



## Environmental and Socio-Economic Impacts of the Ban on Artisanal and Small-Scale Mining at Bonsa, Ghana

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### Abstract

*Artisanal and Small-scale Mining (ASM) in Ghana before its ban in March, 2017 comprised of licensed operators and illegal operators popularly known as galamsey. The ban imposed by the Government of Ghana aimed at curbing the effects of the operation of ASM on the environment and also streamlining the processes involved in their operations. Bonsa, a town in the Tarkwa Nsuaem Municipality whose economic activities were dominated by galamsey before the ban was selected for the research. These operations mostly involved dredging of the river bed, discharging effluents into the river and mining lands close to water bodies for gold. ASM contributes immensely to the overall gold output of Ghana. An investigation was done to determine the environment and socio-economic impacts of the ban of ASM in Bonsa. Water samples, assessment of lands and questionnaires were used as data collection methods to determine these impacts. Results from this investigation show that lands destroyed by galamsey operations largely remain the same, however, results from water samples when compared to previous results performed better in physico-chemical parameters such as pH, dissolved oxygen, and turbidity, but fell short in conductivity and the other parameters. The socio-economic status of the people had dwindled after the ban. It was recommended that through the Multilateral Mining Integrated Project, lands destroyed by galamsey operations should be reclaimed and alternative jobs should be provided. Also, stricter measures should be put in place to ensure better water quality of River Bonsa.*

## 1. Introduction

According to [1], Artisanal and Small-Scale Mining (ASM) in Ghana is defined as the exploitation of mineral deposits at low levels of production with minimum capital investment using unsophisticated equipment for production. Identifying the potential of the sector, the government through policies and regulations legalised and regularised the sector in 1989 with the aim of reviving the sector, facilitating supervision and minimising environmental impacts [2]. Artisanal and Small-Scale Mining (ASM) in Ghana is predominantly about the extraction of gold though there are ASM diamond operators. ASM in 2014 contributed to 34.3% of the country's total gold output which represents 1.49 million ounces of gold in figures and contributed to all the diamonds produced in Ghana [3]. According to the Ministry of Lands, Forestry and Mines of Ghana, there has been an exponential rise in the number of ASM operators representing a 941.73% increase since the promulgation of the Small-Scale Gold Mining Law, PNDC Law 218 of 1989.

Bonsa community is known for ASM operations which are mainly dominated by illegal mining (*galamsey*). Bonsa is located in the Tarkwa Nsuaem Municipal, a mining district in the Western Region of Ghana. Their operations mostly involved dredging of the river bed and discharging effluents into the river. ASM before its halt was operated by both licensed miners and unlicensed operators known as *galamsey*. An estimated 1 000 000 people are stated by the Minerals Commission to be directly involved in the sector since there is no precise data captured for the exact number of people [4]. The influx of foreign nationals mostly led to the high mechanisation increasing environmental concerns though small-scale as stated in the Act 703, Minerals and Mining Act, 2006 are mainly for Ghanaians. The ban of ASM since March 2017 by the Government of Ghana was done with the aim of streamlining the processes involved in its operations [5]. This was as a result of the government's decision to curb the environmental impact of ASM. Water contamination through chemicals such as mercury used in operation, land degradation, deforestation, biodiversity loss among others are some of effects which led to the eventual ban of the operations. Though, the ban has been of positive impact to the physical environment, there exist effects of ASM to the economy and stakeholders involved. The sector offered numerous benefits to people in the community directly and indirectly. Unskilled or less-skilled individuals are engaged in the provision of goods and service to ASM workers. These beneficiaries include gold buying agents, mechanics, electricians, market women food sellers and others. The degree of the environmental and socio-economic impacts of the ban on ASM activities in the area has not been assessed. This paper therefore seeks to determine the socio-economic and environmental impacts of the ban on ASM in Bonsa. The objective of this paper is to determine the environmental and socio-economic impacts of the ban on ASM in a rural mining community with reference to Bonsa Village and assesses the water quality of River Bonsa.

