

Assessment of Arsenic Concentration Distribution and Related Diseases in the Obuasi Municipality of Ghana*

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Abstract

Analytical results for arsenic concentration levels for ground water samples obtained from the Obuasi Municipality in the Ashanti Region of Ghana were compiled. Arsenic is dangerous to human health due to its toxicity. The threat of arsenic to the public sometimes stems from its contamination of ground water. The locations of the sample sources were mapped. The concentration levels were found ranging from 7.2 to 34.5 micrograms per liter ($\mu\text{g/L}$). The results showed that wells and boreholes around the Nyamso River had higher arsenic concentrations. The data on arsenic related diseases from major health facilities were collated and analysed. Arsenic related diseases pertaining in the metropolis include bronchitis, skin cancer and other skin diseases. The results of the trend of the diseases in the communities were analysed and also mapped using GIS overlay procedures. From the maps and graphs, it was observed that there was an increase in the trend of arsenic related diseases and is increasing at an alarming rate annually. Maps produced showed that communities closer to the major health facilities have their sources of water from water bodies which have higher arsenic concentrations. These give indications of the intensity of water pollution and the effects on human health indicating that mining in the Obuasi gold belt has partly affected water patterns of both ground and surface water sources. It is recommended that much research should be conducted to determine areas suitable for boreholes before sinking boreholes in the communities.

Keywords: Arsenic, Gold Mining, Obuasi, Ghana, Maps, Contamination

1 Introduction

Ghana is an important gold mining country in the World with Obuasi as one of the major mining towns. Gold (Au) in Obuasi is associated with sulphide mineralization, particularly arsenopyrite (Griffis *et al.*, 2002). The belief is that the Birimian formation has over ten times the average crystal abundances of gold and arsenic (Kesse, 1985). Arsenic (As) is a natural component of the Earth's crust and it is widely distributed throughout the environment. It is highly toxic in its organic form and causes diseases which mostly affect the respiratory system.

Arsenic is a carcinogen and consumption of arsenic in drinking water is linked to multiple health problems, including bladder, lung, prostate, and skin cancers; cardiovascular disease; diabetes; and neurological dysfunction (Gross and Low, 2013; Lin *et al.*, 2008; Chen *et al.*, 2007; Hoppenhayn, 2006).

The greatest threat to the public from arsenic originates from contaminated ground water. In Ghana, mining plays an important role in the economic growth. However, the gains from the growth are being achieved at the expense of the environment, its degradation and human health. The extraction of gold involves roasting of the ore which sometimes discharges contaminated particles into the environment, which can be washed into

water sources, especially in the mining communities (Anon, 2012; Asiem, 1996).

Mining operations are generally associated with many types of mine wastes, including mine tailings, waste rock and slag. Mine tailings out of those, in particular, act as a main source of environmental contamination (Roussel *et al.*, 2000; Bempah *et al.*, 2013). Arsenic (As) and other metals may be released to the ground and surface water systems, as well as the geological environment due to their solubility and mobility (Jang *et al.*, 2005).

Although the Environmental Protection Agency (EPA) plays a supervisory and regulatory role over activities of mining companies, communities are still faced with environmental pollution issues (Bempah *et al.*, 2013). This present study investigated the potential sources and the rate of distribution of arsenic and other trace elements contamination and their release into the environment.

In the study, maps of the diseases that are related to the arsenic concentration in water bodies are produced. Database was created for the health records and thematic maps to depict the high prone areas. Then using overlay techniques in GIS distribution of arsenic related diseases as well as arsenic content of water bodies were mapped for Obuasi.

2 Resources and Methods Used

2.1 The Study Area

Obuasi is a gold mining town in the southern part of Ashanti Region between latitudes 5°35' N and 5°65' N and longitudes 6°35' W and 6°50' W. It covers a land area of 1 624 km². There are about 52 villages in the Obuasi Municipality which share 30 electoral areas. It is bounded to the east by the Adansi South District, west by the Amansie Central District and to the north by Adansi North District

The Municipality experiences semi-equatorial climatic conditions with a double maximum rainfall regime. Mean annual rainfall ranges between 125 cm and 175 cm. Temperatures are uniformly high all year with the hottest month being March when 30°C is usually recorded. Mean average annual temperature is 25.5°C. Relative humidity is highest (75% - 80%) in the wet season (Anon, 2006). The forest consists of limited species of hard wood, which are harvested as timber. Generally, the Municipality has an undulating terrain with more of hills rising above 500 metres above sea level. The Municipality is made up of some rivers which include; Pompo, Nyame, Akapori, Wheaseammo and Kunka. These rivers are almost polluted by mining and other human activities

According to surveys made by the Statistical services and projections from the 2000 Population and Housing census, the population of the Municipality is about 195 000 (Anon, 2006). The population distribution of the Municipality shows that 48% of the population is in the dependent age groups, thus, between 0-14 years and 65 years and over and 52% constitute the labour force. There are more females than males. Males constitute 49.5% and females 50.55%.

