

Human Health Problems in Bibiani Related to Concentrations of Trace Elements in Water

G., Kusi and D., Aikins

Department of Geological Engineering, University of Mines and Technology, Tarkwa, Ghana.

ARTICLE INFO

Article history:

Received: 3 July 2018;

Received in revised form:

5 September 2018;

Accepted: 5 September 2018;

Keywords

Trace Element Concentration,
Human Health,
Bibiani,
Magnesium,
Iron,
Manganese,
Copper.

ABSTRACT

The Bibiani government hospital over the years has recorded high cases of hypertension, anaemia and musculoskeletal pain. Analysis of data acquired from the Bibiani government hospital showed that, cases of hypertension increased in the years 2015, 2016 and 2017. Similar trend was observed for the other diseases. Using the World Health Organisation standard age categorisation to know the age distribution of the reported cases, of the total number of cases reported for the respective diseases, the adult age group recorded higher percentages. The infant age group, recorded an abnormal percentage for anaemia cases. However, the high percentages recorded for the adult and infant age category needs to be investigated. The groundwater quality parameters were compared with the World Health Organisation WHO and Bureau of Indian Standard (BIS). Essential trace elements namely Iron, Zinc, Copper and Magnesium were found to be deficient in the drinking water of the inhabitants of Bibiani. The deficiency of the above-mentioned trace elements can be assessed as a possible source to health problems in Bibiani.

© 2018 Elixir All rights reserved.

Introduction

Bibiani, the capital of the Bibiani-Anhwiaso-Bekwai district, in the western region of Ghana has a population of about 21,583 as at 2013 (Anon 2018). The main health facility in the area is the Bibiani government hospital which provides health assistance to about 90% of the town's population. The Bibiani government hospital over the years has recorded high cases of hypertension, anaemia and musculoskeletal pain. Analysis of data acquired from the Bibiani government hospital showed that, cases of hypertension increased in the years 2015, 2016 and 2017 (Fig. 3a). Similar trend was observed for cases of anaemia and musculoskeletal pain (Fig. 3b and 3c). Using the World Health Organisation standard age categorisation to know the age distribution of the reported disease cases (Fig.4), It was observed that of the total number of cases reported for hypertension over the four-year period, 47.2% fall within the old category, about 52% fall in the adult category with 0.9% and 0.2% falling in the infancy and adolescent age categories respectively. Among the total number of cases recorded for anaemia, 59% fall in the adult age group and 15% falling within the old age category. 17.6% and 8.3% also fall in the infancy and adolescent age categories respectively. Out of the total number of cases recorded for musculoskeletal pain, the adult age category recorded 69.5%, with It can be argued that reported cases of disease in the old age category can be attribute to normal situation as old age comes with lot of diseases. However, the high percentages recorded for the adult category needs to be investigated since a greater percentage of the population in the community are contracting such diseases. There are many possible causes of these diseases, which include: bad eating habit, alcoholism and environmental factors etc. Many study analyses have examined the relationship between diseases and the

environment and findings of these research have shown that most diseases are caused by interaction of man with his environment.

In Bangladesh, India, China, Taiwan, Vietnam, and Mexico, high levels of arsenic in drinking water have caused serious health problems for many millions of people (Kinniburgh and Smedley, 2001). Endemic Goiter was also recorded in Sri Lanka because of Iodine deficiency in soils (Dissanayake and Chandrajith 2007).

In the Bongo districts of northern regions of Ghana, high fluoride concentration in water was attributed as the source for the endemic fluorosis in these districts (Affam *et al.*, 2012). Accordingly, the present study attempts to assess the quality of the groundwater and how it is impacting on the health of the inhabitants of Bibiani.

Location and Accessibility

Bibiani is in the Western Region of Ghana. It has a population of about 21,583 (Anon., 2018). Bibiani is located approximately at latitude 6.47°N and longitude -2.33°W at an altitude of 250 meters. The most practicable access to the area is from the east on the Kumasi road.