### **1.1 Climatology of the Study Area**

The study area is found in the South Western Equatorial Climate Zone of Ghana. Relative humidity is very high averaging between 75% and 85% in the rainy season and 70% and 80% in the dry season. The area experiences two distinct rainy periods (double rainfall maxima). The first and larger peak occurs in June, whilst the second and smaller peak occurs in October. The mean annual rainfall is over 1750 mm with around 54% of rainfall in the region falling between March and July. The area is very humid and warm with temperatures between 26 °C -30 °C [6]; [7]. This abundant rainfall supports agricultural activities especially rubber plantation in the area.

The area falls largely within the High Rain Forest Vegetation Zone capturing several hectares of the rubber plantation. To a large extent, this contributes significantly to reducing the problem of global warming since most of CO<sub>2</sub> emissions by automobiles are absorbed. Cassava, maize, oil palm, coconut and rubber are some of the crops grown in the area.

### **1.2 Geological Description of the Study Area**

The topography of the area is generally described as a remarkable series of ridges and valleys parallel to one another and it is the reflection of the pitching folding structures of the Banket series of the Tarkwaian system. The Banket and Tarkwa phyllites occur at the ridge whereas upper quartzite and Huni sandstone are present in the valleys. Surface gradient of the ridges are very close to the Banket and Tarkwa phyllites. The ridges are over 100 m above the valley floor [8]. The rocks of the area are of the Tarkwaian system which consists of the series of the shallow arenaceous and argillaceous sediments, sandstones, phyllites and conglomerates derived from the Birimian system. The gold bearing reef within the area is called the Banket reef and is found in the lower part of the Tarkwaian system [9].

Gold mineralisation in the Tarkwaian occurs as auriferous quartz pebble conglomerate and is of placer deposit origin. The stratigraphy of the area includes the Banket group overlain by the Tarkwa phyllites and Huni sandstone. The gold bearing horizon within the Banket group is sandwiched between the quartzite. The Tarkwaian system is in five groups which are [8]:

- i. The Kawere group;
- ii. The Banket series;
- iii. The Tarkwa phyllites;
- iv. The Huni sandstone and Dompim phyllites; and
- v. The Post Tarkwaian Intrusive.

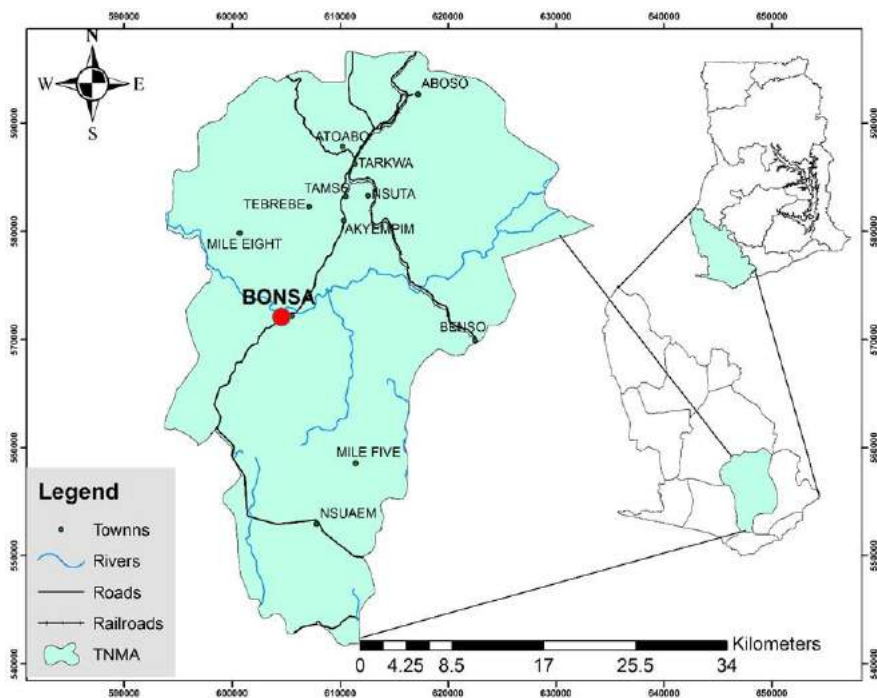


Fig.1: Location of the Study Area, Bonsa [Survey and Mapping Agency of Ghana, 2005]

