ISSN: 2690- 912X

Research Article

Journal of Genetic Engineering and Biotechnology Research

The Concealed Perils to Public Health: Origins of Emerging Non-Communicable Illnesses (NCDs) in Mining Regions of Ghana

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Submitted: 2023, Nov 07; **Accepted**: 2023, Dec 11; **Published**: 2024, Jan 05

Citation: Arhin, E., Osei, J. D., Karim-Abdallah, B., Baah, C., Damoah-Afari, P. (2024). The Concealed Perils to Public Health: Origins of Emerging Non-Communicable Illnesses (NCDs) in Mining Regions of Ghana. *J Gene Engg Bio Res, 6*(1), 01-14.

Abstract

Artisanal and Small-Scale Gold Mining (ASGM) has a rich historical background in Ghana, contributing to over 40% of the country's gold production. However, current ASGM practices have neglected responsible mining operations, resulting in environmental degradation and adverse health impacts. A comprehensive study analysed 3344 soil samples from a mining district in Ghana, revealing high concentrations of arsenic (As), lead (Pb), copper (Cu), and zinc (Zn). These elements are associated with gold mineralisation within the Birimian System. The likely causes of these elevated levels include heavy metal accumulations during mining activities and pesticide/fertiliser usage on farms - which is the primary occupation within this study area alongside ASGM operations. The study identified areas enriched with potentially harmful double-sword elements that require small amounts for human development- indicating serious environmental health concerns within these zones. The highest recorded values were up to 246 ppm for As, 148 ppm for Pb, 87 ppm for Cu, and 200 ppm for Zn. Notably, elevated concentrations of As occurred at Agrave, Bogoso, Juabeng, Gyaba, Gyeduakese etc., while high levels of Pb were found at Bogoso, Agrave, Beposo, Wassa Bekwae, Asaasetre, Donkorworano, Samreboi, Odumase, Anhwerem locations; Cu had high concentrations near Bawdie and Moseaso while Zn was highly concentrated at Kwao Mensah, Kokoasi, Ayensukrom Hamatuo and Abotarey sites.

In conclusion, this paper recommends establishing baseline pollution status measurements before commencing any mining activities followed by regular monitoring to ensure safety standards are maintained - especially regarding the population living around mining communities' good health rights protection.

Keywords: Small-Scale Mining, Wealth, Elements, Potentially Harmful, Health, Enriched

1. Introduction

The Earth is a closed system, and the minerals that aggregate to form rocks tend to readjust themselves whenever the planet is impacted [1]. The stability of these minerals within the Earth's system depends on temperature and pressure in deeper environments [2]. As described by Bowen during magma crystallisation, when magma moves up from the core to the crust and cools, new minerals are formed [3]. Climate also acts on superficial materials near the surface environment, resulting in weathering and transformation of primary minerals into secondary ones.

Certain naturally occurring elements in rocks may be hazardous if exposed to humans. Linkages between some chemicals in geogenic materials (such as rocks, soils, and groundwater) and non-communicable diseases have long been known [4-6]. In Ghana's Birimian terrain, gold is found in association with sulphide minerals such as arsenopyrite (FeAsS), chalcopyrite (CuFeS2), galena (PbS), and sphalerite (ZnFeS). These minerals are stable in deep environments but become unstable in secondary environments where they transform into respective heavy metals like iron (Fe), copper (Cu), lead (Pb) zinc (Zn) and Arsenic (As); while Sulphur goes into solution [7].

Although copper (Cu), zinc (Zn) and iron (Fe) serve as micronutrients at low concentrations they turn toxic when present excessively whereas other heavy metals/metalloids including lead

(Pb) and arsenic (As) are toxic even at very low concentrations [8]. If all these elements are part of rocks that weather to soils then many diseases could originate from earth sources which confirms [6] findings suggesting a link between chemical elements present in landscapes and public health cases.

Most complaints about mining activities focus on the pollution of water bodies, degradation of forest resources, depletion of soil nutrients, destruction of wildlife habitat and reduction of quality air pose threats to human health etc. Human health impacts are documented and reported for example malaria, skin diseases, diarrhoea, fever, colds and catarrh [9]. Necessitating this study was a report by MyJoyOnline revealing that 65 miners were admitted for kidney dialysis in August 2017 in the mining districts along with the prevalence of hypertension, diabetes, and sore throats. Among medical cases stemming from the same mine districts research reports strong evidence of elevated mercury exposures in workers and people living in Artisanal small-scale mining communities [10].

According to cognition regarding element distributions and concentrations within superficial materials contributes towards monitoring potentially harmful element spread causing adverse health effects. The literature attributes renal disease, kidney failure, diabetes, hypertension, and skin-lung-bladder cancers to be due to exposure to toxic concentrations of As, Pb, Cu and Zn. All aforementioned potential toxic elements have connections with gold mines throughout Ghana making it necessary to plot geospatial distributions and concentration maps highlighting probable areas of potential non-communicable disease (NCD) areas.

Enrichment of potentially harmful trace elements and deficiency of essential trace elements in the natural environment causes a widespread impact. The ingestion of contaminated food and water, as well as inhalation of air polluted by natural or anthropogenic sources, necessitates that individuals in developing nations be aware of the hotspots, distributions, and concentrations of disease-causing agents. Therefore, comprehension of these factors would facilitate the development of tactics for addressing environmental health issues that may impede Developing Countries from attaining SDG3 [11,12].

Geological records show that there have been large climate variations caused by natural factors (changes in sun emissions, volcanoes, variations in orbit CO2 levels including human activities). Though not an industrial nation, Ghana is known for its gold mining and agricultural activities [13]. These local activities contribute to changes in the earth's chemistry. Mining operations introduce substances such as mercury (Hg) and cyanide (CN) into the environment during gold processing, which can result in both natural toxins and essential elements migrating. The deposition of toxic minerals that are deeply embedded in the earth after mining occurs not only at the surface level but also results in their transportation to bodies of water, thereby polluting ecosystems. The ramifications of gold mining have a devastating impact on the environment, resulting in deforestation and pollution of water and soil through the release and introduction of toxic chemicals [14]. Several scholars have examined the environmental effects of mining in Ghana; however, they failed to establish a correlation between harmful elements and their impact on human health. Rother (2020) identified that the mobilization of chemical elements, both from human activities and natural geological processes, into the environment is a significant contributor to numerous non-communicable diseases in developing nations. The NCDs previously meant for the Aged and the Rich, now affect people of all ages, particularly in districts affected by mining operations. Exposure to toxic amounts of As, Pb, Cu, and Zn which hitherto were part of deep-seated sulphur minerals found their way to the surface environment through mining. Toxic exposure to these elements contributes to NCD which leads to deaths and also causes congenital malformations [15]. In Ghana, NCDs are now the leading cause of death [16]. It is on this basis that this paper seeks to establish possible linkages between chemical elements released from the underlying rocks, the distributions and concentrations of the trace elements in the superficial environment and corresponding health impacts. This paper also examines the report by the medical health workers in Western and Central Regions citing the increase in renal diseases in the area due to the mining operations.

2. Location, Geology and Physiographic Settings

2.1 Location

The study area is field sheet 0503B in Ghana and covers two districts: Wassa Amenfi West and East Districts situated in the Western Region (Fig. 1). The district capital of Amenfi East, Wassa Akropong, is located 135.1 km south-southwest of Kumasi via Obuasi-Dunkwa-on-Offin Road. Similarly, Asankragwa - the other district capital of Amenfi West is situated approximately 212 km southwest of Kumasi. Notably, all primary roads leading to these districts are navigable throughout the year [17].

