Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 41 (2022) 13-32 EISSN 2543-5426

Seasonal Monitoring of the Economic Sustainability of Fanalou Quarry, Ikpeshi, Edo State, Nigeria

C. O. Amosu[1] and **A. O. Omotehinse**[2]

Department of Mining Engineering, Federal University of Technology, Akure, Nigeria

[1,2]E-mail address: muyixx1zillion@gmail.com , omotehinadeyinka@gmail.com

ABSTRACT

The current study is focused on checking the survival, sustainability and continuity of mining operations on Fanalou Nigeria Company limited by identification of the level of metallic composition and conducting due economic analysis on the production and sales of the dolomite in the quarry. This study identified the concentration of some selected heavy cationic metals such as Magnesium (Mg), Manganese (Mn), Lead (Pb), iron (Fe), Nickel (Ni) and anionic non-metals such as Sulphate (SO_4^{2-}), Chloride (Cl^-) and Nitrate (NO_3^-) as found out in the water and soil samples at five different mine pit locations of case study, using Atomic Adsorption Spectrophotometer (AAS). The results revealed that the mean concentration in the mine pit's water are: Mg (32.10 mg/L), Mn (0.952 ppm), Pb (0.227 ppm), Fe (1.036 ppm), Ni (0.630 ppm) , SO_4^{2-} (1280.00 mg/L), Cl^- (29.27 mg/L); and in the pit's soil: Mg (250.500 ppm), Mn (4.120 ppm), Pb (1.062 ppm), Fe (2.510 ppm), Ni (2.136 ppm) , SO_4^{2-} (224.00 ppm). Mg was observed to be more in concentration as compared to Mn followed by Fe, followed by Ni, followed by Pb and SO_4^{2-}. This amount of metallic concentration has a latent threat to production, especially in pumps applied for mine pit drainage of water. Economic Analysis was also carried out to determine the production trends and profits during the rainy and dry season for the quarry. In the year 2020, it was 36,337,500 naira (in the rainy season) and 68,400,000 naira (in the dry season); in the year 2021, it was 36,112,500 naira (during the rainy season) 68,850,000 naira (at the dry season). The grand annual profits stand as 104,737,500 naira for the year 2020 and 104,962,500 naira for the year 2021. This has been sustainable for continuity of field operations.

***Keywords*:** Metallic Concentration, Economic Analysis, Quarry, Fanalou, Ikpeshi, Mine Pit, Profit, Productivity, Season

(Received 05 December 2021; Accepted 27 December 2021; Date of Publication 28 December 2021)

1. INTRODUCTION

1. 1. Metallic Concentration of Mine Water and Soil and Economic Aspect

Mine water is low quality water which may threaten the sustainability of the environment, as well as the health of man, even though it may be safe for other applications, as long as the necessary precautions are adopted. An increase in the concentration of heavy metals in surface mine water impacts negatively on the productivity in agriculture, as well as on the wellness of the mineral producers, miners, buyers and consumers.

The metallic water that are pumped out the into soil may alter the characteristics of the pH of the soil, its content of organic matter and clay ability, and the capacity of its cation holding exchange properties which causes the release of high metallic concentrations provided for the uptake of plant (Kimberly and William, 1999).

One objective of this study is to check for the concentration of heavy metals in dolomitic mine pits. It is aimed at supporting the existing database of heavy metals contamination influenced by mine water contamination (Ulrich, Brockbank, Johnson and Younger, 2007; Woodruff and Dack, 2004). This would add to the existing knowledge on wastewater and its impacts on the quality of the soil in the environment.

Further objective is to show the economic aspect of production on Fanalou quarry, i.e. the minimization on the cost of operations of the mining cycle (i.e. drilling, blasting, hauling, loading) can significantly help savings (Kozan and Liu, 2017). The adequate appropriation of ore loading and hauling is vital to the minimization of the cumulative mining cost. The optimization of loaders is influenced by the perfunctory features of muck piling operations, i.e. particle sizing, distribution and content of moisture (Singh and Narendrula, 2006). Economic productivity also relies on the predominant season when a particular haulage activity is been carried out; for instance, dry season is more favourable to production than the rainy season.

