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Economic Development, at What Cost: The Case of Kabwe, Zambia

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Abstract

Lead and zinc mining operations in Kabwe, Zambia, ceased in 1994. However, the toxic waste/dump from almost a century of mining is still causing illness and death to many residents who unknowingly were exposed to poisonous waste over time. The mine owners deliberately kept information about the impact of lead exposure on health from employees and residents. Mine hospitals and clinics, which treated all mineworkers and their families, did not share the actual cause of the illnesses with the patients for fear of legal liabilities. Instead, once diagnosed, workers affected by lead were often transferred to divisions in different cities where they continued to suffer from the lead poisoning effects or died. This paper discusses Kabwe's transformation to a vibrant city through mining at the expense of the residents' health as the mines dumped toxic waste without the citizens' knowledge, dexterous effects on the residents, and why these toxic dumps exist long after the mine closures. The paper includes recommendations to rehabilitate the city.

Keywords: Dexterous; Environmental degradation; Mining; Remediation; Rehabilitation; Economic development; ZCCM-IH; Anglo american corporation; Roan selection trust; Consolidated copper mines

Introduction

The closure of lead and zinc mining/refining operations, the catalyst for economic development in Kabwe, Zambia, a city of 300,000 people, left a deeply toxic mountain of tailings and slag locally known as the black mountain. The residue earned the town a spot on "the world's top ten most polluted cities." Despite the rehabilitation efforts over the years, little has changed as the mine waste continues to poison children and adults, resulting in decapitating illnesses or death. Anglo American Corporation owned the Kabwe mine from its inception.

Methodology

Literature review

Even when the assets were transferred to Nchanga Consolidated Copper Mines in 1969 and 1982, when Zambia Consolidated Copper Mines (ZCCM) assumed majority ownership and control, AAC still maintained a minority equity position in the Company. Since ZCCM closed the mine, literature has increased about the century-long legacy of lead poisoning at Kabwe, which has left residents still suffering from the consequences of economic development.

Musonda and Tembo from the University of Zambia examined the soil in areas surrounding the abandoned mine to determine lead and zinc soil contamination [1]. The investigation revealed that lead and zinc content in the soil averaged 1.6 percent and 3.9 percent respectively for soils adjacent to the mine, and 10 milligrams per kilogram (mg/kg) lead and 20 mg/kg zinc for areas further away the mine. The contamination is attributed to "wind dispersion of particulate matter and dry deposition" of the mine waste, thus poisoning the residents who inhaled the particulates or exposed them to the soil.

Yoshinori evaluated the spatial distribution of heavy metals such as lead, zinc, and cadmium on the Copperbelt and Kabwe to understand the extent and characteristics of pollution in each of the predefined clusters. The study concluded that heavy metal pollution existed in areas near mining activities [2].

Bose-O'Reilly et al. analyzed the health impact of lead exposure on children. They discovered that over 95% of children living in the mining neighborhood exhibited elevated blood lead levels of more than ten micrograms per deciliter (μg/dL). About 50% of the sampled children had blood lead levels of more than 45μg/dL, which is extraordinarily high and required immediate medical attention [3].

Yabe studied the effect of lead and cadmium on children's health by determining the presence of these metals in children's blood, feces, and urine. The results showed high lead and cadmium content in the sampled blood, feces, and urine, suggesting that exposure to both metals adversely affected children. The study recommended further clinical studies [4].

Pure Earth, formerly known as the Blacksmith Institute (Walsh), has written many reports about Kabwe concerning the pollution levels and the remediation efforts related to its participation in the collaborative effort between the government of Zambia, the World Bank, and no-governmental organizations on the Copperbelt Environment Project (CEP), a $65 million initiative to clean up toxic waste on the Copperbelt and Kabwe [5]. This project allocated $15 million to Kabwe ($10 million from the World Bank and $5 million from the Nordic Fund) (World Bank Group) [6]. These resources were not enough to create a dent in the pollution levels.

A characteristic of the existing literature is the emphasis on pollution and the failed efforts to rehabilitate the polluted sites. To the author's knowledge, none of the literature analyzes why the remediation efforts have been unable long after the closure of the mining operations. This paper seeks to add to the robust body of knowledge by reviewing existing empirical and qualitative evidence to ascertain why the pollution problems persist today and offers potential solutions.