There are about 52 communities which make up the Municipality. Due to the limited land area, 94% of the population in the Municipality is concentrated along the major roads which run in the valleys. The composition and structure of household in the Municipality are a reflection of the social structure in Ghana. Based on centrality, there are five identified order of settlements. The first order settlements include three communities namely; Boete, Obuasi Central and Mangoase. The second order settlements are Wawase and Tutuka.

Facilities in the Municipality are relatively fairly distributed especially basic facilities like Clinics, basic schools, water and sanitation, communication. It is noted that location of the settlements has been influenced by mining activities.

The mining industry is a major source of heavy metal pollutants in the environment. Various heavy metals such as magnesium, arsenic, mercury and cadmium are emitted from the mines (Duker *et al.*, 2006). The release into the environment of hazardous contaminated materials, around and from the operational areas of the mining plant sites have been found to be the main source of the metals. The release of the toxic materials into the environment as a result of rainfall runoff from and around the operational area of the mines plants, has the potential to cause soil and water pollution

Mine tailings are potential heavy metal source. The separation processes do not extract all the minerals present. The tailings that accumulate in the environment may contain quantities of toxic metals and other minerals. The finely minerals from processing makes contaminants such as arsenic, zinc, cadmium bound up in solid rock accessible to water (Reid *et al.*, 2009).

The activities of *galamsey* operators in Obuasi Municipality also contribute immensely to arsenic pollution in streams and rivers. *Galamsey* operators mix significant volumes of water from the streams with mercury for gold processing (Akabzaa and Darimani, 2001). Fig. 1 shows the Obuasi Municipality (OMA), as well as some of the towns.

2.2 Materials Used

The administrative data for this study was collected from the records Departments of the major Hospitals namely; Bryant Hospital, AngloGold Ashanti Hospital, Government Hospital, SDA hospital, St Jude hospital and Obuasi Diagnostic hospital. The data consisted of diseases related to arsenic and the various locations of the reported cases. The data was collected for a period of four years from 2013 to 2016. Other data were collated from the Water Resource Commission and from the Environmental Department of AngloGold Ashanti in the Obuasi Municipality. This consists mainly of information about the various water bodies around the study area and their arsenic concentrations.

The primary data was obtained by using Handheld GPS receivers to collect the geographical locations of the various hospitals, the locations of wells in the various communities. Some of the samples of the data are presented in Tables 1 to 4.