2. LITERATURE REVIEW

The presence of metallic contaminants is instrumentally used as a signal to a possible presence of dormant and developing risks (Adriano et al., 2004 and Martínez-Sánchez et al., 2008). The idea about the volume of the concentrations of metals on its own is insufficient to assess the deleterious consequence of polluted soils, while metals that are poisonous are available in various chemical pattern in the soil (effortless swapping of ions, metallic oxides, sulfides, nitrates, chlorides carbonates, and so on), which influences their mobility and availability (Nasrabadi et al., 2010, Weisz et al., 2000 and Yu et al., 2001).

From the continued operations of man in mining, for decade and centuries, it is logical and fair to opine that the level of metallic concentrations are influenced by the components of geogeny and anthropogenic (Tarzia et al, 2002). Not too long, several studies have reported heavy metallic contamination to soil, water and sediments as a major environmental issue across the world, and suggested diffusing it out of the land and water (McGrath et al, 2001). For instance, the river bodies flowing through some cities reported pollutions with dense metals caused by constant anthropogenic events and continuous urbanization and (Hamid et al, 2017).

If practicable, mine waste water should be treated for produced acids (Idris et al, 2014), salinity and metallic concentrations, as well as for suspended or dissolved solids which should be properly handled before been released into the environment, or been optionally utilized for its advantage (Amosu and Adeosun, 2021).

Economic optimization is derived by absolutely considering the entire mining system, rather than focusing on just one operation of mining (Ozdemir and Kumral, 2019). The increase in productivity which ensures a long-term economic sustainance is still the most vital condition for maintaining and strengthening the capacity and potential of a company (Zayernyuk et al, 2017).

3. MATERIALS AND METHODOLOGY

In this current study, five mine pit production sites where water challenges to productivity for many years, i.e. location 1 to 5, were selected from Fanalou Quarry, Ikpeshi (Table 1). These sites were chosen on the basis of surface water run-off and mining activities taking place in the surface mine. The concentrations of heavy metals were determined in the water and soil.

3. 1. The Location and Geology of Study Area (Ikpeshi)