The paper presents several distinct parts. Part I provides the literature review and methodology. Part II gives the background to put in context the role of mining in Zambia and the city of Kabwe. Part III examines the effect of lead and cadmium pollution on the health of the residents. Part IV describes the evolution of environmental regulations

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in Zambia and the impact on the cleanup efforts, and why the ecological problems exist today, followed by recommendations to remedy the situation. Part V presents the conclusions.

Background

Mining in Zambia, formerly known as Northern Rhodesia until its independence from British control in 1964, began in Broken Hill with rudimental activities in the 1880s. Full production gained traction in 1923 when Great Britain, through a charter to the British South African Company, gave mineral rights to large mining companies such as the Rhodesia Selection Trust and Anglo-American Corporation (a South African mining conglomerate), leading to the first commercial mining operation in 1928 (Powanga, n.d.) [7].

Mining spread to the Copperbelt province of Zambia, where copper deposits assaying up to 3.8% the highest in the world (Powanga, n.d.), were discovered to make the region the epicenter of mining activities in the country. Mining quickly became the mainstay of Zambia's economic prosperity. At independence, the mining industry played an even more significant role in the economy employing over 60,000 people out of the 4 million people, by far the biggest employer [8]. By 1969, the mining industry peaked at 700,000 metric tonnes of finished copper, becoming the world's second-largest producer of copper after Coldeco-Chile, accounting for over 95% of Zambia's export revenues and more than 20% of the Gross Domestic Product (Powanga, n.d.).

During the same year, the government consolidated the mining industry into Nchanga Consolidated Copper Mines (NCCM) and Roan Consolidated Mines (RCM), with the former Anglo-American Corporation holdings forming NCCM, while the Rhodesia Selection Trust properties became RCM (Powanga, n.d.). The government acquired a 51%-equity position in these two companies for majority ownership and control.

In 1982, the government merged the two companies to form a single state-owned mining enterprise, Zambia Consolidated Copper Mines (ZCCM), with the government of Zambia retaining 60% equity ownership. Kabwe mine became part of ZCCM (Powanga, n.d.).

Later, under the privatization Act of 1992, which established the Zambia Privatization Agency (Makanday), Zambia began transferring ZCCM's assets to the private sector by dividing the Company into eleven smaller units. The privatization process ended in 2000. The government retained minority shares in the new mining companies, as illustrated in Table 1 below (ZCCM-IH). ZCCM morphed into Zambia Consolidated Copper Mines Investment Holdings (ZCCM-IH), with the government of Zambia controlling 80% interest with the remaining 20% coming from minority shareholders (ZCCM-IH).

Investee company	ZCCM-IH shareholding	Company website
Ndola lime company ltd	100.00%	www.ndolalime.co.zm
Misenge environmental and technical services ltd	100.00%	Not available
Kariba minerals ltd	50.00%	www.karibaminerals.com
Maamba collieries ltd	35.00%	www.maambacoal.com
Konkola copper mines plc	20.60%	www.kcm.co.zm
Kansanshi mining plc	20.00%	www.first-quantum.com/our-business/operating-mines/kansanshi
Copperbelt energy corporation plc	20.00%	www.cecinvestor.com
Lubambe copper mine limited	20.00%	Not available
CNMC luanshya copper mines plc	20.00%	Not available
NFC africa mining plc	15.00%	Not available
Chibuluma mines plc	15.00%	www.metorexgroup.com/mine
Chambishi metals plc	10.00%	Not available
Mopani copper mines plc	10.00%	Not available
Nkana alloy smelting company ltd	10.00%	Not available

Table 1: ZCCM-IH ownership structure.

The City of Kabwe, then Broken Hill, named after a mining city in Australia, is the first mining town in Zambia. The discovery of lead and zinc deposits with lead concentrations as high as 20% in 1902 by T.G. Davey sparked the formation of the Rhodesia Broken Hill Development Company in 1904, which set the impetus for widespread mining in 1906.

In 1915, pig iron production commenced, and two years later, the Company commissioned a blast furnace for smelter operations. In 1928, an electrolytic zinc plant with an annual capacity of 15,000 metric tons was installed. The 1940s saw the beginning of underground mining operations. In 1946, the mine started producing ore that fed the blast furnace. In 1954, lead production peaked at 26,550 metric tons per year. These milestones were followed by installing an imperial smelting furnace (ISF) to produce lead and zinc from sulfide ores. In 1975, the Waelz Kiln plant was commissioned to process the carbonaceous material that previously could not be treated under the existing production methods ("BMR Group PLC," n.d.-a) [9].