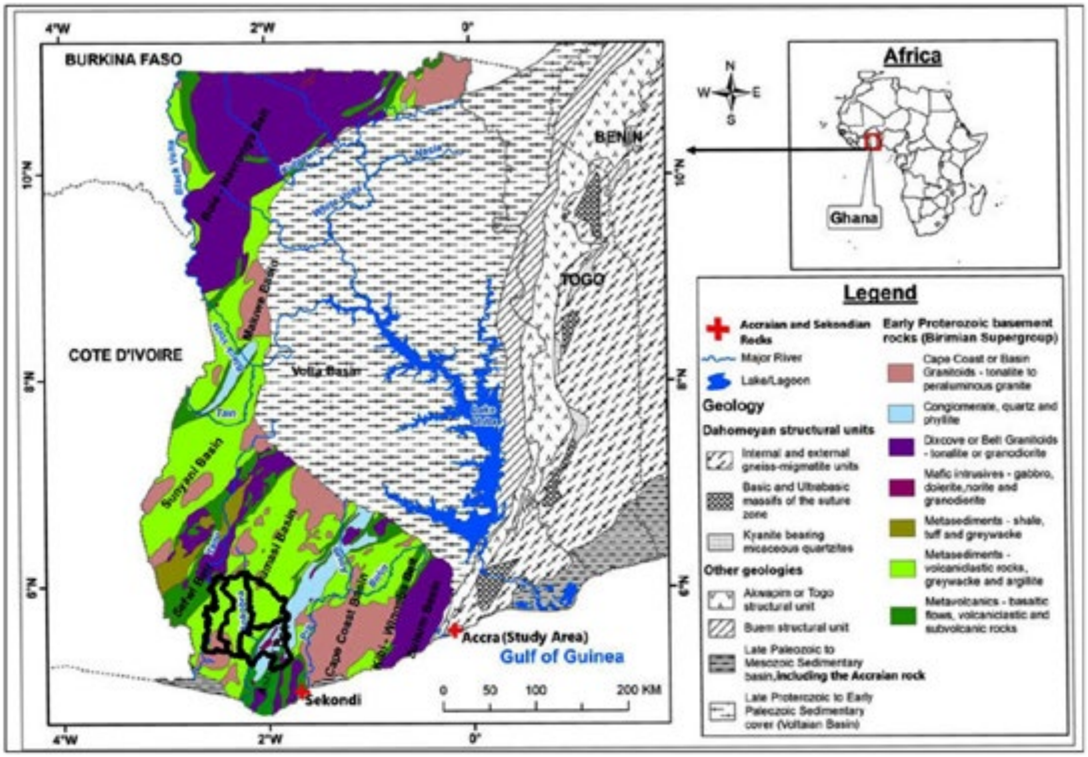


Figure 1. Geology and Location of Study Area

2.2 Geology

The two studied districts are located on Birimian terrain consisting of metavolcanic and metasedimentary rock units, with some granitic intrusions present in certain areas (Fig. 1). The Birimian metavolcanic rocks consist of basalt-andesite-rhyodacite lavas with elevated Mg-Ca-Na contents, as well as volcaniclastics [18]. Similarly, the metasedimentary rocks contain isoclinally folded dacitic volcaniclastics, wackes and argillitic sediments along with granitoids. However, occurring at the the transition between metavolcanic and metasedimentary rock zones are chemical facies [19]. These chemical facies are defined by cherts, manganiferous and carbon-rich sediments, Fe-Ca-Mg carbonates as well as sulphide mineral disseminations. Archival reports show that gold mineralisation has been discovered in association with hydrothermal veins that are rich in sulphide minerals within the transition zone, particularly in areas characterized as alteration zones [20]. Furthermore, arsenopyrite, chalcopyrite, galena, pyrite and sphalerite have been identified among the sulphide minerals that are disseminated throughout both the rocks themselves and their alteration zones [21].

2.3 Physiographic Settings

The topography of the study area is characterized by undulating terrains, comprising low hills and isolated peaks interspersed with both narrow and wide valleys. The altitude of the low and high hills ranges between 190 m to 280 m above sea level. The area experiences a tropical climate marked by distinct wet and dry seasons; the latter occurs from late November to February, as well as briefly in August. Two peak rainfall periods are observed annually: March through July, and September to early November [22]. Annual precipitation levels vary between 700 mm to 2,100 mm. Vegetation in this locale comprises rainforest-type forestland with several canopies of trees alongside undergrowth vegetation. However, indiscriminate deforestation activities such as logging of upper-middle layer trees for commercial purposes coupled with farming practices have resulted in primary forests being converted into secondary forests or shrublands [32]. Enthandrophragma cylindricum (Sapele) and Aningeria spp (Asanfena) are the dominant species occupying an area density of approximately twenty hectares per tree for Sapele while Asanfena occupies fifty hectares per tree respectively [23].

2.4. Occupation

The primary economic activities in the region comprise farming, artisanal small-scale and large-scale mining. The agricultural practice encompasses both subsistence and commercial crop farming, with the use of chemical agents such as fertilizers, pesticides, and weedicides being a common sight [24]. Furthermore, there is an indiscriminate application of hazardous chemicals like mercury (Hg) and cyanide (CN) during gold extraction processes. Such uncontrolled usage of chemicals poses a significant risk to environmental health since these substances can easily contaminate drinking water sources and soil components through mobilization or remobilization into the ecosystem. Research findings indicate that almost all Ghanaians consume what they cultivate or rear for sustenance purposes while selling any surplus produce for trade to meet other essential needs [25]. Some farms also keep small livestock and poultry for meat and egg production in addition to crop cultivation efforts. To address food security concerns adequately while generating income streams necessary for comfortable living standards, it is critical to identify disease-causing hotspots accurately within this context - a move that aligns with several UN sustainable development goals as well [26].

3.0 Methodology

A soil sampling survey was conducted at a 1/50,000 scale on field sheet 0503B. The predetermined sample points were marked out on a base map (Fig. 2) that guided the geochemical survey. To navigate to these points, a GARMIN ETREX GPS device was utilized. Soil samples were taken from a nominal diameter hole of 30 cm and depth of up to 30 cm; the extracted material was then placed in plastic bags for analysis.

At each site, two (2) kg samples were collected from dug-out materials, while composite samples weighing five (5) kg containing no less than three sub-samples were obtained where necessary. In the field, planned weights were acquired using the cone and quartering method. In total, we gathered 2668 soil samples which underwent drying and sieving to <106 µm fraction at our in-house preparation site before being sent off for chemical element analysis by ALS Geochemical Laboratory based in Kumasi - elements analysed included As, Ba, K, Zn, Co, Cr, Cu, Mn, Ni, Pb, Mg, and Fe using ICP-MS technique.

To ensure accurate analytical results of all batches sent to ALS laboratory for testing purposes; control or reference materials known as quality assurance (QA/QC) samples were inserted into every batch consisting of approximately 150 geochemical analyses with one per every twenty-five analysed. Moreover, duplicate precision analyses followed after every forty-fifth soil sample taken from the field samples ensuring accuracy during the data collection process.

