Electronic Waste as a Health Hazard in Delhi NCR Region

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Abstract

Waste from Electronics (e-waste) is likely to be one of the most formidable challenge to sustainable living in the twenty first century. In the year 2016, a staggering 44.7 million metric tonnes (Mt), or an equivalent of 6.1 kilogram per inhabitant (kg/inh), of e-waste was generated annually and this amount is expected to increase to 52.2 million metric tonnes, or 6.8 kg/inh, by 2021. . UNEP Report predicts that by the year 2020, the discarded personal computers will increase five times from 2009, mobiles will be discarded 18 time more and television sets will be discarded twice in India. Recycling of the waste from Electronics is becoming a major cause of concern. It is estimated that every year, there is 3 to 5% increase of waste from electronics in the municipal waste takes place. This also raises concern to the dangers posed to human health due to improper dumping of waste from electronics. This paper presents the possibility of bearing on the incremental cancer risk due to exposure to heavy metals in groundwater in Mandoli area adjacent to Delhi. The chronic average daily intake and incremental lifetime cancer risk (ICLR) for As, Cr, Pb and Cd has been calculated to assess the exposure to carcinogenic diseases.

Introduction

Waste from Electronics (e-waste) is likely to be one of the most formidable challenge to sustainable living in the twenty first century. In the year 2016, a staggering 44.7 million metric tonnes (Mt), or an equivalent of 6.1 kilogram per inhabitant (kg/inh), of e-waste was generated annually and this amount is expected to increase to 52.2 million metric tonnes, or 6.8 kg/inh, by 2021[1]. By an estimate, equivalent of 6.1 kilogram per inhabitant (kg/inh), of e-waste was generated on an annual basis in 2016 in comparison to the 5.8 kg/inh generated in 2014. As per a United Nations report, 1.5 kilogram per inhabitant (kg/inh) e--waste is estimated to have been generated. UNEP Report predicts that by the year 2020, the discarded personal computers will increase five times from 2009, mobiles will be discarded 18 time more and television sets will be discarded twice in India[2]. It has been reported that India generates approximately 2.7 million tons of e-waste annually, where 70 per cent of the total e-waste is generated from 10 Indian states.[3]

Recycling of the waste from Electronics is becoming a major cause of concern. It is estimated that every year, there is 3 to 5% increase of waste from electronics in the municipal waste takes place. This also raises concern to the dangers posed to human health due to improper dumping of waste from electronics. This is linked to the Sustainable Development Goals (SDG) laid by the United Nations in 2015. E-Waste is related to goal 3 of SDG which aspires for Good Health and Well-Being, goal 6 for Clean water and Sanitation and goal 11 for Sustainable Cities and Communities[4]. Waste from Electronics contains many hazardous substances, heavy metals like mercury, cadmium, lead, flame retardants like pentabromophenol, polybrominated diphenyl ethers (PBDEs), tetrabromobisphenol-A (TBBPA), etc.) and other substances[5,6]. Unsafe disposal of electronics equipment is a health hazard as some chemical compounds and elements used during the manufacturing of electronic equipment get released in soil and subsequently in ground water. There are some organic compounds which easily dissolve in lipids and fats, some are bio accumulative in nature which are resistant to breakdown because of long half-lives[7]. A review conducted of the 165 studies that were screened and assessed for eligibility, 23 reported associations between exposure to e-waste or waste from electrical and electronic equipment and physical health, mental health, neurodevelopment and learning outcomes[7]. In most of the developing countries, collection of electronic waste largely gets dumped in the soil or is recycled for extraction of valuable metals using crude and sub-standard methods[1,7,8].

Health Impact due to the toxic metals and hazardous pollutants have been reported in the areas where disposal of waste from electronics has been rampant. Contamination of soil, water and air has been adversely affecting the human health. This paper presents the possibility of bearing on the incremental cancer risk due to exposure to heavy metals in water in Mandoli area adjacent to Delhi.

Impact on Health and Environment

Toxic material in the Electronic wastes is capable of wide spread environmental damage. Circuit boards have Lead (Pb) and Cadmium (Cd) in circuit boards and mother boards, mercury in LCD monitors, polychlorinated biphenyls (PCBs) in capacitors and transformers, brominated flame retardants on printed circuit boards, to name a few[9]. The cadmium from one mobile phone battery is enough to pollute 600,000 litres of water[10].