The discovery of mineral deposits and the full-scale mining operations catalyzed the city's economic development, which evolved into one of the most known mines in Africa. Its strategic location between Lusaka and the Copperbelt's capital city attracted other economic activities such as the Mulungushi Textiles and the headquarters for Zambia Railways, whose railway links Zambia to the Indian and Atlantic Ocean ports. During this period, the city's population rapidly increased to 300,000 (Pure Earth; The New Humanitarian) [10,11]. The town was renamed Kabwe (7x7 Zambia Limited) in 1966, two years after independence (Makanday). As a mining town, Anglo American Corporation ran the mine and most services, including healthcare facilities. This practice continued even after NCCM and ZCCM took over the assets [12,13].

In the 1990s, ZCCM started to wind down its mining operations because the mine was no longer economically viable. During its lifetime, the mine produced the following metals in metric tonnes ("BMR Group PLC," n.d.-b):

- Zinc 1,800,000
- Lead (Pb) 800,000
- Vanadium Oxide 7,816
- Silver 80,000 kg
- Cadmium 235,000 kg

Cclosure came at a considerable price to Kabwe residents. The century of mining, leaching, smelting lead, cadmium, and vanadium ores, left a city polluted with hazardous concentrations of lead in the soil, water, and air. The contamination was due to deliberate mismanagement of tailings and slag dumping by Anglo American Corporation and ZCCM. At the time, there were no requirements to hold companies accountable for mine waste disposal and inform people about the hazards and consequences of heavy metal contamination.

The Kabwe mine site measuring about 3 square kilometers accumulated a mountain of toxic lead tailings and slag measuring 100 feet in height, containing over 6 million metric tons of waste has shown in Figure 1, which to date dominates the skyline of the city.

Figure 1: Black mountain dominating kabwe's skyline.

The toxic waste mountain, dubbed locally as the black mountain, has created a legacy of catastrophic and extensive environmental contamination and human exposure to mass lead pollution, leaving many residents, particularly children, dead and thousands more poisoned. Employees and the residents did not have access to information about the dangers of exposure to heavy metals to avoid legal liability. In addition, there was no government requirement to disclose such information (Bank; CDC; Makanday; Musonda and Tembo; Price). In 2013, the United Nations listed Kabwe as one of the ten most polluted cities in the world (The New Humanitarian) [14].

Effect of exposure to lead on the health of people

Sadly, the contamination is expected to continue for years to come as the lead dust from the black mountain permeates the streets of the nearby high-density areas of Kasanda, Katondo, Makululu, and Chowa townships and their neighborhoods. Lead, a metal widely used in medicine, vehicle batteries, ammunition, and water pipes, to mention a few, is a potent neurotoxin globally responsible for 143,000 deaths and 600,000 new cases of children with learning impairment every year [15]. When a human body is exposed to lead either through ingesting or inhalation, lead is stored in the teeth and bones and attacks organs such as kidneys, the brain, and the central nervous system, causing physical weakness, convulsions, coma, and death both children and adults. Exposure to lead causes severe mental retardation, cognitive impairment, and behavioral disorders or death in children. Impoverished children are particularly susceptible because their bodies absorb more lead when nutrients such as calcium and iron are absent. In women, exposure to high lead levels can cause miscarriage, stillbirth, premature birth, and low birth weight. Figure 2 below depicts the impact of lead on the human body. Note that lead is not the only contaminant of concern in Kabwe. However, the discussion centers on it due to its abundance and highly toxic nature. Other contaminations include high levels of cadmium and zinc (Musonda and Tembo).

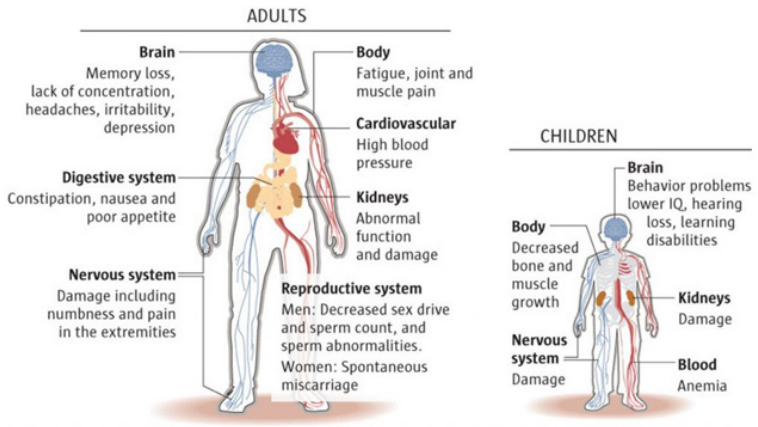

Figure 2: Impact of lead poisoning on the human body.