Geological Province

The area is underlain by Birimian metasedimentary rocks in the eastern parts and by intercalated Birimian metasedimentary and metavolcanic rocks in the western part of the area. Granitoids occur in the south-western corner of the area. The Birimian metasedimentary rocks consist mainly of phyllites with intercalated greywackes and minor tuffs, while the Birimian metavolcanic rocks consist of basalt to rhyolites flows with intercalated tuffs and minor phyllites and chert horizons. Diorite intrusives are found within the Birimian metavolcanic rocks (Kesse, 1985)

Materials and Methods Used

The methods used for this project include: field visit for

sampling of boreholes in the Bibiani community, analysis of groundwater data using Atomic Absorption Spectrometry (AAS) interpretation of results, review of relevant literature

Field Data Collection

The field visit of the study area was done at two different occasions. The first visit was done to study the various locations and to identify the various boreholes to be sampled for the laboratory analysis. Sample collection., taking of pictures and GPS readings of the various boreholes and hand-dug wells were taken on the next visit.

Sampling Procedure

Sampling was done according to the following protocol;

On-site preparation, which comprises of the confirmation of sampling points, cleaning of bottles for sampling by pre-washing with distilled water and rinsing of the bottles with respective water samples to prevent contamination. Rinsing was done three times before sampling.

To ensure purging, the samples were taken early morning when much pressure was on the sources, since field meter needed to check the field parameters were not available.

Sample collection: Various samples were collected from individual boreholes and wells with identification numbers G01 to G13.

Sample storage and transportation: The samples were stored in an ice container with ice cubes in order to prevent reaction from taking place within the samples and was transported to the laboratory via vehicle.



Figure 1. Sampling of borehole for laboratory analysis.

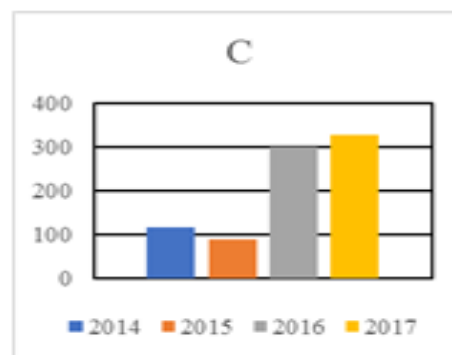
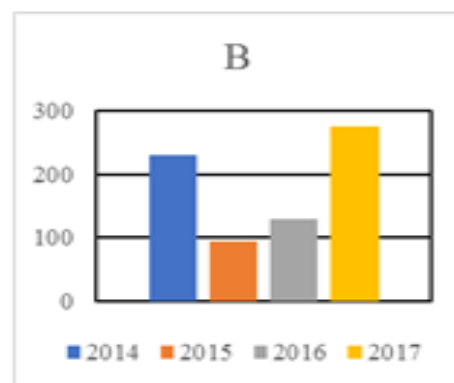
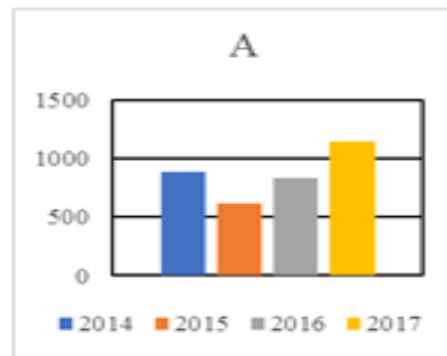


Figure 3. Graphs of Reported Cases of Disease at the Bibiani government hospital (a) Hypertension, (b) Anaemia (c) Musculoskeletal pain.

