

## **An overview of the geology of health in Zimbabwe and surrounding areas**

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### Abstract

Geochemical anomalies of fluorine, arsenic, mercury, cadmium and other chemical elements in soils, sediments and water, as well as exposure to asbestiform materials in mining areas may adversely affect human and animal health. Rural and peri-urban communities in Zimbabwe living within the vicinity of mining and mineralized areas are most prone to the impacts of their environment because of they often rely on artisanal, small-scale mining, and subsistence agriculture. Cases of dental and skeletal fluorosis, mercury and arsenic poisoning and the more deadly mesothelioma have been reported in Zimbabwe dating back to the last millennium and mitigation measures have been proposed in a number of publications, though their implementation is still relatively poor. We intend to summarize the work done up to date on the effects of geological elements on human and ecosystems in and around Zimbabwe, their impacts and the need to further research and implementation of mitigation measures

Keywords: Medical Geology; fluorosis; mesothelioma; environmental and health impacts.

## **Panorámica de la Geología médica en Zimbabwe y áreas aledañas**

### Resumen

Las anomalías geoquímicas de fluoruro, arsénico, mercurio, cadmio y otros elementos químicos en los suelos, los sedimentos y el agua, así como la exposición a materiales asbestiformes en las áreas de minería, pueden afectar la salud del hombre y los animales. Las comunidades rurales y periurbanas de Zimbabwe, cercanas a los frentes de minería y áreas mineralizadas, están propensas a los impactos medioambientales porque dependen de la minería artesanal a pequeña escala y de la agricultura de subsistencia. En estas comunidades se han reportado casos de fluorosis en dentadura y huesos, envenenamiento por arsénico y mesotelioma, que es la mayor causa de muerte en el último milenio. Se han propuesto medidas de mitigación en numerosas publicaciones pero aún con relativa poca aplicación. Se pretende resumir en este artículo los resultados acopiados hasta la fecha en lo que concierne a los efectos de los elementos geológicos en el hombre y en los ecosistemas de Zimbabwe, sus impactos y la necesidad de continuar las investigaciones y la implementación de medidas para la mitigación de esos impactos.

Palabras clave: Geología médica; fluorosis; mesotelioma; impactos medioambientales; salud; Zimbabwe.

## 1. INTRODUCTION

The link between the geological environment and the health of human, animal and plant communities has been known for a very long time and is one that has increasingly gained prominence with more studies being commissioned into the area now referred to as Medical Geology.

Medical Geology is the study of the impacts of geologic materials and processes on animal and human health (Centeno 2010). It is viewed as a dynamic emerging discipline bringing together the geoscience, biomedical, and public health communities to solve a wide range of environmental health problems.

Geochemical anomalies of fluorine (F), arsenic (As), mercury (Hg), cadmium (Cd) and chromium (Cr) in soils, sediments and water may adversely impact human and animal health. These elements, if found in above average quantities against stipulated norms, may lead to different kinds of diseases which include the deformation of teeth and bones (dental and skeletal fluorosis), damaged central and peripheral nervous system, lung and bladder cancer, mesothelioma, among other deadly ailments. However, selenium (Se), besides causing juvenile cardiomyopathy and muscular abnormalities, it does present some desirable health benefits in various ways (anti-cancer, anti-aging, improved fertility, boosts immunity, among others). Other health benefits of these elements can be found in Finkleman (2006).

Sampling, soils and water analysis in the areas prone to such anomalies is essential in assessing the possible health threats presented by these elements. These anomalies are common in high productivity tropical regions which are characterized by high precipitation, high heat, as well as enriched soils; Zimbabwe is no exception.

Given the strain on the Zimbabwean economy and the collapse in the Zimbabwe's health services around 2008 led to a major setback to the already sidelined public and ecosystem health issue regarding the geological impacts of naturally occurring chemical elements on the health sector.

However, work is has been initiated to raise awareness and curb the widespread of such diseases caused by geochemical anomalies and occupational exposure to fibrous minerals. The major setback lies in the record keeping systems in the country, the unavailability of all the data required for analysis, environmental policies formulation and implementation.

## 2. BRIEF OVERVIEW OF THE SITUATION IN ZIMBABWE AND SURROUNDING AREAS

Most of the research done was focused on the different types of cancer, although without an established geological link, fluoride and mercury poisoning effects on human health. Some of the most relevant investigations and projects are discussed here.

