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A study of the geographical shifts in global lead production – a possible corresponding shift in potential threats to the environment

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ABSTRACT

The global shift or movement of commodities and products has been increasing through international trade recently. Although lead is a widely used material and easy to recycle, hence its high rate of recyclability, it is important to manage it in an environmentally sound manner due to its high toxicity. Lead is present in various lead bearing commodities and lead-containing products. One of the commodities is refined lead. Its principal use is in the production of lead acid electric accumulators (LAA), commonly known as lead acid batteries (LAB), for the automotive and industrial sectors. Two principal sources of refined lead production are: lead ores and concentrates, and used lead acid electric batteries (ULAB). During the period 1992–2012, it was observed that trade in both sources increased rapidly. The physical trade data for lead commodities and products have been collated and analyzed based on the Physical Trade Balance (PTB) in order to identify global suppliers and consumers of lead ores and concentrates, and LAB, as well as the information related to production and apparent consumption. 20 countries were identified whose movement of lead commodities and products accounted for at least 70% of the global physical trade and for the production and apparent consumption. The movement of lead ores and concentrates was limited to a few countries, however the LABs was diversified between 1992 and 2012. The concentrations of the lead commodities and products are located in China, the USA, Germany and Australia as major consumers and suppliers. The potential environmental and population health threats due to the lead industry were principally located in countries belonging to the emerging and developing economies or those in transition.

1. Introduction

Lead has a range of unique properties that for centuries has made it a widely used material by mankind in different applications and products. Its consumption pattern has been changing over time, as is the case of gasoline additives and paint pigments that are in the final stages of being phased out and currently it is being used principally in lead acid batteries (LAB) (Mao et al., 2008). In the industrial age lead was in high demand due to its chemical stability in air, water and soils of any type. Among the notable characteristics of lead are its poor electrical conductivity and high resistance to corrosion, therefore it was used to contain corrosive liquids such as sulfuric acid (ILZSG, 2012). Lead, in the form of refined lead, has been produced from mined ore since ancient times, the principal producers have been China, Australia and the USA, followed by Peru, Mexico, Canada and Sweden (USGS, 2014) and since the early 1980s refined lead has also been obtained by secondary production through the recycling of lead acid batteries and it has been a patented process since late 1980s (Hollis, 1990). During the last ten years it has been observed that there is a significant interest in the obtention of refined lead, principally for the production of LAB due to their wide use in automobiles, telecommunications, wind and solar energy industries. Primary and secondary productions are important sources of refined lead. Primary lead is currently obtained as a co-product or by product from other metal extractions, such as copper and zinc, and secondary lead is principally obtained from used lead acid batteries (ULAB).

International trade has been increasing during the last years, and different studies have analyzed it using monetary accounting.

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In general, the monetary accounting methodologies do not provide a complete basis to fully record the material flow and that is why it is important to analyze the physical material flow (Ma et al., 2006; Matthews and Hutter, 2000). The knowledge about the physical size of commodity flows could help in the implementation of preventive measures for resource production and recycling since the consumers are driving the production and as a consequence the environmental pressure (Barrett and Scott, 2012; Lenzen et al., 2012). The Physical Trade Balance (PTB) has been used to identify the dominant suppliers (export surplus) and consumers (import surplus) as a method of estimating the resource flows between countries (Dittrich and Bringezu, 2010; Muñoz et al., 2009). It is also an important tool to express the international trade and the environmental issues involved (Xu and Zhang, 2007). In the present study, the trade balances include resources and products containing lead are presented using PTB. Until the year 2000, the international trade was characterized by the import of resources from developing countries to developed countries (Giljum and Hubacek, 2001), but from 2000 a shift began to emerge with an increasing demand for products in developing countries which, in turn lead to an increase in pollution in other countries where they are produced (Wiedmann et al., 2007). Studies in PTB have been used to identify dominant resource consumers in a global manner, including biomass, metals, minerals (other than metals), fossil fuels and others, covering almost 200 countries. The results of these studies show that the dominant trade commodity is fossil fuel with metals occupying third place, and that also, up to 2005 industrialized countries were net importers, and developing countries, and countries in transition, were net exporters (Dittrich and Bringezu, 2010). In the case of raw materials, it was calculated the trade balances for biomass, fossil fuels, metals and industrial minerals and construction minerals for 15 countries and regions, the results showed that until 2005 OECD countries with a high population density were highly dependant on the supply of raw materials from developing countries (Bruckner et al., 2012).

