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Assessment Of Natural Radioactivity Levels In Illegal MiningPits In Obuasi, Case Study, Obuasi Adansi

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Abstract

The gold deposit at Obuasi in the Ashanti region is found within the Birimian formation, which originated in the Early Proterozoic era. The orebodies in this deposit contain gold-sulphide minerals that are dispersed within metamorphic rocks and volcanic rocks, as well as gold-bearingquartz veins. The gold is primarily found in its natural form, often associated with minerals like arsenopyrite, pyrrhotite, and pyrite within the metamorphic and volcanic rocks. Although the mining sector has made significant contributions to the national government revenue, foreign reserves, and infrastructure development, there are still concerns among many stakeholders that the negative impacts of mining outweigh its benefits. Ghana has a rich mining heritage, but there are concerns among various stakeholders that this has had adverse effects on the development of other vital sectors in the Ghanaian economy and has also led to social issues in mining communities. This research focuses on evaluating a method to assess the potential radiological risks associated with mining activities on the soil in the municipality of Obuasi.

Additionally, the study investigates the socio-economic consequences of the mining operations on households residing in the vicinity of the mine.

The study determined the activity concentrations of for ^{238}*U,* ^{226}*Ra,* ^{228}*Th,* ^{228}*Ra,* ***Th-232*** *and* ^{40}*K in soil samples collected from Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore, Akes respectively using gamma spectrometry. The annual effective dose for* ^{238}*U,* ^{226}*Ra,* ^{228}*Th,* ^{228}*Ra,* ***Th-232*** *and* ^{40}*K in soil samples from Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore, Akes respectively were determined which are 0.122 mSv , 0.192 mSv , 0.396 mSv , 0.421 mSv , 0.488 mSv and 0.085 mSv respectively for Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore and Akes. All mining pits recorded a relatively lower annual effective dose. This means all pits annual dose is below the permissible public exposure of 1 msv/year.*

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I. Introduction

Like many other resource-rich countries, Ghana has experienced significant changes in its mining industry since the late 1980s. Structural Adjustment Programs (SAP), which promoted private sector investments in mining to raise tax revenues and foster economic development, were the driving force behind these developments (Akabzaa & Darimani, 2001). Consequently, in accordance with the SAP guidelines, significant official development and policy adjustments were made in Ghana's mining sector. Ghana currently ranks second in Africa for gold output, andit also produces a sizable amount of manganese, aluminum, and diamonds. However, because of the perceived harm to ecosystems and disturbance of local lives, there are disputes and divergent opinions among stakeholders surrounding the mining business (Kapstein & Kim, 2011).

Nevertheless, mining remains a crucial sector in Ghana's economy. It supplies resources for other industries that yield vital returns and brings in a sizable amount of money for the government. About 6.8% of Ghana's GDP, 40% of foreign exchange profits, and 14% of direct taxes paid to the government came from the mining industry in 2011 (Ministry of Finance Ghana, 2012). According to an analysis conducted in 2009, Newmont Ghana Gold Limited alone was responsible for 1.3% of GDP, 9% of all gold exports, 1% of domestic revenue, and 4.5% of direct investment in Ghana (Kapstein & Kim, 2011). Some parties contend that regular Ghanaians do not benefit from mining, despite these beneficial macroeconomic effects. According to them, the detrimental effects on society and the environment exceed the benefits to the economy (Akabzaa & Darimani, 2001).

II. Materials And Methodology

Study Area

Obuasi West District is located in the Ashanti Region of Ghana, which is situated in West Africa.It is one of several districts in the region and covers an estimated area of 1,171 square kilometers. The district derives its name from its main town and largest settlement, Obuasi,which has gained global recognition for its gold mining activities. The history of the Obuasi area dates back to the pre-colonial era when it was inhabited by the Ashanti people, known for their rich cultural heritage and expertise in gold mining. Gold mining has been a crucial economic activity in the region for many centuries and played a significant role in the rise of the Ashanti Kingdom. During the colonial period, the British established mining operations in Obuasi, leading to the rapid growth and development of the town. The mining activities attracted people from various parts of Ghana and beyond, resulting in a diverse population. According to the 2010 Population and Housing Census conducted by the Ghana Statistical Service, the district had an approximate population of 136,712. (Source: Ghana Statistical Service - Official Website: http://www.statsghana.gov.gh/)