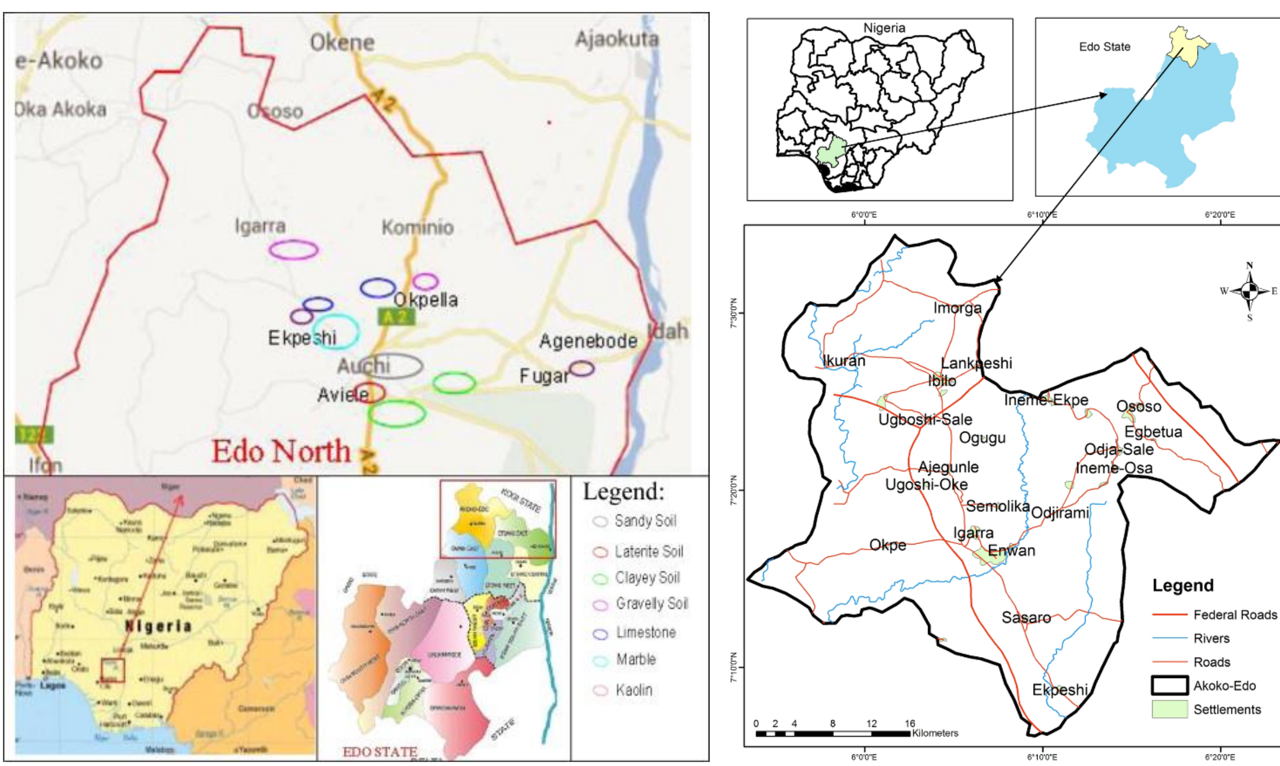


Figure 1. The Map of Ikpeshi, Edo State (Source: Saliu and Komolafe, 2014).

The study areas are dolomite rocks of HNF / Fanalou and Golden girl quarries located at Ikpeshi and its environs in Igarra which lies within latitudes 7°08'N to 7°10'N and longitudes 6°10'E to 6°15'E. It borders on the belt of the schist which is foliated in the NW-SE direction of Igarra which is located in the south-western part of Nigeria.

It is composed of varied sedimentary-based rocks which contain calc-silicate, schist, dolomite, gneiss and marble that got exposed to multiple-phase distortion and invariably thrust-in by the earth's granitic formational process. This stretches from the Pan African mesozoic circular complexes (with the presence of joints and fractures in the granite body) of central and eastern part of Nigeria **(**Ajibade and Wright, 1988); with extending belt to the right flank of the hard plate of West Africa and the north-western hard plate of Brazzaville and Libreville.

The most occurring mineral composition of the rocks includes calcite, dolomite, meta-conglomerates, quartz, muscovite, feldspar (Odeyemi, 1976). The complete mineralogical composition of rocks and their identification in Ikpeshi can be seen in (Umoru, 2021). The structural features in the study location reveals orientations of many directional standpoints. The lithology of the study domain has an all-inclusive and regular pattern that is peculiar with the Pre-Pan African formational activities (Agomuo and Egesi, 2016).

The basement rocks which are about four major groups have been observed within this area. These are the migmatite-gneiss complex, the meta-sediments (schists, calc-silicate rock, quartzites, marble, meta-conglomerates) and the porphyritic older granite which are discordant, non-metamorphosed syenite dyke (Odeyemi, 1976). They are being mined by small-scale miners for industrial minerals and rocks. The calc-silicate rocks are similar to marble, medium to coarse-grained with porphyroblasts. In short, about 80% of Akoko Edo community is underlain by carbonaceous rocks. The topography relief is influenced by the underlying geology. The region is known for quarrying activities dominating the major occupations.

The underground flow of water points towards North-west of the village of Ikpeshi as noticed from geo-electric sections done by Vertical Electrical Sounding (VES) resistivity applying the array of schlumberger (Saliu and Komolafe, 2014).

3. 2. Methodology

The water challenges on Fanalou quarry have been monitored by the analysis of the metallic concentrations in its soil and water; in different mine pit locations in the case study using Atomic Absorption Spectrophotometer (*AAS*) analysis and Turbidity test. This is carried out in the laboratory. Also, is the productivity and income economic analysis of mine production using loading and hauling of dolomite, during the rainy and the dry season. The profit margin is determined for tonnage trips of dolomites for 15 working days in rainy season and 20 working days in dry season. The profit is the cost of sales (or revenue) minus the cost of production (or variable cost) (Obasi et al., 2019) of dolomite per tonnage trip made per day, during rainy or dry season.

