Residual Waste from Selected Industries

Pollution risks from other industrial waste

Our report covers the following chemical pollutants/sectors: (1) pesticides, (2) pharmaceuticals, (3) mining, and (4) e-waste. This is because our highest concern is for environmental and human health in LAMICs and because of the availability, although partially fragmentary, of comprehensive and global databases. Comprehensive databases about industrial production, exports, and imports are, however, generally not publicly available. This is mainly because of the complex production chains and the non-transparency of industrial data (Larsson and Fick, 2009). Chemical pollution from these industries is of a very varied and complex nature. Nevertheless, the scattered data about industrial activities in LAMICs that were available showed the high impacts on human health and there was evidence that industrial pollutants cause significant environmental pollution and degradation (Larsson et al., 2007; Larsson, 2010; Blacksmith Institute and Green Cross, 2012, 2013). Despite the limited availability of data, the industrial sector needs to be considered and discussed as a significant source of highly toxic pollutants and more investigations about industrial pollutants in LAMICs are required. This is especially so since:

1. The start of worldwide chemical intensification and the outsourcing of the industry from HICs to LAMICs (see section **The future of chemical pollutants in low- and middle-income countries,** p. 15; United Nations Environment Programme, 2013c; PricewaterhouseCoopers, 2008; United Nations Industrial Development Organization, 2014).

2. Infrastructure is lacking and obsolete and environmentally unfriendly methods are used for the production and processing of industrial commodities (Yusuff and Sonibare, 2004; Mohanta et al., 2010; Mehraj et al., 2013).

3. Compliance with environmental regulations, if they exist, cannot be guaranteed and there is less (or maybe even no) awareness of the adverse impacts of pollutants on environmental and human health in LAMICs (Blacksmith Institute and Green Cross, 2012, 2013; United Nations Environment Programme, 2013c).

In this section, therefore, we briefly address hazardous pollutants released from several industry segments, such as the cement, paper, textile, and rubber industries.

Textile industry

Introduction

During the manufacture (the scouring, bleaching, coloring, and finishing steps) of wearing apparel, large volumes of water (in general, 60–400 L) are needed to produce and process 1 kg of clothes. In addition, large volumes of hazardous agents are used. Both the amount of water consumed and the agents used depend on the type of fabric being processed (wool, cotton, polyester, etc.) (Yusuff and Sonibare, 2004; International Finance Corporation and World Bank Group, 2007). For instance, 1967 data from the U.S. Department of the Interior's Federal Water Pollution Control Administrations (Federal Water Pollution Control Administration, 1967) showed that washing and rinsing operations for the production of 1 kg of wool and cotton clothes required 250–580 L water, while for the production of 1 kg synthetic clothes about 25–240 L of water were needed. (Data from 1967 is used here because these older data might better represent the actual water consumption in LAMICs where older techniques are applied.) Because of the high consumption of water and chemical agents during the textile manufacturing wetting processes, wastewaters are the major source of chemical pollutants. Thus, the key environmental issues associated with the textile industry are water use, inadequate wastewater treatment, and inappropriate disposal of aqueous effluents, especially in LAMICs (Yusuff and Sonibare, 2004). For a more complete picture, it must be recognized that during the production of natural fabrics, such as cotton and wool, water is also used for growing the plants and raising the animals, which increases the water footprint of these products. Furthermore, in growing the raw materials of natural fabrics (cotton and wool from sheep or other animals) toxic pesticides might be used as well (Syrett, 2002).

Pollution potential from the textile industry

Wastewater from the textile industry often has poor quality by showing high levels (up to 2000 mg/L) of biological oxygen demand (BOD; Multilateral Investment Guarantee Agency, 2004). BOD_5 measures the amount of oxygen (mg/L) required for the microbiological decomposition of the organic material contained in the water within 5 days at a constant temperature of 20°C (United Nations, 2007). The wastewater also has an increased alkalinity, generally, a chemical oxygen demand (COD), and carries an amount of solids (measured as total suspended solids; TSS); [COD indicates the amount of oxygen (mg/L) which is needed for the oxidation of all the organic substances in the water (LAR Process Analysers AG, 2016)]. The most relevant toxic agents that might be used and released during the individual steps in textile manufacturing are listed below.

Washing and scouring operations – non-biodegradable and less degradable surfactants (alkyl phenol ethoxylates, APEs; Scott and Jones, 2000) and organic solvents (phenols; Multilateral Investment Guarantee Agency, 2004; Le Marechal et al., 2012).