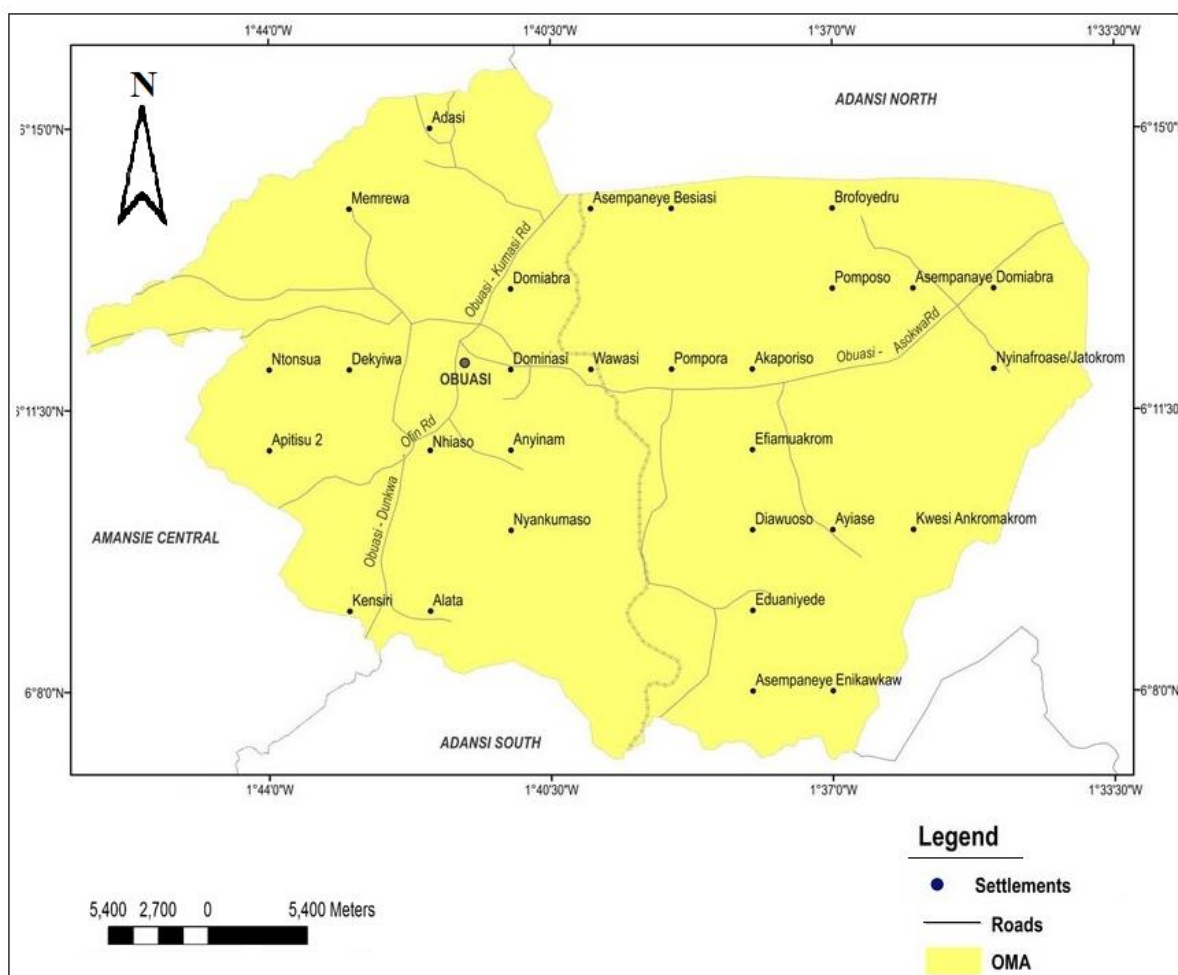


Fig. 1 Obuasi Town and Surrounding Communities

Table 1 Arsenic Concentration Levels of Well Water in Obuasi

Location of Wells	Coordinates of Wells		Arsenic Concentration ($\mu\text{g/L}$)		
			1990	2000	2015
Akaase	202726.9	172199.8	0.02	7.1	18.4
Asuakoo	201632.4	170886.5	0.01	7.4	7.9
Hia	199005.8	168040.9	0.01	4.8	18.9
Sanso	197364.1	164867.1	0.02	10.0	22
Nyam	194445.3	171626.2	0.05	7.8	34.5
Gyimi	205888.6	164813.2	0.02	17.5	28.4
Kunka	207013.1	169741.1	0.03	13.6	11.9
Fenaase	199770.1	172488.1	0.03	10.0	17.6
Wheasamo	193023.2	171824.7	0.01	3.6	10.7
Kwabrefoso	202449.0	167029.1	0.02	10.5	22.7
Ako	198017.9	170495.7	0.02	7.5	7.2
Pompo	205359.4	172486.1	0.01	4.3	18.9

Table 2 Geographic Locations of Major Hospitals

Major Hospital	Northings (m)	Eastings (m)
Government	198496.00	169392.00
Obuasi Diagnostic	196903.40	172413.20
St Jude Hospital	198932.30	170452.60
SDA Hospital	203592.40	169345.00
Bryant Hospital	198503.20	169865.00
Anglogold Ashanti (AGA)	198496.00	169915.00

Table 3 Arsenic Related Diseases (Bronchitis)

Hospital	Number of Patients/Year			
	2013	2014	2015	2016
Government	7605	8960	9500	9950
Bryant	6250	7800	9200	9500
Diagnostic	5025	6352	7939	8202
AGA	3893	4800	6502	7350
SDA	3193	3560	6105	7250
St Jude	1383	2578	3065	4500

Table 4 Arsenic Related Diseases (Skin Diseases)

Hospital	Number of Patients/Year			
	2013	2014	2015	2016
Government	3200	5560	7200	9002
Bryant	2900	4022	6602	7342
Diagnostic	2660	3200	3720	6504
SDA	2500	2882	4540	4802
AGA	2400	2900	4950	5520
St Jude	2000	2500	3102	4995

2.3 Methods Used

The methods employed to execute this study include field data collection of locations of wells

and hospitals using Global Positioning System (GPS) receiver. Data of patients with arsenic related diseases acquired from major health facilities in the study area were processed and analysed using ArcGIS software suite. Post-processing of data was done using GIS software leading to the production of the requisite maps and charts.