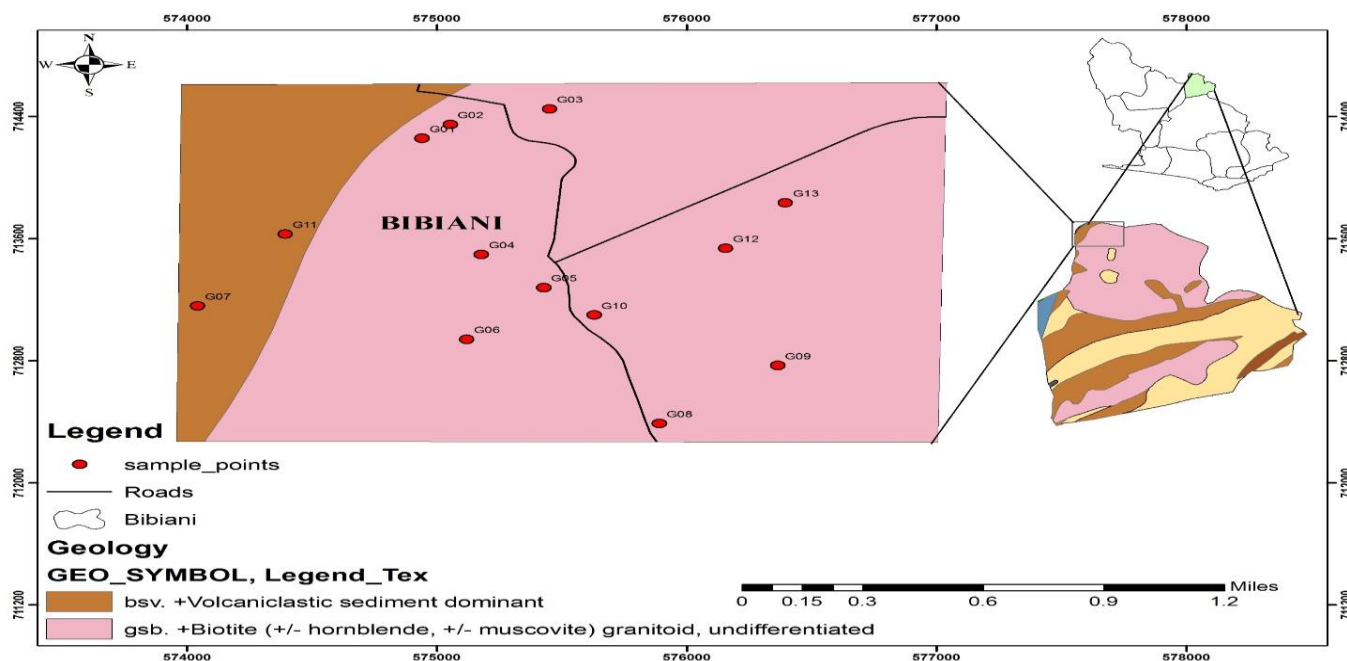


Figure 2. Map of Bibiani showing sample points.

