Health impacts of e-waste processing in India

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At the end of their life cycles, electronic consumer goods like personal computers, mobile phones, TV sets, etc. turn into a specific category of waste, namely electronic waste, or in short "e-waste". In 2016, an estimated 44.7 million tons of e-waste were generated globally (World Economic Forum, 2019). Only 20% of this waste was collected and recycled (ibid).

This emerging category of waste has certain characteristics, which result in its specific treatment. Most important is that e-waste contains several valuable resources like rare earths and valuable metals like gold or copper. Thus, recovering these resources from abandoned devices can be profitable – under certain circumstances. This is connected to the second important characteristic: the valuable resources are hard to extract, since they are bound in composite structures, which require complex treatment. Due to the high diversity of the design of electronic consumer goods, the process of extracting resources is difficult to standardize or to automate. In many cases, e-waste thus needs to be dismantled manually. This labor intensity is one of the most important reasons for the high exports of e-waste to low income countries (for an overview: Abalansa et al., 2021). The export of electronic waste was officially banned in 1989 by the "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal" – yet the export of electronic goods for second-hand use is still legal.

Thus, there is a lively trade of e-waste labelled "second-hand use" moving from countries of the Global North to countries of the so-called Global South, where an active industry transforms waste to treasures – at times at high cost to human health. North America, Western Europe, South Korea and Japan are the sources of illegal e-waste trade, while Mexico, Brazil, Senegal, the Ivory Coast, Benin, Ghana, Nigeria, Eastern Europe, Egypt, India, China, Thailand and Vietnam are the largest recipients (Abalansa et al., 2021). It is estimated that from the European Union alone, 1.3 million tons of e-waste are exported without documentation – and the amounts are rising.

Basically, there are two routes e-waste takes in different sites of the Global South. Either e-waste is upcycled by repairing and re-using older electronic devices – one famous site for this is Accra's Agbogbloshie market (R. Grant & Oteng-Ababio, 2012) – or the waste is dismantled to recover valuable materials. This usually takes place under precarious conditions with multiple adverse health effects for the workers directly involved in e-waste processing, their families and the communities in places adjacent to the processing sites. Recent literature focuses on Ghana (Agyei-Mensah & Oteng-Ababio, 2012; Almazán-Casali et al., 2021; Amankwaa, 2013; Amoabeng Nti et al., 2020; Caravanos et al., 2011; Feldt et al., 2014; Fischer et al., 2020), Nigeria (Ohajinwa et al., 2017), China (Li & Achal, 2020; Zeng et al., 2019; Zheng et al., 2011), Chile (Yohannessen et al., 2019) and India (see below), reflecting spatial 'hotspots' of e-waste processing globally.

E-waste processing in India

India is at the same time a producer, importer and exporter of e-waste. For all three processes, knowledge about the volumes involved is as yet only vague, and most authors quote the same, often quite old sources. One review provides a good overview about the different estimates of the volume of e-waste that have been published in the last decade (Kaushik & Herat, 2020). The current volume of production of e-waste was estimated at 5.2 million tons in 2020 (Chaudhary et al., 2017; Kaushik & Herat, 2020). This is a relatively high estimate compared to other figures given in the same publications, e.g. 1.8 million tons in 2017 (Chaudhary et al., 2017) or a breakup for different types of e-waste adding up to 360,000 tons for 2020 (Kaushik & Herat, 2020). More contradicting figures could be added here from other sources (Bhaskar & Turaga, 2018; Dasgupta et al., 2017; Joon et al., 2017; Ramchurjee & Ramchurjee, 2016; Singh & Kumar, 2013). The Central Pollution Control Board, which is responsible for the oversight of e-waste processing estimates for the financial years 2017–2020, reports the following amounts of e-waste to have been produced in India:

- "For financial year 2017-18, the estimated generation of e-waste is 708,445 tons_for 21 types of EEE.
- For financial year 2018-2019, the estimated generation of e-waste is 771,215 tons_for 21 types of EEE.
- For the financial year 2019-2020, the estimated generation of e-waste is 1,014,961.2

tons for 21 types of EEE (Central Pollution Control Board, 2020, p. 4).