## 2. Methodology

The methods used included data collection through the administration of questionnaires and sample collection for analysis of water. Statistical analysis of the data was done using IBM®. SPSS® Software and Microsoft Excel®.

Structured, close and open ended questionnaires were administered to 100 people living within the Bonsa Community with 73% representing males and 27% representing females. The questionnaires were administered from 5th April 2018 to 14th April 2018. The questionnaires administered probed into the following categories of issues; reasons for migrating to Bonsa, economic state before and after the ban, various socio-economic impacts, level of impacts, number of previous small-scale worker and current occupation.

The data collected was assessed by organising it into two categories: the environmental impact on the community and the socio-economic effects to the people of Bonsa. Water samples from two sample points, observation of degraded land and the administration of questionnaire were considered in assessing the situation in the community. The sample points considered were the upstream with Global Position System (GPS) coordinates (60° 70' 14" E, 57° 28' 75" N) and downstream with coordinates (60° 61' 87" E, 57° 25' 64" N). Water pollution as a result of dredging activities, land degradation and vegetation cover depletion were the principal environment impact and were assessed to identify the possible changes since the ban of Artisanal and small-scale mining. Data collection for the experiment was undertaken on 11th April 2018 where two samples were taken from the two sample points. Four 500ml plastic bottles were used for sample collection. The sampling bottles were rinsed with water from the river at the sample point to reduce or eliminate any contamination that may be present in the bottle. The samples were then taken after these processes and labelled for identification. The samples collected were immediately placed into ice-chest containing ice cubes and sent to the laboratory for analysis. This process ensures low microbial growth and any action that may interfere with the analysis of samples. One sample from each sample point was analysed for the physico-chemical parameters at the Environmental and Safety Engineering Department Laboratory of the University of Mines of Technology, Tarkwa. The two other samples were sent to INTERTEK, another laboratory in Tarkwa, for laboratory analysis. The two sample points were considered because *galamsey* operations were typically done at the upstream and the downstream is the point where water is used for domestic activities by people of the community.

Physico-chemical parameters were analysed for the quality of water in the laboratory. In the case of mining, parameters such as Chemical Oxygen Demand (COD), sulphates, electrical conductivity, nitrates and pH of the water are important. The values obtained were compared to previous results obtained by [10] and then also compared with the Environmental Protection Agency (EPA) standard.

According to [11], Tests called t-tests and based on the t-probability distribution are useful for:

- i. Establishing the likelihood that a given sample could be a member of a population with specified characteristics (Case 1). This is shown in Equation 1; or
- ii. For testing hypothesis about the equivalency of two samples (Case 2) [12].

#### Case 1

$$t = \frac{\bar{X} - \lambda_0}{s_e} = \frac{\bar{X} - \lambda_0}{s\sqrt{1/n}} = \frac{\bar{X} - \lambda_0}{s/\sqrt{n}} \quad (1)$$

#### Case 2

Two independent random samples of  $n_1$  and  $n_2$  are drawn from two populations with means  $\mu_1$  and  $\mu_2$  and variance  $\sigma_1^2$  and  $\sigma_2^2$ . This is shown in Equation 2.

$$z = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}} \quad (2)$$

Since the random variable has a standard distribution and it is assumed that  $\sigma_1 = \sigma_2 = \sigma$ , then Equation 2, reduces to Equation 3 as follows:

$$z = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sigma\sqrt{1/n_1 + 1/n_2}} \quad (3)$$

The above is for the case of known variances  $\sigma_1^2$  and  $\sigma_2^2$ .