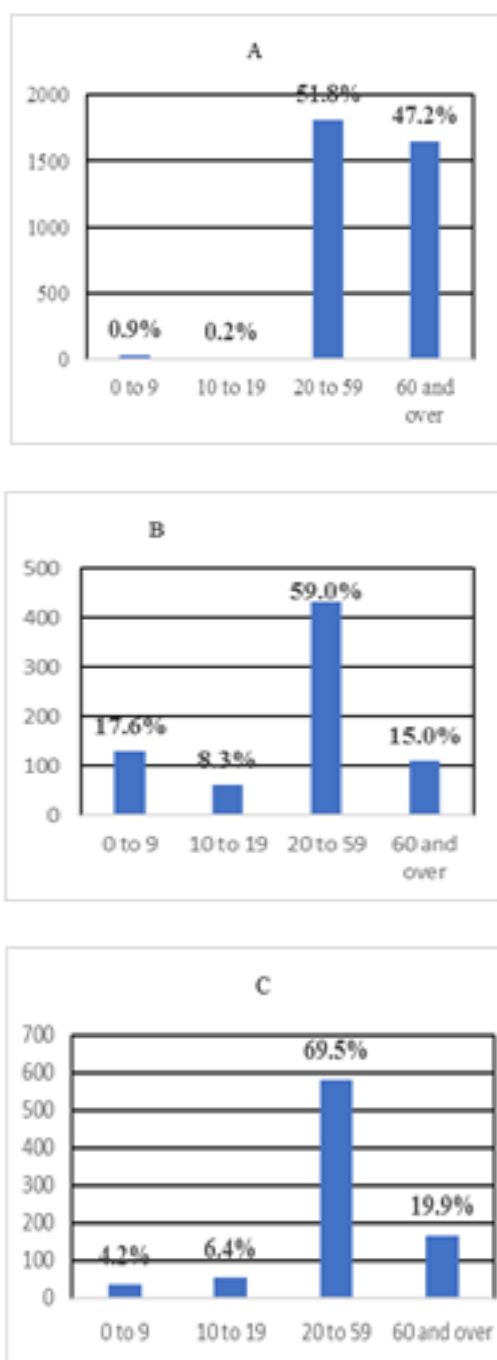


Figure 4. Graphs of Diseases for various age categories reported at the Bibiani government hospital (a) Hypertension, (b) Anaemia (c) Musculoskeletal pain.

Laboratory Analysis

Analyses of samples for levels of water quality parameters were performed at the Environmental and Safety Engineering laboratory. The water quality parameters that were tested are trace metals (Copper, Cadmium, Lead, Manganese, Sodium, Calcium, Potassium, Magnesium, Zinc, Iron and Chromium) and physical parameters such as hydrogen potential, electrical conductivity, total dissolved solids, dissolved oxygen, turbidity, oxygen reduction potential, total suspended solids, salinity, apparent colour, true colour, temperature.

Equipment Reagents Used

The equipment used include: ESTEK multimeter, used to measure pH, electrical conductivity, salinity etc. of the solution. Smart 3 colorimeter; used for testing the turbidity and color. Atomic Absorption Spectrometer (AAS); for detecting the presence of trace metals or cations present in the

solution, 250 ml beakers, Plastic bottles, Wash bottles, Tissue paper. The reagent used include: distilled water, a quantity of nitric acid (HNO₃), blank solution for calibration of the Smart 3 colorimeter, standard solutions for calibration of the AAS and the ESTEK multimeter.

Trace Metals Test Procedure

Atomic Absorption spectrometry (AAS) is a technique for measuring quantities of chemical elements present in environmental samples by measuring the absorbed radiation by the chemical element of interest. This is done by reading the spectra produced when the sample is excited by radiation. The atoms absorb ultraviolet or visible light and make transitions to higher energy levels. Atomic Absorption methods measure the amount of energy in the form of photons of light that are absorbed by the sample. A detector measures the wavelength of the light transmitted by the sample, and compares them to the wavelength which originally passed through the sample. A signal processor then integrates the changes in wavelength absorbed, which appear in the readout as peak of energy absorption at discrete wavelengths. The energy required for an electron to leave an atom is known as ionization energy and is specific to each chemical element. When an electron moves from one energy level to another within the atom, a photon is emitted with energy. Atoms of an element emit a characteristic spectral line. Every atom has its own distinct pattern of wavelengths at which it will absorb energy, due to unique configuration of electrons in its outer shell. This enables the qualitative analysis of a sample. The concentration is calculated based on the Beer-Lambert law. Absorbance is directly proportional to concentration of the analyte absorbed for the existing set of conditions.

Data Analysis

The data obtained were analysed using Microsoft Excel 2016 and the outputs presented in tables to visually display the data.

Results and Discussion

Results

Summary of the statistics on the various levels of physico-chemical parameters and trace elements of groundwater sampled from the study area are presented in Table 1.

To ascertain the soundness and quality of the water for domestic purposes, the values have been placed alongside standards mentioned earlier in this section.

