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# The current trends in lead contamination in Zambian towns: save the innocents

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**Abstract**
Lead (Pb) is a heavy metal which was actively mined in Kabwe, in Zambia's Central Province and to a lesser extent, on the Copperbelt. Though the lead-zinc mine in Kabwe closed almost three decades ago, the risks associated with chronic exposure to the toxic heavy metal have not been addressed and remain a source of grave concern. Kabwe still remains one of the most lead contaminated towns in the world. Studies have shown that lead levels in soil, water and sediment far exceed permissible limits set by the World Health Organization. Recent investigations on the children under the age of seven in the mining towns have revealed arming levels of lead in their blood. Similarly, high level of lead has also been recorded in livestock in the same towns. Lead affects all organs of the body, particularly the nervous system. This paper identifies the various sources of Pb contamination in Zambian towns and the effects of lead toxicity on human health. Currently there are no any mitigation measures in place to protect people and livestock from excessive exposure to lead in the mining towns. The paper proposes sustainable bioremediation measures that can be used to reduce lead contamination in Zambian mining towns.

**Keywords**
*human health, lead contamination, lead toxicity, remediation, Zambia*

## Introduction

### Sources of Lead Contamination in Zambian Towns

Zambia's economy has to a large extent, relied on mining and ore processing. Most of the country's mining and smelting has historically been carried out in the Central Province and Copperbelt Province. Mining cities on the Copperbelt include Chingola, Kitwe, Luanshya and Mufulira, while Kabwe was until the mid-1990s, the major mining town of the Central Province. Lead contamination in Kabwe is of great concern and topical, as highlighted by various stakeholders (BBC News, 2020; Brink, 2019; Caravanos *et al.*, 2014; Human Rights Watch, 2018; Human Rights Watch, 2019; Phiri, 2016). Kabwe had one of the largest lead-zinc mines, which was operational from 1904 to

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1994, when commercial mining and smelting activities ceased (Ettler *et al.*, 2020; Tembo *et al.*, 2006). Small-scale artisanal mining has continued and is unregulated by relevant mining and minerals processing regulators. This is of great concern as the lead-zinc mine and area up to 14 km to the west of the mine are reported to be among the most contaminated in the world (Ettler *et al.*, 2020; Lindahl, 2014).

Various studies have shown that anthropogenic activity such as mining and smelting are a major contributor to heavy metal contamination in low- and middle-income countries (LMICs) like Zambia (Kordas *et al.*, 2018); Majer *et al.*, 2011; Mwaanga *et al.*, 2019; Tembo et al., 2006). Lead contamination is a worrying problem worldwide, especially in developing countries which often lack the resources needed to effectively address the problem, which includes formally shutting down unproductive mines and rehabilitating contaminated mining sites (The World Bank, 2016; The World Bank, 2020a). The monitoring and waste management of emissions, effluent and solid waste from various industries has until recently, not been well regulated particularly in developing countries. Furthermore, there are no guidelines regulating the use of potentially toxic substances such as Hazardous Materials (HMs) in industry such as paint manufacturing (Bandemehr, 2020; Musenga *et al.*, 2017).

Lead is a heavy metal which occurs naturally in form of various ores, such as galena and pyromorphite which once extracted, need to be processed before the heavy metal can be used. Basic processing activities associated with mining include ore crushing, smelting as well as disposal of hazardous mine waste, in various states including gas, liquid and solid (Burga and Saunders, 2019; Caravanos *et al.*, 2014). These activities have contributed significantly to lead contamination in the vicinity of the closed Pb-Zn mine (Burga and Saunders, 2019; Tembo *et al.*, 2006). Lead contamination has a complicated history, particularly in Kabwe, which used to be a thriving mining town before the lead-zinc mine was closed in 1994. The mine run from 1904 to 1994 when it was declared economically non-viable to continue mining and smelting activities. Despite this, small-scale artisanal mining has continued, compounding the problem which includes challenges associated with disposing of solid waste from the closed mine (Human Rights Watch, 2019; Nyambe *et al*, 2014). The solid waste was left untreated, in the open and has since been shown to contain high levels of HMs including, cadmium, copper, lead and zinc (Burga and Saunders, 2019). Tests have shown that the concentration of lead in surface soils from Kabwe ranges from 139mg/kg to 62,142mg/kg, well above both CDC and Zambian guidelines of 400mg/kg and 200mg/kg respectively (Caravonos *et al.*, 2014).

