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Country report

Current status of circularity for aluminum from household waste in Austria

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ABSTRACT

Aluminum (Al) represents the metal with the highest consumption growth in the last few decades. Beside its increasing usage in the transport (lightweight construction of vehicles) and building sector, Al is used ever more frequently for household goods like packaging material, which represents a readily available source for secondary aluminum due to its short lifetime.

The present paper investigates the extent to which this potential source for recycling of Al is already utilized in Austria and highlights areas for future improvements. Thereto a detailed material flow analysis for Al used in packaging & household non-packaging in 2013 was conducted. In practice, all Al flows starting from market entrance through waste collection and processing until its final recycling or disposal have been investigated. The results indicate that about 25,100 t/a (2.96 kg/cap/a) of Al packaging & household non-packaging arose as waste. At present about 9800 t/a, or 39%, are recycled as secondary Al, of which 26% is regained from separate collection and sorting, 8% from bottom ash and 5% from mechanical treatment. The type of Al packaging & household non-packaging affects the recycling rate: 82% of the total recycled quantities come from rigid packaging & household non-packaging, while only 3% of the total recycled Al derives from flexible materials. A significant amount of Al was lost during thermal waste treatment due to oxidation (10%) and insufficient recovery of Al from both waste incineration bottom ash and municipal solid waste treated in mechanical biological treatment plants (49%). Overall it can be concluded that once Al ends up in commingled waste the recovery of Al becomes less likely and its material quality is reduced. Although Austria can refer to a highly developed recycling system, the Austrian packaging industry, collection and recovery systems and waste management need to increase their efforts to comply with future recycling targets.

1. Introduction

The world's population keeps growing, and so does its demand for goods of all kinds. The increasing fear of shortage or unavailability of raw materials from natural sources and the unanswered questions of how to handle the severe impacts on the environment from incessant production are huge challenges in the 21st century (RLI, 2015). The scarcity of raw materials is especially delicate in countries (and communities like the European Union) which are highly dependent on imports of commodities (OECD, 2015).

Changing the way of use from a linear to a more integrated pattern, where the consumption of raw materials is reduced and the re-use of existing goods is encouraged, could be an important step towards meeting these challenges (EEA, 2016). Such an integrated pattern is the essence of the concept of the Circular Economy. While there is no uniform definition of Circular Economy, all do have the same bottom-line: "the objective of the circular economy is to preserve the value of utilized resources and materials as long as possible, to use them as frequently as possible, and to produce as little waste as possible (ideally none at all)" (Wilts, 2016). The European Environment Agency EAA (2016) adds that Circular Economy has "a positive, solutions-based perspective for achieving economic development within increasing environmental constraints". The European Commission has introduced an ambitious "EU Action Plan for the Circular Economy" and has released various legislative proposals like the "Proposed Directive on Packaging and Packaging Waste", which demands that 65% of all packaging waste should be reused and recycled by the end of 2025, resp. 75% by 2030 (EC, 2015).

The packaging sector in Austria produces around 1.3 million t of packaging waste p.a., which is equivalent to more than 30% of Municipal Solid Waste (MSW) generation (BMLFUW, 2017), while contributing only 1% to the gross national product (PROPAK, 2017).

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One of the frequently used packaging materials is Al, due to its versatility and outstanding properties. It serves as a barrier against light, fluids, oxygen, microorganisms and other substances, prevents flavor or scent impairments, and ensures durability. Packaging usually has short life cycles and therefore requires constant reproduction of packaging materials.

In order to gain primary aluminum, the raw material has to be extracted from Bauxite in an energy-intensive process. Using secondary instead of primary raw material through recycled and remelted Aluminum scrap can reduce the energy input by 90–95%. The mining of Bauxite also has severe impacts on the local and global ecology because large extraction areas are situated in tropical rainforests and the red mud that remains can lead to environmental damage. Furthermore, dependency on imports, price volatilities and insecurities of supply caused by geopolitical factors have to be considered (Rüttinger et al., 2016; Wilts, 2016).

The environmental, political and economic impacts associated with the production of Al packaging could promote the use of secondary Al, which requires that recycling be optimized and losses in the recycling chain minimized (Aludium, 2017; Bühler, 2017). The minimum targets for reuse and recycling with respect to Al contained in packaging waste stipulated in the "Proposed Directive on Packaging and Packaging Waste" are set at 75% by the end of 2025 and 85% by the end of 2030 (EC, 2015). For Austria this also requires an adjustment to the Austrian Packaging Ordinance 2014 (Verpackungsverordnung, VVO), which specifies a minimum recycling rate of only 50% for metals (Republik Österreich, 2014). The Al balance for packaging applied in this study differs from official surveys because it includes all Al used as packaging material and therefore expands the usually licensed Al packaging quantities applied, which consider only packaging containing more than 80% Al.