Brominated Flame Retardants (BFR) are used as additives and are blended with polymers to make fire resistant plastic casings in electrical and electronics equipment. BFR's and Brominated Diphenyl Ethers (BDE) have been reported to be potential endocrine disruptors which binds with thyroid hormone and create physiological imbalances[11]. Triphenyl phosphate (TPP) is an organophosphate flame retardant used in electronic equipment and has been reported as a potent inhibitor of enzyme monocyte carboxylesterase in human blood cells[12]. It has been also reported that workers who handle waste from electronics in recycling facilities in Europe, China have been found to have higher blood levels of Polybrominated Diphenyl Ethers (PBDEs), a brominate flame retardant, probably due to inhalation of dust contaminated with PBDE[13,14].

Heavy metal pollution in water and soil has been reported largely from informal electronic waste sites. It has been observed that vegetables grown in the vicinity of e waste processing sites were high on heavy metal pollution. The bio accumulation of heavy metals was observed maximum for Cd and Pb[15]. Rice (Oryza sativa) grown near electronic waste dumping sites have exhibited heavy concentration of metals like Pb and Cr. This is because water samples within and near the dumping sites exceeded the water quality standards. The measurement of the ability of a plant to translocate the metals from roots to shoots and leaves when measured showed high concentrations of metals exceeding permissible limits[16].

Heath Risk Assessment at Waste Site Near Delhi

Processing electronics waste in developing nations has largely been carried out using informal means. Financial incentive and ambivalence towards e-waste disposal rules among the people has created a large market for disposal of electronic equipment and extraction of metals[17]. There are a dozen sites inside and near Delhi where waste disposal of electronic equipment takes place on large scale. Within Delhi, Seelampur, Mayapuri, Shastri Park and Nehru Place are well identified electronic waste informal recycling sites. Loni and Mandoli area, located at the border of Delhi have been well reported in journals as informal electronic waste processing sites. Toxic Links, Greenpeace and GTZ organisations have reported surveys conducted on informal disposal of electronic waste and contamination of soil and water at such sites.

At Loni and Mandoli, informal recycling of waste circuit boards, compact fluorescent lamps (CFLs) to extract lead, aluminium and iron has been seen as the primary activity. Dismantling and desoldering of the circuit boards results in the waste collected which is then set on fire in open fields to extract copper. Concentrated sulphuric and nitric acid are used for processing of printed circuit boards (PCB) and largely discharged in to open lands[18]. An environmental risk assessment of heavy metal contamination in Mandoli industrial area was reported by Pradhan and Kumar[19] to study the contamination status in surface soils, plants and groundwater. They observed in their study that the Mandoli area is affected by heavy metal concentration in the surface soil due to use of acid bath, open air burning and dumping of electronic waste. Heavy Metal content was also observed in the ground water samples.[19]

The paper reports that the heavy metal concentration of Al, As, Cr, Pb and Se in water samples collected from the Industrial area in Mandoli, were above the permissible limit of the Indian Standards and World Health Organization (WHO) guidelines. The table listing the concentration of heavy metals, based on Duncan's post hoc analysis, present in the ground water in the industrial and residential area in Mandoli has been reproduced here in Table 1. The data shows that a high concentration of heavy metals in water enhances the risk of cancer in the people living in that area. For the residents in the area, tube wells are the only source of water. The growing industries in that area are creating scarcity of fresh drinking water.

This paper explores the possibility of human exposure to heavy metals based on their concentration in water. The chronic daily intake is as given in equation (1)[20]. Based on the given equation, daily chronic average life intake has been calculated for the heavy metals As, Pb, Cr and Cd. The USEPA (United States Environmental Protection Agency, 1991) has defined the cancer risk as "the incremental probability of an individual to develop cancer over a lifetime as a result of exposure to a potential carcinogen"[21]. Table 2 and Figure 1 depict the daily chronic average life intake of the heavy metals.

$$Chronic\ Daily\ Intake\ \left(\frac{mg}{kg-day}\right) = \frac{Average\ Daily\ Dose\ (\frac{mg}{day})}{Bodyweight\ in\ kg} \quad \text{------------} \quad (1)$$

A commonly reference benchmark for Incremental Lifetime Cancer Risk is value of 10−6 which is the probability that 1 person may develop cancer out of 1,000,000 people exposed to a carcinogen[22].The permissible limits are considered to be 10−6 and <10−4 for a single carcinogenic element and multi-element carcinogens respectively[23]. Table 2 lists the calculated Incremental Lifetime Cancer Risk for the heavy metals in the industrial area and residential area of Mandoli area. The slope factor for the heavy metals is taken as the standard value stated by Integrated Risk Information System (IRIS) U.S. Environmental Protection Agency Chemical Assessment Summary National Centre for Environmental Assessment[24].