There is evidence of the lead-zinc mine being a major source of HM contamination, provided by Majer *et al.* (2011) whose study showed that surface soil contained up to 4% more lead, compared to reference soil horizon at a depth of 80 – 90 cm over most of the area they surveyed. Further evidence supporting the assertion that mining, smelting and mine waste are a major source of soil and air pollution in Kabwe is available. Tembo *et al.*, (2006) have shown that areas downwind of the mine and smelter are the most heavily contaminated areas of Kabwe with lead as well as cadmium, copper and zinc. Additionally, Ettler *et al.*, (2020) conclusively showed that slag dust highly contaminated with cadmium, lead, vanadium as well as zinc, is a key source of soil pollution and also exposes humans to the toxicants, resulting in adverse effects on their health. Yabe *et al.* (2015) showed that dust is the main source of lead exposure, with (blood lead levels) BLLs of children in areas of Kabwe close to the mine exceeding the 5μg/dL limit, providing evidence of lead exposure from blood, faeces and urine tests in children from areas close to the mine. Finally, Ikenaka *et al.*, (2010) categorically indicated that HM contamination in Zambia exhibits regional disparities, with moderate or low HM contamination in areas distant from mining beds.

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Other than the mining industry, other sources of lead contamination in Zambia, as is the case with most low- and middle-income countries (LMICs) include lead-paint as highlighted by Bandemehr (2020), the International Pollutant Elimination Network (IPEN) in 2020 as well as Musenga *et al.*, (2017). Others sources are the continued high demand for lead-acid batteries (Kordas *et al.*, 2018; Rees and Fuller, 2020) and the vast amounts of electronic-waste produced worldwide (Rees and Fuller, 2020). Furthermore, the inadequate enforcement of regulations or lack of regulations in the majority of LMICs controlling the production, import and sale of lead-paint (Bandemehr, 2020; Rees and Fuller, 2020), coupled with deterioration of lead-paint on walls and surfaces which exposes entire households to the toxicant. A 2017 study carried in Livingstone by Musenga *et al.*, (2017) showed that 36% of the paints analyzed contained 90ppm or more lead by dry weight, while 18% contained elevated lead levels in excess of 10,000ppm dry weight. The same study showed that brightly coloured paints posed the highest risk, with 50% having a lead concentration above 90ppm dry weight, though some white paints had lead concentrations above 10,000ppm as well. The most hazardous of the brightly coloured paints were yellow, orange and green with 40%, 100% and 20% of the paints having lead levels greater than 10,000ppm, while the highest lead levels of 120,000ppm were detected in orange paint manufactured for home use (Musenga *et al.*, 2017). Currently, there is a drive to enact lead-paint laws aimed at eliminating the global use of lead in paint (Bandemehr, 2020; Rees and Fuller, 2020; IPEN, 2020). According to a global report by IPEN (2020), Zambia is one of several African countries which either have legislation or in the process of putting legislation in place aimed at controlling lead content in paint.

Other than lead-containing solvent-based paints, lead-acid batteries are extensively used worldwide. According to Rees and Fuller (2020), 85% of the lead produced worldwide is used for the manufacture of lead-acid batteries, while 95% of lead used is recycled from used lead-acid batteries, which are used in motor vehicles. Rees and Fuller (2020) estimated that worldwide, 50 million tonnes of electronic waste are produced each ear, including electric wire containing as much as 4,000ppm of lead. The informal recycling of lead-batteries further exposes individuals to lead-laden fumes as well as lead-containing particulate matter (Rees and Fuller, 2020). It has however been argued that because Zambians are disproportionately exposed to lead from lead-acid batteries since the country lacks lead-acid battery recycling industry (Nachiyunde *et al.*, 2013). This despite the fact that the heavy metal is a potent multi-organ toxicant affecting the neural and cardiovascular systems (United Nations Environment Programme, 2010) and has no known safe limit for exposure in children (Human Rights Watch, 2019). Though no study has identified from the literature in Zambia, recycling of lead-acid batteries can be inferred as a source of lead contamination due to recycling of batteries occurs on an unknown scale, or that the lack of recycling of lead-acid batteries contributes to contamination from improperly disposed lead-acid batteries (Nachiyunde *et al.*, 2013).