Chokunonga et al. (Eds.) (2009, 2010) reported three cases of deaths resulting from Mesothelioma in the over 60-year age group in Zimbabwe. However, no data was presented on the specific regions of Zimbabwe from where these cases were reported, making it difficult to ascertain the probable cause of the deaths. It can only be inferred that such deaths were related to occupational exposure in areas where asbestiform and other fibrous minerals are mined, the most probable areas being Zvishavane and surrounding areas.

The authors mentioned above also reported cases of different types of cancers but the causes and areas where the resultant deaths occurred were not specified making it difficult to infer the geological link, thus prompting for studies that can reveal such an association. Chinguno and Mudimbu, co-authors of the present paper, have started working on MPhil and DPhil studies respectively that can provide the possible link.

Arsenic, cadmium, calcium, hexavalent chromium, manganese and lead anomalies, as well as radon exposure, are known to cause or promote bladder, prostate, liver, lung, skin, kidney and colon cancers; as well as renal insufficiency, osteoporosis, neurological diseases, nephropathy, cardiovascular damages, "rice water" diarrhoea, encephalopathy, multi-organ dysfunction, among others (Yuanyuan et al. 2012; IARC 2011; Finkelman 2006; Tchounwou et al. 2003; Centeno et al. 2002a, 2002b; Boffetta et al. 1994).

An application for access to health data was made to the Permanent Secretary of the Ministry of Health in June 2013, and the authorisation was granted in July 2013 with the actual records finally received in December 2013. Some gaps exist in the data as records for most parts of Zimbabwe are missing and requests have been made for the data.

The health data available to the authors of the present paper is on specific diseases/states by district for the Sanyati Catchment and surrounding areas. This and other data to be made available will be used in conjunction with a preliminary spatial analysis for conducting analyses that will guide the full DPhil development and lend the research a detailed focus. A preliminary assessment of the data for cancers and other

diseases has been conducted and is graphically presented below in Figures 1 to 3.

The Chirumanzu district show the highest percentage distribution of the population with follow-up cases of both prostrate and cervical cancer in 2012 (Figure 1), with Gweru recording the highest follow-up cases per 100 people in the district with breast cancer. Copper and gold are the major minerals mined in these areas, and part of the causes for these high rates of cancers may have a geological link due to mineral assemblages and the mining methods used.

The district of Kadoma has the highest percentage distribution of the population recorded for follow-up cases of renal failure in 2012, with the number of cases recorded representing 0,03 % of the population (Figure 2). Most people in this area are artisanal and small-scale gold miners, mostly exposed to mercury.

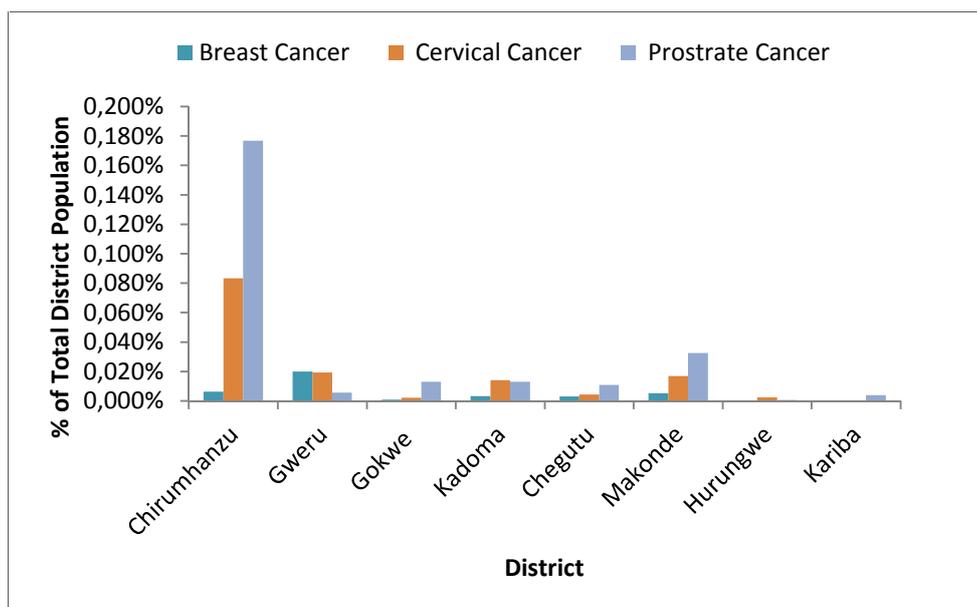


Figure 1. Percentage distribution of follow-up cases in 2012 for Breast, Cervical and Prostrate cancer in some districts within the Sanyati catchment for which data was provided. (Data Source: Ministry of Health and Child Welfare, Census, 2012).