Thus  $H_0: \mu_1 - \mu_2 = d_0$  and the alternative can be two-tailed or one-tailed and the level of significance must be stated. The more prevalent situation involving test on two are those in which variances are unknown. If we assume that both distributions are normal and  $\sigma_1 = \sigma_2 = \sigma$ , the pooled t-test may be used [11]. The test statistic, Equation 4 is given by the following test:

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - d_0}{S_p\sqrt{1/n_1 + 1/n_2}} = \frac{(\bar{X}_1 - \bar{X}_2) - d_0}{S_e} \quad (4)$$

Where  $t$  is the t-value,  $\bar{X}_1$  and  $\bar{X}_2$  are the means of the two groups under comparison, and  $n_1$  and  $n_2$  are the number of observations in each group. Where  $S_p$  is a pooled estimate of the standard deviation of the two groups in Equation 4 and is given as Equation 5 as follows:

$$S_p^2 = \frac{S_1^2(n_1 - 1) + S_2^2(n_2 - 1)}{n_1 + n_2 - 2} \quad (5)$$

The degree of freedom in Equation 5,  $\nu = n_1 + n_2 - 2$

### 3. Results and Discussion

In Table 1, comparing the values obtained, it was observed that turbidity, pH and dissolved oxygen (DO) levels improved. Parameters such sulphate, phosphate, chloride ion, colour, nitrate and total dissolved solids (TDS) increased as compared to the previous results obtained. The values were then compared to the Environmental Protection Agency (EPA) standard in Table 2. This showed only physico-chemical parameters pH for both samples and DO for sample B falling within the required standard. The values obtained at the upstream and downstream showed differences and this may be attributed to dredgers working on the river body at night at the blind side of the security agencies.

Table 1: Comparison of Water Quality Results with Previous Results

Parameter	Sample Point A (baseline)	Sample Point A (Present)	Sample Point B (baseline)	Sample Point B (Present)

Turbidity ( <i>NTU</i> )	294	151.25	459	126.50
pH	6.46	7.04	6.29	7.10
Colour ( <i>PCU</i> )	100	753	450	797
DO <i>mg/l</i>	8.2	6.53	8.5	4.73
Conductivity $\mu\text{s/cm}$	98.7	143.70	89.7	128.70
Sulphate ( $\text{SO}_4$ ) <i>mg/l</i>	16	6.906	19	6.342
Phosphate ( $\text{PO}_4$ ) <i>mg/l</i>	0.30	0.234	0.49	1.421
Cl <sup>-</sup> <i>mg/l</i>	5.9	3.753	6.1	3.532
Nitrate ( $\text{NO}_3$ ) <i>mg/l</i>	5.3	0.074	9.4	2.932
TDS <i>mg/l</i>	59	91.4	54	70.4

Table 2: Comparison of Water Quality Results with EPA standard

Parameter	Sample Point A (Present)	Sample Point B (Present)	EPA STANDARD
Turbidity ( <i>NTU</i> )	151.25	126.50	5
pH	7.04	7.10	6.5-8.5
Colour ( <i>PCU</i> )	753	797	15
DO <i>mg/l</i>	6.53	4.73	>5
Conductivity $\mu\text{s/cm}$	143.70	128.70	750
Sulphate ( $\text{SO}_4$ ) <i>mg/l</i>	6.906	6.342	250
Phosphate ( $\text{PO}_4$ ) <i>mg/l</i>	0.234	1.421	4

### 3.1. Water Pollution

Physico-chemical parameters were analysed for the quality of water in the laboratory. In the case of mining, parameters such as Chemical Oxygen Demand (COD), sulphates, electrical conductivity, nitrates and pH of the water are important. The values obtained were compared to

previous results obtained by [10] and then also compared with the Environmental Protection Agency (EPA) standard. Tables 1 and 2 show the various results of the laboratory test. Activities of small-scale miners in the Bonsa Community led to vegetation destruction causing land depletion. Activities such as clearing vast expanses of forest, digging trenches and upturning of vegetation which in turn left the land bare and exposed to agents of erosion. Lands were destroyed and where deep surface mining were done, they were usually abandoned and uncovered corroborating with similar results obtained in [13] for the Tarkwa Mining District.