Dietary uptake of lead through consumption of HM contaminated food in general has already been stressed as being of concern in affected towns (Mwaanga *et al.*, 2019; Mwase *et al.*, 1998; Nachiyunde *et al.*, 2013; Syakalima *et al.*, 2001). Various studies have shown that lead accumulation in vegetation as well as animals is prevalent in previously mined as well as actively mined areas. For instance, Nakayama *et al.*, (2013) showed that wild rats accumulated lead and other HMs in various organs, linking these elevated lead levels to soil pollution. They further investigated the biological effects, including expression of metallothionein genes. In their study, Nakayama *et al.*, (2013) showed that Chingola has elevated levels of Cu and Co in soil, as well as Pb and Cd. Though there is no major Pb and Cd mining or processing in the Province, the presence of these metals in soils from the Copperbelt is likely due to mining activities (Lindahl, 2014). Yabe *et al.*, (2011) and Yabe *et*

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*al*., (2013) showed that the concentrations of Pb, Cd and other HMs far exceeded maximum levels set for human consumption in organs including liver and muscle of cattle and free-range chickens respectively raised in areas of Kabwe close to the mine. In the 2013 study, they further determined that levels of the same HMs were low in broiler chickens which don't scavenge for food from the environment. Additionally, Kapungwe (2013) further demosntrated that food crops irrigated with wastewater in Kafue, a non-mining town was contaminated with lead. Kapungwe's study showed that various food crops, including vegetables like Chinese cabbage, pumkin and bean leaves as well as tomatoes were contaminated by HMs such as Pb with concentrations well above permissibe limits. Furthermore, Mihaljevic *et al*., (2011) and Nyambe *et al*., (2014) have illustrated that Pb accumulates in vegetation, where it passes into the human food chain via consuption of either contaminated plants (Kapungwe, 2013) or animals feeding on contaminated vegetation (Yabe *et al*., 2011; Yabe *et al*., 2013).

**Effects of Lead Exposure on the Human Health**

Lead exposure primarily occurs through three different routes namely 1. Exposure to the HM from the environment, 2. Consumption of contaminated food such as fruit, vegetables and meat products and 3. Inhalation of particulate matter containing high levels of lead (Majer *et al*., 2011). All three of these exposure routes are present in Zambian towns affected by lead contamination (The World Health Organization, 2015). Therefore, addressing lead contamination is critical due to the metal's ability to accumulate in the tissues of humans, making it one of the most harmful pollutants. Lead mimics an important metabolic metal, calcium by disrupting calcium-dependent metabolic processes (Burga and Saunders, 2019). One way in which it does so is by inducing the activation of protein kinase C (PKC), to which it readily binds compared to calcium (Burga and Saunders, 2019). It alters gene expression, as well as protein synthesis. According to Burga and Saunders (2019) and the Human Rights Watch (2019), lead exposure in Kabwe is more commonly associated with its negative effects on the neurodevelopment of young children. However, adults exhibit the same neurological symptoms, though less severe at higher blood levels of between 40 μg/dL to 120 μg/dL. Tests carried out to determine (blood lead levels) BLLs of children in lead contaminated townships of Kabwe showed elevated levels of the metal, ranging between 13.6μg/dL to 65.0 μg/dL (Caravanos *et al*., 2014). In general, the BLLs of children exposed to lead in LMICs are well above the Center for Disease Control (CDC) recommended value of 5 μg/dL, and children with BLL 45 μg/dL need lead chelation therapy (Caravanos *et al*., 2014; Rees and Fuller, 2020; Yamada *et al*., 2020).

Humans at all stages of development are at risk from the negative effects of exposure to lead. Since lead is stored in teeth and bones of pregnant females, it leaches into the maternal bloodstream and affects foetal development and growth. (Burga and Saunders, 2019). According to the Human Rights Watch (2019), females exposed to lead have a higher probability of suffering miscarrieages. Furthermore, the metal is transmitted to the foetus via the placenta, and to nursing children through maternal breast milk (Human Rights Watch, 2019). Children aged seven and below are particularly vulnerable to the effects of lead toxicity via their gastrointestinal tract (GIT), as compared to adults. Their hand-to-mouth and object-to-mouth behaviour causes ingestion of dispproportionately higher quantities of the metal through pica (Burga and Saunders, 2019). This is more so because their playgrounds are contaminated with wind-blown particulate such as contaminated dust (Mwaanga *et al*., 2019; Ettler *et al*., 2020). Furthermore, the soils of the playgrounds themselves are highly contaminated with lead from solid mine waste from tailings and the 'Black Mountain' (Human Rights Watch, 2019). Ettler *et al*., (2020) indicated that the bioaccessible fractions (BAFs) of pollutatnts from slag dust of up to 96% lead, 100% vanadium and 81% zinc, noting that the health risk to individiuals inhaling slag dust is high, even under