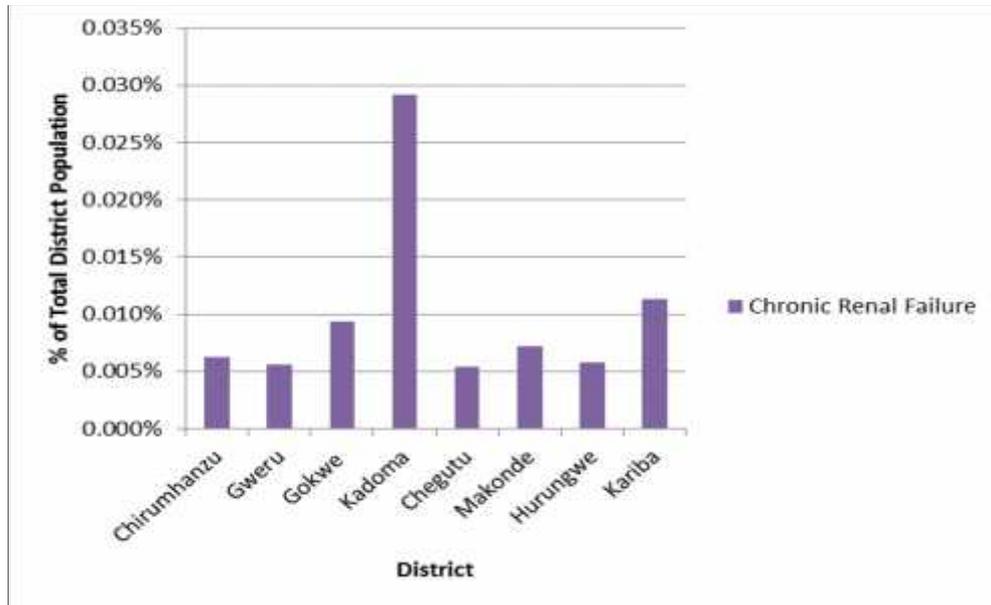


Figure 2. Percentage distribution of follow-up cases in 2012 for Chronic Renal failure in the districts for which data was provided. (Data Source: Ministry of Health and Child Welfare, Census, 2012).

The districts of Chirumhanzu, Kadoma and Kariba in 2010 over the period January to July had significant percentage of the population with recorded pneumonia and diarrhoea cases (Figure 3).