At the closure of the mine in 1994, soil contamination was extremely high. Lead content in the soil near the mine varied from 20,000 to 100,000 ppm. It was as high as 245,000 ppm in hotspot areas in contrast with the United States' regulatory permissible levels of 2,000 ppm for industrial sites, 400 ppm for residential locations, and 200 ppm for agricultural sites. The natural level of lead in soil is less than 20 ppm (Pure Earth).

Residual areas registered soil lead content ranging from 4,000 to 38,000 ppm and above 250,000ppm for houses near the wastewater canal that runs through several townships. The channel was designed to drain toxic material from the mine site safely but is now clogged due to years of neglect and tends to overflow during heavy rain spells spewing the poisonous waste, silt, and garbage on the banks, children's playing parks, people's back yards and gardens(Pure Earth) contributing to further contamination of the surrounding areas. Air samples from the nearby municipalities often exceeded 0.15 milligrams per cubic meter compared with the United States' limit of 0.02(n.d.). Also, the black mountain emits dust into the air, water, and soil surfaces close by unabated (Jesuit European Social Center; Makanday) [16].

A survey carried out between 2000-2008 by the blacksmith institute (Walsh) in collaboration with the World Bank under the CEP fund found that chronic exposure to lead over a prolonged period left many residents severely sick and damaged for life. Out of a city of 300,000 residents, over 210,000 people, up to 255,000 in some studies (Boyle; Pure Earth) had lead levels ranging from 60-120 micrograms per deciliter (ug/dl) (Blacksmith) or 12-24 times above the acceptable 5 ug/dl [17,18].

Between 2003 and 2008, the CEP (Komex International Ltd) charged in part with substantially reducing the blood lead levels in children to less than 25 µg/dl, found that children between 0-7 years old had lead blood concentrations, well above five µg/dl blood Reference level used by the Centers for Disease Control and Prevention (CDC) [19,20]. The study also showed that lead soil contamination, particularly within the townships adjacent to the defunct mine site, was higher than the acceptable level of 400pm for residential areas in the United States. Table 2 below shows the study results, which ranged from a low of 507 to 3,008 milligrams per kilogram, all way above the acceptable levels of the natural level of 200 parts per million.

Township	Soil content in soil (milligrams per kilogram)
Kasanda	3,008
Makandanyama	1,613
Chowa	1,233
Mutwe Wansofu	1,148
Makululu	870
Luangwa	507

Table 2: Lead soil contamination.

This observation is more concerning when the World Health Organization's opinion is considered, which states that there is no safe level of lead poisoning because even concentrations as low as five µg/dl, once thought "safe," may have been responsible for growth retardation, behavioral issues and learning disabilities in children [21]. In the case of Kabwe, some neighborhoods showed children's blood lead concentrations reaching fatal levels of 200 µg/dl with an average blood lead concentration of between 50 and 100 µg/dl.

In 2014, the Blacksmith Institute (Caravanos et al.) sampled children ranging in age from 2 to 8 years from hotspot areas to determine their exposure to lead poisoning. The tests showed a mean blood lead level of 48.3 µg/dl, and more than 50% of children needed medical treatment (Blacksmith Institute; Caravanos et al.). More than 26.5% of the children showed blood lead levels that exceeded 65 µg/dl, the highest reading on the LeadCare IIä instrument used in the tests, suggesting that lead more severely poisoned these children than the readings indicated.

In 2015, the University of Zambia, in collaboration with Hokkaido University, tested children from the severely contaminated townships of Chowa, Kasanda, and Makukulu. The results showed that 100% of the sampled children had blood lead levels of more than five µg/dl. The program recorded blood lead levels exceeding 65 µg/dL in Chowa 18%, Kasanda 57%, and Makululu 25%. Additionally, out of the sample population, fourteen children had elevated blood lead levels of between 150 µg/dL and 300 µg/dL (Hiwatari et al., n.d.) [22].