3. Results

The summary statistics for the four selected elements, namely As, Pb, Cu and Zn were generated to determine their minimum, maximum, mean and standard deviation values. These results are presented in Table 1 to facilitate the identification of hotspots associated with disease-causing elements.

Elements	Maximum	Minimum	Mean	Standard Deviation
As	246	2	17.194	15.544
Pb	148	5	7.344	4.941
Cu	87	4	12.59	8.203
Zn	200	6	28.121	13.580

Table 1. Summary statistics of trace elements in soil samples in the study area (Unit measurements (mg/kg).

As a component of the quality assurance/quality control analysis aimed at monitoring analytical precision, three distinct reference materials were subjected to the assessment. The results of the analytical evaluation conducted on these three reference samples are depicted in Figure 3, while Table 2 displays the recovery rates determined by comparing the concentration values of the certified reference material with its measured values.

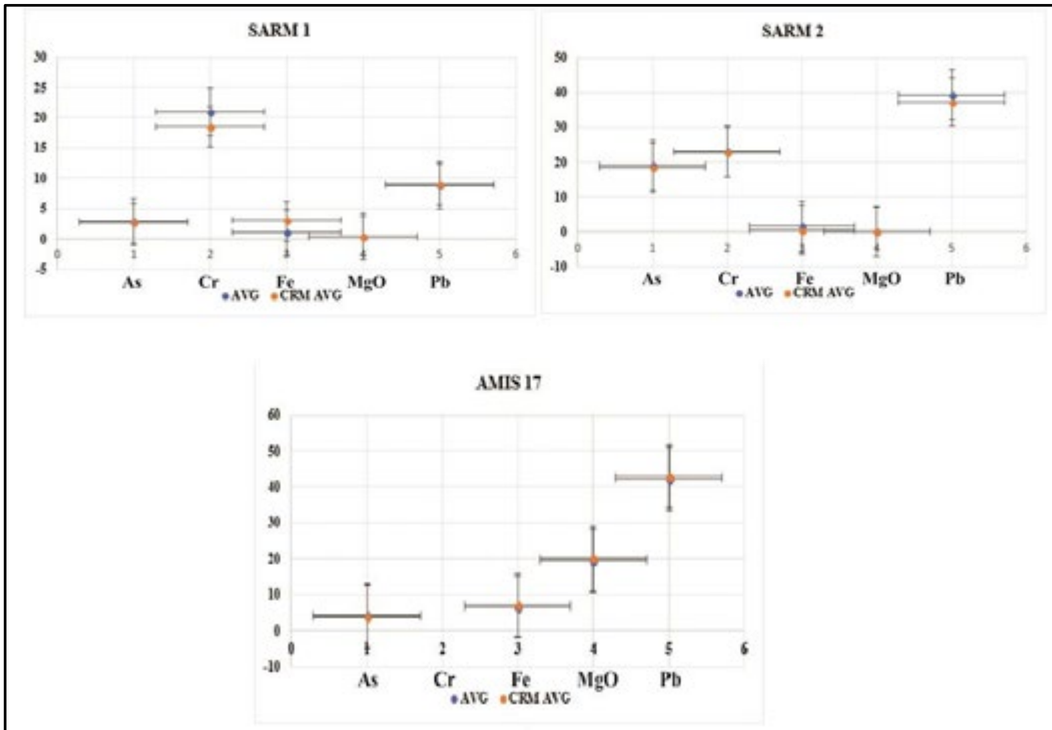
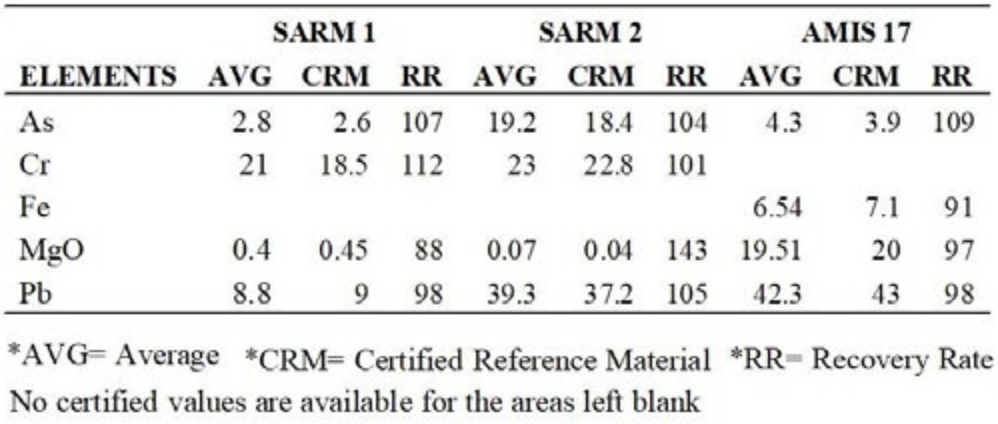


Figure 3. Analytical quality assessment comparing CRM certificate values of As and Pb and measured CRM values in this study



	SARM 1			SARM 2			AMIS 17		
ELEMENTS	AVG	CRM	RR	AVG	CRM	RR	AVG	CRM	RR
As	2.8	2.6	107	19.2	18.4	104	4.3	3.9	109
Cr	21	18.5	112	23	22.8	101			
Fe							6.54	7.1	91
MgO	0.4	0.45	88	0.07	0.04	143	19.51	20	97
Pb	8.8	9	98	39.3	37.2	105	42.3	43	98

*AVG= Average *CRM= Certified Reference Material *RR= Recovery Rate

No certified values are available for the areas left blank

Table 2. Recovery rates between As and Pb in CRM certificate values and their measured CRM values.

Figures 4-11 illustrate the spatial distributions and concentrations of the aforementioned elements, along with their corresponding potential disease maps. Additionally, Figure 12 displays a disease pattern map for these four elements released from sulphide minerals (namely arsenopyrite, chalcopyrite, galena and sphalerite) that are believed to be correlated with gold deposits within Ghana's Birimian System.

These maps were generated utilizing Probability Kriging, a methodology that combines traditional kriging - a spatial interpolation technique - with a probabilistic framework [27]. The probability kriging equation can be expressed as follows:

$$P((\mathbf{s}) \leq z|\mathbf{Z}) = \Phi \frac{z-\hat{Z}(s)}{\sigma(s)} \qquad (1)$$

Here, Z(s) represents the spatial random variable at location s and Z is the vector of observed values. Moreover, $\hat{Z}(s)$ denotes the kriging estimate of z at location s while σ(s) corresponds to its respective kriging standard deviation. Additionally, Φ serves as the cumulative distribution function of the standard normal distribution.

The expression P((s) ≤ z|Z), on the other hand, indicates the probability that the true value at location s is less than or equal to z given observed values whereas Ẑ(s), again refers to the kriging estimate of the spatial variable at said location and σ(s), still pertains to its associated kriging standard deviation.

The generated maps for the four soil elements display each pixel's likelihood of exceeding or falling below a predetermined threshold at a given location. These thresholds, which include accepted baseline values for As, Pb, Cu, and Zn in soils, are utilized to produce Probability Kriging maps. According to these maps indicate the probability of contaminant concentrations surpassing selected thresholds such as As, Pb, Cu and Zn. Regions with higher probabilities represent communities that contain harmful elements causing diseases [28]. In a GIS environment, hotspots and cold-spots maps utilize specific thresholds to determine predictions that receive either 0 or 1 classification status.

