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Recycling of Waste paper and to Reuse

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Abstract: ***Paper product manufacturing involves a variety of chemicals used either directly in paper and pulp production or in the conversion processes (i.e. printing, gluing) that follow. Due to economic and environmental initiatives, paper recycling rates continue to rise. In Europe, recycling has increased by nearly 20% within the last decade or so, reaching a level of almost 72% in 2012. With increasing recycling rates, lower quality paper fractions may be included. This may potentially lead to accumulation or un-intended spreading of chemical substances contained in paper, e.g. by introducing chemicals contained in waste paper into the recycling loop. This study provides an overview of chemicals potentially present in paper and applies a sequential hazard screening procedure based on the intrinsic hazard, physical-chemical and biodegradability characteristics of the substances. Based on the results, 51 substances were identified as potentially critical (selected mineral oils, phthalates, phenols, parabens, as well as other groups of chemicals) in relation to paper recycling. It is recommended that these substances receive more attention in waste paper.***

Keywords: Hazardous substances; Paper; Priority pollutants; Recycling; Waste management.

I. INTRODUCTION

Paper recycling is one of the most well-established recycling schemes applied to waste materials today. Recycled paper is an integral part of paper and pulp production, with estimated utilisation for recycling in Europe of about 72% in 2012 (an increase of 20% from 2000) (CEPI, 2013a). In addition to recycled paper being an important raw material for the paper industry (CEPI, 2013b), it has also been demonstrated in several studies that paper recycling may offer significant environmental benefits in a lifecycle perspective (Laurijssen et al., 2010; Villanueva and Wenzel, 2007). Thus, paper recycling may be regarded as beneficial from both a resource and an environmental perspective and should be promoted as much as possible. However, increasing concerns related to the presence of potential harmful chemical substances in paper have been voiced within recent years (e.g. Biedermann et al., 2011b; Liao and Kannan, 2011; Pivnenko et al., 2013), for example in relation to the migration of chemicals from packaging materials into food (e.g. Begley et al., 2008; Biedermann et al., 2013; Gärtner et al., 2009; Lorenzini et al., 2013). While further increasing paper recycling rates can undoubtedly be achieved in Europe, the quality of the waste paper may ultimately decrease as more and more "marginal" paper fractions are collected for recycling and the contents of harmful substances in paper thereby increase. A systematic overview of the chemical substances potentially present in waste paper for recycling is therefore needed to provide a basis for further evaluation of the quality of waste paper as a resource, and ultimately also to maintain consumer acceptance of recycled paper in general.

II. PAPER PRODUCTION

Paper production and manufacturing operations generally consist of the following two phases:

i) paper and pulp production by the paper industry (i.e. different quality grades of paper) and ii) paper product manufacturing by separate industries (e.g. periodicals, packaging materials, books, etc.). Chemicals in waste paper may originate from a wide

range of sources, namely intentionally added (i.e. additives, inks, pigments, glues, etc.), part of a reaction and/or biodegradation or added during the use phase of the paper or during the waste management phase (e.g. cross-contamination from other waste materials during collection). Chemicals are added in order to improve the production process itself and the quality or functionality of the final product. Starting with paper production, chemicals are introduced through the use of synthetic additives, which include retention aids, sizing agents, coatings, biocides, synthetic binders, etc. Synthetic additives represent slightly more than 1% v/v of raw materials used in paper production (ZELLCHEMING, 2008), the largest share of which (90% v/v) are functional additives (Moench and Auhorn, 2002) intended to be retained in the paper product. The next step, where the paper is converted into a final product, may include printing, dyeing, addition of adhesives and labels, etc. During the processing, chemicals may dissolve and be removed via wastewater, volatilize and be released to air or remain in the solid matrix and thereby be present in newly manufactured paper products. When waste paper is added to the process, this may potentially introduce new substances from the use and waste management phase. Knowing which potential partitioning a given chemical (or group of chemicals) will follow is vital for identifying potentially critical substances which may end up being concentrated in the fibres and be reintroduced into consumer products.

Recent studies have demonstrated that paper and paper products may contain high numbers of chemical substances (BMELV, 2012; Bradley et al., 2008), most of which can be associated with the printing industry, where more than 7,000 chemicals may be used in food-packaging ink production alone (EuPIA, 2012).Nevertheless, very little quantitative information is available regarding the presence of specific substances in paper products or waste paper potentially sent to recycling. Most existing studies target a specific group of chemicals or paper products (e.g. Becerra and Odermatt, 2012; Geens et al., 2012; Song et al., 2000; Trier et al., 2011), and attempting to identify every single chemical present in paper has proved to be challenging (BMELV, 2012).

Although specific regulations covering paper food packaging do not exist, European legislation on items (i.e. plastics, metal, paper, etc.) brought into contact with food prevents the use of chemicals that could migrate into foodstuffs and adversely affect human health, as well as the quality and nature of food (EC, 2004). This legislation covers paper packaging produced from virgin fibres, but when paper is recycled, the producers may not be aware of the presence of any specific chemicals added throughout the lifecycle of the paper. Consequently, the paper industry, and the final output paper quality, is affected by the presence of chemicals in the recycled paper,

e.g. chemicals introduced during the use phase or via paper products from other countries. In 2012, more than 5 million tonnes of paper (approx.11% of recycled paper) was imported into Europe from the USA, Russia, Brazil, Canada, etc. for paper product manufacturing (CEPI, 2013a).