The amount of imports is likewise uncertain, with a figure of 50,000 t said to be imported to India every year – an amount quoted in almost every scientific paper that can be traced back to a report by the German development agency GTZ, which has remained unchanged ever since (GTZ & MAIT, 2007). Thus, the amount of e-waste generated and imported remains largely unknown. The same holds true for the export volume of e-waste.

Another repeatedly quoted and unquestioned estimate from that report is that 95% of e-waste is processed in the informal sector. One recent paper challenges this figure, estimating the percentage at 85% – 94% (Bhaskar & Turaga, 2018). The rationale for exporting e-waste is that high-tech facilities in European countries can use pre-processed e-waste (by informal workers) to extract valuable resources (Chaudhary & Vrat, 2017a; Vrat & Chaudhary, 2019).

Fig. 1: Informal processing of e-waste in Delhi (C. Butsch)

In India, several authorities are involved in the management and control of e-waste: the Ministry of Environment, Forest and Climate Change (MOEF), the State Pollution Control Boards (SPCB), the Directorate General of Foreign Trade (import and export under the Basel convention) and the Port Authorities and Custom Authorities.

The legal framework for handling hazardous waste was set up by the Environmental Protection Act (1986) (Chaudhary & Vrat, 2017b). In 2008, e-waste was first explicitly mentioned in the hazardous waste rules, and in 2011 the first e-waste handling rules were released, becoming effective in the year 2012 (Chaudhary & Vrat, 2017b; Joon et al., 2017; Singh & Kumar, 2013). These rules introduced two principles: Extended Producer Responsibility (EPR) and Restriction of Hazardous Substances (RoHS). While, under certain preconditions, EPR assigns the producers of electronics responsibility for the handling of electronic goods, RoHS restricts the amount of certain hazardous components, like heavy metals in electronic goods. With new rules released in 2016, these principles were operationalized. They forced producers of electronic goods to form Producer Responsibility Organizations (PRO) in order to jointly set up state-of-the-art collection centers for e-waste collection and recycling. According to the Central Pollution Control Board (CPCB), 400 collection centers were registered all over India in 2021, with a capacity to handle 1,068,542 tons of e-waste annually (Central Pollution Control Board, 2021).

The state-certified processing sites set up by the PROs (i.e. “the formal sector”) could, even according to optimistic estimates, only handle a minor share of India’s e-waste. There are multiple reasons for this. One study identifies 16 different barriers to the effective implementation of existing rules, including poor infrastructure in the “formal sector”, inadequate consumer information, shirking responsibility by producers, the limited capacity of the concerned government agencies and a dominance of the “unorganized sector” (Chaudhary et al., 2017). This dominance is linked with, e.g., political patronage (Vrat & Chaudhary, 2019) or lack of capacities in the “formal sector” (Ramchurjee & Ramchurjee, 2016). Other studies highlight the consideration that “waste” is regarded as the base of livelihoods for waste-pickers, waste-traders and refurbishers, who are part of a complex value chain (Fig. 2) (Borthakur & Govind, 2017; Chaudhary et al., 2017; Corwin, 2018; Dasgupta et al., 2017; Laser, 2016; Ramchurjee & Ramchurjee, 2016).

This value chain starts at the doorstep of consumers, where so-called *kabadiwalas* collect all types of discarded electronic devices to sell them to smaller waste dealers. Here, devices are sorted and either sold to refurbishers or enter the stream where they are dismantled. From some devices, spare parts are collected and sold to the service industry for repairing older devices, while the rest are dismantled to extract valuable components (Ramchurjee & Ramchurjee, 2016). Thus, only a small share of electronic products can be considered “waste”, but they re-enter the market through several routes. It is important to distinguish between the different actors involved in this “informal” processing of e-waste, as the health burden differs significantly. It is highest where waste is dismantled without adequate occupational safety. Thus dismantlers are usually those experiencing the highest health burden (Joon et al., 2017) and often this dangerous work is conducted by marginal groups (Fig. 1) (Ramchurjee & Ramchurjee, 2016; Vrat & Chaudhary, 2019).