Dyeing operations – benzidine-based azo-dyes (some of the azo-dyes can lead to the formation of environmentally toxic and carcinogenic amines) or sulfur dyes, and dyes which contain heavy metals (intentionally or contaminated with arsenic, cadmium, chromium, cobalt, copper, nickel, lead, and zinc), or chlorines (Multilateral Investment Guarantee Agency, 2004; Yusuff and Sonibare, 2004; International Finance Corporation and World Bank Group, 2007). Dyeing carriers can involve heavy metals or chlorines. For the dyeing of polyester and polyester-wool mixtures at lower temperatures, halogenated carriers are used to help the dyes penetrate the polyester fibers (Multilateral Investment Guarantee Agency, 2004; Syrett, 2002; Le Marechal et al., 2012).

Bleaching operations – involve the use of sulfur and chlorine-based bleaching agents (sulfur dioxide gas and sodium hyperchlorite), caustic soda (NaOH), acids, and surfactants (the use of peroxides is recommended) (Multilateral Investment Guarantee Agency, 2004; Yusuff and Sonibare, 2004; International Finance Corporation and World Bank Group, 2007; Le Marechal et al., 2012).

Cloth protection – for the protection of natural fabrics and clothes, hazardous pesticides are used sometimes (dieldrin, pentachlorophenol, and arsenic or mercury based pesticides). Synthetic clothes may contain plasticizers and brominated or fluorinated flame retardants (Multilateral Investment Guarantee Agency, 2004; Le Marechal et al., 2012).

Case study of concern of the textile industry

Rahman et al. (2008) assessed the environmental impacts of the wastewater effluents from the textile and dyeing industries on the ecosystem of Karnopara Canal at Savar, Bangladesh. By monitoring the physicochemical properties, such as pH, color, dissolved oxygen, BOD, COD, TSS, total dissolved solids, alkalinity, salinity, turbidity, electrical conductivity, iron, and ammonia, they revealed that all the water of the Karnopara Canal was outside the tolerable limits of the Department of Environment, Bangladesh standards. Thus, these highly polluted effluents had adverse impacts on the surrounding land and aquatic ecosystems and even on the local community (Rahman et al., 2008). Figure 29 is a picture of untreated effluents from the textile, the dying, and the leather industries. Data from Hämäläinen et al. (2006) showed that the estimated number of fatal occupational accidents is much higher in LAMICs than those of HICs (especially in India, China and Sub-Saharan Africa). This indicates that working conditions in LAMICs are often poor, less safe, and less controlled.

Figure 29: *Untreated wastewater from the textile, dying, and leather industries in Savar, Bangladesh (Picture: Daniel Lanteigne, 2010a).*

Leather industry

Introduction

During the production of leather, several different processes need to be carried out. Of these, the tanning process is the most important one from an environmental point of view. During the tanning processes, the skins of animals are treated to produce leather. Large amounts of different hazardous chemicals are required to make the raw animal skins more visually attractive and robust. For example, to remove and break down the hair and animal parts on the hides, sulfides are used. Chlorides are used to preserve the leather from decomposition. Often, trivalent chromium salts are used to further stabilize leather products (Blacksmith Institute and Green Cross, 2012). Similar to the textile industry, large volumes of water are needed during the leather tanning process as well. During the processing of 1 kg of raw material, 30–40 L of wastewater is produced (Ingle et al., 2011). Hence, wastewater effluents from the tanneries (especially if they are untreated) are the major exposure pathway releasing hazardous chemicals into aquatic systems (Blacksmith Institute and Green Cross, 2012). The key environmental issues associated with the leather industry are, therefore, the same as those for the textile industry – high water consumption, inadequate wastewater treatment, and inappropriate disposal of aqueous effluents. According to the database of the Blacksmith Institute, there are over 100 contaminated tannery sites (Figure 30). Of these, the greatest amount of contaminants is released from poorly run and managed small scale facilities and in legacy leather processing sites. It was calculated that more than 1.8 million persons are at risk worldwide because of the pollution of these sites (Blacksmith Institute and Green Cross, 2012).