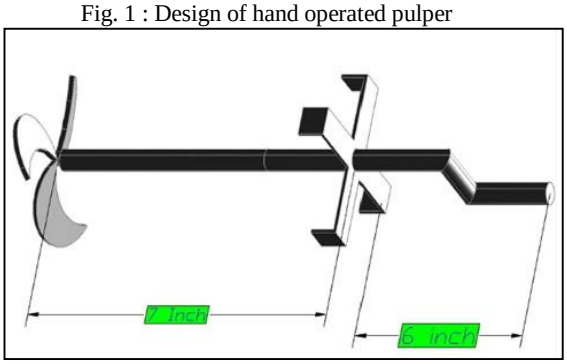
Without a comprehensive overview of which chemical substances should be prioritised in relation to paper, and which substances should ultimately be avoided, it may not be possible in the future to ensure both high recycling rates and at the same time a high quality of the paper products based on recycled fibres. As direct and substance-by-substance analysis is not practically feasible, a systematic screening of un-problematic chemicals is needed, in order to identify those substances which may be considered most problematic and critical for the future recycling of paper.

The overall goal of this study is to provide a basis for systematically addressing the recyclability of waste paper with respect to the potential presence of hazardous substances. The specific objectives are: i) based on existing literature, to compile a list of chemical substances potentially applied in paper production and paper product manufacturing, as well as chemicals identified directly in paper, ii) based on a sequential hazard screening procedure to identify the most critical chemicals from this list based on their harmfulness, physical-chemical properties and biodegradability and iii) to evaluate potential implications related to the management of paper waste and paper recycling.

III. MODEL AND FRAMEWORK

Paper recycling generally involves the collecting of waste paper, sorting them by their types, processing them into raw materials and manufacturing new products using these recycled raw materials. The whole process is briefly described below. To start the paper recycling process, the waste paper needs to be sorted such as by newsprint, computer paper, magazine paper etc, as different types of paper are treated differently during the paper recycling process to make different types of recycled paper products. The sorted paper is usually soaked in a pulper, which contain water and chemicals. The waste paper is shreds into small pieces. Heating the mixture breaks the paper down more quickly into tiny strands of cellulose (organic plant material) called fibers. Eventually the old paper turns into a mushy mixture called pulp. The pulp is forced through screens containing holes and slots of various shapes and sizes. The screen removes small contaminants such as bits of plastic and globs of glue. This process is called screening. In addition, the pulp may also be spun around in large cone-shaped cylinders. Heavy contaminants (e g. Staples) are thrown out of the cone via centripetal forces, while lighter contaminants collect in the center of the cone and are removed. This process is called cleaning. The next stage in the paper recycling process involves deinking – removing the ink from the paper fibers of the waste paper. Sticky materials like glue residue and adhesives are also removed at this stage. During refining the pulp is beaten to make recycled fibers swell, making them ideal for paper making. If the pulp contains any large bundles of fibers, refining separates them into individual fibers. If the recovered paper is colored, color stripping chemicals remove the dyes from the paper. Then if white recycled paper is being made, the pulp may need to be bleached with hydrogen peroxide, chlorine dioxide or oxygen to make it whiter and brighter. If brown recycled paper is being made, such as that used for industrial paper towels, the pulp does not need to be bleached.

Fig. 1 : Design of hand operated pulper



In the last stage of the paper recycling process, the cleaned up pulp is ready to be made into recycled paper. The recycled fiber can be used alone, or blended with new wood fibers (i.e. virgin fibers) to give it extra strength or smoothness. The pulp is mixed with water and chemicals, such that the pulp is 99.5% water. This watery pulp mixture then enters the head box of a paper making machine, and is sprayed in a continuous jet onto a huge wire mesh-like screen moving very quickly through the paper machine. On the screen, water starts to drain from the pulp, and the recycled fibers begin to bond together to form a watery sheet. The sheet then moves rapidly through a series of felt-covered press rollers which squeeze out more water from the pulp. In this way recycled paper is created. The following equipment is necessary for the experimental setup of paper recycling process: Pulper, Screener, Roller

1. SETUP AND PROCEDURE

In order to recycle paper the following equipment were made in CUET workshop. The hand operated pulper machine was made by Eusufzai Z. (2012). The total height of the pulper is 13 inch. It has support at its middle to hold on pulp container. Screener was made with stainless steel net and wooden frame as shown in figure 4.3. The stainless steel net has 80 holes per inch. After making the pulp it was settled down on the screener. In order to make roller the following materials were used.

>> Stainless Steel Pipe(Length - 1 feet; Outer Diameter – 2 inch, Inner Diameter – 1.5 inch)

>> Mild Steel Bar(Length - 1.5 feet, Diameter -0.75inch)

>> Two Ball Bearings(Bearing no. 6904ZZ, Inner Diameter – 20mm, Outer Diameter – 37mm, Width 9mm.)

Fig. 2: Pulper machine and screener In recycling of waste paper mainly the following process were followed.

- Pulping
- Screening
- Rolling
- Drying

Pulping

Pulp was made by adding waste paper with water. After using various waste paper and water ratio the best pulp was found at a ratio of 100gram paper and 4 litres of water. Pulp was made with the help of hand operated pulp machine.

Screening

After getting the pulp it was poured on the screener. As a result the pulp slurry was settled downed on the screener.

Rolling

After screening the pulp, it was rolled with the help of the hand roller in order to remove extra water from the pulp**.**

Drying and Paper Making

After rolling it was dried in the sunlight for about 2 hours. After drying it was pulled over the screener carefully. The final recycled paper was as like as shown in the figure 4.

IV. CONCLUSION

The development of manually operated paper recycling process is much cheaper than the automated paper production process. It can serve dual purposes, it can be manned permanently at a stationary position or it could be shifted from one place to another as the case may be. One great advantage to be derived from the use of this process is that the cost of running it is minimal compared to what it takes to run a full plant. The simplicity of operation of this machine ensures that no too much technical skill is needed to operate it. In addition it is an environment friendly process**.**

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