

Soil Health as a Determinant to Health of People: Example of Soil Selenium Deficiencies in Kintampo Area of Ghana and their Implications to Some Non-Communicable Diseases

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Abstract

Selenium (Se) is a trace metalloid that is a natural constituent of many foods, and also available as a dietary supplement. Although excessive intakes of dietary Se may be harmful, insufficient intake of dietary Se may contribute to thyroid failure, cretinism, cardiomyopathy, immune dysfunction, bone defects, inflammation, male infertility, and probably increased risk of certain human cancers. In this study, a total of 43 stream sediment samples were collected along streams using geographic information system to predetermine co-ordinates in the Kintampo area of Ghana. Concentration of Se and pH were determined. Degree of contamination, pollution load and geo-accumulation indices were calculated. Information was gathered on the health indices from health centers of communities. Our findings showed that sandstones, shales, mudstones and phyllite rocks present have pH levels of 6.4 in the sediments formed over the parent rocks. Checks on the quality analysis indicated good assay repeatability among the duplicate pairs of sediment samples ($p = 0.31$). The geometric mean was 0.11 ppm for selenium. The analyzed results of all samples showed Se-deficiencies at over 80% of the area (i.e. $Se < 0.2$ mg/kg). The deficiency of Se in most areas is feared to hamper the antioxidant role of dietary supplementation of selenium for the population as they eat what they grow. The health indices data obtained from the health facilities in the study area confirmed the presence of Se-related-diseases. This thus makes healthy eating not effective mechanism of preventing element-related-diseases. However, correcting these Se-related diseases may require more than drug prescriptions by clinicians and following the advice of only nutritionists and dieticians. Concerted efforts and contributions from nutritionists, geoscientists' particularly medical geologists and other medical workers are prerequisite to remedy some of these public health concerns.

Keywords: Selenium (Se); Soil Health; Non-Communicable Diseases

Introduction

Due to its dual toxic and health-beneficial character, Selenium (Se) is widely referred to as the 'double-edged sword element' with an information gap between its impact and disease [1,2]. The impacts of elements in geologic materials mobilized by geological processes

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and their subsequent impacts on animal and human health have focused on selected health problems caused by some trace elements resulting from element excesses or deficiencies. Nutritionists and dieticians often report of healthy diets as a means of humans keeping healthy and thus place much emphasis on healthy eating. The evolution of the earth from Stone Age to the current technological age suggests that the mineral or nutrients in food crops today may be different from the same environment a century ago. Explanation to this could be attributed to the differences in toxicity levels of elements in the environment. The connection between the health and well-being of humanity being closely linked to the quality of air, water, and soil, all of which are influenced by the regional and local geology where a population lives is still not obvious to a lot of professionals. Geoscientists and professionals of related geoscientist disciplines have observed the ultimate source of all chemical elements is the rocks of the Earth: the outermost layer of the earth, called crust, supplies all trace elements or nutrients. The geologic process of which weathering is one, results in gradual breakdown and decomposition of rock into its constituent minerals and ultimately into various elements that are released into the environment to supply essential elements and sometimes harmful substances.

Food crops grown in farms take up the elements released from the rocks into the soils. This means that vegetables and fruits may contain more than what nutritionists recommend as portions of the healthy foods as they will take up some of the released elements in the soils. This might not be a problem in the developed world as they do not eat what they grow but may be a big issue in developing countries where we eat what we grow.

This article is picking on selenium whose excesses or deficiencies contribute to some health problems. It is obvious that a healthy soil will provide healthy and uncontaminated food crops that will be essential for human health and well-being. This is exactly what the United Nation is looking for all nations. The earth however is made up of rocks which by the definition of geologists is an aggregate of minerals that break down eventually into elements in the surface environment. However, the assertions from nutritionist and perceptions of some medical professional suggest an existence of knowledge gap on the beneficial health effects of some trace elements example such as Se. It is worth noting that in many areas of the developing world, several reported non-communicable diseases occurrences are attributes to the lack of knowledge on the local health. There are so many element-related-diseases of which several undocumented Se health-related disorders [3] are part but not accounted for because of the disconnect between the various disciplines (Geoscientist-Nutritionist and Medical Workers) that should work together. The wellbeing of humankind through making healthy eating a habit to support the attainment of the sustainable development goal three (SDG 3) particularly in the developing countries requires more than nutritionist efforts.

Location, physiography and geological settings

The study was carried out in the Kintampo North Municipality and Kintampo South District located in the Bono East Region of Ghana. The area is characterized by a forest-savanna type of vegetation as it marks the transitional zone between the northern grassland and southern forest regions of the country. These two districts cover an area of about 6,621 square kilometers with a resident population of approximately 159,701 [4]. Kintampo Municipality is approximately 426 km driving distance via the N6 highway from Accra through Kumasi (Figure 1).

Methodology

A total of 43 stream sediment samples were collected from predetermined locations along streams by navigating to these locations with Global Positioning System (GPS) devices. The geo-availability of Se levels in sediments was assessed to determine the enrichment variables, degree of contamination, pollution load indices, pH and geo-accumulation of Se in the communities of Kintampo, Bono East Region of Ghana with the objective of highlighting its health impacts.