Discussions

Trace elements (or trace metals) are minerals present in living tissues in small amounts. Some of them are known to be nutritionally essential, others may be essential (although the evidence is only suggestive or incomplete), and the remainder are nonessential (toxic). All trace elements are toxic if consumed at sufficiently high levels for long enough periods. The difference between toxic intakes and optimal intakes to meet physiological needs for essential trace elements is great for some elements but is much smaller for others.

Iron:

Iron concentration in natural waters depends on the geology of the area. The natural source of iron in waters includes weathering of rocks. The mean concentration recorded in the study was 0.033 mg/L and the levels range between 0.001 and 0.173 mg/L (Table 1). These levels are below the desirable limits of the BIS.

Table 1. Statistical Analysis of the Water Quality Parameters against the WHO and BIS.

Parameter	Unit	Mean	Minimum	Maximum	Standard Deviation	WHO	BIS	
							Desirable	Permissible
pH	pH unit	5.67	4.18	6.84	0.75	8.50	6.50 -8.50	6.5 -9.2
E.C	S/cm	366.38	50.00	1382.00	373.89	6.50		
TDS	mg/L	245.00	34.00	922.00	249.52	1000.00	500.00	1500.00
DO	mg/L	5.07	3.46	6.81	1.09	500.00		
TURB	NTU	2.57	0.00	8.47	2.89	5.00	2.50	10.00
TSS	mg/L	3.46	0.00	12.00	3.53	500.00		
SALIN	mg/L	183.00	25.00	689.00	186.43			
APP-CL	Hz	27.38	0.00	85.00	30.00	15.00		
TRUE-CL	Hz	17.46	0.00	67.00	27.82	15.00	5.00	
TEMP	°c	28.89	28.60	29.20	0.21			
Cu	mg/L	0.01	0.00	0.02	0.01	2.00	0.05	1.50
Cd	mg/L	0.00	0.00	0.01	0.00	0.00	0.01	0.01
Pb	mg/L	0.00	0.00	0.00	0.00	0.01	0.05	0.05
Mn	mg/L	0.09	0.00	0.67	0.18	0.40	0.05	0.50
Na	mg/L	13.75	9.16	20.69	4.09	200.00		
Ca	mg/L	7.45	0.23	47.77	12.65	200.00	75.00	200.00
K	mg/L	12.93	0.37	98.25	26.72	30.00		
Mg	mg/L	3.13	0.14	5.63	2.15	150.00	30.00	100.00
Zn	mg/L	0.00	0.00	0.00	0.00	3.00	5.00	15.00
Fe	mg/L	0.03	0.00	0.17	0.05	0.30	0.30	1.00
Cr	mg/L	0.00	0.00	0.00	0.00	0.05	0.05	0.10

Iron is an essential trace element for both plants and animals. It is required by most organisms for essential growth and development. Its deficiency could cause adverse biological effects. The toxicity of iron depends on whether it is in the ferrous or ferric state, and in suspension or solution. It may act as inhibitors to various enzymes. Iron deficiency is recorded to be the cause of the cases of anaemia which affects roughly a third of the world's population. Anaemia is a major and global public health problem. Several chronic diseases notably chronic kidney disease, chronic heart failure, cancer, and inflammatory bowel disease are frequently associated with Iron Deficiency Anaemia (IDA) (Lopez *et al.*, 2016). Another study by Killip *et al.*, suggests that deficiency of iron in diet and food is attributed as the cause of anaemia in humans (Killip *et al.*, 2007). The Recommended Daily Allowances (RDA) for iron is 10-18 mg (NRC, 1989). It is evident from other studies that, the level of iron in the groundwater being below the desirable limit of the BIS is a cause of the high anaemia cases recorded in Bibiani.