Figure 30: *Untreated wastewater of leather tanneries in Bangladesh is released into the environment (Picture: Daniel Lanteigne, 2010b)*

Pollution potential from the leather industry

Wastewater effluents from tanneries have, similar to textile industry effluents, high levels of BOD and COD (Bosnic et al., 2000; Mohanta et al., 2010). Normally, natural and healthy water systems can handle a specific amount of effluents with a high oxygen demand, the effluents of tanneries (especially if untreated) however, often contain excessive loads of water with a high oxygen demand. This can lead to an oxygen withdrawal, adversely affecting the plants, vertebrates, and invertebrates or even causing their death (Bosnic et al., 2000; Mohanta et al., 2010). Besides these aqueous pollutants, large amounts of solid waste are produced during leather production. These solid wastes mainly contain leather particles and the residues of the dead animals, or they originate from chemical discharges and precipitated reagents used during the processing of the leather. If these solid wastes are not adequately removed from the wastewater they can precipitate as sludge and clog wastewater pipes or cover plants and sediments, thus causing the environmental degradation of aquatic systems (Bosnic et al., 2000).

From the pollutants released from the tanneries, chromium is considered to be the one of greatest concern from the environmental and human health perspectives Cr(III) (which is mainly used in the tanning process) is less toxic under certain environmental conditions. In the presence of manganese oxides or other strong oxidizers (Rai et al., 1989) this trivalent chromium can be oxidized to Cr(VI), which is classified in IARC group 1, carcinogenic to humans (International Agency for Research on Cancer, 2015). Organic solvents, sulfides, ammonia, chlorides, and additional heavy metals, such as lead and cadmium from dyes, can be found in the wastewater effluents of tanneries as well (Bosnic et al., 2000; Mohanta et al., 2010; Blacksmith Institute and Green Cross, 2012).

Case study of concern in the leather industry

Studies conducted in 2007 and 2013 by the Blacksmith Institute in the Hazaribagh district of Dhaka, Bangladesh, provide lists of the world's 30 (Hanrahan et al., 2007) and 10 (Blacksmith Institute and Green Cross, 2013) most polluted places. In the Hazaribagh region there are about 200 tanneries on about 25 ha of land, employing between

8000 and 12,000 people (Pearshouse, 2012; Blacksmith Institute and Green Cross, 2013). There, about 75 tonne of solid waste and about 22 million L of wastewater are generated per day (Azom et al., 2012). Most of the wastewater is discharged into the Buriganga River, Dhaka's water supply, without any treatment (Pearshouse, 2012; Blacksmith Institute and Green Cross, 2013). In effluents of one of those tanneries, the BOD5 was measured at 3600 mg/L and the COD at 9300 mg/L. Both far exceeded the permitted standards. Concentrations of chromium of 4043 mg/L, chloride of 45,000 mg/L, lead of 1944 mg/L, and sulfide of 145 mg/L have been measured. These are much higher than the permitted levels of 2 mg/L for chromium, 600 mg/L for chloride, 0.1 mg/L for lead, and 1 mg/L for sulfide (Rahman, 1997; Pearshouse 2012). Although these values were measured in 1997, the results from studies of the Blacksmith Institute and Green Cross (2013), Pearshouse (2012), and Azom et al. (2012) showed almost no improvement had been achieved in this region and almost no action taken in waste management (wastewater and solid waste) or for the development of sound leather production.

The pollution of the leather industry (tanneries) is not only adversely affecting the environment, but also the workers and local people of the Hazaribagh district of Dhaka, Bangladesh. There, local residents are living besides channels with untreated tannery effluent. The residents and workers from the tannery facilities suffer from rashes, itches, fever, diarrhea, and respiratory problems. The workers from the tannery facilities especially suffer from the poor occupational health and safety conditions. This is shown through the adverse health effects, such as premature aging, discolored, itchy, acid burned, and rash-covered skin, aches, dizziness and nausea, respiratory diseases, and elevated cancer rates. These arise because the tannery companies do not often provide adequate protective clothing (gloves, masks, boots, and aprons) and because of the unsafe and dirty working conditions (Pearshouse, 2012).

Paper industry

Introduction

In some regions, especially in Indonesia, the paper industry might be responsible for deforestation because of its unsustainable pulpwood harvesting practices. In addition, the pulp and paper industry is, among others, one of the world's largest consumers of energy. The industry is emitting large amounts of GHGs. Although deforestation and the high emission of GHGs have significant impacts on environmental and human health, for this report we are focusing more on the highly toxic organic and inorganic compounds that are released into the environment through paper production (Ince et al., 2011; WWF, 2015). During paper production, large volumes of water are used. For instance, even if state-of-the-art technologies are used, water consumption is about 60 L/kg of paper produced (Thompson et al., 2001; Ince et al., 2011). Data about the degree of pollution caused by the paper industry in LAMICs are much less readily available than data about textile and tannery pollutants. Nevertheless, given the large volumes of water required during paper production, the environment can be exposed to large volumes of wastewater with toxic compounds, especially if poorly-functioning, or even no wastewater treatment facilities are available. This often the case in LAMICs (Corcoran et al., 2010).