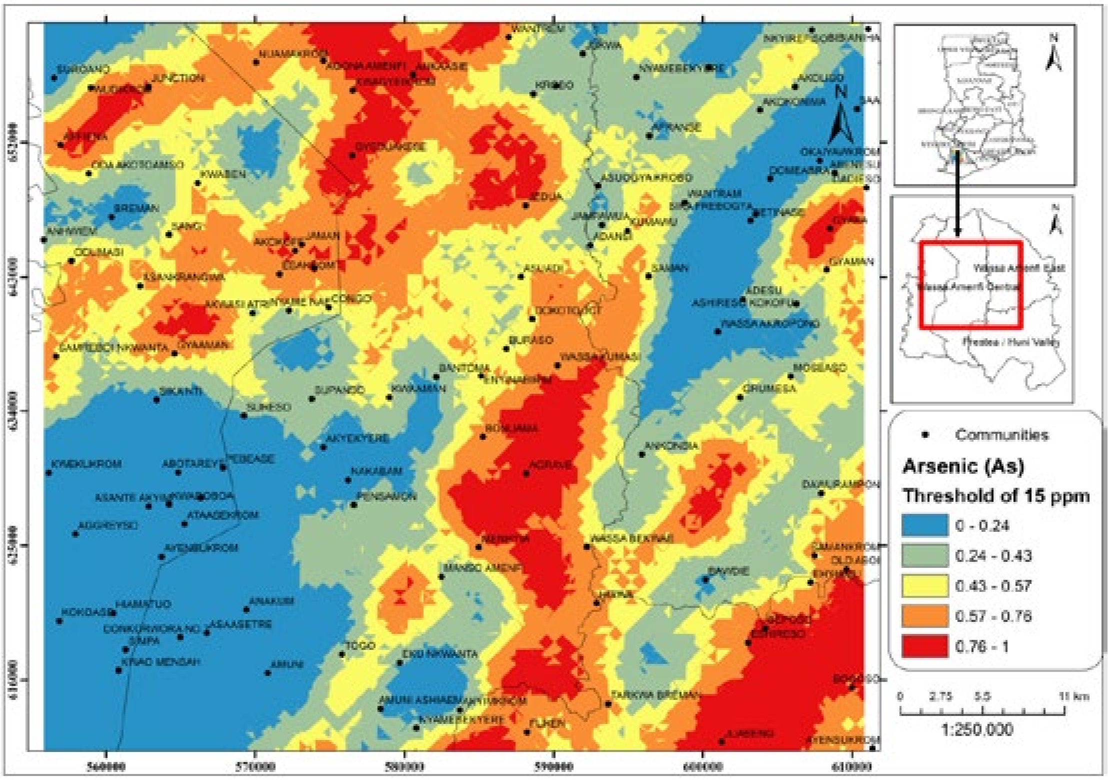


Figure 4. Arsenic (As) concentration levels in soils Wassa Traditional Areas

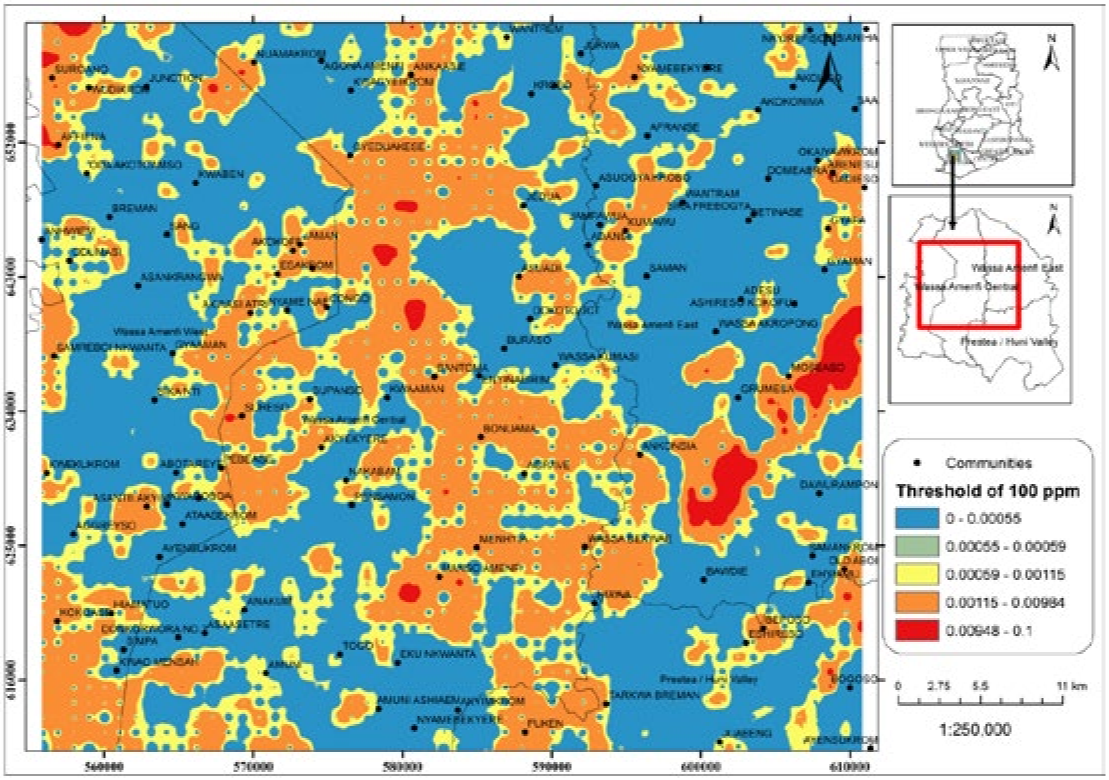


Figure 5. Copper (Cu) concentration levels in soils Wassa Traditional Areas

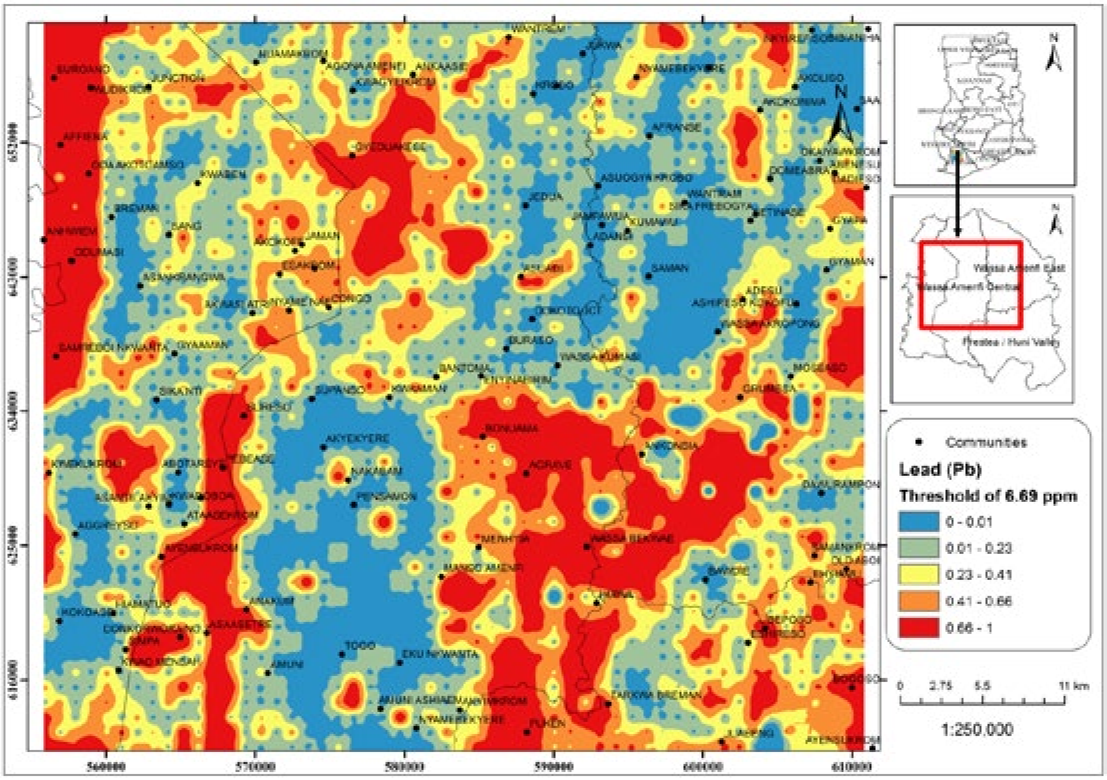