The progress in cleaning up the contaminated lead was glacial. As summed up by the 2016 World Bank report(World Bank Group), "Little has been achieved in remediating the situation" as, on average, children's blood levels were still "10 times above the United States safety limits and even higher in hotspots". Yabe et al echoed this observation—they reported the presence of alarmingly high levels of lead and cadmium in children's blood, feces, and urine of children living in the areas near the mine. Feces contained up to 2252 mg/kg, dry weight and urine content of up to 2914 µg/l and cadmium presence of up to 7.7 µg/l and up to 4.49 mg/ml kg, dry weight in fecal matter, and up to 18.1 µg/lin urine. The concentrations of metals were more elevated in children less than three years old than older children in the 4-7 year range.

Even more catastrophic, the actual number of people affected or will continue to be affected by lead poisoning is unknown because new contamination ways continue to emerge. First, the mine closure left employees jobless, including 5,000 employees from contractors supplying goods and services to the mine. The opening of Sable Zinc processing plant, Fine Steel, Zalco, Chiman Manufacturing Ltd, Ferro-alloy, and Super Deal near the Mine Plant in subsequent years, partially offset the joblessness. However, the mine closure completely changed the commercial landscape of this once vibrant city because the number of new jobs was lower than the job losses(BMR Group PLC).

Many residents in desperate need of income, up to now illegally mine the black mountain without professional tools, protective outfit and usually barefooted, as depicted in Figure 3. Artisanal miners sell the salvaged lead metal to the nearby Chinese Company, SuperDeal Investment Limited, which runs a furnace to process manganese ore (editor) [23]. The recovered metal at such a high risk fetches a meager US$0.25 for 25kg of zinc compared with $1.25 for the same quantity of coal (The New Humanitarian). Even worse, youths with little employment alternatives are also engaged in this activity to eke out a living or support their families with little or no income.

Figure 3: Illegal mining at Black Mountain.

Playing in the black mountain and drinking from the wastewater canal constitutes the second source of pollution. Children play in the black mountain soil breathing in harmful lead dust. They also drink from the heavily contaminated wastewater canal (Figure 4). From the preceding discussion, it is clear that that progress has been minimal, and the source of contamination still exists.

Figure 4: Children playing in toxic waste and drinking water from wastewater canal.

Reasons why the tailings and slag dump still exist

The government of Zambia and the international community made some effort to address the legacy environmental issues (ZCCM-IH) [24]. However, the effort to clean up Kabwe has at best been ineffective, not to mention the government's deafening silence on compensating the victims. In the interim, the environmental contamination continues.

Several factors contribute to the accumulation of toxic waste, the eventual failure of the cleanup operations, and the lack of victims' compensation. First, though the environmental laws came into effect in 1970, as shown in Table 3, long after the intense pollution had occurred over the years, the government's monitoring and control of the mine sites were ineffective. The environmental pollution worsened when ZCCM, took over the management and control of Zambia's mines as part of the nationalization exercise in 1969. The Company, now responsible for 80% of the country's export revenues, became bloated and riddled with inefficient bureaucracy, making it difficult for the environmental authority to monitor its activities (Makanday) effectively.

Year	Environmental component target/objective
1970	*Natural resources act/nature conservation
1971	*Game parks and birds act/wildlife conservation
1974	Natinal fisheries act/ protection
1978	Public health act/waste management and environment
1982	Ratified the 1972 world culture and heritage/ eco-tourism statutes of international union for the conservation of nature and natural resources(IUCN)
1985	Petroleum exploration and production act /pollution control conservation strategy/sustainable use of resources
1986	*Local administration act (trade effluents)/pollution control
1987	Zambezi river authority act/water resources management
1988	National heritage act/conservation tourism
1990	*enacted environmental protection and pollution control act/integrated pollution control and leads to the establishment of environmental council of zambia in 1992. *forestry act(amended in 1999) and currently under review ratified montreal protocol and vienn a convention
1991	*Zambia wildlife act(amended 1998)
1993	Ratified ramsar and bonn convention;and the endangered species of wildlife fauna and flora(CITES) covention on biodiversity.**water pollution control regulations(effluent and wastes si no.72)
1994	Ratifed basel convention /trans boundary hazardous waste; and pesticides and toxic substances regulations(SI.No. 20)/agriculture and environment
1995	Town and country planning act 1995(approval and revocation of development plans). The energy regulations act(cap 436;SI.No. 16 of 1995)/energy and environment.
1996	**Air pollution control(licensing and emissions standards)regulations(SI. No 141).Ratified UN framework combating desertification.
1997	Environmental impact assessment regulations (si.28)
2000	**Hazardous waste management regulations (SI No. 125)
2001	**Ozone depleting substances regulations (SI No. 27)
2003	*Water act: applies to water rights, impounds for irrigation
2006	Ratified kyoto protocol-UNFCCC
2008	Launched the first environmental policy
2011	Environmental management act no.12/repeals environmental protection and pollution act of 1990. more and stiffer penalties to violators. Water resources management act/repeals water act of 2003.
2013	Environmental Management act no.12/repeals environmental protection and pollution act of 1990. more and stiffer penalties to violators. Water resources management act/repeals water act of 2003.To make stringent all enviormental regulation.
	*Denotes repealed acts or regulations and **denotes repeals specially by environemntal management (licensing regulations)SI.No.112 of 2013.