These lands which were mostly destroyed by the action of small-scale miners largely remained unrehabilitated and were exposed to erosion. The pits were filled with water and served as death traps to farmers and also a breeding ground for mosquitoes. In certain areas, trees cut mostly left in the river forcing it to cut a new course. However, George Amon Assebian, a prominent businessman in Bonsa has converted about four abandoned pits to productive fish ponds in the community. The community of Bonsa is made of people with different occupations. Market women, shop owners, farmers, masons, carpenters, and others live within the community. The ban on small-scale mining has however caused a standstill in the businesses of people. Artisanal and small-scale mining though when in existence was harmful to the environment but it provided people who engaged in it a source of employment. People gave so many reasons as to why they engaged ASM before it was banned. Most of the youth were engaged in small-scale mining due to the unemployment situation in the community and considered it as a means of providing their basic needs. Fig. 2 shows the groups of respondents and their reasons for living in Bonsa.

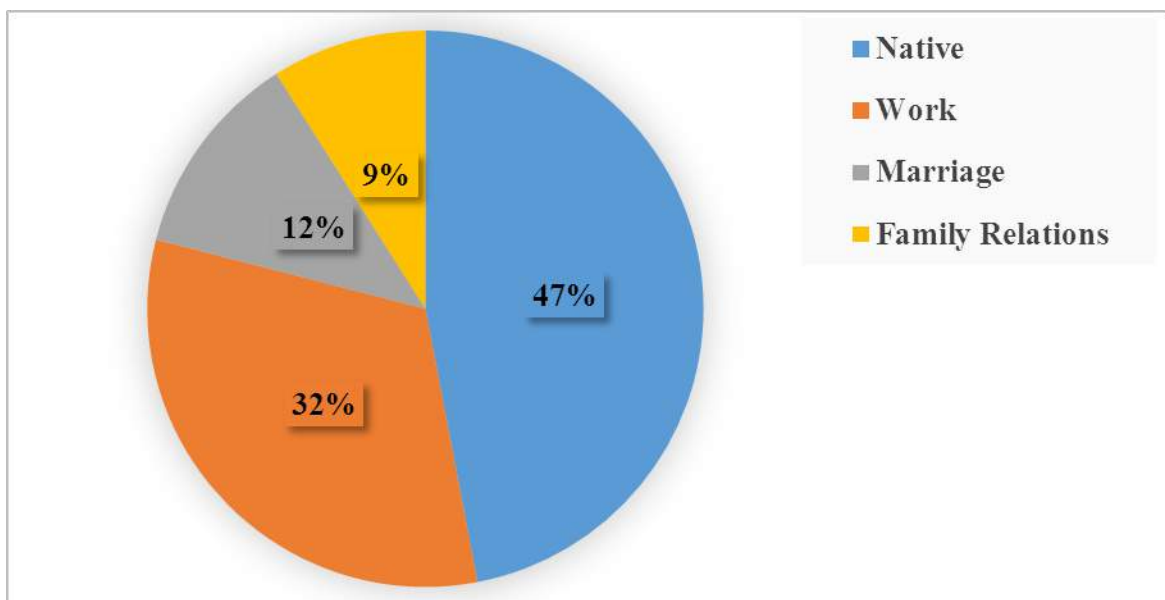


Fig. 2: Reasons why Respondents Live in Bonsa

ASM workers just before the ban represented 53% of the respondents and 47% of the respondents were of other forms of employment. After the ban, 66% represented other forms of employment and 34% represented ASM workers who are currently unemployed. These are shown in Fig. 3 and Fig. 4 respectively.