This study involves one non-ferrous metal, Lead, in order to ascertain how the interconnection has evolved among and between the countries involved in the shift of its commodities and containing products through trade. Another study also involved only lead as commodity, where it was included as refined primary and secondary lead, during the period 1974 and 1996, with a focus on the impact of secondary material trading and recycling, exposing the fact that lead scrap trading has decreased since 1997 due to its controlled movement (Van Beukering and Bouman, 2001).

The aim of this study is to present and identify where the sources of refined lead involved in the global lead trading are located and which principal countries are involved, in order to ascertain a possible regional management protocol of used LABs. In addition, to determine whether there is a pattern or a trend in movements, use and consumption during the last two decades. This information is important to study the prospects for secondary lead production and its potential environmental benefits, such as lower energy requirements and fewer environment impacts, because secondary lead is not mined.

2. Methodology

The lead commodities and products were selected according to the Standard International Trade Classification (SITC). Some of them were included as a general product together with different kinds of non-ferrous metal products. For example the case of electric accumulators or batteries (the focus in this study was lead acid batteries, as was found in the Harmonized System (HS), but in SITC, it included not only lead acid, but also nickel–cadmium, nickel–iron and other electric accumulator technologies). Therefore in the lead commodities and products included in this study there were some listed under HS classification (SD, Commodities).

The data sets needed for this analysis were import and export statistics (including re-import and re-export), primary and secondary lead production statistics and the global end-use breakdown of the lead consumption by product. They were obtained from the UN Comtrade Commodity Trade Statistics Database (UN Comtrade, 2014) which is one of the most comprehensive collection of international trade flows (Dittrich and Bringezu, 2010; Dittrich et al., 2012; Schandl and West, 2010), the U. S. Geological Survey, USGS (Barry et al., 2013), and the CHR (Roberts, 2003, personal communication CHR, 2014). This data is organized into the Supplementary Data (SD), at the worksheets: Raw data Comtrade, Raw data USGS, and End-use breakdown.

The time series was collated in a period covering two decades (1992–2012), in order to make an identification of the key trends in the global lead commodities and products shifts (Lenzen et al., 2012). The lead commodities and products were classified according to the different stages determined in the lead life cycle established by Mao (Mao et al., 2008), who developed a material flow analysis framework for lead, the principal stages were defined as Production, Fabrication and Manufacturing, Uses and Waste Management. The Physical Trade Balance (PTB) was established by subtracting exports from imports according to the OECD definition (UN, EC, IMF, OECD and World Bank, 2003). If the result was negative it meant that there was an export surplus or a net supplier of commodities and if it was positive an import surplus or net consumer (Schandl and West, 2010). From the cumulative PTB it was possible to establish the prevalent commodities traded and their changes during the period of time studied. All the countries involved in the movement of lead commodities and products were classified by regions. The regions were established by the geographical distribution presented by World Bank (WB) and International Monetary Fund (IMF) (World Bank, 2014; IMF, 2012).

From this data, the principal countries involved in the lead movement were determined using the mean of the physical weight for each commodity in every country during the two decades. As the PTB presented positive and negative values, the mean of the values and the absolute values were calculated. The countries that contributed at least 70% of the total traded in each commodity (called Concentration Ratio, CR) were selected as the principal countries involved in the lead movements. The heterogeneity of the trading through the years was explored through statistics (ANOVA calculation). The lead movement was presented on the basis of the production, import and export data and apparent consumption. The apparent consumption was calculated by the production value plus the PTB value. The quantity of refined lead used in the LABs production was calculated using the global lead end-use breakdown (CHR, 2014). The global map-based chart was constructed based on import and export data, using Excel 2013 and Inkscape for visualizing data and information. The total value of the export/import trade by the countries is represented by the size of the circles, the divisions of the pie indicate the value of the exported/imported materials or commodities between two interrelated countries, which is also represented by the pattern of the arrow that joins them. The complete information about total exported and imported and the individual value between two interrelated countries are given at SD, 2874 net and LAB net.

3. Lead traded commodities and products

It has been observed that the lead commodities and products according to SITC and HS for import and export in the different stages totaled eighteen and they were used for this study (SD,