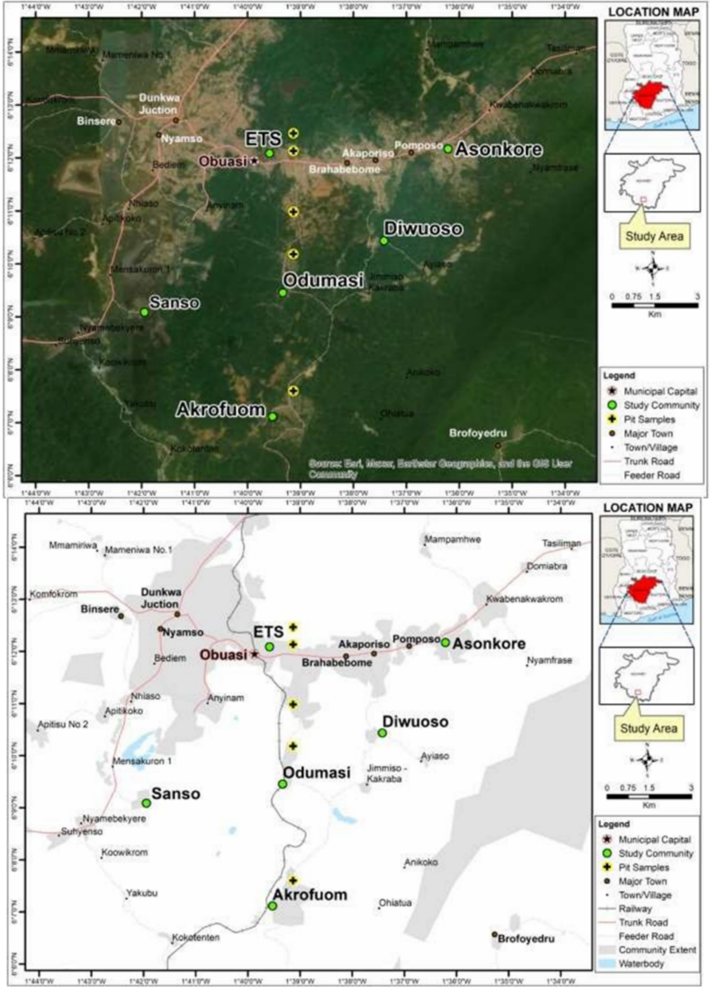
Sampling Method

A quantity of thirty (30) soil samples were randomly obtained from six (6) mining pits in obuasiThese areas are; Sanso, Anyinam, Toytown, Akrofuom, Bossman and PTP .

Geographic Setting:

Obuasi West is located in the Ashanti Region of Ghana, around 280 kilometers northwest of the capital city, Accra. This region is renowned for its abundant gold deposits, and Obuasi is hometo one of Africa's largest gold mines, operated by a well-known mining company. The mining pit in Obuasi West covers a significant area and has undergone extensive excavation and extraction activities.

Fig. 3. 1 Map of the study areas



Sampling Method

Thirty (30) soil samples were randomly acquired from six (6) mining sites at Obuasi municipal assembly. These sites are; Sanso, Bossman, PTP,Toytown, Anyinam and Akrofuom

Processes of mining

Mining activities in Obuasi, Ghana primarily focus on the extraction of gold from the Obuasi Gold Mine, which is recognized as one of the largest gold mines in Ghana and Africa. The mining process in Obuasi involves several distinct stages, including exploration, development, production, and reclamation. Here is a summary of the typical mining process in Obuasi:

1. Exploration: The mining process commences with exploration efforts to identify potential gold deposits. Geologists and geophysicists conduct surveys, collect samples, and analyze data to assess the presence and quality of gold-bearing rocks in the area.
2. Development: Once a promising gold deposit is identified, the mine development phase begins. This phase encompasses the construction of necessary mine infrastructure such as access roads, tunnels, shafts, and ventilation systems. Additionally, relevant equipment and machinery are installed during this stage.
3. Production: Following the completion of mine development, the production phase commences. This phase involves the extraction of gold-bearing ore from the underground mine. In Obuasi, underground mining is the primary method employed, specifically utilizing the sublevel caving technique. In sublevel caving, the ore body is progressively undercut, allowing the ore to cave and be collected in a controlled manner.

