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Unsound waste management and public health: The neglected link?

Is the link between improper management of solid wastes and its potential adverse effects upon the health of the general population sufficiently understood and valued by our societies? Here, inevitably without getting into the core scientific evidence in great detail, we revisit what we fear has become an undervalued debate. We aspire that our short analysis could contribute to revitalising the efforts for a robust evidence base regarding the contribution of sound solid waste and resource recovery management practices to the protection of public health.

Historic origins: Sanitation and onwards

The birth of modern solid waste management (SWM) is associated with the era which saw the development of sanitation in the middle of 19th century in the UK. The Victorians were possibly the first to establish and widely implement legislation that mandated the collection and disposal of municipal solid waste (MSW), based on the 'miasma' theory (falsely) connecting the odours of putrefying organic matter with infectious disease transmission. They went on to invent a series of waste processing technologies. In fact, there were already organised SWM practices motivated by recovering value and resources from the MSW, as the study of London's dust-yards has demonstrated; but, since then, the perceived protection of public health became the most decisive driver for dealing with MSW. The historic trajectory of underlying forces equipped us with additional important reasons to innovate for SWM, not least with local and, recently, global environmental protection (e.g. pollution prevention from leachate or methane emissions from engineered landfills, respectively), which in turn also enable longer term public health protection via minimisation of ecological exposure pathways.

The astonishing achievements of environmental engineering in controlling the adverse effects of solid waste via effective complex processing, some major failures, and a few recent decades of emphasis on recycling has moved the focus on the public and occupational health performance of the waste processing technologies. The driver of public health protection became blurred among its important recent counterparts – even more so in an emerging era of an aspired circular economy primarily driven by long-term prosperity considerations (materials availability, business, and job creation) rather than guarding human health. But, don't we risk losing sight of the forest for the trees here? Whereas it is understood and can be openly admitted that there are no entirely risk-free waste processing options, we would argue that the key related public health challenges on a worldwide scale remain fundamentally within low income and environmentally developing countries – the Global South. This is where massive needs are, and where proportionally greater benefits can be gained.

Current and emerging challenges

The recent seminal Global Waste Management Outlook (GWMO) (United Nations Environment Programme and International Solid Waste Association, 2015) estimated 2 billion people without access to primary waste collection and 3 billion people without safe waste disposal services. Composition and quantities of waste, both on a chemical compound level and on a complex product level, cannot be compared with the simple MSW of the mid-19th century, comprising largely of coal-burning residues (ashes and cinders), rags, leather, and inedible food residues. One could speculate that the risk posed by today's MSW and wider solid waste arisings (hazardous, e-waste, healthcare) could be orders of magnitude higher than that of the Victorian sanitation era.

Unsound waste management means, in practice, that the waste is littered or dumped in the immediate/nearby environment, such as in waterways, burned in the open in backyards, streets, or ovens/stoves; and, where collected, is disposed of in dumpsites without functioning control measures in place, left there available to informal sector recyclers (waste pickers) often with open fires continuously burning and domesticated/wild animals grazing. The list of resulting possible threats to the public health is long and variable – we will not repeat it here. They involve emissions of potentially toxic elements (PTEs), generation of volatile organic compounds (VOCs) and bioaccumulative persistent organic pollutants (POPs) and harbourage and breeding grounds for disease-carrying vectors; direct and indirect (via wider ecosystems), acute, and chronic exposure of humans, including vulnerable populations, children, and pregnant women; and exposure routes, such as inhalation, contaminated food ingestion, and dermal contact.

A recent study commissioned by the International Solid Waste Association (ISWA) vividly reminded us of the threats posed by uncontrolled dumpsites and their realities (Mavropoulos and Newman, 2015), either to the considerable communities of informal recyclers that survive working on them, or to the urban settlements in the vicinity of the dumpsites. The study considers dumpsites as a global health emergency and calls all international stakeholders to create a proper roadmap for their closure. The practice of co-disposal of hazardous waste and healthcare waste with MSW is increasing the challenges. The

fact that the items disposed of and/or set on fire contain various combinations of the tens of thousands of man-made chemical compounds is an additional source of concern. Nanoparticles are also a family of substances that are now increasingly present in our MSW and our understanding for their fate is still in its infancy. Concurrently, an unidentifiable amount of marine litter, including a considerable percentage of plastics, leaks into the aqueous environments (rivers, seas, oceans) posing novel potential – still to be well understood and proven – public health challenges.

From time to time, particular cases stand out and are studied in-depth or break into the news, usually just with anecdotal evidence supporting them. Recently, a massive fire at the dumpsite of Mumbai, India, created a stir because the sheer magnitude of the plume became visible from satellites in space. Epidemics of infectious diseases were reported to breakout, supposedly owing to flooding caused by uncollected plastic bags that blocked the drainage systems, or by mosquito species known to cause dengue and yellow fever breeding in discarded tyres. Some places, such as Accra, Nigeria, where massive e-waste quantities are reprocessed by improper means, have gained a reputation for extreme pollution and associated acute health impacts to the locals.

Insufficient evidence?