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conservative inhalation and ingestion of dust of 100mg per day. Studies by Caravanos *et al.*, (2014) as well as by Yabe *et al.*, (2015) have indicated that children younger than seven years of age are dispproportionately affected by lead toxicity in Kabwe, with 18% (Chowa), 57% (Kasanda) and 25% (Makululu) of children having elevated blood lead levels (BLLs) greater than 65μg/ dL. There are both behavioural and biological reasons for this (Yabe *et al.*, 2015).

Symptoms of lead toxicity in children with elevated BLLs include aggresion, delinquent behaviour as well as attention deficit hyperactivity disorder (ADHD), delayed learning and lower IQ compared to peers (Burga and Saunders, 2019). This is the result of inhibition of absorption of the metals calcium, iron and zinc which are vital for neurodevelopment (Burga and Saunders, 2019). Adults exposed to lead exhibit the same neurological symptoms as children do, though the effects manifest at higher BBLs (Burga and Saunders, 2019). It should be stressed that there is no known safe limit of exposure to lead in children, while chronic exposure results in irreversible effects on affected individuals (Human Rights Watch, 2019).

**Remediation of Lead Contamination**

Despite the negative effects of lead contamination on human health, no significant remediation has been carried out to mitigate lead exposure or clean-up the contaminated areas. A 2003 World bank funded project which provided lead chelation therapy has run its course and therapy is currently unavailable (Caravanos *et al.*, 2014). Other attempts from the same project involved surface soil removal with replacement, soil remediation and relocation residents from lead contaminated communities (Caravanos *et al.*, 2014; Human Rights Watch, 2019). Studies are on-going, most exploring the chemical remediation of HM contaminated environments such as lead. This includes the use of chemical immobilizers like raw dolomite, calcined dolomite and magnesium oxide by Tangviroon *et al.*, (2020). Tangviroon *et al.*, (2020) showed that immobilizers precipitate of hydroxides of lead and zinc, decreasing their leaching concentration below regulated values. The hydroxides of lead are however, not entirely safe either. They possibly act like ionic lead, are suspected carcinogenic when inhaled or swallowed, affect fertility and are toxic to the developing foetus (Tangviroon *et al.*, 2020). It is therefore imperative that non-chemical methods of remediation are explored to mitigate the effects of lead toxicity on human health. Leteinturier *et al.*, (2001) investigated a phytogeochemical approach to Pb remediation and proposed that phytostabilization using identified indegenous taxa, is the only viable solution to mitigating the effects of lead contamination. Another study by Kachenga (2017) explored the phytoremediation potential of indeginous plants growing at tailings dams contaminated with copper and suggests that more research is needed to identify indigenous plants with potential for phytoremediation of HMs including Pb. Furthermore, Uchida *et al.* (2017) concluded that some indegenous plant species remain viable during the dry season and can consequently be used for phytoremediation of HMs. A more recent study by Festin *et al.*, (2019) proposed expanding the pool of plant species for phytostabilization as well as the phytostabilization potential of organic amendments such as biochar.

## Methodology

This paper is based on a literature review on lead exposure in Zambian towns. It also draws on articles from the media, which highlight the sources and effects of lead contamination in Zambia. A database search of EBSCO Host and Google Scholar was done using the key terms 'bioremediation', 'health effects', 'lead contamination' and 'lead toxicity'. Author versions/ pre-prints relevant to the paper were included in the review.

## Results

The literature search shows that lead contamination is pervasive in Zambian towns. The most

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contaminated towns are mining towns, though lead contamination has been identified in water bodies which run through mining towns. The popular media (BBC News, 2020; Branan, 2008; Brink, 2019; The New Humanitarian, 2005), human rights advocates (Human Rights Watch, 2018, 2019) as well other stakeholders from the general population (Leighday, 2020; Mwenda, 2020) recognize that mitigating the effects of lead contamination is important in ensuring the welfare of the general population and children in affected towns in particular. The literature has highlighted three main exposure routes shown in the figure 1.