Respondents were asked about their earnings before and after the ban and the level of satisfaction in each case. The monthly earnings in Ghana Cedis were classified into classes from 0 - 200, 200 -

500, 500 - 1 000 and above 1 000 and the level of satisfaction on a scale of 1-10. The mean and standard deviation for each class (level of satisfaction) and total mean and standard deviation for the level of satisfaction before and after were calculated. The total means obtained for the level of satisfaction before and after the ban were subjected to a two-sample t-test to determine if there exist a significant difference between the means of before and after ban of ASM. Fig. 5 shows the comparison between the data before and after the ban of ASM in Bonsa. Tables 3 and 4 show the descriptive statistics for the data before and after the ban of ASM respectively.

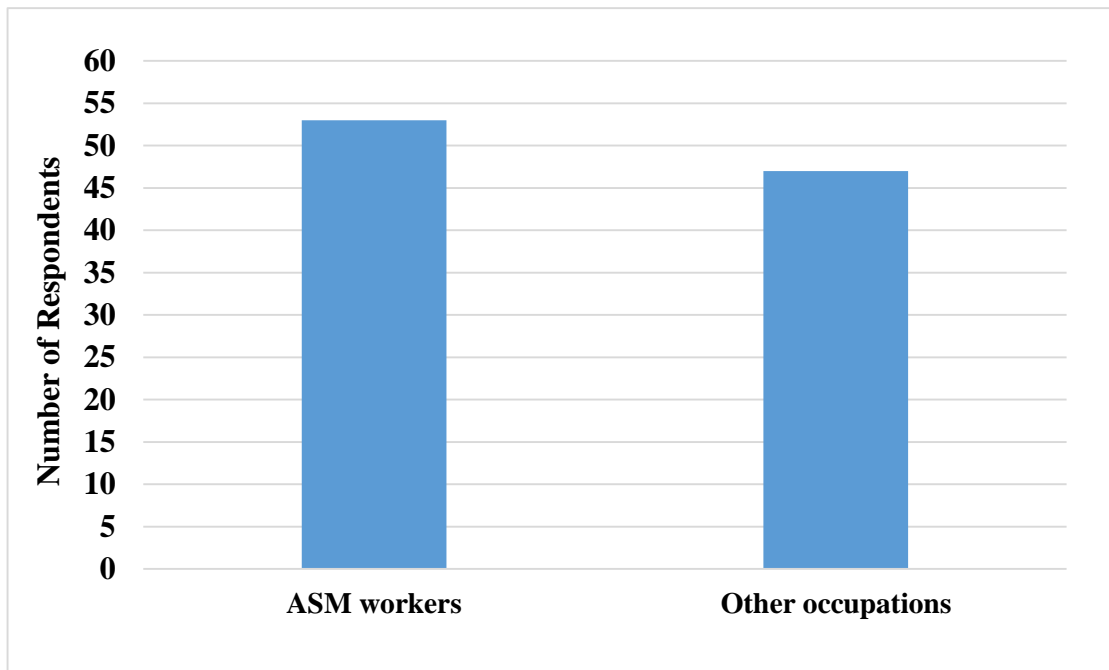


Fig 3: Occupations of Respondents before the Ban of Small-Scale Mining



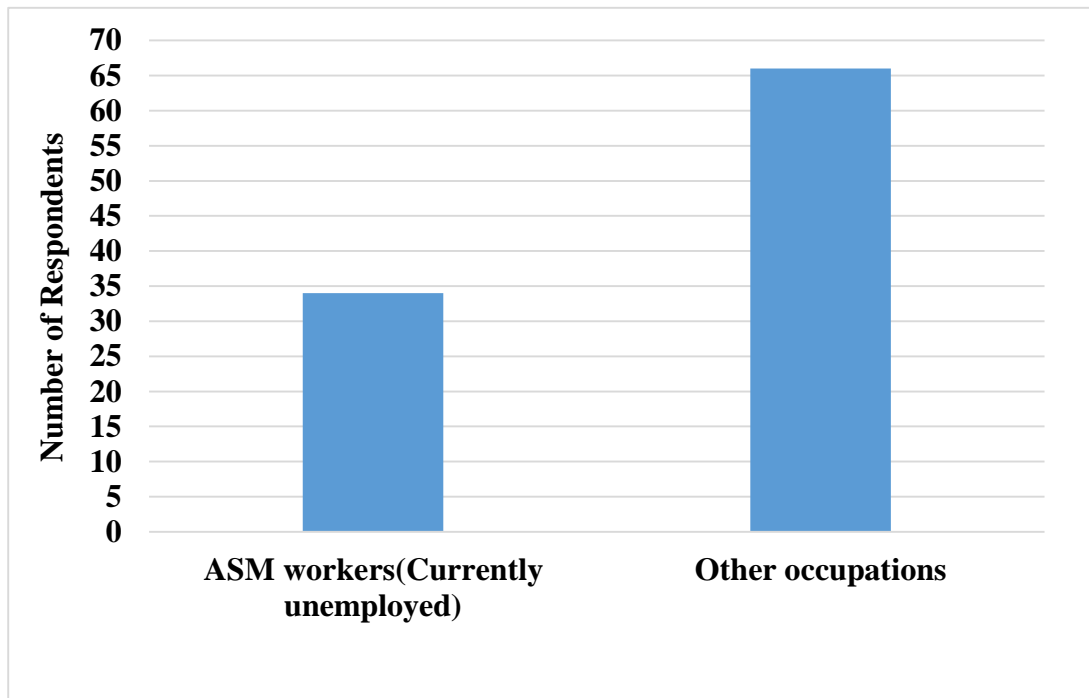


Fig. 4: Current Occupation of Respondents after the Ban of Small-Scale Mining

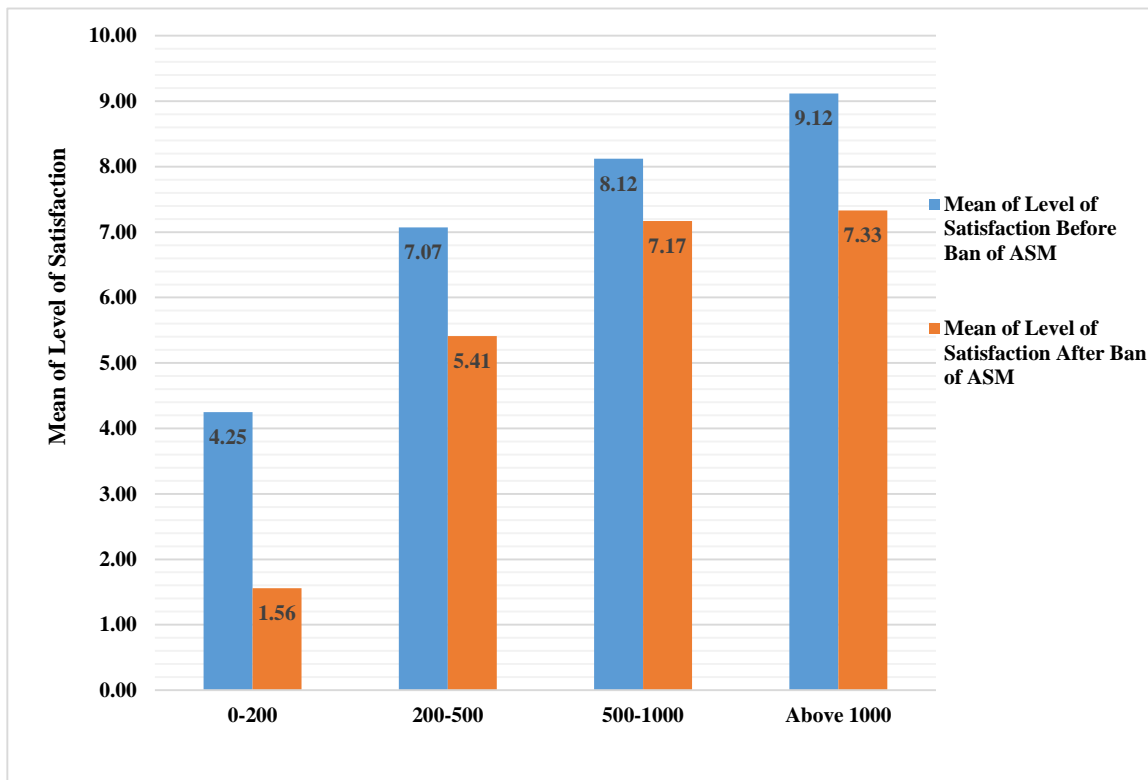


Fig. 5: Mean Plot of Data before and after Ban of ASM

Table 3: Descriptive Statistics for Data before the Ban of ASM

Class of Earnings(GHC)	Number of Respondents	Mean Level of Satisfaction	Std. Deviation
0-200	4	4.25	0.957
200 – 500	30	7.07	0.583