Results and Discussions

Notably, humans, like all living organisms, biosynthesize the proteins, nucleic acids, phospholipids and many of the smaller molecules on which they depend for life functions. As Se cannot be synthesized or generated at rates adequate to support vital functions, their health

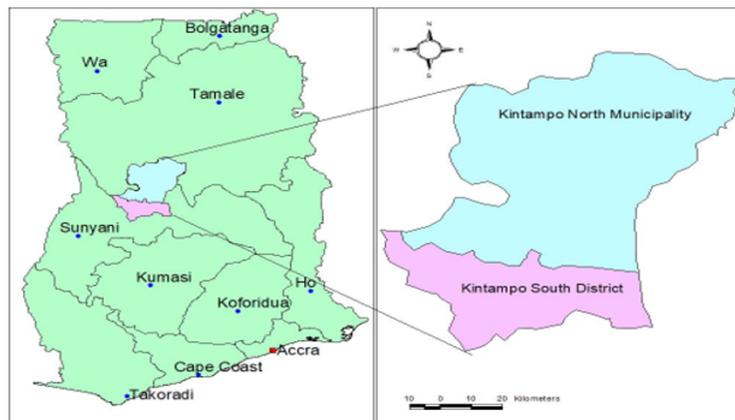


Figure 1: Location of the study area.

and well-being also depend on their ability to obtain from their external chemical environments [5]. Our findings showed that sandstones, shales, mudstones and phyllite rocks present have tendency to host Selenium as observed in similar geological province. However, with the mean sediment pH level of 6.4 considered acidic made the release of Se into the sediments weak and subdued. A geometric mean of 0.11 ppm of selenium was obtained for the area. This was seen as Se-deficiency (Figure 2) and could be that the Se expected to be released into the soils got absorbed into Fe-oxides to form other compounds or were impacted upon by the organic matter. These are expected to be researched into latter. The quality assurance analysis showed good repeatability among the duplicate pairs of sediment samples ($p = 0.31$) and thus had great confidence in the analytical data received from the laboratory.

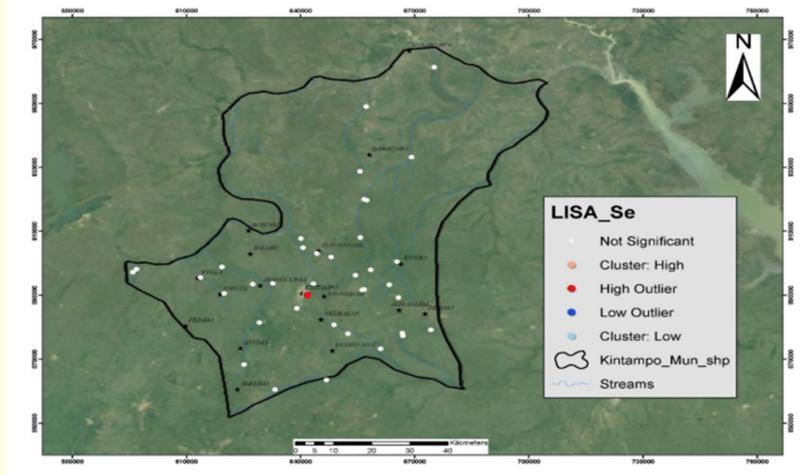


Figure 2: Local indicator spatial analysis (LISA) map showing the hotspots and col-spots of selenium (Se) in the study area.

The Se-deficiency could be their lack in the parent material or could be as a result of the permeability of the soil material coupled with a slightly acidic soils and the presence of other organic matter affecting Se bioavailability identified in the study field [6,7]. Se bioavailability in plant food becomes animal food for synthesis and/or storage as plants tap their Se from the sediments according to the pH of the soil [8]. Therefore, the human body should have substantial amounts of Se obtained mostly from foods they consume [9]. These elements ultimately come from soils and in turn, from the parent materials from which soils are derived [5]. Therefore, good mineral nutrition is, in part, a geologic issue. Deficient levels have resulted in Se-related diseases or disorders requiring effective intervention in communities of Kintampo area.

More than 10% of people in Kintampo area that reported at health facilities have issues or were diagnosed to have bone disorders. This has been observed in areas that are Se-deficient and so it could be due to the population's consumption of Se-deficient foods. Apart from those who probably had accidents, Se deficiency in diets could be the cause of the bone disorders. Selenium status, according to Carolien, *et al.* (2016), was positively associated with bone mineral density [10]. The population or individuals with the lowest levels of dietary Se may have the highest risk of developing osteoporosis [10]. The authors think a dose response relationship should be considered in this area, meaning selenium intake has a negative correlation with osteoporosis risk. This implies that the more an individual consumes food rich in Se, the lower their risk of bone disorders. Also, Se deficiency decreases the activity of selenoproteins and is able to compromise the immune system, thyroid function and cognitive development of individuals. It is impossible to see the trace element contents in consumed food but it's possible to assess soil health.

Conclusion

The study found the area to be deficient in Se (< 0.2 mg/kg) except few areas around Dwenewoho and Habitat near the Kintampo Township that registered Se concentrations of 0.4 mg/kg. The health indices data obtained from the health facilities in the study area confirmed the presence of Se-related-diseases. However, correcting these Se-related diseases may require more than drug prescriptions by clinicians. Concerted efforts from nutritionists and geoscientists particularly medical geologists and other medical workers are required to remedy this public health concern.

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