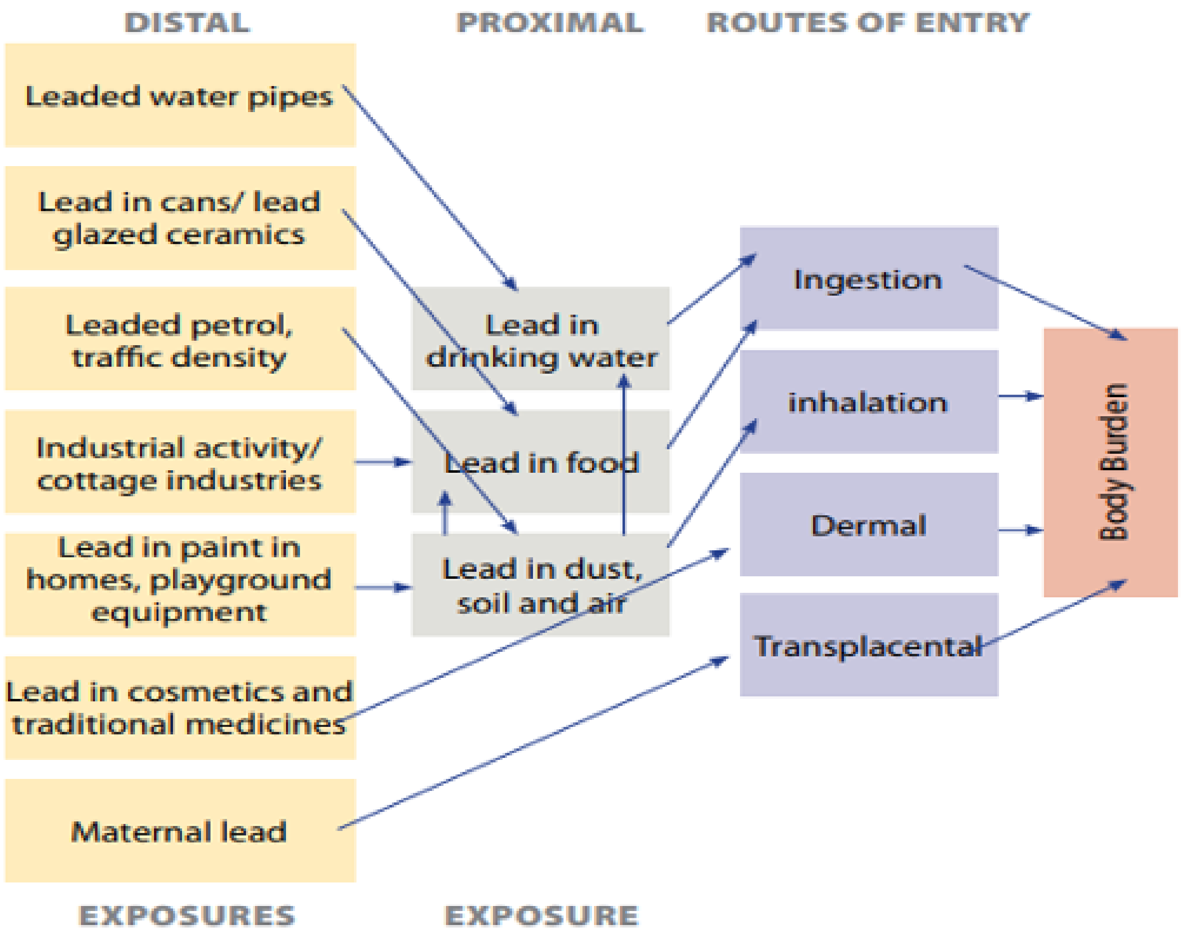


**Figure 1.** Sources and routes of exposure to lead metal (Source WHO, 2015).

According to Plumlee and Morman (2011), exposure routes are the various ways in which humans take up substances from the environment. There are three main exposure routes namely inhalation, ingestion and eye/ skin contact (Plumlee & Morman, 2011; The World Health Organization, 2015). The main exposure routes through which both adults and children are exposed to lead are ingestion (Ikenaka *et al.*, 2010; Ikenaka *et al.*, 2012; Yabe *et al.*, 2011; Mwase *et al.*, 1998; Nakayama *et al.*, 2013; Yabe *et al.*, 2013; Syakalima *et al.*, 2001; Yabe *et al.*, 2015) and inhalation (Branan, 2008; Caravanos *et al.*, 2014; Ettler *et al.*, 2011; Ikenaka, *et al.*, 2010; Ikenaka *et al.*, 2012; Makondo *et al.*, 2013; Nakayama *et al.*, 2011; Nakayama *et al.*, 2013; Tembo *et al*, 2006; Yabe *et al.*, 2015).