Maps of the diseases that are related to the arsenic concentration levels in water bodies were produced in ArcGIS using overlay techniques. Database and thematic maps were created for the health records to depict the high prone areas. Then using overlay techniques in GIS distribution of arsenic related diseases as well as arsenic content of water bodies were mapped for Obuasi Metropolis.

3 Results and Discussion

3.1 Results

From the data processing and analysis, it was observed that the arsenic concentration levels of the major rivers and water bodies have increased from the period 1990 to 2015. This clearly shows the extent of the impact of mining activities on the water bodies within the study area. River Nyamso, Sanso and Kwabrefo show a rapid increase in the concentration levels. Fig. 2 shows the rate of increase in the arsenic concentration of water bodies within the study area.

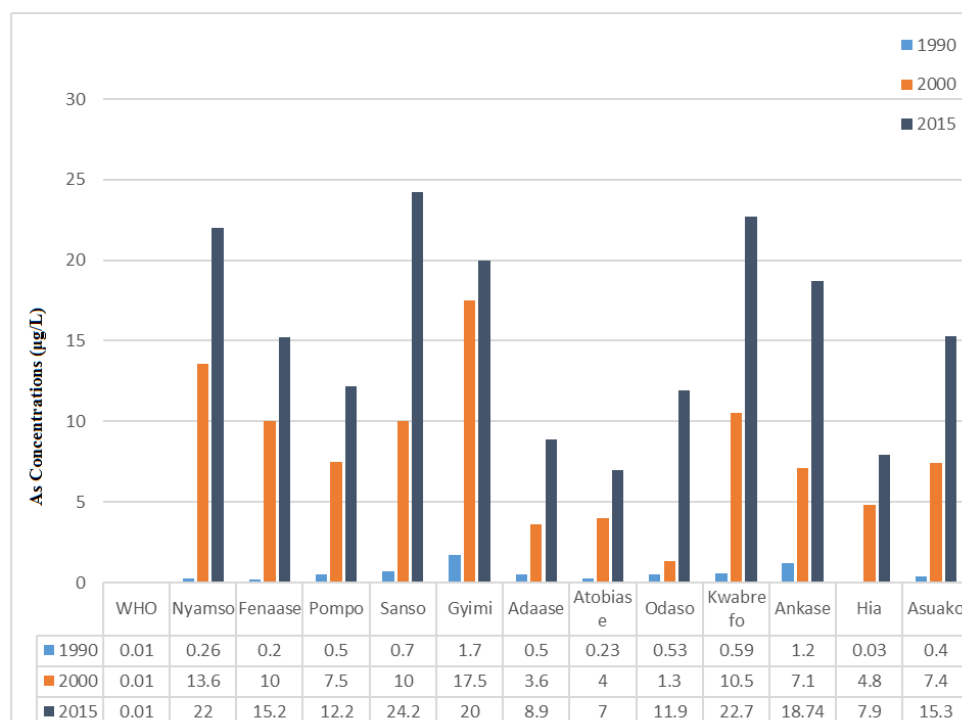


Fig. 2 Arsenic Concentration (1990-2015) of Rivers in Obuasi

3.1.1 Spatial Distribution of Arsenic Concentrations

A thematic map showing areas of arsenic concentration levels was created. Fig. 3 shows the magnitude of the arsenic concentrations from the various wells within the study area with River Nyam having the highest concentration followed by Sanso and Kwabrefo.

The extremely high levels of arsenic in the Nyam area stem from the fact that the river is a direct recipient of the discharges from the treatment retention sump and the tailings dam. Kwabrefo River is also noted for *galamsey* activities. This also causes the underground water to be polluted due to the toxic release. As shown in Fig. 3, the concentration of Arsenic in the various wells is high, with wells around the Nyam River and Kwabrefo River having the highest concentrations.

3.1.2 Positions of Hospitals

The map of the major hospitals and clinics in the Obuasi Municipality is presented and analysed. The locations of the major hospitals are uniformly distributed across the central portion of the Municipality. The output map obtained is shown in Fig. 4.

3.1.3 Disease Distribution

The four year period of study was combined and the various diseases were analysed individually with respect to the major hospitals. Figs. 5, 6 and 7 indicate how the diseases have over the years and the spread and the output of patients per year as shown in the proceeding Figs. 5, 6 and 7.