Pollution potential from the paper industry

Like most industrial effluents, the wastewater effluent of the paper industry can have elevated BOD5, COD, and TSS levels, which can adversely affect aquatic environments (Pokhrel and Viraraghavan, 2004). In addition to these elevated levels, the most relevant and hazardous agents that might be released during the several steps of paper manufacture are listed below.

Wastewaters from wood preparation processes contain suspended solids, dirt, and organic matter, and they have elevated BOD levels. The wastewater from the digester house, which is referred to as 'black liquids', contains chemicals that were used for cooking the wood as well as for extracting lignin and other hot water extracts of the wood. A comprehensive literature research by Pokhrel and Viraraghavan (2004), covering the wastewaters of the digester house, show that the highest level of BOD5 was 13,088 mg/L, that of COD was 38,588 mg/L, and that of TSS was 23,319 mg/L. In addition, higher levels of halogenated compounds (measured as adsorb-able organic halides, AOX) and volatile organic carbons (VOC), such as terpenes, alcohols, phenols, methanol, acetone, chloroform, etc., can be measured in these effluents as well (United States Environmental Protection Agency, 2002; Pokhrel and Viraraghavan, 2004). During the subsequent pulp washing, wastewater with higher BODs, CODs, and amounts of suspended solids are generated in the main (United States Environmental Protection Agency, 2002; Pokhrel and Viraraghavan, 2004). During pulp bleaching, the pollutants of highest concern are adsorbed organic compounds, inorganic chlorine compounds (ClO^{3-}), organochlorine compounds, such as dioxins, furan, and chlorophenols, and VOCs, such as acetone, methylene chloride, carbon disulfide, chloroform, chloromethane, trichloroethane, and others (United States Environmental Protection Agency, 2002; Pokhrel and Viraraghavan, 2004). The paper making process can generate wastewater with organic compounds, solvents, and heavy metals from dyes (United States Environmental Protection Agency, 2002; Pokhrel and Viraraghavan, 2004).

Case study of concern for the paper industry

Because there is a lack of data and information, no appropriate and recent case example of pollution by the paper industry in LAMICs has been found. It would be relevant to further investigate the exposure, fate, and environmental risks of pollutants released by the paper industry.

Construction industry (cement industry)

Introduction

Cement is used as an important binding agent within the construction industry. It is produced all over the world in large quantities. According to the United States Geological Survey, global production of cement was about 4 billion tonne per year in 2013 (United States Geological Survey, 2014). Cement production involves a series of different processing steps, including (Karstensen, 2006):

- Quarrying the raw materials
- Grinding the raw materials
- Fuel preparation and combustion (preparing conventional fossil fuels and alternative fuels)
- Clinker burning (involving drying, preheating, calcination, clinkering, and clinker cooling)
- Preparation of mineral additives at the cement mill
- Cement packing and dispatching.

All these steps are described in more detail in the report on Formation and Release of POPs in the Cement Industry (Karstensen, 2006). Of these processes, clinkering is the central one and, from an environmental and human health perspective, the most relevant one – not because of the cement, but because of its energy consumption. To produce clinker, the silica and calcium carbonate bearing raw materials of the cement are added to a kiln system. The clinker is formed by the drying/preheating, calcination, and sintering of the raw material at temperatures in the range of 1000 to 1500°C (Karstensen, 2006; Conesa et al., 2008; Lei et al., 2011). This process consumes large amounts of energy. A state-of-the-art furnace used for clinkering needs about 3000 MJ per tonne of produced clinker (Habert et al., 2010). To produce this energetic input, conventional fossil fuels, such as coal, lignite, petroleum coke, or oil are burned. More recently, waste material – including waste oil, used tires, paint thinners, degreasing solvents, solvents from the ink and printing industries, chemical by-products and solid waste from pharmaceutical and chemical manufacturers, municipal solid wastes, and sewage sludge – are added to the regular fuels as inexpensive substitutes for the conventional fuels to reduce costs during this energy-intensive process. The organic and inorganic air pollutants arising from this combustion process are of highest environmental concern, especially if the combustion processes in the furnace are poor (lower temperature, bad mixing, and a shortage of oxygen). The pollution is worse if the exhaust fumes of the cement production facilities are not filtered and controlled, which might be the case in LAMICs. In this case, toxic inorganic and organic pollutant can be released (Conesa et al., 2008).