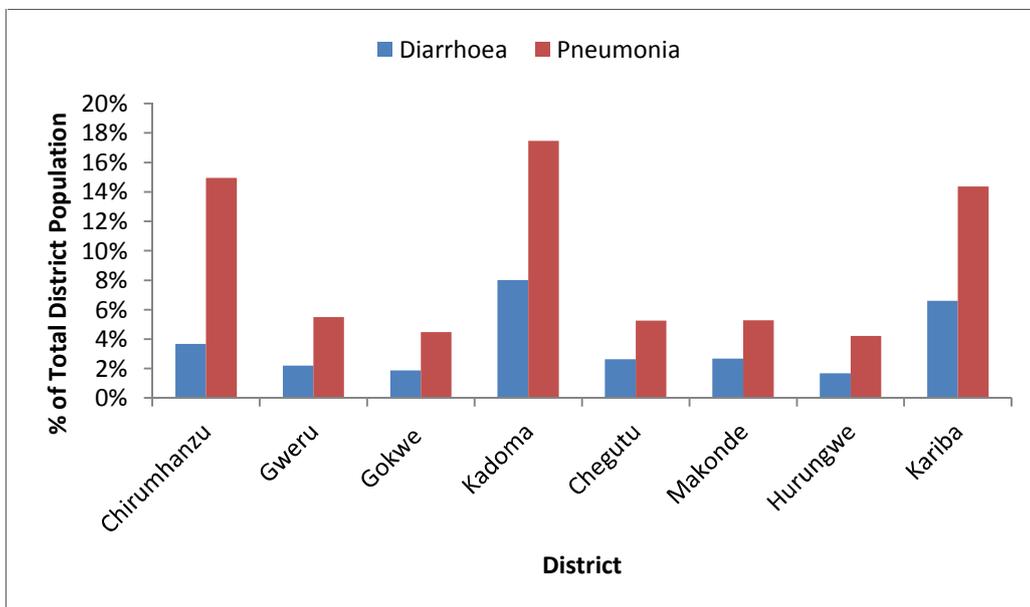


Figure 3. Percentage distribution of diarrhoea and Pneumonia cases recorded in 2010 (Jan-Jul) in some districts within the Sanyati catchment for which data was provided. (Data Source: Ministry of Health and Child Welfare, Census 2012).

Mamuse et al. (2007) conducted a dental survey involving 1,883 children from 35 primary schools and a geochemical sampling of 95 corresponding

water sources. They determined fluorosis prevalence and fluoride distribution in water supply in Gokwe North District, in the north-west of Zimbabwe. The overall fluorosis prevalence in the assessed children was 43 % and for individual schools the prevalence was in the range 13-94 %.

Their study showed that excessive fluoride concentrations in drinking water, enough to cause skeletal fluorosis in the long term occur in the area. Fluorosis incidences of up to 94% at individual schools were reported, and this demonstrated that fluorosis in Gokwe North is a major problem whose containment is a matter of urgency. Mamuse et al. (2007) suggested mitigation measures that included prescriptive lithostratigraphic-constrained well depths, casing of bores penetrating fluoride-bearing formations, water testing and defluoridation.

Mamuse (2003) determined the relationship between the spatial distribution, lithostratigraphic controls and implications for human health of the fluoride-contaminated drinking water in Gokwe District (NW Zimbabwe). A high prevalence (62 %) of dental fluorosis had been reported among schoolchildren (Figure 4) in that area. After sampling and analyses, he concluded that fluoride contents in drinking water were higher than the World Health Organization standards of 1,5 mg/L.

Based of fluoride ranges in the different drinking water sources analysed in the research by Mamuse (2003) and Mamuse et al. (2007), these authors identified different fluorosis-risk zones and presented them in a fluorosis-risk map using a Geographical Information Systems (GIS) tool and other data analysis software. Details and illustrations can be found in the above studies referred to in this paragraph.

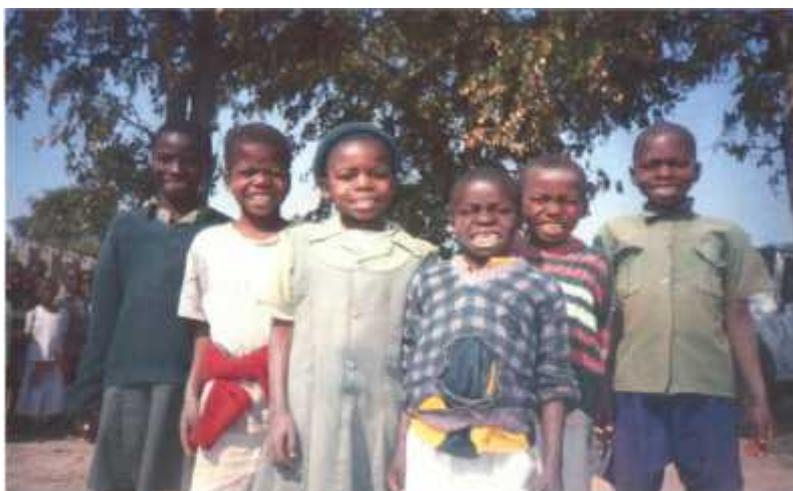


Figure 4. Schoolchildren in Gokwe showing deformed teeth due to dental fluorosis. Courtesy of Mamuse (2003).