Conclusion

The assessment of the health risk based on the concentration of the heavy metals As, Pb, Cr and Cd in the water of Mandoli residential and industrial area indicates that the incremental lifetime cancer risk (ICLR) above the safe limit of 10^{-6} for three of the given heavy metals listed in Table 2. The ICLR for Cd at the residential and industrial site of Mandoli is 5.14285 x 10^{-5} and 1.28571 x 10^{-3} respectively. The values indicate that ICLR due to Cd concentration in water is higher than the permissible limit although in the residential area the risk is lower than the residential area. The ICLR value for As is 2.448945 x 10^{-4} and 4.28571 x 10^{-5}; for Cr is 1.22448 x 10^{-3} and 4.08163 x 10^{-5} in the industrial and residential area respectively, are above the safe limit of the incremental lifetime cancer risk. The incremental risk of cancer due to Pb in the residential area and industrial area is 1.38775 x 10^{-7} and 6.93877 x 10^{-8} respectively is within the safe limits. The release of heavy metals in the local environment of Mandoli due to the informal disposal of electronics waste is reflected in the presence of concentration above the permissible limits in the ground water. Prolonged exposure to such contaminated water can lead to carcinogenic diseases, multi organ failure. Safety measures to protect human life at electronic waste disposal sites can curtail the probability of exposure to carcinogenic dieaseas.

Element	Industrial Area Site (mg/L) (SE)	Residential Area Site (mg/L) (SE)	BIS Indian Standards (IS 10500:2004), Limits		World Health Organization (WHO Guideline) Maximum allowable concentration
			Desirable	Permissible	
As	0.04 (0.01)	0.007 (0.001)	0.01	0.05	0.01
Cd	0.05 (0.02)	0.002 (0.00)	0.003	No relaxation	0.003
Cr	0.60(0.01)	0.02 (0.002)	0.05	No relaxation	0.05
Pb	0.04 (0.002)	0.002 (0.001)	0.01	No relaxation	0.01

Table 1: Concentration of Heavy Metals in the water samples of the Mandoli Area[19]. SE= Standard Error

Element	Potency Factor/ Slope Factor $(mg/kg\text{-}day)^{-1}$	Chronic Daily average life Intake (mg/kg-day)	Incremental Life time Cancer Risk
As At Industrial Area Site	1.5	1.63263 x 10^{-4}	2.448945 x 10^{-4}
As At Residential Area Site	1.5	2.85714 x10^{-5}	4.28571 x 10^{-5}

Pb At Industrial Site	8.5 $\times 10^{-3}$	1.63265 $\times 10^{-4}$	1.38775 $\times 10^{-7}$
Pb At Residential Site	8.5 $\times 10^{-3}$	8.1632 $\times 10^{-6}$	6.93877 $\times 10^{-8}$
Cr At Industrial Site	5 $\times 10^{-1}$	2.44897 $\times 10^{-3}$	1.22448 $\times 10^{-3}$
Cr At Residential Site	5 $\times 10^{-1}$	8.16326 $\times 10^{-5}$	4.08163 $\times 10^{-5}$
Cd At Industrial Site	6.3	2.04081 $\times 10^{-4}$	1.28571 $\times 10^{-3}$
Cd At Residential Site	6.3	8.16326 $\times 10^{-6}$	5.14285 $\times 10^{-5}$

Table 2: The chronic daily average life intake and Incremental Life time Cancer Risk calculated for heavy metals.