Pollution potential from the cement industry

The conventional and/or substitute fuels and the raw material can contain heavy metals that can be released during the combustion processes. The higher toxic heavy metals, Hg, Tl, Pb, and Cd, are volatile or semivolatile, while As, Cr, Cu, Sb, and Zn remain in the clinker material. Inadequate combustion of organic matter and fossil fuels produces highly toxic, mutagenic, and carcinogenic products. Persistent and bioaccumulative compounds, such as dioxins, furans (PCDD/Fs), and PAHs, can be generated and released into the environment (see section **E-waste pollutants of environmental concern** (p. 106) for their impact on the environment. Other hazardous compounds, like HCl, hydrogen fluoride, oxides of nitrogen, sulfur dioxide, and VOCs, such as benzenes, toluenes, xylenes, and phenols, can be released as well (Karstensen, 2006; Conesa et al., 2008; Mehraj et al., 2013).

Case study of concern for the cement industry

A health risk assessment study focusing on the health risk to residents living in the vicinity of a cement manufacturing plant was conducted in Khrew, Jammu and Kashmir, India by Mehraj et al. (2013). In this region, cement manufactories, brick kilns, stone crushers, and automobile exhaust are the main emitters of air pollutants. There, cement production is quite high and enough of the raw materials – limestone/chalk, marl, and clay/shale – required for cement production are available to supply several factories in Khrew, Wuyan, and Khonmoh. The study revealed that in Khrew about 15,000 to 20,000 people, who live within a 2 km to 3 km radius of the cement manufacturing facilities, are directly affected by the pollutants released from cement production. In this region, cement dust, which is emitted during cement production and deposited in a thin layer, affects human and environmental health. This deposit comes about mainly because there is no efficient dust control equipment, but also because there are no adequate filter systems used during the manufacture of cement (The Vox Kashmir, 2013). Cement production can adversely affect environmental and human health through cement dust and/or chemical pollution released during the heating process. The latter pollutants are adsorbed to the dust particles. Because of its high and aggressive alkalinity, frequent inhalation of cement dust can cause respiratory diseases in the long run. This is particularly the case for workers involved directly in cement production and processing, and for residents living in the vicinity of cement production plants. Many workers in India are not wearing appropriate gloves, masks, or footwear (The Vox Kashmir, 2013; Mehraj et al., 2013). Contact with cement dust can cause serious and irreversible injuries to the eyes. Skin contact can cause damage to nerve endings, can burn the skin, or can cause irritant contact dermatitis (Hanson Heidelberg Cement Group, 2009).

When comparing the incidence of disease in Khrew with that in Burzahama, a city without any adjacent cement production facilities, there was a significant increase in the incidence of disease that can be directly associated with the continuous exposure to cement dust in Khrew (The Vox Kashmir, 2013; Mehraj et al., 2013).

Rubber industry

Introduction

Today, the production and use of rubber, naturally or synthetically produced, is indispensable in our daily lives. Given its physical properties, such as being flexible and resilient at the same time, and its waterproof and dielectric characteristics, rubber is widely used in many industrial products (conveyor belts, gasket rings, as adhesives, tires, or in fan belts, and automotive radiator hoses). It is contained in many commodities that are used in our daily lives (clothes and footwear, toys, and rubber gloves; Vishnu et al., 2011). Rubber production has increased continuously over the last decades. In 1996, about 15.5 million tonne of rubber were produced; today yearly rubber production is 27.5 million tonne. Of this, 56% is synthetic rubber and 43% originates from natural rubber material (International Rubber Study Group, 2014). In general, rubber production consumes large amounts of energy and water. Large amounts and a wide range of chemicals, and sodium sulfites and ammonia as anticoagulants, activators, dyes, acids, vulcanization agents, accelerators, and softeners are added to the raw material during the production of latex and rubber. This can lead to the release of large volumes of hazardous chemicals into the environment during the production processes (United States Environmental Protection Agency, 2002; Edirisinghe et al., 2008; Vishnu et al., 2011). Given the large volumes of water used during the cooling, cleaning, and washing processes during rubber production, large amounts of wastewater are produced. For the production of 1 kg of natural raw rubber, 40–50 L of wastewater are generated (Edirisinghe et al., 2008).

