Zinc Recycling

Stocks and Flows

As a material, zinc follows a complex life cycle from extraction as an ore, through refinement and use in society, to eventual collection and recycling of products at the end of life. This life cycle can be characterized by collecting information at various stages of production, manufacturing, use, and waste management. In addition, information on these "stocks and flows" of material can be used to calculate recycling indicators at the national, regional, or global scale, along with illustrating temporal trends and future trajectories of in-use stocks in developing areas.

What is Material Flow Analysis?

A tool called Material Flow Analysis (MFA) is used to characterize the zinc life cycle, which is based on the mass balance principle. In MFA, a material life cycle is described by identifying 1) the main stages (processes) of a material, 2) the main flows connecting these processes, 3) the stocks in which a material is accumulated over time, and 4) its release from these stocks. These processes are interconnected through the generation and use of scrap in different forms and at different life stages. Flows are quantified by using a variety of data sources, estimates, and mass balance. Four main processes characterize the life cycle for zinc (Figure 1): Mining & Smelting (production), Fabrication & Manufacturing (products), Use (service), and Waste Management & Recycling (end of life).

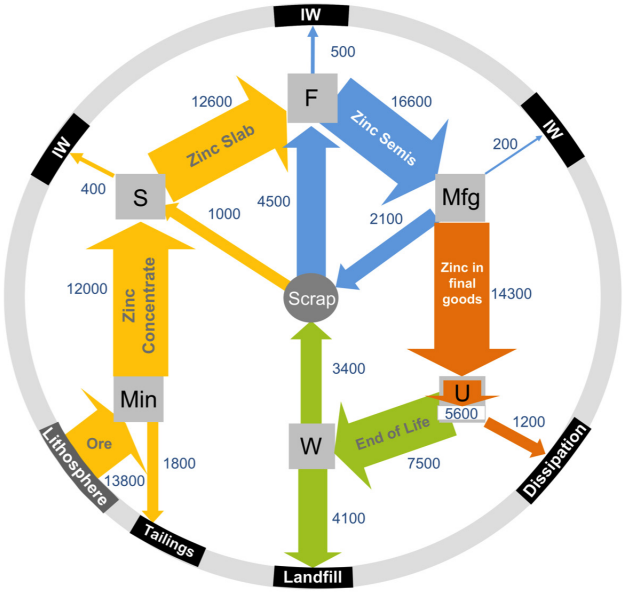

Figure 1. Global anthropogenic cycle of zinc in 2010 (kilo tonnes). Similar figures can be constructed for any country or region shown in Figure 2. Min = Mining, S = Smelting, F = Fabrication, Mfg = Manufacturing, U = Use, W = Waste Management, IW = Industry Waste

How is the material life cycle for zinc determined?

To characterize the zinc life cycle, country-level data is collected on production, products (intermediate and finished products), waste management (scrap collection and recycling), and trade (imports and exports) for 52 countries (Figure 2). In addition, manufactured products entering use are differentiated into six main sectors (construction, transportation, industrial and metal working machinery, electrical and electronic products, and miscellaneous) to apply estimates of product lifetime and eventual collection rates. The selection of countries represents at least 90% of the combined flows to zinc mining, smelting, and usage at the global level, which can be combined to represent flows at the regional or global scale. Primary sources for information on the various flows of material include international study groups, geological surveys, statistical archives and numerous peer-reviewed publications. Data has been collected as part of an ongoing collaboration between the zinc industry and academics at Yale University engaged in global material flow analyses.

Figure 2. Countries for which the anthropogenic cycles of zinc in 2010 were constructed.

How do zinc life cycles vary regionally?

