

# Environmental Effect of Lead Contamination on Mining Communities in Zamfara State, Nigeria: A Review

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## Abstract

Farming constitutes the primary source of livelihood for the people of Zamfara State, Nigeria. With the increased awareness among the people of solid minerals abundance in the region, artisanal gold mining activities have increased in and around residential compounds and community areas. The competitive struggle to earn more money amidst unsafe mining practices releases tons of lead dust from processing of contaminated gold ore into the air. This is deposited on soil surfaces, drinking water, edible plant leaves and fruits. Investigations revealed alarming levels of lead concentrations in the environment. Lead concentrations in soil around the residential compounds have reached over 100,000 ppm. This is extreme over the concentration limit of 400 ppm for residential areas applied in USA and France. Similarly, the mean blood lead level concentration of 119 µm/dL found in more than 100 children diagnosed with severe lead poisoning in Daretta and Yargalma villages is alarming considering that 10 µg/dL blood lead level is associated with impaired neurological development in young children. The higher lead levels reported in soils of farmlands and cultivated crops (385 to 688 mg/kg) in Abare village are due to processing of contaminated gold ore. The lead pollution crisis, which is widespread, covers at least 47 villages affecting more than 30,000 residents most of them children. The United Nations and multiple partners from within and outside Nigeria have been working relentlessly since the lead poisoning outbreak was reported by MSF in March, 2010. They aim to achieve a healthy, secure and sustainable environment in the affected region through coordinated and holistic strategy.

**Keywords:** Environment • Contamination • Mining communities • Lead poisoning • Zamfara state

## Introduction

The proliferation in recent time of unregulated artisanal gold mining activities in Zamfara State, Nigeria has fuelled instability and lead poisoning crisis across gold mining communities primarily in Anka and Bukkuyum Local Government Areas thereby placing a significant burden on the already fragile economy and health care system in the state [1]. The act of manual grinding into fine particles and processing of gold found in lead-rich ore resulted in extensive dispersal into space of lead dust, causing massive environmental contamination from the lead deposits in villages and compounds where the gold ore are being processed. In March, 2010, Medecin Sans Frontieres (MSF) (Doctors without borders) discovered an unprecedented epidemic of lead poisoning in the State. An estimated 400 to 500 children were reported to have died as a result of lead absorption [2]. A team of experts comprising members from the CDC

(Centre for Disease Control) office in Abuja, the Nigerian Federal Ministry of Health, Nigerian Field Epidemiology and Laboratory Training program, the World Health Organization (WHO) and MSF came to Zamfara State. The team was sent to one of the villages to find out the cause of the children's death [3].

In response to the poisoning crisis, the Joint Environment Unit (JEU) from the office of the United Nations Resident Coordinator (UN RC) in Nigeria in collaboration with the Federal Ministry of Health (FMOH) led field a sampling and analysis mission to investigate the lead pollution and poisoning situation primarily to determine the quantities of lead in ground and surface water. These paved the way for the subsequent assessments of lead levels in soil [2]. The mission was supported by the Government of the Netherlands with technical experts and equipment deployed from the Environment Assessment Module (EAM), comprising of a mobile laboratory designed and assembled specifically for international deployment. Mapping support was provided by the Operational Satellite Application Program (UNOSAT) of the United Nations Institute of Training and Research (UNITAR) (Table 1) [4].

**Table 1.** Scope of lead pollution and poisoning in Zamfara as of September, 2010.

S.No	Village	Pollution	Poisoning	Treatment
1	Yargalma	Confirmed	Confirmed	Ongoing (<5 years)
2	Daretta	Confirmed	Confirmed	Ongoing (<5 years)
3	Abare	Confirmed	Confirmed	Emergency Only
4	Sunke	Confirmed	Confirmed	Emergency Only
5	Tungar Daji	Confirmed	?	Anticipated
6	Duza	Confirmed	?	Anticipated
7	Tungar Guru	Confirmed	?	Emergency Only

Source:[4]