Zinc

Zinc is one of the earliest known trace metals. It is an essential micronutrient for all organisms as it forms the active site in various metalloenzymes. It is found in virtually all food and potable water in the form of salts or organic complexes. Zinc occurs in rocks and ores and can enter water through both natural processes such as weathering and erosion, and through industrial activity. In the study, the levels of zinc concentration were all below detection limit of 0.002 mg/L. These values were found to be below the desirable limit for the BIS (Table 1). This shows a deficiency of zinc in the water used for domestic purposes. Severe, moderate, and marginal zinc deficiencies have been reported in the United States (Hambidge *et al.*, 1986). According to the National Research Council, the Recommended Daily Allowances (RDA) for zinc is 8-15 mg (NRC, 1989). Zinc deficiency resulting in growth retardation, hypogonadism, immune dysfunction and cognitive impairment affects nearly 2 billion subjects in the developing world (Prasad, 2009). In

the recent study, zinc deficiency can be related as a possible source of health problems that occur as stated in literature by Prasad.

Copper

Copper is known to be a common trace metal found in minerals and rocks of the earth's crust. The occurrence of natural sources of copper in water is due to weathering processes or from dissolution of copper minerals and native copper. Metallic copper is insoluble in water. The mean concentration recorded in the study is 0.006 mg/L, with levels ranging between 0.001 and 0.023 mg/L (Table 1). These levels were found to be below the desirable limits for the BIS. Copper deficiency has been associated with anemia, particularly in young children (Danks, 1980). According to Dunlap, it has been reported that copper deficiency causes anaemia in malnourished infants (Dunlap *et al.*, 1974). In the study, 17.6% cases of anaemia was recorded infants (0-9). The cause of the anaemia among the infants can therefore be assessed as copper deficiency in the drinking water in the study area.

Manganese

Manganese is a trace element which can be both essential and toxic depending on the dose consumed. In the study, sample points G01, G02, G04, G08, G09, G12 and G13 recorded levels of manganese below the BIS permissible limit. G05, G06 and G07 had levels above the desirable limit of the BIS but below the permissible limit. G11 recorded a level 0.667 (Table 1) mg/L which is above the permissible limit of the BIS. Data from the Korean National Health and Nutrition Examination (KNHANES) shows that, Manganese level is associated with an increased risk of hypertension in the Korean adult population (Lee and Kim, 2011). On the other hand, no difference has been discovered between levels of Manganese and rate of mortality of coronary heart diseases when drinking water sources in two regions of Finland were tested.

Whereas differences were found for certain other trace elements, including copper and chromium (Punsar *et al.*, 1975). From these studies, Manganese levels in the drinking water of the inhabitants can be attributed as the source of the high cases of hypertension recorded earlier in this study.

Magnesium

Magnesium is the eighth most abundant element in the earth crust and it is the third most abundant element dissolved in seawater after sodium and chlorine. It is one of the most essential trace elements and plays important roles in humans. The average adult body contains about 25 g of magnesium, approximately 60% of which is found in bone. The RDA of magnesium in humans is 3.5mg. In the study, the mean concentration of magnesium is 3.130 mg/L and ranges between 0.139 and 5.627 mg/L (Table 1). The mean value of magnesium level was found to be below the desirable limits for both the BIS and WHO. This shows deficiency of magnesium in the water used for domestic purposes by the inhabitants of Bibiani. According to Abraham and Flechas, magnesium deficiency plays a possible role in musculoskeletal pain. On the other hand, several fibromyalgia (musculoskeletal pain) manifestations such as fatigue, muscle weakness, irritable bowel and paresthesia are similar to symptoms of magnesium deficiency (Abraham and Flechas, 1992). With these literature, magnesium deficiency in the groundwater can be attributed as a possible source of the high cases of musculoskeletal pain. In Taiwan, Yang and Chiu examined whether levels of calcium and magnesium in drinking water are protective against hypertension. Report from the study showed that low levels of magnesium in drinking water is related to the risk of death from hypertension. Magnesium deficiency has been implicated in the pathogenesis of hypertension (Yang *et al.*, 1999). In the recent study, magnesium deficiency in the drinking water can also be implicated as a possible source of hypertensive cases recorded by the government hospital.