Pollutions potential from the rubber and plastic industry

If the effluents are not treated, these discharges can have high levels of BOD and COD. The effluents contain high levels of organic compounds, such as rubber particles, carbohydrates, proteins and amino acids, and uncoagulated rubber particles, and TSS. The effluents of the rubber industry are of an acidic nature. In addition, the effluents of rubber factories can contain sulfur compounds, ammonia, or acids, such as formic, acetic, or oxalic acid (United States Environmental Agency, 2005; Edirisinghe et al., 2008; Vishnu et al., 2011). The presence of high loads of organic material, hydrogen sulfides, ammonia, and amines can cause a foul-smelling odor, especially in water with high BOD and COD. The dissolved oxygen levels are low, which makes the water unsuitable for drinking for several kilometers downstream from the rubber

Figure 31: *Water pollution suspected to emanate from rubber industries near Hanwella, Sri Lanka (Picture: Revolve Water, 2014).*

production facilities (Vishnu et al., 2011). Furthermore, consistent with this deterioration in water quality, there is evidence that the continuous discharges of the wastewater effluents of the rubber industry considerably affect the biota of the water body. This is particularly so if the effluents are untreated, which might be the case in several regions in LAMICs (Arimoro, 2009).

Moreover, the inappropriate disposal of rubber material as solid waste or its incineration can cause severe environmental pollution as well. Given that rubber degrades slowly, its disposal can have serious ecological risks and adverse aesthetic effects to the terrestrial and aquatic environment. The incomplete or inadequate combustion of rubber material and solid waste can lead to the formation of highly toxic, carcinogenic, and persistent chemicals, such as PAHs and polyhalogenated hydrocarbons (dioxins and furans; United States Environmental Protection Agency, 2005; Wang and Chang-Chien, 2007).

Case study of concern for the rubber industry

In Sri Lanka, the rubber industry is considered one of the main industrial polluters. There, the effluents of rubber production plants often are discharged directly into water bodies without any treatment, resulting in environmental pollution and a deterioration in water quality (Edirisinghe et al., 2008).

In a comprehensive study by Edirisinghe et al. (2008), wastewater effluents of 62 rubber manufactories in Sri Lanka were analyzed. It showed that about 50% of the wastewaters of the Sri Lankan industries tested exceeded the general standards and tolerance limits for BOD, COD, and TSS values specified by the Sri Lankan Central Environmental Authority (CEA). For instance, an average BOD of 1063 mg/L, an average COD of 2010 mg/L, and an average TSS of 242.9 mg/L were measured. The CEA tolerance limits for wastewater effluents are 50/60 mg/L for BOD, 400 mg/L for COD, and 100 mg/L for TSS. A polluted river, which is close to the rubber industries near Hanwella, Sri Lanka is shown in Figure 31.

Market share of several industrial commodities – mapping the risks

To date, comprehensive data about industrial pollutants are neither compiled nor available. Nevertheless, with the help of data about market share it is possible to identify potential risk areas with high industrial activities. These data can give the first hints as to those regions where more risk assessment studies and further investigation would be required.

With the demographic changes and chemical intensification (see section **The future of chemical pollutants in low- and middle-income countries**, p. 15), which are more pronounced in LAMICs, general industrial production is shifting from HICs to LAMICs. The data of the International Yearbook of Industrial Statistics 2014 (United Nations Industrial Development Organization, 2014) indicated that the market share (%) of China for commodities produced by such manufacturing sectors as leather, paper, rubber, and textiles, and the share of chemical products doubled from 2005 to 2012 (not shown here). During the same period, the USA's share of these commodities decreased by one-half to three-quarters.