This paper aims to analyze the current status of Al management for Al packaging & household non-packaging in Austria and to identity potentials for improvement with respect to the implementation of a circular economy, as required by the European Commission. Austria was chosen as a case study.

2. Material and methods

In this study the method of Material Flow Analysis (MFA) is used to capture, describe and investigate the physical flows (Brunner and Rechberger, 2017) of Al packaging & household non-packaging in Austria for 2013. The material flow model presented delineates the different stages of waste management (collection, sorting, treatment and disposal) and the recycling process itself (re-melting) (Fig. 1). In practice, the following processes are considered:

- Household Al packaging & non-packaging consumption
- Waste collection and sorting
- Incineration and bottom ash treatment
- Mechanical treatment
- Industrial incineration (cement industry)
- Aluminum smelter (melting plant)
- Al losses
- Landfill.

Al in packaging & non-packaging was subdivided into three product groups: rigid, semi-rigid and flexible (López et al., 2015). The allocation to these categories is based on a survey of a product-related substance flow analysis (ProSFA) for residual waste (RW) in Vienna by Taverna et al. (2010). The wall thickness of Al (Table 1) as defining element strongly influences the behavior of Al during waste treatment (e.g., oxidation during combustion, separability via eddy current separator) and affects also the recovery yield of Al scrap in the melting plant (e.g. higher losses for flexible Al).

2.1. System description and data collection

All data refer to the year 2013. If no data were available, reference data from different times were used and associated with a degree of uncertainty (see Section 2.2).

For packaging Al, it was assumed that waste generation equals the market volume of packaging as it is generally disposed of shortly after use and any stocks of packaging can hence be neglected. In contrast, the lifetime of non-packaging is much longer and varies by product. In this study, the lifespan of non-packaging as well as its stock buildup was disregarded. Only the annual quantities of discarded non-packaging goods from households into MSW were considered. The determined recycling rate of Al refers to all Al (packaging and household non-packaging) present in MSW.

2.1.1. Market volume and waste generation

The input flows F1.01–F1.06 describe the amount of Al packaging & household non-packaging used in Austria in 2013. Different products were distinguished (beverage cans, beverage cartons, composite foils and other packaging & household non-packaging).

The market volume of packaging and waste quantities of household non-packaging was calculated from data of Austria's leading packaging compliance scheme Altstoff Recycling Austria (ARA, 2017), a survey on packaging by Hauer et al. (2015) and various waste analyses. The market volume of beverage cans (F1.01) and beverage cartons (F1.02) were based on market volume and collected quantities (ARA, 2017; Hauer et al., 2015). Beverage cartons partially contain Al foil (ARGE Hauer, 2016), whereby an average Al content of 4% was assumed (Fachverband Kartonverpackungen, 2017).

The market volume of Al composite foils was difficult to identify because no specific data were available. This is mainly due to the fact that the material share of Al has to be above 80%, otherwise it is classified as composite material and is not officially allocated to Al packaging because the dominant material is mostly plastic or paper (ARA, 2015). For the Al balance conducted, however, all Al used in composite material was relevant and thus included in the mass balance. The market volume of Al in composite foil (F1.03) was estimated based on the ProSFA study for residual waste (RW) in Vienna by Taverna et al. (2010). These data were compared with a Spanish study by López et al. (2015) and estimates from the European Aluminium Association (EAA, 2017) and the European Aluminium Foil Association (EAFA, 2017).

Other Al packaging (F1.04) include Al packaging except beverage cans, foils in beverage cartons and composite foils. Data about their usage in Austria were obtained by a market survey and waste analyses conducted by Hauer et al. (2015).

Al household non-packaging comprises household foil and other non-packaging items such as household wares, fittings, tubes, coins, or coffee capsules. The amount of household foil (F1.05) was based on a market analysis from Hauer et al. (2015). The volume of other Al household non-packaging (F1.06) was difficult to assess and could only be estimated via various sorting analysis (Amt der Kärntner Landesregierung (Ed.), 2012; AARGE Abfallanalyse Oberösterreich 2013, 2014; HARGE Hauer, 2016; Boku, 2011; Hauer et al., 2015; Hauer and FHA, 2010; IUT and SDAG, 2014; Land Salzburg, 2013; Salzmann Ingenieurbüro, 2000).

2.1.2. Collection and sorting

After usage, Al packaging & household non-packaging enter separate collection & sorting systems (F2.01) or end up as RW (F2.02) or occasionally as bulky waste (BW) (F2.03). Littering