

Copper flow in Brazil and its comparison with other economic regions

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Abstract

This quantitative study characterizes the copper cycle in Brazil (base 2005), including its process stages (production, manufacture, use and waste management), using the Substance Flow Analysis.

Its result shows us that Brazil is a net importer of copper (64,000 t), but in beginning of 2010 decade, it will change due to a new producer of refined copper. In 2005, copper consumption was 1.44 kg/capita, and 0.52 kg/capita stay "in use" as stock mainly at infrastructures, buildings, electrical equipments and household appliances. Waste generation (1,411 kg/capita) is close to the European index (1,865 kg/capita), smaller than Latin American (3,000 kg/capita) and bigger than Asiatic (852 kg/capita) and African (192 kg/capita) ones.

Copper content was accounted for in the seven major residues flows (municipal solid waste - MSW, construction and demolition - C&D, waste of eletro-eletronic equipments - WEEE, end of life vehicles - ELV, solid sludge - SS, hazardous industrial waste - HIW, non hazardous and industrial waste - NH&IW). The copper content in each of these flows were calculated: 27,8% in C&D, 27,7% in WEEE, 19,7% in MSW and 13,2% in HIW. It differs from other regions where a concentration of copper in WEEE is highly apparent (83% in Latin America and 62% in Africa). WEEE and ELV have counted less than 1% (weight) but concentrate about 38% of residual copper after its use.

Copper recycling, different of other countries of Southeast Asia, is not a predominant activity in Brazil. Its index is 25%, far from North American and Asiatic (60%), European (48%), and African (34%) ones. Such a low rate has resulted in 141,000 t released to biosphere (including the landfills). Copper released per capita for Brazil is 0.75 kg, in an intermediate position together with Latin America, with Europe in the top (1.4 kg/capita) and Asia/Africa in the bottom (0.23 kg/capita). If considering contamination indicator, copper release amount by territorial extension (area), Brazil again is in intermediate level (16.3 kg/km²) with Europe (159.5 kg/km²) four times upper than Asia (37.9 kg/km²) and Africa is the last one with 6.6 kg/km².

Brazilian indicators are low comparatively to the other ones but it does not mean that nothing need to be done. To diminish the environmental pressure and optimize the secondary copper recycling, governmental policies should implement restriction mainly in WEEE and ELV flows during their final destination, incentive by economic instruments such as charging manufacturers and consumers to recover copper post-use, besides prioritize on education and awareness of unsustainable consumption and production patterns practiced nowadays.

1. Introduction

For decades, it has been discussed the unsustainable model of production and consumption of metals, either in terms of its intensity or in form of its use. The capacity of natural resources has been constantly updated, not only by technological advances that allow its extraction to levels of concentration before economically non-viable as the discoveries of new fields to explore, which combined with new material substitutes, are postponing the time limit for its use and consumption. Moreover, the demographic statistics indicate a growth in world population, mainly in China, India and southern hemisphere countries, which combined with the economic growth based on the current unsustainable patterns, would anticipate the limits of exhaustion of these natural resources.

In this context, in which the natural cycle of replenishment of natural resources is unable to meet the growing human demand, it is essential to understand the functioning of these new cycles operating the current industrial metabolism. Without minimizing the importance of the consumption elimination to effectively conserve natural resources, new tools for managing by-products

generated in the post-use have been implemented, and Substance Flow Analysis (SFA) has been applied to identify new sources, indicating new challenges and opportunities to achieve this goal. The Brazilian reserves of copper in 2007 accounted for 1.5% of world ones, and production reached 1.3% of all copper produced worldwide. The national industrial sector, including the production of refined, to electrical conductors and the semi-manufactured, had a turnover of US\$ 5,030 millions, generating US\$ 890 millions in taxes and 18 millions jobs, with exports of US\$ 1,650 millions. Maintaining the exploitation of 218,400 t/year considering the current known reserves (14.8 millions t) one can estimate the depletion of copper in about 70 years (DNPM, 2008).

This paper quantifies the flow of copper in its stages of production, consumption and final destination in the Brazilian society for the year 2005, following the methodology of Global Stock and Flow Project - STAF (Lifset et al., 2002; Bertram et al., 2002; Spatari et al., 2002; Kapur et al., 2003; Vexler et al., 2004; van Beers et al., 2003). Similar papers covering continents (Europe, Asia, Latin America, Africa, Oceania, Middle East) have been made for the copper and zinc, and also for countries of European Union (Bertram et al., 2002), Japan (Kapur et al., 2003), China (Guo and Song, 2008, WANG et al., 2008), Australia (van Beers and Graedel, 2007) or to cities (Cape Town - van Beers and Graedel, 2003), which have generated many production and consumption indicators.