A more detailed look at the global market shares of commodities from the leather and footwear, paper, rubber and plastic, textile, wearing apparel, and chemical production industries (Figure 32) is informative. It can be seen that these commodities are produced in considerable quantities in LAMICs as well, while the high market shares of these different commodities for China are obvious at first sight. The increase in the market shares of these industrial commodities during 2005 and 2012, and the high levels of market share achieved for industrial commodities in China further confirm the outsourcing of industries from HICs to LAMICs. In China, particularly, the market shares of leather and footwear, textiles, and wearing

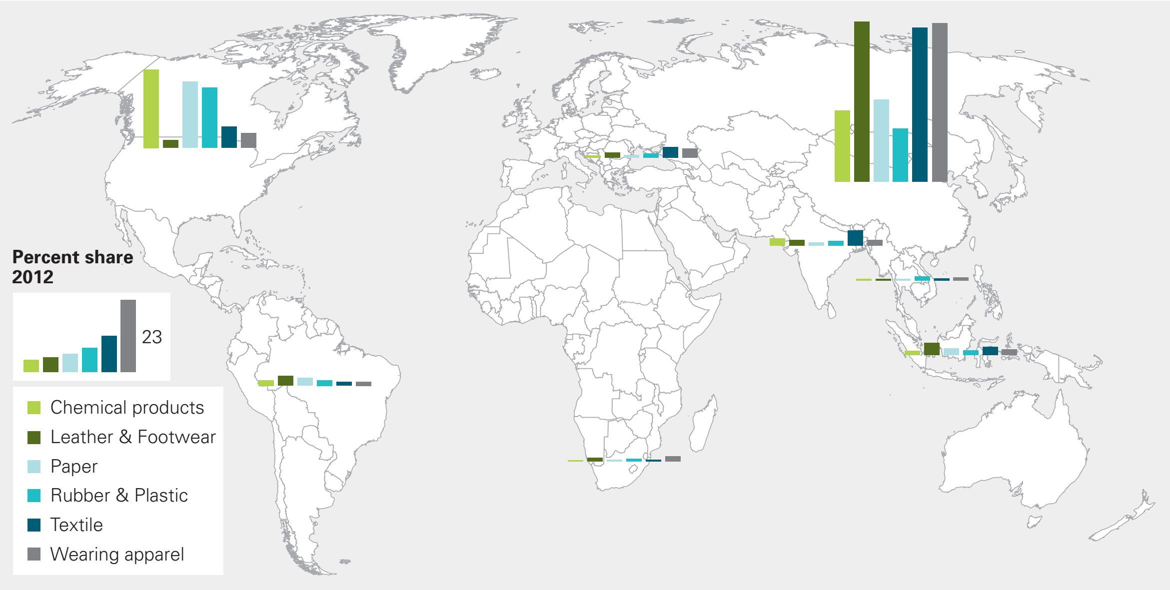

Figure 32: *Proportion (%) of the global market shares of chemical products, leather and footwear, paper, rubber and plastic, textiles, and wearing apparel in Brazil, China, India, Indonesia, South Africa, Thailand, Turkey, and the USA for 2012 (United Nations Industrial Development Organization, 2014)*

apparel far exceed those of the USA, which, with its high market shares of industrial commodities, acts as a representative of HICs. However, the market shares of chemical products, paper, and rubber and plastic commodities are comparable in both countries.

In addition, the Turkish, Indonesian, Indian, and South African market shares of wearing apparel (1.5 – 2.8%) and the Indian, Turkish, and Indonesian shares of textiles (2.5 – 4.5%) are comparable to those of the USA (4.3% for wearing apparel and 6.2% for textiles). This indicates that considerable amounts of these commodities are produced and put on the market as well. In LAMICs and China, according to the market share data presented in Figure 32, the leather and foowear production activities in Indonesia, India, and Turkey are considerable as well (1.6 – 3.5%).

Nevertheless, it must be remembered that the percentage market shares of Brazil, India, Indonesia, Thailand, Turkey, and South Africa, but not China, were based on the sum of the shares just from LAMICs in the International Yearbook of Industrial Statistics 2014 (United Nations Industrial Development Organization, 2014). Because of that, these percentage values were normalized to those of the world share, which might cause an increase in the uncertainty of the data and be incorrect if evaluated on a country scale. The market share values (%) of China had been calculated already by considering the global market share values.

Besides the market share values, data about the production of industrial raw materials could be used also to localize areas with high industrial activities. This information can then be used to identify potential risk areas where high amounts of toxic chemicals might be released into the environment. This holds true especially for regions with high industrial production rates and where unsustainable and environmentally unfriendly production practices are applied. Consequently, by considering these data, presumptive risk areas where environmental and human health might be affected could be assessed.