   Underground mining operations in Obuasi involve drilling, blasting, and the utilization of load- haul-dump (LHD) machines to transport the ore to the surface. The extracted ore then undergoes processing, which includes crushing, grinding, and chemical treatment to extract the gold.
4. Reclamation: As mining activities progress, concurrent reclamation efforts are undertaken to mitigate environmental impacts and restore the land. This includes the closure of underground workings, land regrading, and re-vegetation of the area. Waste management and water treatment processes are also implemented to minimize the impact on the surrounding environment. Throughout the entire mining process, strict adherence to safety and environmental standards is upheld to safeguard workers and minimize the ecological footprint of the mine. Typically,mining operations in Obuasi are carried out by a mining company that possesses the requisite permits and licenses from the Ghanaian government, ensuring compliance with regulations and responsible mining practices.

Samples Preparation and Physical Parameters

The soil was obtained from the pit in surrounding areas of Obuasi .All collected samples were assigned unique codes and stored in a closed transparent materials. The material coding were SA Pit1 for samples obtained from mining pit at Sanso, ANM pit 2 for samples obtained from mining anyinam pit 2, pit 3 for samples obtained at Toytown, AKM pit 4 for samples obtained from Akrofuom , BM for samples obtained from Bossmann and PTP for samples obtained from Pompolar treatment plant.

The samples were crushed into powder by using a 0.6 mm mesh sieve, and dried It for about 24 hours at 100˚C in an oven to dehydrate the material. The powdery samples were weighed separately, kept in a special containers (plastic) securely for about 3- 4 weeks to allow the radiological substances such as ^{40}K, ^{238}U and ^{232}Th to attain secular equilibrium for their daughter nuclides to settle before measurement of radioactivity (Hassan et al., 2016).

Activity concentration and estimation of doses calculation

^{238}U activity in the material was obtained by analyzing the energy peak of 609.31 keV emitted by ^{214}Bi. Also, ^{232}Th activity concentration was obtained by analyzing the 911.21 keV peak emitted by ^{228}Ac. ^{40}K activity was determined based on the energy of 1460.83 keV. Equation 1 expresses the activity in Bq/kg for soil samples.

$$Asp = \frac{N_D}{P.\ .\eta\ (E).m}$$

The equation mentioned in Equation 2 is used to estimate absorbed gamma dose rate (Dγ) at a m beyond the ground for soil samples (Faanu et al. 2016). This calculation involves the activity concentration of the radionuclide in the samples (N_D), emission probability of gammaray (P), the absolute counting efficiency of the detector system ($\eta(E)$), the counting time of the sample (Tc), and the mass of the sample (m) in kilograms (kg).

Absorbed Dose (μGy/year) = $\sum$ (Ai × Di)… 3.3

Where:

Di is the dose conversion coefficient for the i-th radionuclide (in μGy/year per Bq/kg)

Table 3.1 showing Radionuclides with their corresponding Dose convection factor

	Radionuclides					
	U-238	Ra-226	Th-228	Th-232	Ra-228	K40
Di is the dose conversion coefficient µGy/year perBq/kg	0.46	0.92	0.62	0.58	0.80	0.003
Dose conversion coefficients (DCi) Sv/Bq ×10-7	0.45	2.8	3.6	2.3	6.9	0.062
Dose Conversion Factor (DCFi)Sv/Bq × 10^{-7}	5.5	2.8	7.2	2.3	6.9	0.062

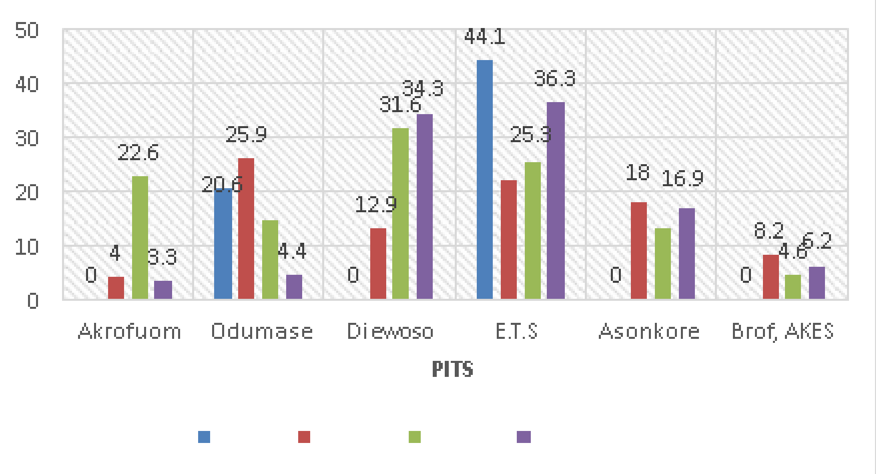
Table 3.2. The activity concentration Absorbed and Annual Dose in soil samples, 2024.