Health effects of informal e-waste processing

High occupational health risks are especially prevalent for dismantlers in informal settings, while they are lower for refurbishers and workers in formal settings (Annamalai, 2015; Joon et al., 2017). Here, the lack of occupational standards results in multiple exposures towards the hazardous materials contained in e-waste. Among the hazardous materials are chemical elements and compounds like aluminum, cadmium, chromium, lead, mercury or nickel, which are included in cables, connectors and batteries. Printed circuit boards, coatings and linings contain various potentially poisonous flame retardants, phthalate plasticizers and polymers (Ádám et al., 2021; Agyei-Mensah & Oteng-Ababio, 2012; Annamalai, 2015; Joon et al., 2017; Perkins et al., 2014). As the majority of e-waste processing takes place in informal settings, occupational standards are not maintained, and often primitive means are used to extract potentially valuable components. Plastics are burned in order to access metal components, exposing workers to toxic fumes. Furthermore, the use of acids for leaching exposes workers to skin contact with acids, inhalation of acidic fumes causes health problems, and dismantlers suffer injuries and burns, often because primitive techniques are applied (Fischer et al., 2020; Perkins et al., 2014). The adverse health effects of the poisonous substances in e-waste (named above) and occupational conditions are in principle well known and have been described in several studies (Grant et al., 2013; Zeng et al., 2019). Dismantlers suffer physically from the unsafe working conditions (e.g. Agyei-Mensah & Oteng-Ababio, 2012; Akormedi et al., 2013; Fischer et al., 2020; Ohajinwa et al., 2017; Yohannessen et al., 2019). Besides occupational injuries and various forms of poisoning, workers suffer from respiratory and skin diseases, and various diseases of the nervous system, kidneys and endocrine disruption (Grant et al., 2013; Noel-Brune et al., 2013; Ohajinwa et al., 2017; Perkins et al., 2014).

In some places, the families of e-waste workers are directly exposed, too, because e-waste processing takes place in or around the home. In others, workers take home poisonous substances on their clothes or hair (e.g. brominated flame retardants or Cadmium) and thus expose their family members (Grant et al., 2013). Communities in the vicinity of e-waste sites are likewise exposed to various hazardous components of e-waste, which are dispersed via air (dust, smoke), water (runoff, groundwater) and soil (Awasthi et al., 2016; Caravanos et al., 2011; Leung, 2019; Li & Achal, 2020; Orisakwe et al., 2019).

In communities in the vicinity of e-waste processing facilities, it is often difficult to link negative health consequences (and diseases) to single sources. One literature review shows higher concentrations of hazardous, potentially carcinogenic substances in the blood and hair of persons living close to e-waste processing sites (Awasthi et al., 2016). Several studies found pregnancy complications in communities close to e-waste processing sites, resulting in an increased number of stillbirths and children with neurological deficits (Chen et al., 2011; Grant et al., 2013). In China, a number of studies show the effects of exposure to toxic substances from e-waste processing on human DNA in populations residing close to e-waste sites (Liu et al., 2009; Xu et al., 2015; Yu et al., 2018).

Several studies address negative effects on children's health. A study analyzing a cohort of pre-school children close to Guiyu found elevated levels of several toxins, especially lead, in their participants' blood samples. These were correlated with growth and mental deficits compared to a control group (Zeng et al., 2019). Similar adverse effects were found in other studies (Cai et al., 2019; Leung, 2019; Li & Achal, 2020). Negative impacts occur where children are actively involved in e-waste processing (Annamalai, 2015).

Fig. 2: E-waste collection center near Kolkata (C. Butsch)

Questions for future research

Existing literature covers the structures, processes and actors of different streams of e-waste quite well. Likewise, the pathogenic pathways of substances released during e-waste processing are well understood. What is not yet well understood are questions around the structural production of health vulnerabilities of e-waste workers. A research approach rooted in the syndemics concept (Singer et al., 2017) would allow for analyzing the parallel occurrence of disease patterns in certain population groups and may provide valuable insights. Further, the health resilience strategies of e-waste workers may also provide valuable insights: What kinds of coping strategies do they employ to deal with health threats and ill health and why do they adopt them?

Going beyond the mapping of pathogens and disease, answers to these questions will allow for a better understanding of the underlying causes of health inequities for these highly exposed groups. At the same time, understanding of the agency of e-waste processors may help to increase general understanding of the coping strategies of marginalized groups.

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