Similar studies on the causes of dental fluorosis have been conducted in Mt Darwin (Ashton et al. 2001; Demberere et al. 2006)

Mercury is a harmful substance to humans, animals and aquatic life, either indirectly or directly through bioaccumulation in the food chains (Tunhuma 2007). It is a poisonous substance when inhaled, causing lung cancer and skin disease, or when washed away, later absorbed and accumulated in living organisms (UNDP 2005).

Valoi et al. (2002) argued that mercury use among people involved in the gold mining activities is not considered hazardous. However, direct skin contact and inhalation of mercury vapour occurs in the amalgamation process. Personal hygiene is often insufficient and mercury contaminated hands are not always washed before eating, leading to contamination of food and, hence, direct ingestion of mercury. In addition, domestic utensils, like cups or platters, are used both in the panning process and for domestic purposes.

To the contrary, other studies (Chouinard & Veiga 2008) showed that mercury contamination of people working with informal gold mining is a major problem. Also, it poses a potential threat to people not working with gold mining, but living in the gold mining communities, and have been seen to show evidence of mercury exposure/uptake, indicating contamination through food and water.

The Global Mercury Project (GMP), an initiative of the United Nations Industrial Development Organization (UNIDO), through the results co-authored by Chouinard & Veiga (2008), showed the prevalence of mercury poisoning among the individuals practising Artisanal and Small-scale Mining (ASM) in Zimbabwe.

GMP assessed the health status of a sample population of 218 volunteers in Kadoma and 55 from a control area in Chikwaka, using their environmental and health assessment protocols. 269 blood samples, 273 urine samples, and 233 hair samples were collected and analysed. Medical questionnaires, historical, clinical, neurological and toxicological tests were used to examine general health of the participants and symptoms of mercury poisoning were discovered.

The GMP study showed that the entire population living in the mining areas is severely exposed, with exposure of amalgam burners and children working with mercury being the most extreme. Miners and millers are frequently directly exposed to mercury contamination, primarily through vapour inhalation, particle ingestion, and skin contact

at amalgamation and roasting sites. Breast milk in some cases was contaminated with mercury. The control group was within a normal range.

Typical symptoms of mercury intoxication were prevalent in the exposed group and the GMP research group used these signs to confirm a considerable exposure to mercury, and these symptoms ranged from signs of a damaged central and peripheral nervous system (ataxia, dysdiadochokinesia, pathological reflexes, coordination problems and concentration problems. No symptoms were observed in the control group (Chouinard & Veiga 2008).

Several of the occurring metals in the Pungwe River basin are highly toxic, and have the ability to bio-accumulate in the food chain, e.g. mercury, cadmium and lead. High cadmium concentrations were measured in the entire basin. The gold mining activities indirectly affect the cadmium concentrations by increasing the riverine sediment concentrations, hence the elevated concentrations of cadmium bound to particles in the Nhamacurara River. It is likely that high concentrations of cadmium in the soils end up in the rivers due to the gold mining activities (SWECO & Associates 2005).

The major obstacle in implementing awareness and control measures is that the Nhamacurara River is a bilateral river, flowing through both Mozambique and Zimbabwe. This fact causes several obstacles when the problem of the informal gold mining activities is addressed. Organising monitoring of the mining activities is harder since people tend to work on both sides of the border (SWECO & Associates 2005).

Several other studies also showed the toxicity of arsenic, fluoride, mercury and related chemical elements to human and ecosystems health in and around Zimbabwe (Phiri 2011; Kushe 2009; Kundell 2008; Ashton et al. 2001)

### 3. DISCUSSION

The unavailability of information and funding is hindering research in the field of Medical Geology in Zimbabwe, which, in essence, relates to human and ecosystem health from a geo-environmental point of view. Other regional developing countries, including Mozambique, South Africa, Tanzania, are also struggling to find lasting solutions to such a matter.

Based on the review of some of the authors referred to in this paper, a large number of locals in the mining towns, for example gold, coal mining places and artisanal miners, as well as the ecosystems, are prone to

contracting diseases due to water and food poisoning, occupational exposure and habits.

In most of artisanal and small-scale mining activities, habits, access to cheap processing material, inadequate technical knowledge, funding and environmental health awareness results in uncontrolled land degradation, over consumption of water and release of toxic chemicals to the environment.

There is need to curb the proliferation of such uncontrolled bad practices in mining activities and water resources management before it is further aggravated by the failure of subsistence economies, conflicts that may result in the displacement of populations, and diseases such as HIV/AIDS due to promiscuous habits, which are generally associated with such means of survival.