Furthermore, the literature review shows that the primary source of lead contamination in Zambian towns is the mining and smelting industry, which contaminates soil (Lindahl, 2014; Nachiyunde *et al.*, 2013; Tembo *et al.*, 2006), sediment as well as

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water bodies which flow through or receive water from the mining towns (Mbewe *et al.*, 2016); (Mkandawire *et al.*, 2017). Lead-based paints are also a source of lead contamination which is pervasive in primary settings such as homes and schools (IPEN, 2020; Musenga *et al.*, 2017; The World Health Organization, 2015). Moreover, roadside pollution from leaded petrol phased out March 2008 (Makondo *et al.*, 2013; United Nations Environment Programme, 2010) continues to be of great concern due to the cumulative and environmental persistence of Pb (Nachiyunde *et al.*, 2013; Tembo *et al.*, 2006). The metal's behaviour enables it to accumulate in the food chain including plants and humans are exposed via ingestion (Nachiyunde *et al.*, 2013). Evidence to the accumulation of Pb in plants is provided from the study by Mihaljevic *et al.*, (2011).

Studies carried out on various segments of the towns, include analysis of roadside soil (Makondo *et al.*, 2013; United Nations Environment Programme, 2010), soil and sediment (Ettler *et al.*, 2011; Ikenaka *et al.*, 2010; Tembo *et al.*, 2006). Other studies focused on living organisms including trees on the Copperbelt (Mihaljevi *et al.*, 2011), fish (Mbewe *et al.*, 2016; Mwase *et al.*, 1998; Syakalima *et al.*, 2001), domestic animals like chickens and cattle as well as wild animals like rats and Lechwe antelope (Ikenaka *et al.*, 2012; Nakayama *et al.*, 2013; Syakalima *et al.*, 2001; Yabe *et al.*, 2011; Yabe *et al.*, 2013). There have also been human studies, focussed on the analysis of children's BLLs (Caravanos *et al.*, 2014; Pure Earth, 2014, 2017; Yabe *et al.*, 2015). Efforts towards remediation, which have shown promising results are underway (Hiwatari *et al.*, 2019; Kachenga, 2017; Tangviroon *et al.*, 2020; Uchida *et al.*, 2017; The World Bank, 2020b).

## Discussion

The literature has highlighted the dangers lead contamination poses to humans. The literature cited has shown that the primary source of lead contamination in Zambian towns is mining, which historically accounts for most HM contamination in general (Lindahl, 2014). One source of lead poisoning which has not received as much attention as mining and smelting is lead paint, which is still used in the country. Nationwide, one can surmise that household exposure to lead from solvent-based paints is of great concern as highlighted by Musenga *et al.* (2017) and IPEN (2020). For adults, occupational exposure from lead-containing paints occurs during painting. Over time as the paint peels and is converted into fine particulate material such as dust, it contributes to lead-contaminated house dust which occupants are exposed to (Fig. 2).

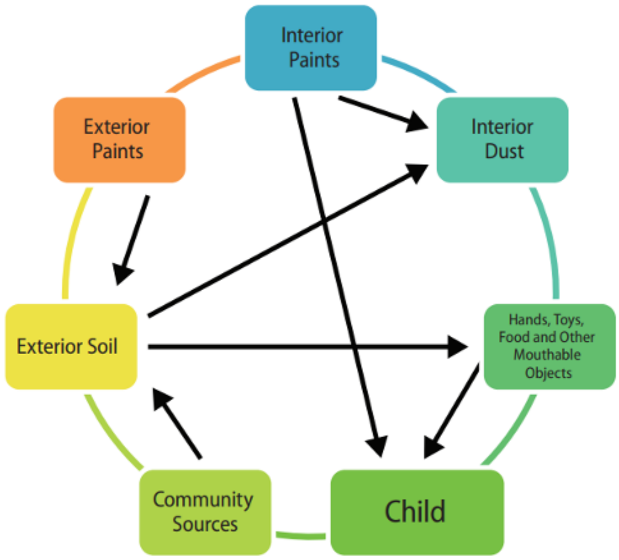


**Figure 2.** How children are exposed to lead from environmental sources (source Wani et al. 2015).

Children are particularly at risk from lead contaminated dust, both indoors from flaking lead-containing paints, as well as outdoors due to their hand-to-mouth and object-to-mouth behaviour (Burga and Saunders, 2019).