Table 3: History of environmental regulation in zambia.

In the 1990s, the government enhanced the environmental regulations by enacting the Environmental Protection and Pollution Control Act/Integrated Pollution Control, which led to the establishment of the Environmental Council of Zambia in 1992. In 2011, the Environmental Council of Zambia, through the parliamentary Environmental Management Act, transformed the entity into the Zambia Environmental Management Agency (ZEMA), an independent statutory environmental and coordinating body (ZEMA) [25].

ZEMA was assumed responsibilities to "protect the environment and control pollution" and to "ensure sustainable management of natural resources, protection of the environment and prevent and control pollution," to safeguard the health and wellbeing of people, animals, plants, and the environment, among others. ZEMA produces various reports and oversees policies, plans, and programs that may impact the environment, such as mining, quarrying, and power plants. However, the contracts that the new mine owners signed with the government indemnified them from past environmental liabilities (ZEMA).

Second, the mining industry is the bedrock of Zambia's economy for export earnings and employment. The government shied away from addressing the dexterous environmental and health effects of mining waste on the surrounding communities. Though Kabwe Mine was owned and operated by Anglo American Corporation for about 80 years, the Company refused to own up its mess. Instead, it cut deals with the desperate Republic of Zambia, which previously had passed up the $2 billion offer from the Kafue Consortium during the privatization process to avoid cleaning up the area even though it was responsible for the mess. When B and R asked the Company in its October 1990 issue why it "did not own up to the killer mess,"? The response was, "Since the nationalization almost 40 years ago, (we) effectively took these issues into government hands. We are not in a position to comment further about the matter, but we certainly do not believe that Anglo American is in any way responsible for the current situation", implying that Anglo American corporation did not deny polluting but passed on the liability to the government.

Results and Discussion

Third, ZCCM, which took over from Anglo American Corporation, only succeeded in worsening the situation by operating the mines without proper environmental pollution controls, particularly during depressed revenues when the Company did not invest in critical capital equipment as part of the cost-saving measures. In 1985, an electrostatic

precipitator that captured particulate matter from the plant dust and smoke broke down. A replacement device was never installed (Makanday).

The concealment of information by the mine owners constitutes the fourth factor. Residents and employees were not aware of the lethal effects of lead poisoning both under Anglo American Corporation and under ZCCM. The mine owners deliberately kept this information away from the mine owners mainly because there was no legal requirement to disclose such information (Makanday) and for fear of legal liability. For example, the Makanday Zambia Centre for Investigative Journalism reported that "Kabwe miners who were subjected to medical checkups if found with high lead-blood levels, were either redeployed or transferred to other divisions where they eventually died without any compensation. By 1990, the number of personnel who were "leaded out" dramatically increased."

The same report stated that public health workers were not allowed to inform the victims of lead contamination. In some cases, doctors passed their symptoms as malaria infections. During this time, ZCCM owned the clinics and hospitals that treated these patients. The report quotes a former ZCCM staff saying, "It was quite frustrating for us because we knew the problem, but we could not tell the parents."

Additionally, there was no system for warning residents when excessive emissions or overflows from tailings dams occurred. Moreover, this practice continues even today. For example, in 2016, the Zambian high court ordered the London-listed mining and commodities trader Glencore to pay 400,000 Zambian Kwacha (£30,000) in damages to the widower of Beatrice Mithi, a politician that choked to death in Mufulira after inhaling Sulphur dioxide fumes emitted by Mopani's copper smelter(Rob, Davies) [26]. Mopani, a subsidiary of Glencore Mines, owns a smelter, a refinery, a concentrator, and a mine in Mufulira with an annual copper output of 98,869 tonnes of copper (ZCCM-IH), making it one of the world's biggest producers [27,28].