## Heavy Metals Concentration and Environmental Concerns

Lead is one of the naturally occurring non-essential heavy metals in soils. Exposure to lead can be biologically, chemically and physiologically toxic to the human body even at low concentrations [5]. Exposure to lead is very dangerous, especially for children and once deposited on the soil, it is very difficult to remove. The entire contaminated soil has to be replaced with clean one [3]. Lead contamination is a phenomenon in which the lead content in the environment outweighs natural concentration and causes deterioration of the environmental quality [6]. Heavy metals have specific gravity greater than 5.0 g/cm<sup>3</sup> and atomic number greater than 20 [7]. Despite global efforts over the past several decades to reduce heavy metal pollution, their exposure has persisted, posing great and urgent environmental and public health concerns [8,9]. Serious human health risks particularly for children under 6 years of age are associated with lead poisoning. Once absorbed by the human body, lead is extremely difficult if not impossible to remove. Hence, prevention is better than cure (Table 2) [10].

**Table 2.** Levels of lead contamination in soil by USEPA standard.

Soil lead level (mg/kg)	Lead contamination status of soil
Less than 150	None to very low
From 150 to 400	Low
From 400 to 1,000	Medium
From 1,000 to 2,000	High
Greater than 2,000	Very high

Source: [10]

## Assessment of Lead Contamination in Zamfara Communities

As of the beginning of September, 2010, lead contamination was confirmed in seven villages and a total of 430 compounds were identified. These areas were subsequently earmarked for remediation in order to give way for medical treatment of the affected persons mostly children. The affected villages are Abare, Tungar Guru, Tungar Daji, Sunke, Duza, Yargalma and Daretu [2]. Investigations of other villages in the state revealed that lead poisoning was widespread. Thousands of children had dangerous levels of lead in their blood with several deaths of children and animals. Reports have indicated that lead poisoning was largely responsible for the disappearance of ducks populations in this and other parts of northern Nigeria since early 2010. It was the largest known outbreak of lead poisoning in history [3]. The town of Bagega in Anka Local Government Area is considered the national hub for the informal gold trade and ore processing. Many family compounds and communal areas in the town had lead concentrations in the soil above 1,000 ppm [1].

### Lead Decontamination Activities

Zamfara State Ministry of Environment and Solid Minerals (ZMoE) with technical assistance from the Blacksmith Institute (BI) of New York and TerraGraphics Environmental Engineering (TG) have helped to secure clean environments in the seven contaminated villages and 430 compounds which commenced from June, 2010 to March, 2011 [11]. The remediation process include identification of contaminated areas in the villages, removal of all contaminated soil and deposition in secure landfill sites and its replacement with clean soil [3]. The World Health Organization and multiple partners have been assisting the State and Federal Authorities to prevent further environmental contamination with lead. These include relocation of ore processing activities and storage of ore materials away from villages; adoption of new processing methods that will reduce the emission and dispersal of lead dust, as well as, hygiene measures such as removing contaminated clothes, socks, shoes and washing before returning home [1].

### Sources of Lead Contamination

Lead is naturally occurring bluish-gray metal present in small quantities in the earth's crust [4]. Lead typically occurs in soils at concentrations ranging from 10 to 50 mg/kg but due to contamination from various industrial sources, urban soils often have much greater lead concentrations frequently ranging from 150 mg/kg to as high as 10,000 mg/kg at the base of a home painted with lead-based paint [10]. The main sources of lead exposure are lead-based paint, gasoline, cosmetics and toys, household dust, industrial emissions and lead contaminated soils [12]. Lead is a very soft metal used in pipes, drains, soldering material, covering of ammunitions, batteries and as gasoline additives [5,13]. An estimated 4.5 to 5.5 million tons of lead used in gasoline remain in soil and dust. Also soils adjacent to heavy traffic volume areas in cities and busy roadways have the highest concentrations of lead [10].