Figure 6. Lead (Pb) concentration levels in soils Wassa Traditional Areas

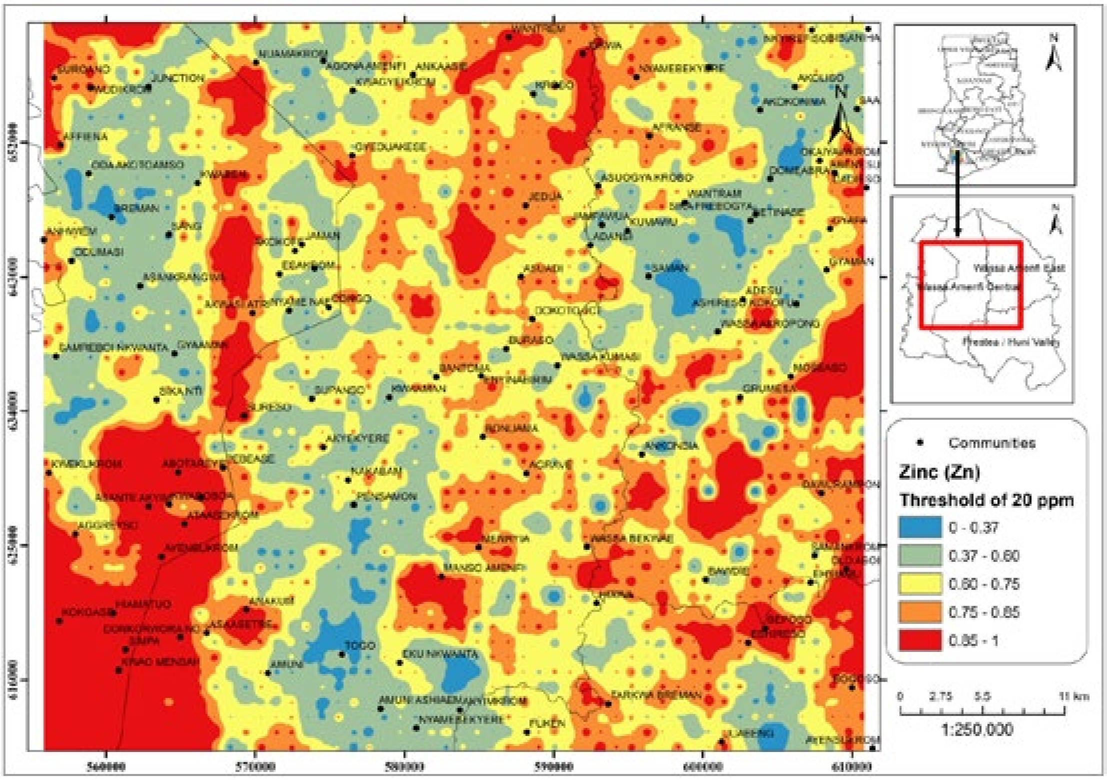


Figure 7. Zinc (Zn) concentration levels in soils Wassa Traditional Areas

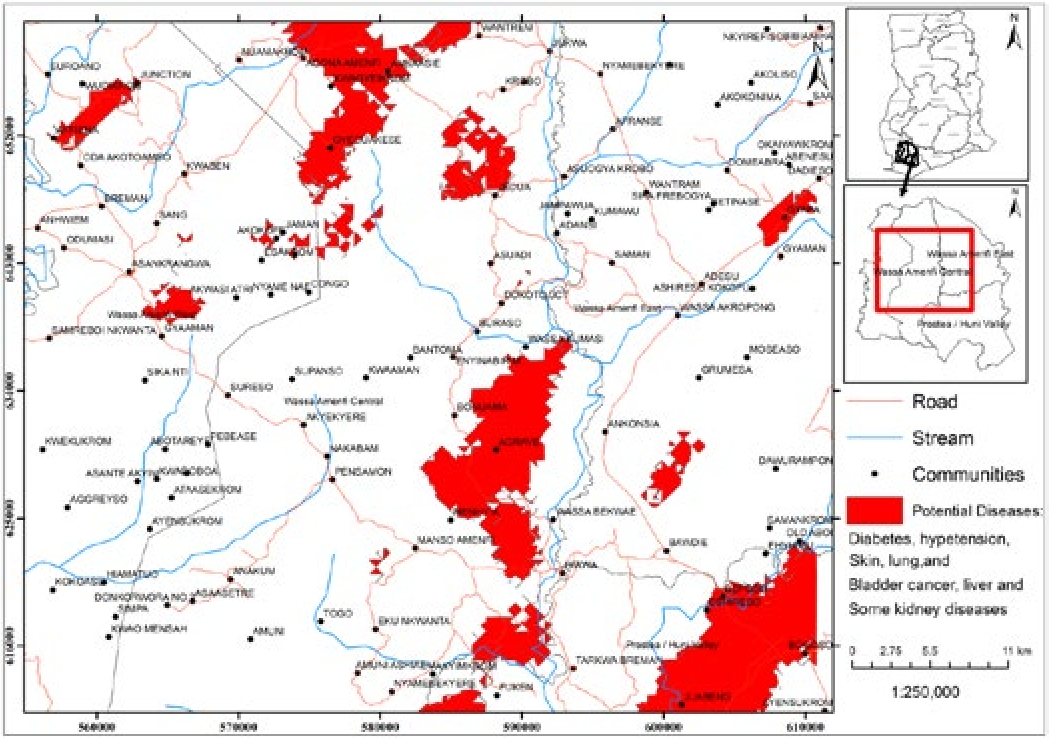


Figure 8. Arsenic (As) related -diseases hotspots map derived from soils in Wassa Traditional Areas