500 – 1000	41	8.12	0.557
Above 1000	25	9.12	0.726
Total	100	7.90	1.235

Table 4: Descriptive Statistics for Data after the Ban of ASM

Class of Earnings(GHC)	Number of Respondents	Mean Level of Satisfaction	Std. Deviation
0 – 200	52	1.56	1.11
200 – 500	39	5.41	0.938
500 - 1000	6	7.17	0.408
Above 1000	3	7.33	0.577
Total	100	3.57	2.379

Using the t-test,

Null Hypothesis,  $H_0: \mu_{LB} = \mu_{LA}$

Alternative Hypothesis,  $H_1: \mu_{LB} > \mu_{LA}$

Level of Significance,  $\alpha = 0.05$

$$S_p^2 = \frac{3(1.235)^2 + 3(2.379)^2}{6}$$

$$S_p = 1.895$$

$$t = \frac{7.90 - 3.59}{1.895 \sqrt{\frac{1}{4} + \frac{1}{4}}}$$

$$t = 3.216$$

But  $t_{0.05}(6) = 1.943$  obtained from critical values for t-distribution data.

The computed value of 3.216 exceeds the table value of  $t_{\alpha} (v)$  and so lies in the critical region. Hence the  $H_0$  value can be rejected leaving us with the  $H_1$  which shows the mean level of satisfaction before the ban of ASM to be greater than the mean level of satisfaction after the ban of ASM.

The activities of ASM through ignorance of technology or rush to escape for illegal occupation of land has resulted in huge spans of lands being destroyed by such activities. The ecosystem and the fauna and flora are disturbed by such activities and most of the mined-out pits and waste dumps are not reclaimed rendering these lands useless to other activities which may be of enormous benefits to development and economy [14]. Most of these unreclaimed lands turn into death traps and breeding grounds for insects which may cause illness to people in the community. Water pollution, land pollution and atmospheric pollution are the physical environmental impact of ASM. It is recommended that: (i) Stricter measures should be put in place to ensure a better water quality of River Bonga, (ii) Through the Multilateral Mining Integrated Project (MMIP), measures should be put in place to reclaim lands destroyed by galamsey activity.

#### 4. Conclusion

Based on the objective and the findings, it can be concluded from the data that:

- i. The water quality of River Bonga was better when compared with results obtained before the ban of ASM improved in physico-chemical parameter such as turbidity, pH and DO but increased in physico-chemical parameters; sulphate, phosphate, chloride ion, colour, nitrate and TDS;
- ii. The lands destroyed by galamsey operations largely remained the same; and
- iii. The existing socio-economic situation in Bonga during the compilation of data was relatively worse when compared with data before the ban of ASM.

#### Nomenclature

n	number of observations
s	standard deviation of observations
$s_e$	standard error of mean
$\bar{X}$	mean of the sample
$\lambda_0$	hypothetical mean of population

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