We are aware that treating the waste in such a manner may result in releasing substances able to pose carcinogenic or non-carcinogenic human health risks. Yet, surprisingly or not, as documented in most of the relevant recent systematic reviews, arguably for most of the cases there is insufficient scientific evidence produced on the causal relationship and its magnitude between these sources, pathways, and their suspected implications to humans. For example, the most recent available generic review on the impact of waste management practices to human health dates back to 2009 and mainly focuses on modern processing/disposal technologies, not on dumpsites or open burning (Giusti, 2009). It concludes that 'evidence of adverse health outcomes for the general population […] is usually insufficient and inconclusive.' Most of the scientific literature is understandably focused at the occupational/working community health implications and do not sufficiently examine implications to the wider general public health. These are unsettling facts and provide a blurred and weak message to the decision-makers. We can take a closer look at the case of informal sector recyclers (waste picking, inclusive recycling).

Informal recycling sector and health

Informal sector recycling is a reality around the world, being the most prominent source of recyclables in low income countries and a major survival strategy for vulnerable (marginalised and/or impoverished) urban population fractions (e.g. ca 0.5%, worldwide average in cites). At long last, an increasing volume of literature starts examining the human health dimension of the informal sector to the workers themselves (occupational) and their communities, and wider urban populations. For example, they may work/live in dumpsites without suitable personal protection equipment and without access to basic health services. However, to our best understanding, authoritative studies are still largely missing.

A generic case that has unfortunately escaped the attention of the policy and decision-makers in the Global North relates to the mistakes we have done with the use of poly-brominated flame retardants, such as the carcinogenic and banned-in-Europe (but apparently not in China) deca-BDE (brominated diphenyl ether), by including them in the plastics casings of consumer products, eventually exported to be recycled in the Global South. Tang et al. (2016) remind us about the potential health effects of mechanical recycling of such plastics components in Wen'an, China, for 30 years, involving 'at peak times […] approximately 100,000 people engaged in this industry.'

Resource recovery from e-waste

A specific sub-category, where there is proliferation of recent research studies, is the handling of e-waste (Waste electrical and electronic equipment – WEEE) by the informal sector, working to recover secondary raw materials, typically in Western Africa or South East China. Open burning of polyvinyl chloride (PVC) to recover copper (Cu) from cables; and acid/caustic leaching of printed circuit boards to obtain precious metals are typical unsustainable recovery operations. In a systematic review of the literature, Grant et al. (2013) concluded that there exists 'significantly negative correlations between blood chromium concentrations and forced vital capacity in children aged 11 and 13 years' and that 'people living in e-waste recycling towns or working in e-waste recycling had evidence of greater DNA damage than did those living in control towns.' Interestingly, they considered a wider range of potential health impacts including 'mental health and neurodevelopment.'

Challenges for (epidemiologic) research

Research into epidemiology has made considerable advances, but the complexity of world we live in has also increased, making it very challenging to establish these much-needed links between unsound management of solid waste and the public health. Various researchers attempting much needed epidemiological studies, systematic reviews, and meta-analyses point us to the great difficulties we still face in the direction of generating robust evidence and offer specific insights on what needs to be improved, and how.

For example, Giusti (2009) summarised why prospective cohort studies are costly and hard to devise owing to the large populations needed to establish the necessary statistical power to identify clinical effects, minimising false positive and negative assertions. But, such large populations may not be available. Many criticise the absence of even cross-sectional studies that can form the basis of hypotheses to be tested. But, even these are

just a beginning and cannot address the developments over time that time-consuming longitudinal research can offer. Control for confounding factors is still insufficient in many efforts, and so is effective randomisation. Eventually, when multiple results are compared in meta-analysis, these may be suffering from publication bias resulting in reporting of only the positive findings; and pooling of samples remains difficult to address. Grant et al. (2013) explain how the 'synergistic and inhibitor effects of exposure to chemical mixtures' also are a known limitation and gap in our knowledge.

Integration of cutting edge findings from non-waste-related research is necessary in order to comprehend better the potential health impacts and design solid research, but it remains poor. For example, research led by Professor Noakes, Institute for Public Health and Environmental Engineering (iPHEE) at the University of Leeds, explores in detail the air pathway of exposure, looking at the release and transport of airborne substances (Elston et al., 2013) (biological and not), resulting in, among else, re-establishing a lost connection with the old 'miasma' theory. Arguably, expertise on waste and resources management is fundamental for the design of effective relevant research efforts, but alone cannot suffice – extensive and in-depth collaboration with medical and health experts in cross- and intra-disciplinary teams are central to successful investigations. We have not seen many collaborations with such features to-date. The interface between sanitation (excreta and wastewater management) and SWM is also underexplored and the GWMO has made the right noises in this direction, requesting more effective integration. Quantifying the cost of inaction, is another area awaiting major improvements and research efforts.

Call for action

The strong link between public health and improper management of solid waste, unsound efforts for resource recovery included, should remain at the forefront of delivering a better quality of life in general and possibly can lead to massive improvement in low income and environmentally developing countries. Notwithstanding this, it is worrying that the scientific evidence establishing the strength and importance of this link seem not to be as clear or robust as would have been required. *Waste Management & Research* welcomes manuscripts that are based on sound methodologies on this grand challenge of our times. It may be time to re-establish the weakened connection between waste and health, so that decision makers have no doubt about the need to act to allocate resources to eliminate unsound waste management practices all over the world. ISWA, by co-publishing the GWMO with UNEP and by releasing the '*Wasted Health*' report, is contributing in this direction. But, how much evidence do we need in order to act?

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