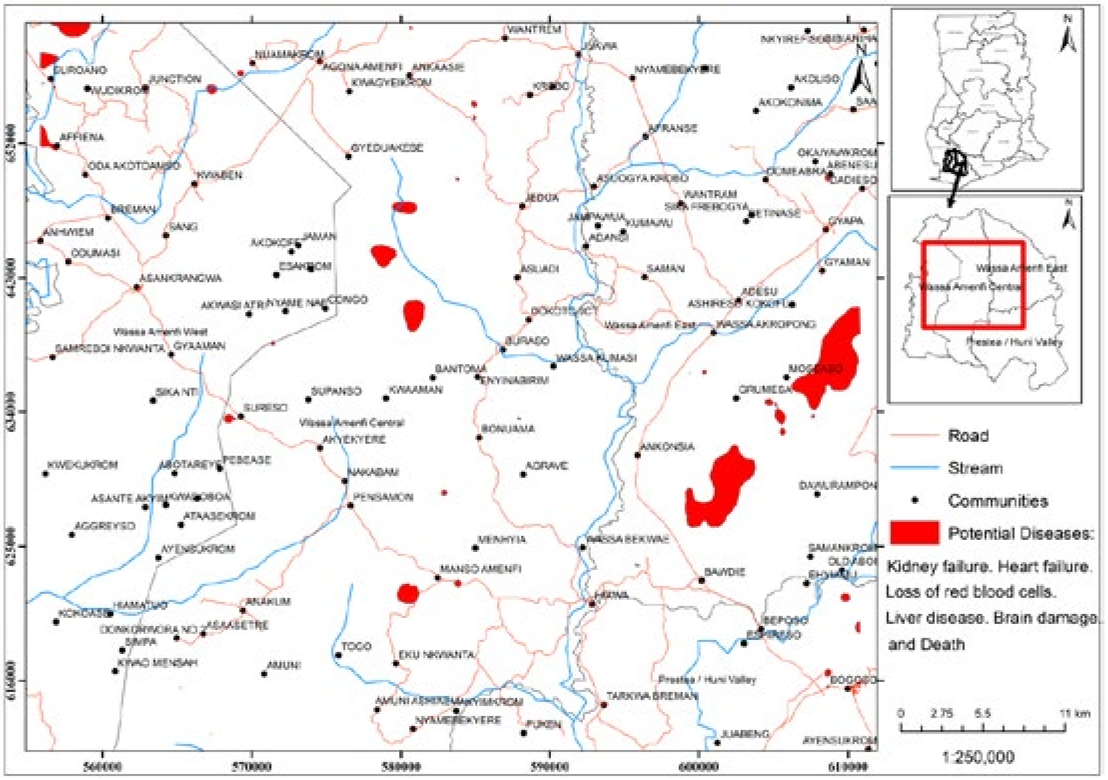


Figure 9. Copper (Cu) related -disease hotspots map derived from soils in Wassa Traditional Areas

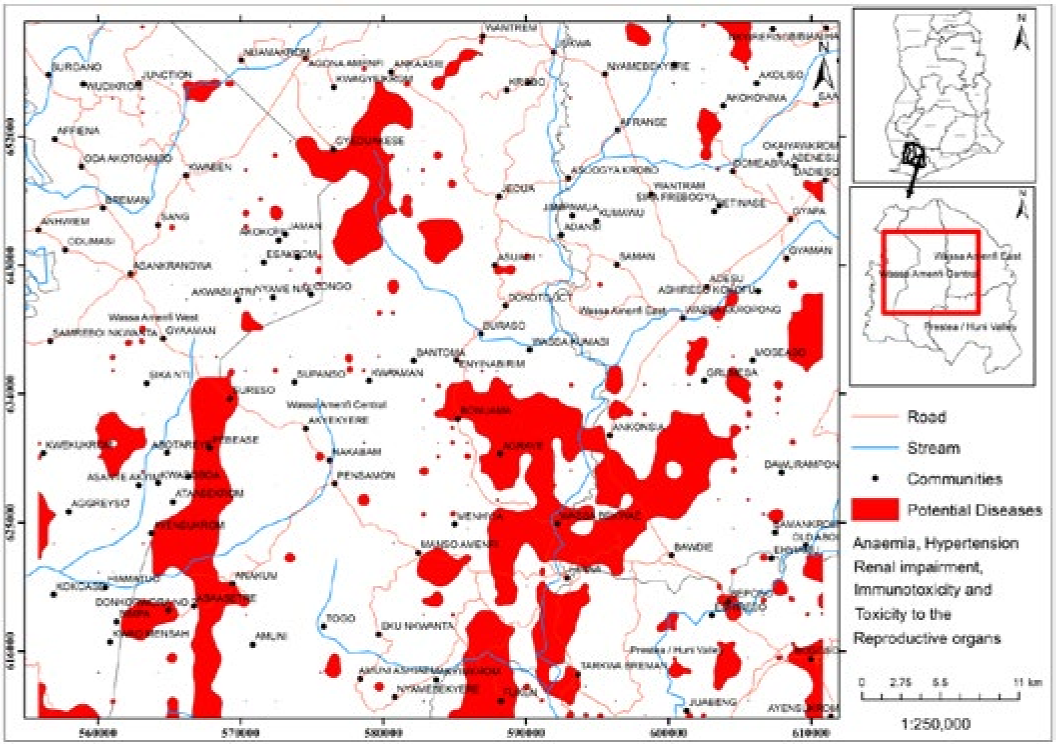


Figure 10. Lead (Pb)) related -diseases hotspots map derived from soils in Wassa Traditional Areas

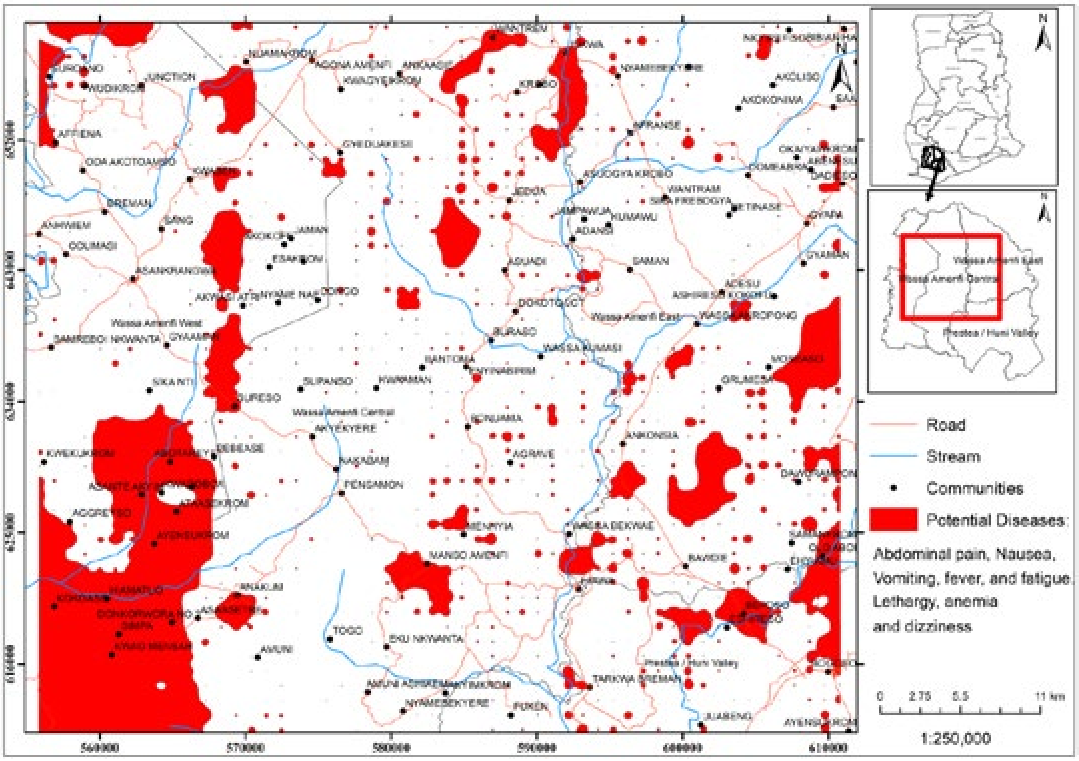


Figure 11. Zinc (Zn) related -diseases hotspots map derived from soils in Wassa Traditional Areas