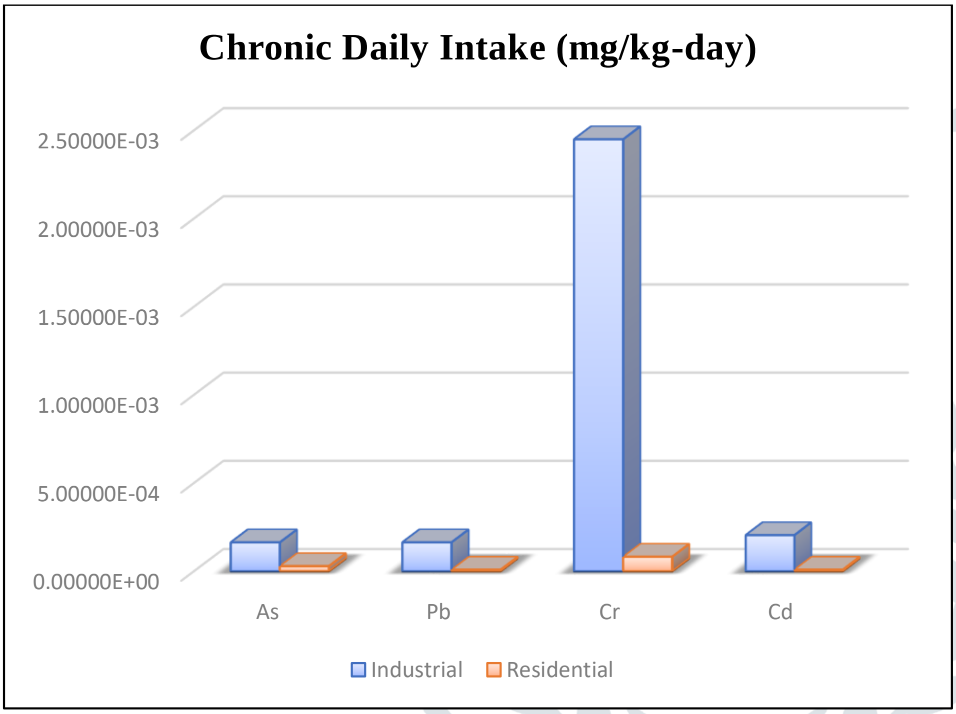

Figure 1: The graphical representation of the chronic daily intake of heavy metals in Mandoli area.

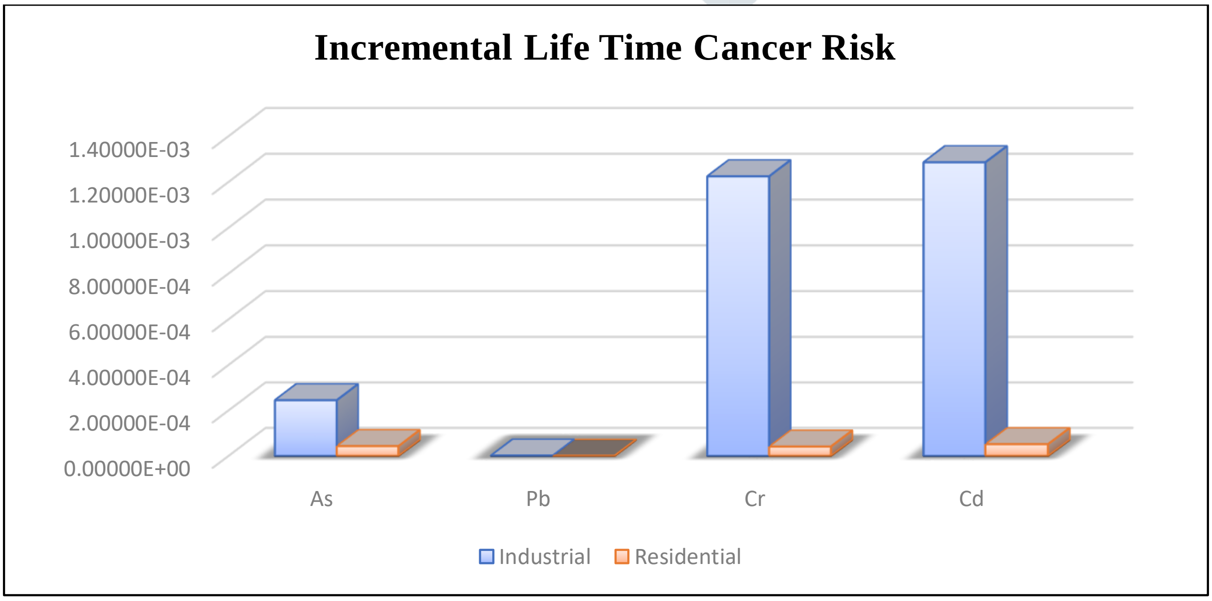

Figure 2: Incremental Lifetime Cancer Risk (ICLR) due to the heavy metals in the Mandoli Area

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