Figure 33 shows that the highest amounts of cement are produced in LAMICs, such as China and India (67.5 – 1880 million tonne/year). The amounts of cement produced in other LAMICs, like Turkey, Brazil, Iran, Vietnam, Egypt, Thailand, Mexico, Pakistan, Indonesia, Algeria, Malaysia, and the Philippines (in descending order), are of the same order of magnitude as those of the HICs – United States, Japan, Russia, Republic of Korea, Saudi Arabia, Italy, Germany, Spain, France, and United Arab Emirates (descending order). In 2010, production in these countries ranged between 1.5 and 67.5 million tonne/year (United States Geological Survey, 2012). Hence human and environmental health might particularly be affected in LAMICs with the highest cement production rates and where obsolete methods are used. This is particularly so if adequate devices to control the emission of industrial pollutants into the environment are lacking or if the workers and employers of the cement industry are poorly educated and not aware of the toxic chemicals and pollutants released during their work. The health of people in general is threatened if the industrial areas are densely populated, as is the case in Khrew, India (The Vox Kashmir, 2013; Mehraj et al., 2013; see the **Case study of concern for the cement industry**, p. 135).

In general, it can be assumed that the potential for excessive hazardous pollution is highest in those LAMICs that have experienced a remarkable economic boom within a short period of time, such as China (United Nations Industrial Development Organization, 2014). Often in these countries, the regulatory systems, the technical equipment, the know-how, and the financial capacity are not sufficiently well developed. They are unable to address adequately the increased industrial production and to soundly manage the handling, use, trade in, and disposal of hazardous pollutants, which are used in, or generated during, production (African Ministerial Conference on Environment and United Nations Environment Programme, 2004; United Nations Environment Programme, 2013c; European Chemical Industry Council, 2013; United Nations Industrial Development Organization, 2013).

Although there is some information about the market share and production of industrial commodities, these data are not comprehensive and are too fragmented for a proper environmental and human health risk assessment study. Therefore, to localize risk areas where human and environmental health are endangered, more comprehensive and transparent data about industrial activities (production, export, import, and water and energy consumption) and the monitoring of exhaust gases and wastewater effluents are required to predict the impacts of industrial pollutants in more detail.

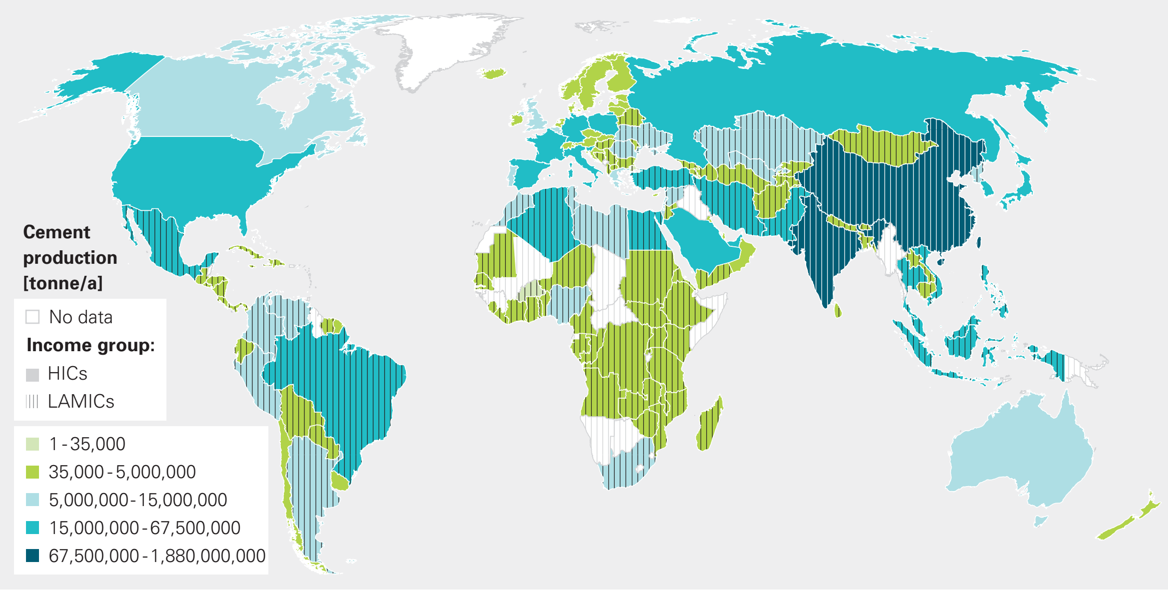

Figure 33: *2010 cement production in different countries (United States Geological Survey, 2012)*