Mufulira residents have long complained about health issues arising from the smelter fumes. A group from the Jesuit European Social Centre touring the area could not breathe freely because of the overpowering toxic smelter fumes and were surprised to see children playing outside, suggesting that these children were exposed to the poisonous fumes daily. The group also observed an open sewer that ran along the dirt road that meandered through the municipality (Jesuit European Social Center) [29]. The conditions on the Copperbelt are encapsulated in the video at https://www.youtube.com/watch?v=uamzirLswjk&app=desktop by Alice Odiot and Audrey Gallet in collaboration with Stéphane Horel.

The fifth factor involves contractual obligations. During the privatization process in the 1990s, the new owners, after due diligence, demanded that the government shoulder the burden of environmental liabilities before completing the acquisition of the mines. The government agreed to retain the liability through the newly formed entity (Makanday), ZCCM-IH resulting in the insufficient rehabilitation effort.

Finally, the metal recovery technologies employed over the years did not fully recover the minerals, resulting in high mineral content in the slag and tailings residue, which later became a significant factor in the mine site rehabilitation efforts. When mining operations ceased at Kabwe, estimates show that 6.5 million metric tonnes of the tailings and slag still contained 5.48% zinc and 5.50% lead (BMR Group PLC). The government was reluctant to get rid of this waste in anticipation of attracting new investors to recover these metals.

After the mine closure, the government sold the surface rights to the mine site and the tailings stockpiles to the private sector in Table 4 depicts the progression of these transactions.

Year	Transaction
1999	In 1999 Sable Zinc Kabwe Limited (SZK) was formed and acquired the Kabwe Division Leach Plant and some of the mine tailings dumps from ZCCM. Sable Zinc Kabwe (SZK) Limited rehabilitated part of the Kabwe Leach Plant to recover zinc metal contained in the surrounding tailings with zinc recovered until 2004.
2006	SZK produced the first copper and cobalt from the Kabwe site using feed ore brought from the Metorex Limited operations at Ruashi Mine in the Democratic Republic of Congo (DRC).SZK obtained approval to convert the zinc circuits to a copper circuit to produce copper cathodes through solvent extraction and electrowinning (SX/EW).
2008	Berkeley Minerals Resources PLC (BMR), a London *AIM-listed enterprise purchased some of the Kabwe Mine Assets from Zincorous Investments and Dorset Solutions Limited.
2010	with permission from SZK, who still held the small-scale mining license over the Kabwe Mine Site area, BMR conducted verification processes on the Kabwe Tailings Dumps and finalized two JORC Resource Statements on the Washing Plant and Leach Plant Tailings dumps respectively, in 2012. During 2010, the small-scale mining license SML 1, now renumbered as 7081-HQ-SML, was sold by SZK to Enviro Processing Limited (EPL), a 100% subsidiary of BMR that is registered in Zambia, with Company registration No 88917. During 2012 BMR completed the acquisition of all the relevant assets at the Kabwe Mine Site, which included Mine Plots from ZCCM-IH, Alberg Mining and Silverlining and the Large Scale Mining License 6990-HQ-LML, previously LM1 from ZCCM-IH (EPL MPDP, 2013).

Table 4: Mine transactions since the closure.

Conclusion

Kabwe residents continue to suffer from the effects of decades of soil, water, and atmospheric heavy metal contamination, which exist even today despite initiatives by the World Bank, NGOs, and the government. The pollution was so extreme; the United Nations/ Blacksmith named the city one of the world's top ten worst polluted places. The residents were unknowingly lead-poisoned because the mine owners deliberately withheld information on the hazards and consequences of lead poisoning. The exposure has and continues to cause many deaths and illnesses today. Moreover, the mine owners did not compensate the victims. The cleanup efforts have been unsuccessful due to a myriad of reasons. The primary reason stems from the mining industry being the major source of government revenue; for that reason, it receives preferential treatment from the government. In Kabwe, the highly poisonous mining residue is still present because the government hopes to have the private sector recover metals from the rubble. The government sold the rights to the mine site to the private sector to extract the residual lead and zinc immediately after closing the plant make it impossible for any remediation efforts to remove the mountain of residue that had accumulated over time.