Mitigation measures should include proper legislation, awareness and the promotion of appropriate technology in order to enhanced the environmental management within the ever-increasing number of people turning to artisanal and small-scale mining as the only alternative to the subsistence farming activities for rural population.

Possible solutions have been suggested by some authors who have conducted research in these environmental and health concerns in Zimbabwe (Chouinard & Veiga 2008; Mamuse et al. 2007; Telmer 2006; Bernaudat 2003; Mamuse 2003; Maponga & Ngorima 2003; Mabvira 2003). These include public awareness on the effects of toxic elements on human and ecosystem health, policy and governance reforms, and community economic diversification, introducing improved mining practices, increased efficiency of use and transition to alternative technologies.

Also, measures should be put in place regulate the illegal access and use of mercury, regulate the fluoride level in drinking water, the recording of and availability of data on toxic elements to the public.

Of prime importance is the establishment of possible geological-health data analysis and presentation, models for references, mechanisms of intoxication and implementation of possible solutions to reduce the impacts of the toxic elements discussed above. These measures can also be extended to other Medical Geology issues such as Geophagia (the deliberate ingestion of soil), endemic goitre, ingestion of high concentrations of organic compounds in drinking water, and those highlighted in Table 1.

Table 1. Some of the common medical conditions caused by deficiencies and excesses of known chemical elements in geological spheres

Chemical element	Disease/Medical condition		References
	Cancer	Other	
Arsenic	Bladder, liver, lung, skin, urinary bladder, kidney and colon	Cardiovascular and peripheral Vascular Disease, Developmental anomalies, Neurologic and Neurobehavioural Disorders, Diabetes, Hearing Loss, Portal Fibrosis, Hematologic Disorders (Anaemia, Leukopenia and eosinophilia)	Tchounwou et al. 2003; Centeno et al. 2002b; Centeno et al. 2002a; Eisler 2003; Boffetta et al. 1994;
Cadmium	Bladder, kidney, lung	Hypertension, vascular and neurological changes, Itai-itai	
Selenium		Severe physiological impairment and organ damage(e.g. juvenile Cardiomyopathy) muscular abnormalities in adults Keshan disease Kashin-Beck disease	(Fordyce 2005; Selinus and Frank 2000; Christian et al. 2006
Lead	Neurological, IQ (children), Anaemia		
Fluorine		Enamel and skeletal fluorosis, fluorosis	Edmunds and Smedley 2005; Saravanan 2008
Chrome	Kidney, liver, lung		
Mercury	Brain, kidney, lung, neurological Hg changes		
Calcium		shorter stature in animals, weak bones, osteoporosis, rickets	Komatina 2004
Iodine	IDD (Goitre)	Reduced IQ Miscarriages Birth Defects Cretinism	Komatina 2004
Cobalt	Lung, liver	Vitamin B-12 deficiency	Komatina 2004
Sodium		exhaustion of nervous system	Komatina 2004
Silver		Argyria (Argyrisim)	

#### 4. CONCLUDING REMARKS

The impacts of geologic materials and processes on animal and human health is evident and widespread in Zimbabwe, the most common cases being attributed to high fluoride levels in drinking water, mercury

poisoning, exposure to toxic elements through occupational exposures, habits and lack of knowledge.

The country is still at grassroots level in trying to combat the health impacts of these geological elements partly due to lack of public awareness, extended research and funding, and the required technology and equipment used to predict the potential impacts of toxic geochemical elements on humans, animal, plant and aquatic life.

In addition, Zimbabwe is still emerging from an economic meltdown spanning over a number of years, with mining taking the lead in the economic recovery. Most people have turned to mining for survival. The initiative to promote indigenisation through small-scale mining should also be coupled with the required education, expertise, funding and equipment to minimize the associated health hazards.

Detailed research and projects are essential in the establishment of possible toxic element distribution and health data integration, background concentration, Apparent Effects Threshold (AET), mechanisms of intoxication and implementation of possible solutions to reduce the impacts of the diseases caused by toxic elements. Extensive studies should include individual metal's bioavailability, bioaccumulation as well as biomagnification in order to determine the ecosystems health.

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