2. Methods

Methods of quantification of flows (Kapur and Graedel, 2006) can use dynamic technique (top-down) or static one (bottom-up). In the first (top-down) the input information of a material in a particular physical area is accounted. This amount is then divided among the main consumer sources. In the second (bottom-up), the main sources (cars, refrigerators, air conditioners etc) in a physical area that contains the material under study are identified and counted. The accounting result of these sources multiplied by the concentration of metal in each of them is the inventory, or stock, at the time considered. Usually the time and effort as well as the availability of information won't be sufficient for this, and it is necessary to apply these two techniques combined. The difference between total input and discarded entries accounted in the same period of time is the stock in use.

The various steps and flows are summarized in the stages of the life cycle of the copper (Graedel et al., 2004; Spatari et al., 2002). In this study the life cycle of the copper was divided into blocks associated with the stages of production, fabrication and manufacturing, use and storage, and waste management, as described below.

2.1. Production

The main information reference was the Brazilian Mineral Summary (DNPM, 2006), with base year 2005. Internal reports of Vale, Mineração Caraíba and Caraíba Metais were also used, as well as reference literature for the concentration of copper in the residual flows (Ayres et al., 2002).

2.2. Fabrication and manufacturing

The flows were characterized according to the SINDICEL (2005) in semi-manufactured, comprising the production of rolled products, pipes and fittings, rods and wires, and the manufactured, such as wires and cables with applications in energy, telecommunications and others.

The domestic consumption of products that use copper was obtained by mass balance, considering the national production, imports, exports, primary and secondary scrap recycling, (DNPM, 2006; SINDICEL, 2005).

2.3. Use and storage

The copper gets out the previous stage (fabrication and manufacturing) as final product (electrical cables, water pipes) or added to an assembled product (cars, engines, electronic equipments) which will be used in various economic sectors as the civil and industrial constructions, automotive and infrastructure. Due to difficulty in obtaining information in the copper use, it was estimated the output flow of this step, as waste flows. The stock of copper that is in society at a certain period of time is estimated as the difference between what get in as consumed products and what get out as waste streams.

2.4. Waste Management

Spatari et al. (2002) classified 7 categories of waste generated after its use:

2.4.1. Municipal Solid Waste – MSW was estimated using the data from the Bank of Multidimensional Statistics (BME) of the Brazilian Institute of Geography and Statistics (IBGE, 2000a), considering not only the domestic and commercial waste collected, but also the waste of the streets, in 5,475 Brazilian municipalities. The population considered was based on the census of 2000 (IBGE, 2000b) and 2005 (IBGE, 2005) and the concentration of copper in various streams of waste generated were adopted those used by Bertram et al. (2002).

2.4.2. Construction and Demolition Waste - C&D was based on John and Agopyan (2001) and the population of 1996 was corrected (IBGE, 2000b), besides the concentration of copper was the same as the residue generated in Europe (Bertram et al., 2002).

2.4.3. Wastes from Eletro-Electronic Equipment - WEEE were divided into two categories: Consumer goods and capital goods, which use 70 and 30% of copper for that segment (Bertram et al., 2002). The consumer goods were obtained from the synthesis of social indicators (IBGE, 2007), which indicates the percentage of Brazilian households that have phone, computer, refrigerator, freezer, TV set, washing machine, mobilis and air conditioning. Applying a mass coefficient (Kumar and Shrihari, 2007), it was estimated its quantity by weight. The annual generation was obtained considering the linear distribution along its life cycle (Jianxin et al., 2008). The concentration of copper was the weighted average concentration of consumer goods and capital ones (Bertram et al., 2002).

2.4.4. For the estimation of End of Life Vehicles - ELV it was used a curve of scrap (Meyer, 2001) for light vehicles by year of licensing. For bus and truck the lifetime of 15 years (FENABRAVE, 2008) and the entire fleet with that age comes out of circulation at the same time. The number of vehicles put into service yearly was based on licensing data of the National Association of Automotive Vehicle Manufacturers (ANFAVEA, 2008).

2.4.5. The Solid Sludge - SS, from municipal wastewater treatment plants, is also a source of copper. Machado (2001), used data from 275 treatment plants, that serve 13 million people in medium and large cities and it was estimated 11.87 kg of solid sludge (dry basis) percapita. year. In the same work, it was estimated the concentration of copper at 255 mg/kg of solid material, using the samples of these stations.