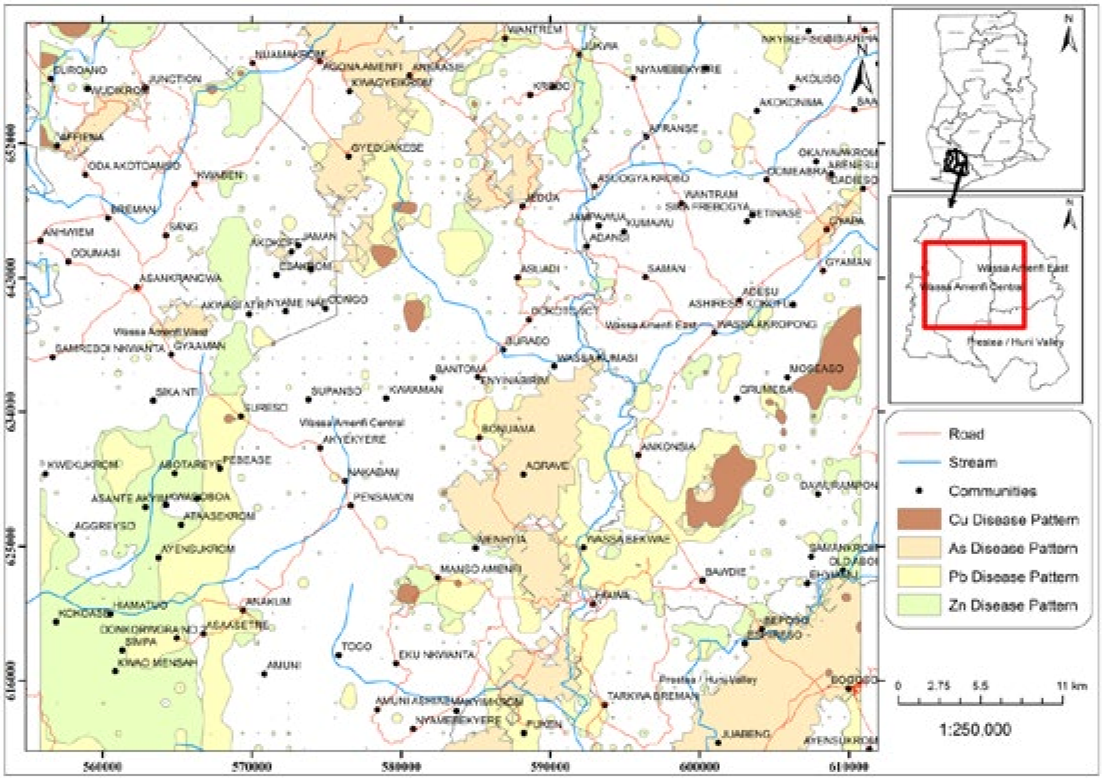


Figure 12. Merged Disease Hotspots map derived from soils in Wass Traditional Areas

4. Discussions

4.1 Analysis of Quality Assurance

The reference samples demonstrated excellent reproducibility for all elements, except Fe and Cr analysed from the reference material labelled SARM1 (Fig. 2). The percent precision measured for the field duplicates was deemed acceptable (Fig. 3) as there were no significant variations between paired samples. Major elements recorded in the samples showed minimal average variation ranging from 1.5% to 9.3% between duplicate sample pairs, with Na and Mg being exceptions at 18.8% and 35.2%, respectively. Variations in lead (Pb) and cobalt (Co) concentrations in duplicate pairs were attributed to their proximity to the detection limits of the instrument used for measurement purposes.

Certified reference materials indicated small errors that raised confidence levels regarding analytical quality data; thus, increasing the trustworthiness of results obtained from laboratory tests.

Quality assurance analysis also considered recovery rates of selected elements such as Cr, As, and Pb in reference materials SARM1, SARM2, and AMIS17 respectively expressed as a percentage against CRM certificate values. The recovered As analysing the CRM samples was 107%, while Cr stood at an impressive rate of 112%. Pb had a rate of about 90 %, that was not too bad! Measured CRM using reference material SARM2 saw recoveries for both As & Pb above 100% each; meanwhile, AMIS17's readings produced only 98% for Pb. However, recovery rates proved satisfactory across these three different sets of reference materials yielding somewhere within 85. - 120 percentile range!

4.2 The Analytical Data Assessments

The distinctiveness of As, Pb, Cu, and Zn in this study lies in their oxidation from sulphide minerals that exhibit geochemical fractionation characteristics leading to either depletion or accumulation of elements to toxic levels due to natural rainfall and other environmental activities. Table 1 reveals the minimum concentrations of potentially harmful elements such as As and Pb at 2 ppm and 5 ppm respectively, while their maximum concentration levels were found to be 216 ppm and 148 ppm correspondingly. Likewise, Cu and Zn are essential nutritional elements for humans but also display varying concentrations (Table 1). Although these elements are generally present in soils at low concentrations, they can become elevated or depleted due to both natural processes and human activities. The minimum (ranging from 2 -6 ppm), as well as the maximum (ranging from 87-246 ppm) displayed in Table 1, illustrate the impact of both natural processes and human activities on element concentrations. This further suggests that some areas or communities may experience hotspots or cold spots of disease-causing elements where there is an excess of harmful components compared with baseline values found within soils.

Although Cu and Zn are essential nutrients; too much exposure could prove fatal. Ingesting food or drinking water contaminated with high levels of copper can result in its build-up within internal organs such as the brain, liver, and lungs which eventually would lead to kidney failure, heart failure, loss or reduction of red blood cells, liver disease, brain damage etc. Similarly, excessive exposure to zinc could lead to abdominal pains, nausea, vomiting, fever and fatigue among other symptoms. Additional effects comprise fatigue, anaemia and vertigo or dizziness. Furthermore, based on Table 1, the computed arithmetic means for the four chosen elements are 17.19 ppm, 7.34 ppm, 12.59 ppm and 28.12 ppm respectively. By comparing these values to globally accepted baseline concentration levels as explained by deductions could be made that the baseline concentration levels represent natural heavy metal content present in samples without human or urban influences under idealized conditions around a mean value within an expected range of approximately 95%. The explanation provided by definition indicates that both anthropogenic and natural processes have an impact on element concentrations [29]. As illustrated in Table 1, average concentrations of As, Pb and Zn exceed their respective baseline values while Cu's average is lower than its corresponding baseline value.