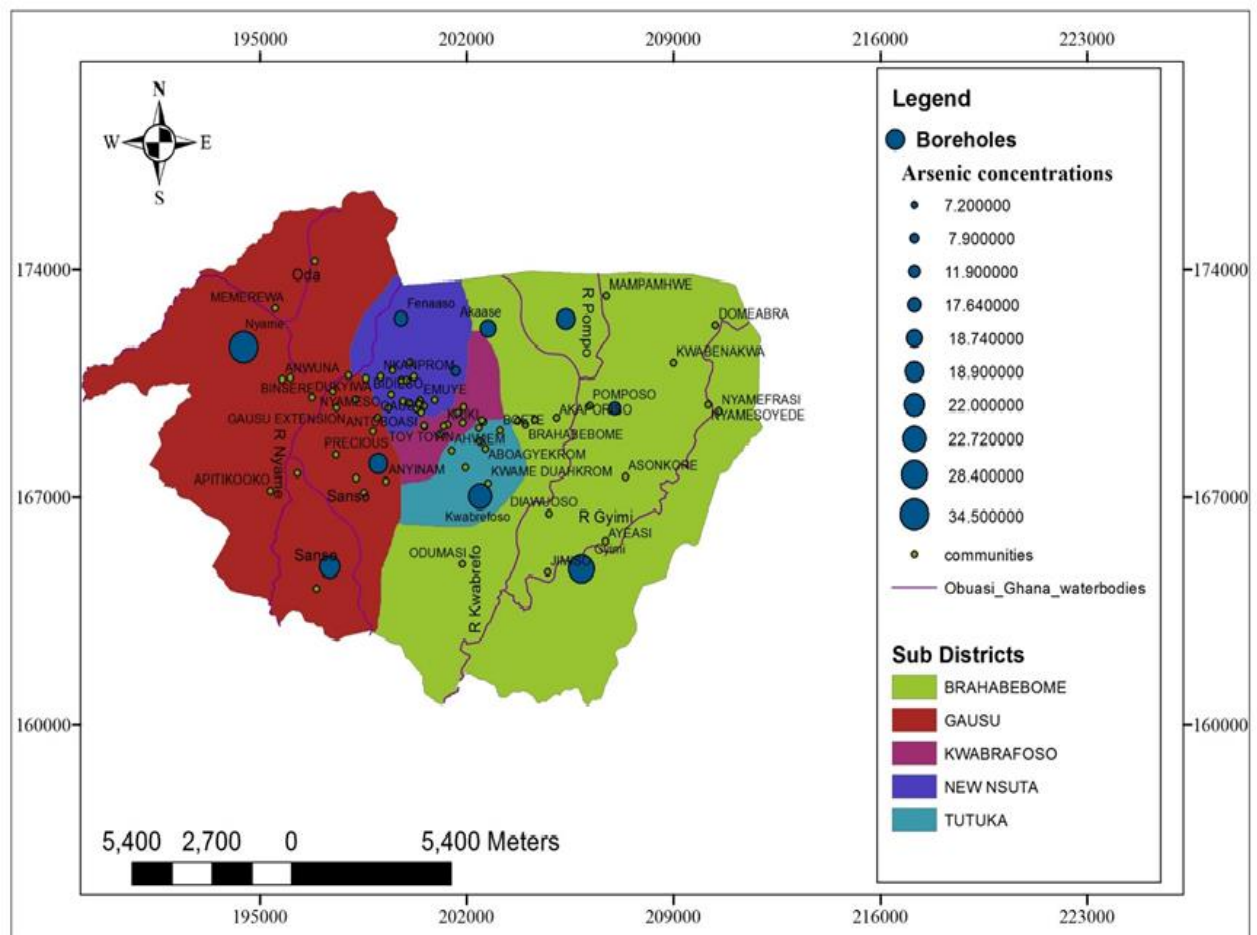


Fig. 3 Map of Arsenic Concentrations of Wells/Boreholes

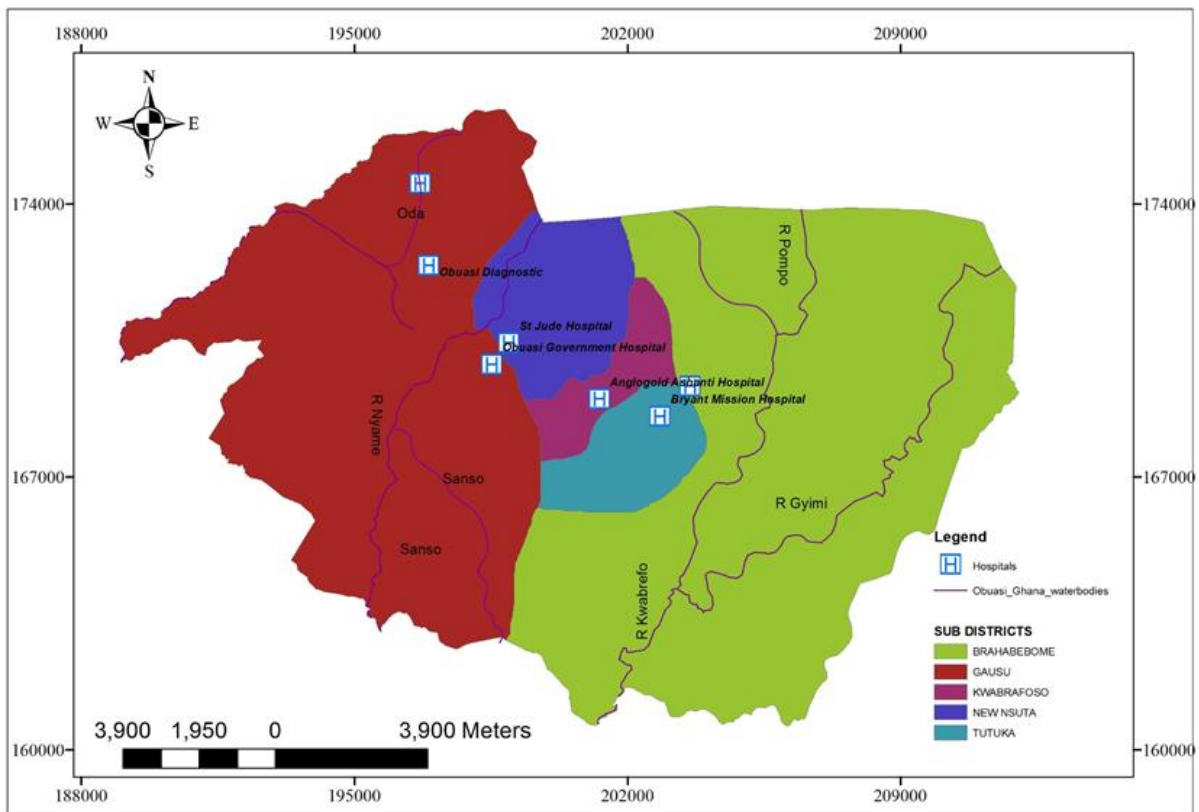


Fig. 4 Spatial Distribution of the Major Hospitals

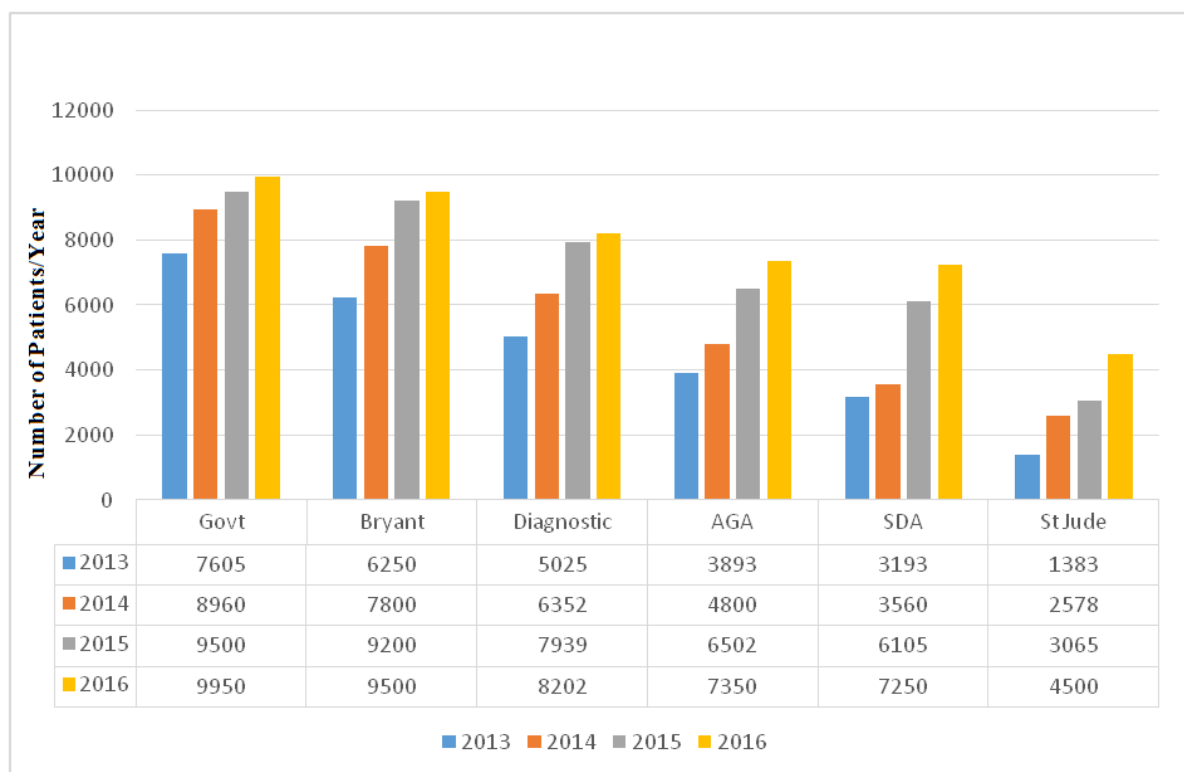


Fig. 5 Distribution of Bronchitis at Variuos Hospitals

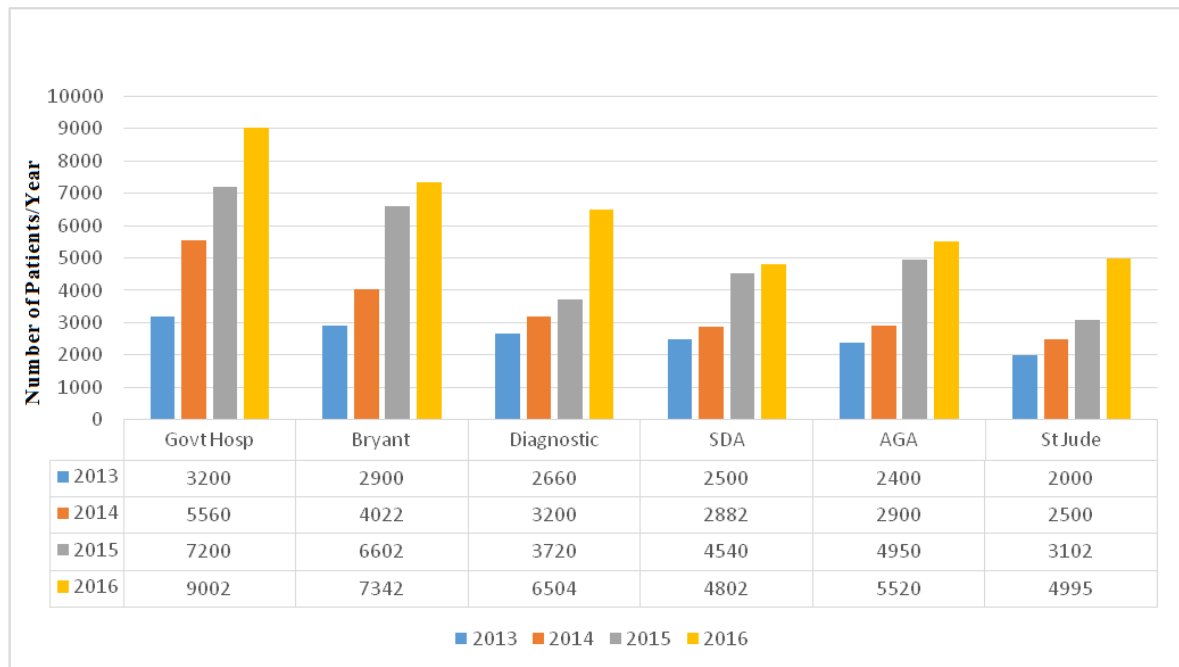


Fig. 6 Levels of Skin Diseases at the Hospitals

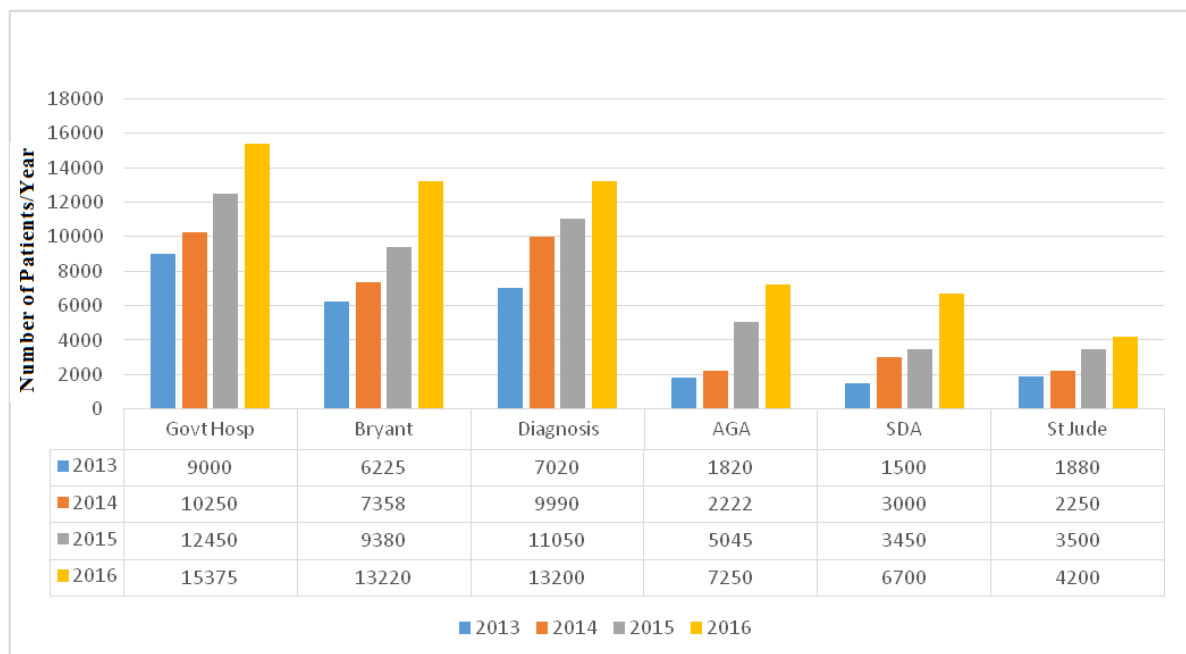


Fig. 7 Distribution of Upper Respiratory Tract (URT) Diseases Reported

3.2 Discussion

Arsenic levels in the study area are very high and have been increasing steadily as observed in Table 1 and Fig. 2. Comparing the levels in the years 1990, 2000 and 2015, sturdy growth was observed. All the rivers in the study area were found to contain certain levels of Arsenic with River Nyamso having the highest followed by River Kwabrefo, down to River Oda as shown in Fig. 3.