China currently has a dominant share of zinc flows into mining, fabrication, use and waste management (Figure 3). In the cases for fabrication & manufacturing and use in society, this dominance approaches 50% of the global flow. To this end, China currently consumes seven-times as much zinc in final products as the next largest user, the USA. Other regions that contribute to major flows of material include Europe and North America (smelting, fabrication & manufacturing, final use, and waste management). In contrast to flows related to production and use, European zinc flows into waste management is roughly equivalent to China. This can be explained by two factors; 1) materials associated with recent industrialization in Asia, generally, have long lifetimes and have not matured to the point where they have come to end of life (i.e., building materials are still in use), and 2) Europe, along with other developed regions, have more mature waste management and recycling practices.

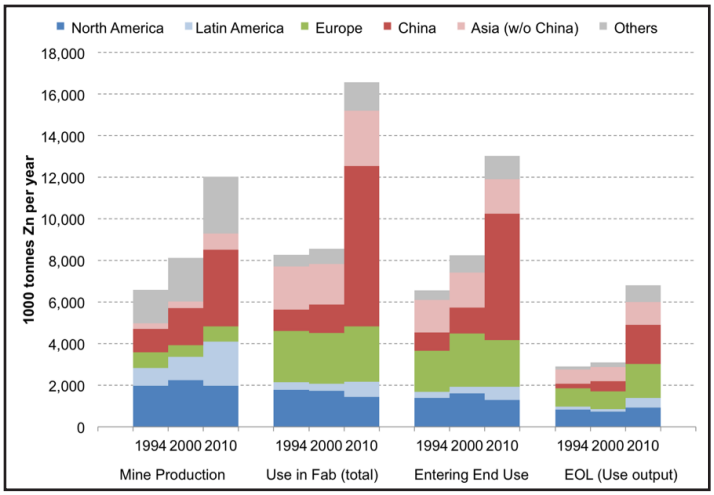

Figure 3. Key historical flows of zinc (EOL = End of Life, Fab = Fabrication)

What does the global zinc life cycle show regarding waste management?

The global cycle of anthropogenic zinc can be obtained by aggregating the cycles of 52 countries (Figure 1). From this perspective we can conclude that 45% of zinc coming to end of life is being recycled (global End of Life Recycling Rate); this indictor increases to >50% for Europe and North America due to a mature waste management industries. Similarly, secondary zinc accounts for 25% of all zinc use (global Recycled Content). The majority of scrap, generated from end of life flows and new scrap from manufacturing go directly back into fabrication. The remainder, which is lower grade zinc scrap, goes back to the smelter for refining similar to zinc concentrate. Approximately half of the amount of zinc going into use (14.3 Mt) is leaving in-use stocks as products that have come to end of life (7.5 Mt). As a result, nearly 6 Mt of zinc are being added to in-use stocks annually. The largest losses to the environment occur in waste management with the landfilling of end of life products and residues from new and old galvanized steel scrap treatment. These waste management losses (4.1 Mt) are equivalent to the combined losses of the other cycle processes.

Are historical trends in material flow evident?

In general, flows into production, fabrication, use, and waste management have nearly doubled since 1994 and increased about 50% since 2000 (Figure 3). Although Latin American has contributed to growth in production, China represents the majority of growth in each of the flows. The only relative change in material flow from developed regions (Europe or North America) was associated with zinc coming out of use, which nearly doubled between 2000 and 2010. This illustrates the effectiveness of waste management initiatives in these areas that are geared towards improved collection and recycling networks.

How is the zinc industry using the life cycle information?

The most obvious opportunity for improving recycling rates exists in developing regions, where mature recycling networks and investment in infrastructure are still evolving (e.g., only 30% of available zinc is recycled at end of life in developing regions). One challenge is the lack of regulations that incentivize collection and processing, rather than landfilling, of products and scrap (e.g., residues generated from steel recycling). As countries begin to follow the lead of Europe and North America in this regard, the zinc industry has developed new infrastructure for recovering zinc from these waste streams. In support of these efforts, the International Zinc Association continually generates and monitors information on the effectiveness of zinc recycling to help communicate and promote the many ways zinc contributes to a sustainable society.

zinc
...essential for life

More detailed information is available on the IZA website at www.zinc.org.