The selected elements, like all trace elements in soils, exhibit varying concentration levels as demonstrated by Table 1. The concentrations of the elements that oxidize from sulphide minerals may be influenced by the type of parent material and soil characteristics after weathering, such as pH, cation exchange capacity (CEC), particle size distribution, organic matter content and oxide content. These properties contribute to the accumulation or dispersion of trace elements throughout the environment. When parent materials contain high concentrations of trace elements, soils developed on them are likely to have elevated levels of these substances. Consequently, some landscapes may harbour hotspots or cold spots for disease-causing agents depending on whether element concentrations are high or low in specific locations within those areas. For instance, As, Pb, Cu and Zn have minimum and maximum analytical values shown in summary statistics (Table 1). While minimum measured values for these trace elements appear lower than globally acceptable values in soils; maximum measured values far exceed such standards. Comparing minima with maxima allows us to plot average element concentrations across different soil samples against global averages used as thresholds to grid data defining hotspots and cold spots associated with disease-causing sites outlined herein.

Identifying hotspots and cold spots is significant not only for environmental purposes but also because it reveals potential diseases that may emerge from certain areas characterized by either high or low-exposure terrains with both essential and potentially harmful elements. These observations can help inform policy development aimed at mitigating health-related issues arising from trace element exposures.

As depicted in Figures 4 and 8, there exist areas with elevated and depleted concentrations of arsenic (As). These areas may be referred to as hotspots and cold spots, respectively. The overlap between these areas and some communities that host hundreds of people renders the inhabitants vulnerable to toxic As exposure. As documented in the literature, such exposure to potentially harmful element As could result in various ailments including hypertension, skin-lung-bladder cancers, liver and kidney disorders. Gyaba, Agrave, Juabeng, Bogoso, Gyeduakese, Ankaasie Eshireso and Beposo are among the susceptible communities identified in Figure 8. Identifying sources of As-related diseases would be challenging unless environmental geochemistry is assessed alongside disease linkages evaluation. Nevertheless, individuals residing within hotspot areas consuming food produced within those regions or drinking untreated water sourced from them will inevitably experience the listed illnesses. Prevalence rates will depend on the degree and duration of exposure. In this case, children diagnosed with hypertension would be attributed to their exposure to trace elements rather than linking it to lifestyle factors alone. In times past cumulative pollution resulting from natural phenomena as well as human activities became prevalent in our environment; age was a primary factor associated with arsenic-related diseases but today this narrative has changed since people across all ages can fall victim to such maladies.

Similarly, as illustrated by Figures 5 and 9; copper (Cu) hotspots and cold spots which characterize Affaina, Moseaso, and Abenesu localities have the propensity to render residents in these areas to be prone to Cu-related health issues. Some of the diseases are heart failure, kidney malfunctioning, brain damage, liver disorders and loss of red blood cells.

This, therefore, implies that not all renal patients living in these areas have their condition linked solely to lifestyle choices since some may have unknowingly ingested toxic amounts of both As and Cu either through food or drinking water intake. Moreover, Figs.6 and 10 highlight Pb concentration anomalies along with corresponding diseases covering about forty percent (40%) of study area landmasses.

Of great concern is the potential impact of Pb exposure on human health, as evidenced by a review of relevant literature which highlights nervous system dysfunction and anaemia among children, while adults are more susceptible to cardiovascular dysfunction and neurological decline. Additionally, Pb exposure may contribute to high blood pressure, brain damage, kidney impairment and reproductive health issues in adults. Symptoms associated with Pb poisoning include headaches, stomach cramps, constipation, joint pain and trouble sleeping; individuals may also experience fatigue or irritability or suffer from loss of sex drive. Unfortunately, many affected individuals do not seek medical attention due to their lack of apparent illness. As a result, they often fail to recognize Pb-related ailments including hypertension or anaemia until it is too late for effective treatment. Identifying regions where such diseases are prevalent would be critical in developing appropriate therapeutic strategies aimed at preventing their further spread throughout those populations. In particular, Figs 7 and 11 illustrate that southwestern communities exhibit toxic concentrations of Zn leading one to conclude that inhabitants within these areas may experience various Zn-related diseases such as abdominal pains or nausea along with vomiting, fever, lethargy, anaemia, dizziness etc. It should be noted, however, that even low levels of zinc deficiency could increase the risk factors associated with diabetes mellitus or obesity among certain populations.

The disease patterns related to various elements, as illustrated in Figure 12, exhibit how different communities preserve distinct disease patterns. For instance, Cu-related diseases dominate the eastern side of the study area and trend northeast-southwest while Zn-related diseases mainly occur in the Southeast. The Zn-Pb-related diseases are predominant in the Southwest portion while As-Pb tends to be in the middle third of the study area. The southeastern tip is characterized by As-related diseases which are associated with As-toxic exposure. In contrast, isolated disease patterns for As, Zn and Pb prevail in northern portions of the study area, whereas a small Cu-related-disease pattern is evident at its northwestern extremity.

Countries worldwide strive to ensure healthy lives and promote well-being for all ages. Ghana has set a goal to reduce premature mortality from non-communicable diseases (NCDs) by one-third through prevention and treatment before 2030. From Figure 12, it is apparent that there are numerous NCDs whose sources can be traced back to four elements having an association with gold in the Birimian Systems of Ghana. This could explain why emerging cases of hypertension, diabetes and many renal diseases have become prevalent in Ghana among people across all age brackets rather than just affecting affluent older individuals.

It seems scientifically incorrect to attribute causes behind children under ten years old being diagnosed hypertensive or diabetic or developing renal impairment simply due to attitudinal reasons; instead, exposure beyond or below what their bodies require concerning trace elements may be responsible for such conditions as Paracelsus had emphasized regarding dosing distinctions between toxicity and treatment.

Therefore, Figs 4-12 suggest outlining hotspots and cold spots of disease-causing elements must define preventive measures better since consuming homegrown produce and unprocessed water remains common practices, especially among developing nations where NCDs cause maximum fatalities like Ghana. If the intentions of the developing countries, of which Ghana is one aim towards attaining SDG 3 and seek to promote healthy living and well-being across all ages; then there is the need to situate a proper attention and action implementation plan accordingly without delay!

5. Conclusion

The study recognized carrying out an environmental geochemical survey is the fundamental first step to identifying and outlining areas with potential environmental health issues. The geospatial maps developed from results obtained from the environmental geochemical survey led to the establishment of hotspots and cold spots of disease-causing elements in this study. The maps illustrated the possible diseases associated with toxic exposure to As, Pb, Cu and Zn. Of the four elements studied, As, Pb and Cu were found to result in predominantly hypertension, diabetes, renal disorders and cardiovascular diseases. Zinc is a known essential trace mineral required for human health; however excessive exposure can lead to abdominal pain, nausea, vomiting, fever, lethargy fatigue anaemia and dizziness.

The study further found that populations residing in communities exposed to these toxins are at risk of ingesting or inhaling them unknowingly until these elements whether essential or harmful accumulate within their bodies to cause illness [30-32]. The authors believe that prevention rather than curative measures must be taken to achieve well-being as enshrined in SDG 3.

Once more, this study has unearthed that ailments once attributed to lifestyle choices may originate from environmental circumstances such as exposure to hazardous substances. By pinpointing the origins of these disease-causing elements, it becomes feasible to manage them effectively, thus curtailing the transmission of emerging non-communicable illnesses - particularly those rampant in developing nations like Ghana where they contribute significantly to mortality rates.

Ultimately, the authors assert that achieving SDG 3 objectives and fostering a thriving nation requires strategic implementation of hotspot/cold spot maps showcasing disease trends derived from environmental geochemical data. This approach enables the generation of precise geo-spatial maps, which prove instrumental in improving the quality of life for all citizens.

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