from deinking sludge incineration to be used as a pH control agent in the papermaking process. Due to its high alkalinity, fly ash can be used to replace commonly used alkali sources such as caustic soda. Controlling the pH during the paper making process is essential for process efficiency and productivity. Furthermore, due to the high content of calcium oxide (CaO), these fly ashes have important antimicrobial properties. This is of particular importance for the production of recycled containerboard, where old corrugated container (OCC) is used as raw material. OCC is a dirty raw material, aligned with long residence times in storage towers and process conditions (temperature, pH and starch availability) create the perfect environment for uncontrolled microbial proliferation.

By giving a second life to the usually landfilled fly ashes, Omya is contributing to mineral recycling and taking important steps in the implementation of a sustainable circular economy model in the pulp and paper industry. Nonetheless, this development will imply new challenges including the establishment of new business models and value chains. Ultimately, waste recycling and conversion into value-added products will reduce production costs, expand current product portfolios and boost market opportunities.

Table 1: Waste in the pulp and paper industry. Adapted from Bajpai, P.; "Management of pulp and paper mill waste", 2015 and Schuivens, J.; "Mineral recovery from deinking sludges", 2020.

Paper Grades	Waste Produced (Kg/t product)	Estimated mineral quantity (%)	Main mineral source
Tissue (recycled)	300-400	50	Deinking sludge, water treatment
Paper (recycled)	150-200	70	Deinking sludge, water treatment
Containerboard (recycled w/o deinking)	50-100	3-5	Rejects
Carton board (recycled w/o deinking)	50-100	3-5	Rejects
Kraft pulping	100	5-10	Lime mud, water treatment
Mechanical pulping	60	0-5	Water treatment