2.4.6. The Industrial Hazardous Waste - IHW was based on the inventories of 11 states, which represent 78 % of the Brazilian GDP (ABRELPE, 2007).

2.4.7. For Non-Hazardous and Industrial Waste - NH&IW was used the same source of information (ABRELPE, 2007) and used the proportionality of his generation to the GDP of the states considered. Therefore it was estimated the generation of other states and obtained the total amount of hazardous and non hazardous industrial wastes.

And finally, the losses to the biosphere were counted as the difference of what was estimated in waste streams and their destinations. Even the WEEE estimated at 70% that are stored in houses and in the second hand market (Vexler et al., 2004).

3. RESULTS AND DISCUSSION

Its result shows us that Brazil is a net importer of copper (64,000 t), but in beginning of 2010 decade, it will change due to a new producer of refined copper. In 2005, copper consumption was 1.44 kg/capita, and 0.52 kg/capita stay “in use” as stock mainly at infrastructures, buildings, electrical equipments and household appliances. Waste generation (1,411 kg/capita) is close to the European index (1,865 kg/capita), smaller than Latin American (3,000 kg/capita) and bigger than Asiatic (852 kg/capita) and African (192 kg/capita) ones.

The amount of copper in use for less than one year was 94,900 t, equivalent to 36% of its internal consumption.

The total waste generation in Brazil was estimated at 1,411 kg/inhab.year, it represents in magnitude, 4 kg/inhab.day. The most generation was NH&IW, representing 43%, which added to the MSW (26%) and C&D (27%), summarize 96%.

The amount of copper contained waste reaches 170,606 t/year, namely WEEE and C&D (47,000 t/year each one), followed by MSW (33,617 t/year), NH&IW (22,491 t/year) and ELV (16,745 t/year).

The WEEE (0.2%) and ELV (0.6%) represent less than 1% of total waste generated, but together contain almost 38% of copper released in anthroposphere (27.7 and 9.8% respectively). This is because of high concentrations (7.6 and 1.1%) of copper in such flows.

Since it was adopted the same concentration that was used in waste in Europe, the amount of copper in the C&D waste can be a source of high inaccuracy.

It differs from other regions where a quantity of copper in WEEE is highly apparent (83% in Latin America and 62% in Africa). WEEE and ELV have counted less than 1% (weight) but concentrate about 38% of residual copper after its use.

The statistic data of Brazilian recycling system is very imprecise, since the informal economy dominates this segment. Namely, the figure of the copper recycling, mainly secondary scrap, is nonexistent. In addition there is the fact that equipment obtained unlawfully is an important source of scrap metal that returns to the manufacturing process. DNPM (2006) mentioned 26,000 t for this flux on 2005, representing 14% of the potential of copper available after its use, including industrial one (tailings and slag). Vexler et al. (2004) estimate that the informal market for recycling of secondary copper in Latin America is 80% of the formal one. Assuming that ratio we would have a total of 46,800 t of copper recycled in 2005, which represents 25% recycling of copper available. Efforts have been made in developed countries to optimize the copper recycling after use, since it is growing to an unsustainable way of production, and copper in use in society will become an alternative to feed the manufacturing process. This will need to map, how and where the copper is deposited after use.

4. CONCLUSIONS

Brazil has a low per capita copper consumption, 1.44 kg/inhab.year. It can also be seen as a country with potential for growth in its consumption, as the areas of infrastructure, telecommunications and building are implemented.

The accounting of copper cycle in Brazil can now be made through available data from governmental institutions and manufacture associations with relative accuracy, especially for the initial stages of the cycle (production, manufacturing, import and export). In the final destination data flows to waste, it requires larger volumes of information to form a basis of reliable data that may be useful for decision making by the institutions that develop governmental policies.

Following the global trend, the flow of WEEE and ELV will be the biggest opportunities of copper sources. Despite representing less than 1% by weight, together contain almost 38% of copper released to anthroposphere. They are residual flows with high added value and that now justifies their recycling by the other metals they contain. Significant share of these flows are part of an informal economy, encouraging a market for second hand equipments for less demanding and specification of spare parts.

The recycling informations for these two flows are almost inexistent, which hinders the improvement in the process of reuse.

The copper in use in the society was accounted in 94,900 t/year. It deserves a thorough examination with respect to its dynamic process. The speed of concentration can direct governmental policies restricting the destinations of equipments or types of wastes that contain copper to optimize the process of recycling.

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