Furthermore, the coloured paints are preferred for painting the interiors of buildings as well as equipment on children's playgrounds in various schools. This should be a source of concern, as it has been shown that 50% of brightly coloured paints on the Zambian market contain elevated concentrations of lead (IPEN, 2020; Musenga *et al.*, 2017). The same analysis by Musenga *et al.*, (2017) showed that 100% of white paint had

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lead concentrations, though concentrations were less than 90ppm. Children are also more likely to ingest and inhale lead contaminated dust as the play indoors or outdoors (Musenga *et al.*, 2017) (Fig. 3).

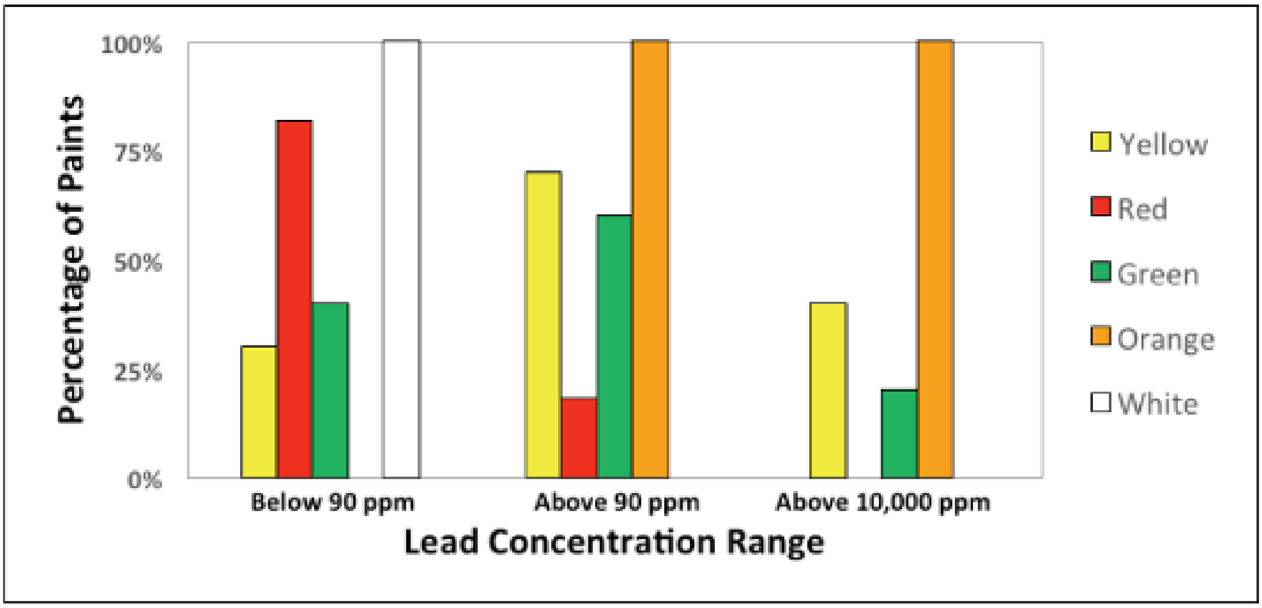


**Figure 3.** Distribution of lead concentrations in home-use solvent-based paints by colour (Musenga et al., 2017)

**Table 1**. *Distribution of lead concentration by colour (Musenga et al., 2017).*

| Color | No. of Samples | No. of Samples Above 90 ppm | No. of Samples Above 10,000 ppm | Minimum Lead Content (ppm) | Maximum Lead Content (ppm) |
|---|---|---|---|---|---|
| Red | 11 | 2 | 0 | < 60 | 1,000 |
| White | 11 | 0 | 0 | < 60 | < 60 |
| Yellow | 10 | 7 | 4 | < 60 | 88,000 |
| Green | 5 | 3 | 1 | < 60 | 13,000 |
| Orange | 2 | 2 | 2 | 33,000 | 120,000 |