### Mechanism of Lead Contamination

Lead occurs naturally in soil and does not biodegrade over time but remains in soil for thousands of years [10]. Lead tends to accumulate in the upper 1 to 2 inches of the soil unless the soil has been disturbed by excavation, tillage, landscaping or gardening activities. Soil lead is held tightly on very fine clay and organic matter surfaces, so as organic matter increase, lead availability decreases [14]. Some lead added to the soil may combine with other elements in the soil to form lead containing minerals such as lead phosphate (pyromorphite) under high soil pH [10]. Movement of lead from soil into ground water will depend on the type of lead compound and characteristics of the soil, and when released into the air, lead may travel long distances before settling to the ground [4]. The higher levels of lead contaminations recorded in the soil and cultivated crops (385 to 688 mg/kg) in farmlands of Abare village is not unconnected with the processing of gold contaminated with lead ore in the village.

### Potential Hazards of Lead Contamination

Humans and animals get exposed to lead either by direct contact with contaminated soil mass, fine soil particles, air-borne dust, contaminated

clothing, shoes or even pets in the house [10]. Exposure may result from eating garden produce contaminated with lead taken up from soil into the plant tissues or lead dust on edible leaves and fruits. When lead dust is in the air, children and adults can breathe in lead particles. They can also be exposed to drinking water or eating food contaminated with lead (Table 3) [4].

**Table 3.** Tolerance limits of some heavy metals in drinking water by WHO standard.

S.No	Heavy metal	Upper limit of concentration (mg/L)
1	Pb	0.05
2	Hg	0.001
3	Cd	0.01
4	As	0.05
5	Se	0.01
6	Cr (VI)	0.05
7	Cu	1.0-1.5
8	Zn	5.0-15.0

Source: [6]

Children are more vulnerable to lead poisoning than adults. Lead poisoning in children causes neurological damage leading to reduction in intelligence, loss of memory, learning disabilities and problems of coordination. Prenatal exposure to lead can cause reduced birth weight, immune suppression and allergies [15]. Lead poisoning manifestations in adult human populations may include tooth decay, loss of appetite, headache, confusion, apathy, irritability and insomnia [16]. Like the humans, animals poisoned by lead exhibit both abdominal and neurological disorders (Table 4) [17-22].

**Table 4.** Maximum permissible limits of some heavy metals in soils by WHO standard.

S.No	Heavy metal	Maximum permissible levels in soil (mg/kg)
1	Pb	100
2	Cd	3
3	Cr	100

Source:[18]

### Situation Report and Ongoing Challenges on Zamfara Lead Poisoning

The center for disease control (CDC) has been instrumental in the environmental health investigation and emergency response. The CDC as of 2016 estimates that there were over 40 additional contaminated villages affecting more than 30,000 residents. The situation is such that the prevailing environmental and health emergency cannot be resolved quickly. It requires remediation alongside medical treatments and persuading people to adopt new practices and behaviors. WHO and multiple partners have positioned that, resolving the Zamfara lead poisoning disaster requires coordinated and integrated medical intervention, environmental remediation and establishment of safer mining and processing methods [1,3]. Consequently, there is the need for long term engagement on the part of leaders and authorities at community, state and federal levels in the country. This will also require the engagement of health and environment professionals, technical partners and donors (Table 5).

**Table 5.** Regulatory standards (mg/kg) of Pb, Cr and Cd in soils by countries.

S.No	Country	Pb	Cr	Cd
1	Australia	300	50	3
2	Canada	200	250	3
3	China	80	150-300	0.3-0.6
4	Germany	1,000	500	5
5	Tanzania	200	100	1
6	Netherlands	100	180	13
7	New Zealand	530	20	3
8	United Kingdom	70	180	1.8
9	United States of America	200	11	3

Source: [18-22]

## Conclusion

Agriculture is the main occupation of the Zamfara people especially the rural populace. The area is also richly endowed with solid minerals including gold and the villagers had started mining gold to earn more money using unsafe methods. Lead contamination from the unsafe mining activities continued to become widespread in the mining communities causing high mortality rates among children and morbidity in adult populations. Animals were also not spared when they eat grasses or drink water contaminated with the lead. With constant remediation efforts, medical interventions and adoption of safer mining practices, lead contamination is envisaged to be reduced to its lowest minimum.

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