SampleCode	Activity Concentration,Ai (Bq/kg)						Absorbed Dose (µGy/year) = ∑ (Ai ×DCi)	Annual Dose (mSv/year) = ∑ (Ai × DCi × Ti (8,760 hours per year)	CancerRisk× 10-3 (∑ (Ai
	U- 238	Ra-226	Th-228	*Ra-228*	*Th-232*	*K-40*			
									×DCFi × Ti)
Akrofuom	>DL	4	22.6	3.3	12.9	184	28.38	0.122	0.181
Odumase	20.6	25.9	14.4	4.4	9.4	155.4	45.84	0.192	0.313
Diewoso	>DL	12.9	31.6	34.3	32.9	244.5	78.75	0.396	0.460
E.T.S	44.1	21.9	25.3	36.3	30.8	283.6	103.91	0.421	0.600
Asonkore	>DL	18	13.0	16.9	151	134.4	126.14	0.488	0.462
Brof, AKES	>DL	8.2	4.6	6.2	5.4	95	18.77	0.085	0.097

The table above shows the activity concentration, absorbed and annual Dose of soil samples (Bq/kg) - obtained in mining soil from the selected area. The analysis revealed that 0.122 mSv/year, 0.192 mSv /year, 0.396 mSv/year, 0.421 mSv/year, 0.488 mSv/year and 0.085 mSv/year for Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore, and Akes respectively**.**

The graph below shows the activity concentration of soil samples (Bq/kg) - obtained in mining soilfrom the selected area.

Fig 3.1



III. Conclusion

The study of the impact of Obuasi small scale mining pit has revealed no significant environmental and ecological consequences resulting from mining activities in the area.

However, the findings of this research highlight several key issues that need urgent attention to mitigate the negative effects on both water bodies and biological organisms.

Firstly, mining operations in Obuasi have led to water contamination, primarily through the release of heavy metals and acid mine drainage. This pollution poses a serious threat to aquatic ecosystems, causing harm to fish populations and other aquatic organisms. The presence of thesepollutants not only affects the immediate mining site but can also have far-reaching consequences for downstream water sources and communities.

In conclusion, the study examined the activity concentrations of ^{238}U, ^{226}Ra, ^{228}Th, ^{228}Ra, ***Th-232***and ^{40}K in soil samples collected from Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore, Akes respectively using gamma spectrometry.

The annual effective dose for ^{238}U, ^{226}Ra, ^{228}Th, ^{228}Ra, ***Th-232*** and ^{40}K in soil samples from Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore and Akes respectively were determined which are 0.122 mSv, 0.192 mSv , 0.396 mSv , 0.421 mSv , 0.488 mSv and 0.085 mSv respectively.

All mining pits recorded a relatively lower annual effective dose. Almost all sites annual dose is below the permissible public dose of 1 mSv/year. This means, over exposure to intolerable concentration may have no damaging effect on human livelihood but can however become dangerous when the are over accumulated.

The skewness of the annual dose is -0.537. A negative skewness value suggests that the data is skewed to the left, indicating that the majority of the data points are concentrated towards the higher end (above the mean).

The hazard indexes for external gamma radiation safety, H_{ex} for the selected mining sites were all below the detection limit. That's less than unitary. Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore and Akes respectively were determined as 0.5, 0.6, 0.04, 0.6,0.8and 0.01. US EPA has proposed 1.0 as the hazard index value which is the standards below which no evident clinical effect. The hazard index obtained in this study were less than the threshold limit and therefore has lower tendency of carcinogenic risks. (Aluko TS, et at. 2018)

The cancer risk calculations, which estimate the probability of developing cancer due to the radiation exposure, also showed relatively low values across the sites. Which were 0.313×10^{-3}, 0.460×10^{-3}, 0.600×10^{-3}, 0.462×10^{-3},and 0.097×10^{-3} for Akrofuom, Odumasi, Diewoso, E.T.S , Asonkore and Akes respectively. The highest cancer risk was observed in the ETS site, with a value of 0.600×10^{-3} peryear. This indicates that the radiation levels in the studied areas are not likely to pose a significant cancer risk to the local population.

The analysis of the soil samples suggests that obuasi soil have higher levels of naturally occurring radionuclides. From scientific stand point, mining remains a radiological challenge since there is no adequate information for this practice because it contains radiological elements that enter the human system in much higher concentrations than normal. Nevertheless, there is increase evidence that the continuous mining may leads to external radiation exposure. Moreover, extensive education of health implications of unsafe mining practices should beintensified.

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