Further compounding the problem is the fact that these paints are easily accessible due to the relatively low cost ranging between ZMK35 to ZMK150 at the time of analysis of concentration of lead in paints (Musenga *et al.*, 2017).
Rees and Fuller (2020) concluded that as many as one third of the world's children, most of them from Africa and Asia are exposed to elevated Pb levels of 5µg/dL or higher. This is corroborated by reports from the World Bank, which estimates that of the more than 10, 000 children tested for lead toxicity, 2, 500 had elevated BLLs of 45µg/ dL or higher (The World Bank, 2020a). This is still cause for worry as lead toxicity occurs even upon exposure to relatively low concentrations of the heavy metal, with serious effects resulting from chronic exposure. For instance, Yamada et al. (2020) concluded that 74.9% of residents in the vicinity of the closed Pb-Zn mine in Kabwe had BLLs greater than standard reference level for lead poisoning of of 5 µg/dL. Lindahl (2014) and Yamada *et al.* (2020) highlight the fact that the scale of lead poisoning in affected

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towns remains immense even in cases where mining has stopped, as is the case with the Pb-Zn mine in Kabwe, which was closed almost three decades ago. This is particularly worrying because there is no known safe limit for exposure to the heavy metal in children (Human Rights Watch, 2019). The lack of safe level of exposure for children, coupled with prenatal exposure, behavioural and biological factors mean that children are disproportionately affected by lead toxicity as evidenced by the alarmingly elevated BLLs of children tested. Children's CNS is more susceptible to lead toxicity (Yabe, *et al.*, 2015), while neonatal exposure occurs via pregnant females (Burga and Saunders, 2019; Human Rights Watch, 2019). Toddlers are exposed via nursing mothers (Yamada, *et al.*, 2020) and coupled with nutritional deficiencies of Ca or Fe, they tend to absorb more lead compared to adults (Yabe, *et al.*, 2015). This causes disordered behaviour such as aggression, Attention deficit hyperactivity disorder (ADHD) and delinquency (Burga and Saunders, 2019) which has implications on educational achievement due to low IQ (Burga and Saunders, 2019). Other negative effects of lead exposure in children are biological and include hypertension, reproductive problems and developmental (Burga and Saunders, 2019; The New Humanitarian, 2005).

Current analysis of different methods of post mining landscapes restoration have shown that bioremediation is much more superior to physical and chemical methods (Rigoletto *et al.*, 2020). The biggest disadvantage of both the physical and chemical methods is that they are too expensive. In most cases these methods also work better in combination with the biological methods.

**Bioremediation of Lead Contamination**

The World Bank (2020a) notes that progress has been made towards remediation under the Zambia Mining and Environmental Remediation and Implementation Project. Through overall implementation progress is rated as 'moderately unsatisfactory' as of December 21$^{ST}$, 2020, there has been some success. One success story involves the remediation of Mine Primary School which lies a mere 198.12 meteres from the dumpsite under the ZMERIP (The World Bank, 2020b). The report is however silent on the nature of remediation underway. Uchida *et al.*, (2017) provided a convincing argument for bioremediation when they identified Pb-tolerant plants including those belonging to the families *Caesalpiniaceae* and *Fabaceae* which could be used for phytoremediation as they remain viable all year round. Plants are a good choice for bioremediation because they stabilize soil and reduce air-borne particulate material such as dust, thus reducing exposure to humans living in Pb-contaminated areas. Phytoremediation although cheap, it is time consuming. It takes many years to restore a contaminated area. Bioremediation using fungal and bacterial species is much more preferred method (Rigoletto *et al.*, 2020). It has a potential to be used cheaply on a large area.

## Conclusion

Though mining and smelting activities at the Pb-Zn mine in Kabwe ceased almost three decades ago, the effects of lead contamination remain a critical problem in Zambian towns affected by the mine's legacy. The prevention of lead exposure as well as lead remediation need to be prioritized by various stakeholders as this will address the various health, educational and environmental concerns posed by lead toxicity. The use of sustainable bioremediation strategies should be encouraged in lead contaminated areas in Zambia.

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## Conflict of Interest

The authors declare that there are no conflicts of interest.

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