Conclusions

The results of this study show that, the physical parameters analysed from the groundwater samples were below expectations when compared to the WHO and BIS. Except for G10 which recorded higher values of physical parameters compared to the remaining sample points. The concentrations of the trace elements recorded in the study, were below the desirable limits of the WHO and BIS. manganese was found to record higher concentrations in some of the groundwater samples. Some essential trace elements namely Iron, Zinc, Copper and Magnesium were found to be deficient in the drinking water of the inhabitants of Bibiani. These findings suggest that, the deficiency of the above-mentioned trace elements can be assessed as a possible source to health problems in Bibiani.

Acknowledgment

My sincerest thanks go to God Almighty for granting me the grace and strength to finish this work and to my

supervisor, Mr. Derrick Aikins for his guidance and supervision. My sincere gratitude goes to all the lecturers in the Department of Geological Engineering (UMaT) for the knowledge imparted to me. To Mr. Meshack Tei of the Environmental and Safety Laboratory for his time and effort in analysing the samples collected. A heart felt gratitude to Mr. Robert Ossamu of Bibiani Government Hospital for his time during my hospital data collection. I cannot forget my family, I am much grateful for your support and always being there for me no matter the situation I find myself. Lastly to my course mates and friends, I say God richly bless you all and make everyone great.

References

- Abraham, G.E. and Flechas, J.D., 1992. Management of fibromyalgia: rationale for the use of magnesium and malic acid." *Journal of Nutritional Medicine*, 3(1), pp.49-59.
- Affam, M., Arhin, E. and Asamoah, D.N., Source of Endemic Fluorosis Attributed to Igneous Granitoids In Northern Ghana: A Case Study.
- Danks, D.M., 1980. Copper deficiency in humans. *Biological roles of copper*, pp.209-225
- Dunlap, W.M., JAMES, G.W. and Hume, D.M., 1974. Anemia and neutropenia caused by copper deficiency. *Annals of Internal Medicine*, 80(4), pp.470-476
- Hambidge, K.M. and Krebs, N.F., 1986. Zinc requirements and zinc intakes of breast-fed infants. *The American journal of clinical nutrition*, 43(2), pp.288-292.
- Prasad, A.S., 2009. Impact of the discovery of human zinc deficiency on health. *Journal of the American College of Nutrition*, 28(3), pp.257-265
- Punsar, S., Erämettä, O., Karvonen, M.J., Ryhänen, A., Hilska, P. and Vornamo, H., 1975. Coronary heart disease and drinking water: a search in two Finnish male cohorts for epidemiologic evidence of a water factor. *Journal of chronic diseases*, 28(5-6), pp.259-287.
- Killip, S., Bennett, J.M. and Chambers, M.D., 2007. Iron deficiency anemia. *American family physician*.
- Kinniburgh, D.G. and Smedley, P., 2001. Arsenic contamination of groundwater in Bangladesh.
- Kim, Y. and Lee, B.K., 2011. Iron deficiency increases blood manganese level in the Korean general population according to KNHANES 2008. *Neurotoxicology*, 32(2), pp.247-254
- Kesse, G. O (1985) "The Rock and Mineral Resources of Ghana" A.A Balkema, Rotterdam 610 pp
- Lopez, A., Cacoub, P., Macdougall, I.C. and Peyrin-Biroulet, L., 2016. Iron deficiency anaemia. *The lancet*, 387(10021), pp.907-916.
- National Research Council, 1989. *Recommended dietary allowances*. National Academies Press.
- Yang, C.Y. and Chiu, H.F., 1999. Calcium and magnesium in drinking water and the risk of death from hypertension. *American journal of hypertension*, 12(9), pp.894-899.