Though this study was limited to Kabwe, the same situation is happening on the Copperbelt evidenced by the incident in Mufulira where a government official died from inhaling sulfur dioxide contaminated air and the events described in the video. The paper's recommendations include stiffer penalties for polluting and incentives for compliance, compensating the victims, cleaning up the city through a fund that the mining industry will contribute to, and turning the city into an industrial park.

Recommendations

To redress the Kabwe situation and to prevent similar catastrophic events from happening at mine sites, the government must do the

following:

1. Demand reclamation plans from mine-owners in addition to the usual social and environmental impact assessments to allow mining companies to bring the land back to the initial stage once the mines reach the end of their economic life.

2. Establish a unit that will interpret applicable environmental rules and regulations to potential miners to avoid inconsistencies or conflicts between and within various laws, management and ensuring that the rules and regulations are applied consistently.

3. Establish a cleanup and compensation fund for Kabwe with amounts paid by the polluters (Anglo America and ZCCM-IH) plus a nationwide tax of 1% tax on beer, cigarettes, gasoline, and hotels and transportation to be plowed back into cleaning up Kabwe and compensating the victims.

4.Turn Kabwe into an industrial park once the cleanup is comcompletion to catalyze new economic activities and create new jobs.

5. Increase fines and penalties for noncompliance and extend negligence liabilities to company executives. Additionally, build in incentives for compliance tie them to the length of incidence-free periods.

References

1. Musonda BM, Tembo F (2004) Lead and Zinc pollution of soils in the Kabwe lead-zinc mining area. J Sci Technol 1(3): 77–85.
2. Ikenaka Y, Nakayama SMM, Muzandu K, Choongo K (2010) Heavy metal contamination of soil and sediment in Zambia. Afr J Environ Sci Technol 4(11).
3. Bose-O'Reilly S, Yabe J, Makumba J, Caravanos J, Ericson J, et al. (2017) Lead intoxicated children in Kabwe, Zambia. Environ Res 165: 420-424.
4. Yabe J, Ikenaka Y, Ishizuka M, Kabalo Nketami A (2018) Lead and cadmium excretion in feces and urine of children from polluted townships near a lead-zinc mine in Kabwe, Zambia. HUSCAP 202: 48-55.
5. Walsh B (2007) The World's Most Polluted Places.
6. World Bank Group (2016) The World Bank.
7. Powanga L (2019) Divesting the Zambian Mining Industry.
8. Bank TW (2012) Zambia - Copperbelt Environment Project (cep).
9. BMR Group PLC (2010) BMR Group PLC, Kabwe.
10. Pure Earth (2007) World's Worst Pollution Problems.
11. The New Humanitarian (2006) Kabwe, Africa's most toxic city.
12. 7*7 Zambia Limited (2017) Investing in people an investment for a better future.
13. Makanday (2017) Hidden documents reveal the shame of Kabwe's toxic deaths.
14. Price L (2017) The Black Death of Kabwe.
15. Brink S (2016) What Flint, Mich., And Kabwe, Zambia, Have In Common.
16. Jesuit European Social Center (2017) A choking beast of prey – Mega Mines in Zambia. JESC.
17. Blacksmith (2009) Kabwe-Project-Completion.
18. Boyle A M. (2017) The World's Most Toxic Town.
19. Komex International Ltd (2002) Environmental Assessment.
20. CDC (2019) Blood Lead Levels in Children.
21. WHO (2018) Lead poisoning and health.
22. Hiwatari M, Yamada D, Hangoma P, Narita D, Mphuka C, et al. (2020) Assessing the population-wide exposure to lead pollution in Kabwe, Zambia: an econometric estimation based on survey data. 10: 1-11.
23. Editor (2010) Zambia: Chinese firm to process manganese in Kabwe.
24. ZCCM-IH (2016) Zambia Extractive Industries Transparency Initiative.
25. ZEMA (2019) Zambia Environmental Management Agency.
26. Rob D (2016) Zambia: Court orders Glencore to pay compensation after ruling toxic emissions at copper plant led to death of politician. BHRRC.
27. ZCCM-IH (2019) Annual reports ZCCM Investments Holdings Plc.
28. ZCCM-IH (2019) Who We Are.
29. BMR Group PLC (2004) Father of vannamei.