The geospatial distribution of the Arsenic concentration levels in the area is shown in Fig. 4 giving the fair knowledge of the spread of the Arsenic in the study area.

Furthermore, Obuasi Government Hospital recorded the highest cases throughout all the years followed by Bryant Hospital as shown in Figs. 5, 6 and 7. Based on this, a survey was conducted on the area where Obuasi Government hospital is

located and the communities that mostly attend the hospital. Observation of Fig. 4 revealed that Obuasi Government Hospital is located in the Gausu Sub-District. It is the major hospital within the area that offers services to most communities like Binsere, Apitikooko, Donkyiwa, Mmerewa, and Mensahkrom. These communities are closer to the River Nyam which has the highest Arsenic concentration and River Sanso whose arsenic concentration is also high due to deposition of tailings waste of the mines. Further investigations revealed that the communities depend on the wells and boreholes daily for water usage and also drinking. This makes the inhabitants living in those communities prone to above mentioned diseases.

Bryant hospital is also located in the Brahabehome Sub-District and offers services to communities like Diawuso, Aboagyekrom, Kwameduakrom and Asankore. These communities are within the gold mining zones and the water bodies are all being polluted by toxic materials including arsenic. These expose the inhabitants to diseases caused by heavy metals. Most of the farmers also farm around these rivers and use the water for irrigational purposes.

4 Conclusions

Data on arsenic concentration levels in ground water available for wells and rivers across Obuasi Municipality, a major mining area in Ghana, has been analysed. A concentration of 7.2 micrograms per liter or greater in 45% was found in the samples collected from various sources. Comparing the arsenic concentration levels in ground water by physiographic data indicated that the areas around the north-western, central and the south-eastern sections of the Municipality have the highest medians levels of arsenic concentrations. The highest percentage of samples recorded, with many locations having higher concentration levels, are higher than the EPA levels. The results indicate that mining activities in the Obuasi gold belt has affected water quality patterns of ground and surface water sources. The maps and graphs presented showed that there is an increase in the trend of diseases related to arsenic. The importance of this study demonstrates the relationship of arsenic related diseases and their spread giving an idea of the intensity of water pollution and the effects on human health.

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