Collection of Water Samples

Collection of Soil and Water Sample was done at the field of Fanalou Nigeria Company Limited, but test analysis for some parameters of pH and conductivities was carried out at the Department of Chemical Engineering in Yaba College of Technology, Nigeria, while the Atomic Absorption Spectrophotometer (*AAS*) analysis and Turbidity test was conducted in the Department of Chemistry in Federal University of Technology, Akure, Nigeria. Water samples were collected randomly inside the mines of the study area. Soil samples were also obtained inside a nylon pack and well labelled for easy and appropriate identification. These samples were conveyed to the laboratory for testing, to determine for metallic composition and their concentrations, and values for turbidity, dissolved Oxygen, temperature and conductivity.

Figure 2. Collecting Water samples

Laboratory technique

Laboratory work was carried out using Atomic Absorption Spectrophotometer (*AAS*) analysis on the samples of soil and water obtained from the field. *AAS* analysis aided in the determination of composition and the trace of elements in the Ikpeshi samples. Test was also conducted is the pH, conductivity and total dissolved solid tests.

Economic Analysis

(i) Productivity / Income Economic Analysis

(a) During The Rainy Season:

Number of T rips Per Day: ranges from 8 to 22 trips (March to November, 2021)

Total Tonnage Trips per Day
= Cost Price (or Rate) per Tonne (i.e. =N=5000) X Number of Trips per Day

Tonnages for 15 working Days
= Total Tonnage Trips per Day X Number of Work Days per Month (i.e. 15 Days)

Price (Rate) of Tonnage Trips for 15 working Days [(i.e. Cost of sales) as =N=5000/Tonne]
= Tonnages for 15 working Days X Cost Price (or Rate) per Tonne (i.e. =N=5000)

Price (Rate) of Tonnage Trips for 15 working Days [(i.e. Cost of Production) as =N=2750/Tonne]
= Tonnages for 15 working Days X Cost of Production (i.e. =N= 2750)

(b) During The Dry Season:

Number of T rips Per Day: ranges from 45 to 54 trips (December to February, 2021)

Total Tonnage Trips per Day
= Cost Price (or Rate) per Tonne (i.e. =N=5000) X Number of T rips Per Day

Tonnages for 20 working Days
= Total Tonnage Trips per Day X Number of Work Days per Month (i.e. 20 Days)

Price (Rate) of Tonnage Trips for 20 working Days [(i.e. Cost of sales) as =N=5000/Tonne]
= Tonnages for 20 working Days X Cost Price (or Rate) per Tonne (i.e. =N=5000)

Price (Rate) of Tonnage Trips for 20 working Days [(i.e. Cost of Production) as =N=2750/Tonne]
= Tonnages for 20 working Days X Cost of Production (i.e. =N= 2750)

(ii) <u>Profits</u>

(a) Profit per Tonnage Trip (For Rainy Season):

= Price (Rate) of Tonnage Trips for 15 working Days (Cost of sales) (i.e. =N=5000/Tonnes) Minus Price (Rate) of Tonnage Trips for 15 working Days (Cost of Production) (i.e. =N=2750/Tonnes)

(b) Profit per Tonnage Trip (For Dry Season):

= Price (Rate) of Tonnage Trips for 20 working Days (Cost of sales) (i.e. =N=5000/Tonnes) Minus Price (Rate) of Tonnage Trips for 20 working Days (Cost of Production) (i.e. =N=2750/Tonnes)

(iii) <u>Annual Profit</u>

Profit per Tonnage Trip for Rainy Season + Profit per Tonnage Trip for Dry Season

Statistical Analysis

Microsoft Excel was used for descriptive statistical analysis

4. RESULTS

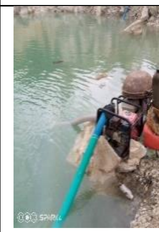
4. 1. Monitoring Through Mine Pit Samples for Individual Locations

Different field results were obtained from monitoring via analysis and test of mine water parameters or metallic concentrates from water soil/sand using Absorption Spectrophotometer (*AAS*). The result is seen in Table 1 and Table 2.

4. 2. Analysis of Mine Water and Soil Parameters

The results in Table 1 and Table 2 show the major ionic concentration and the qualities of the water and soil/sand in the study area. There are five (5) production mine pit locations considered in this study, as seen in Table 1 below:

Table 1. The Mean Metallic Concentrations from Water and Soil Test Using AAS

		Location 1	Location 2	Location 3	Location 4	Location 5	Units
Mine Pit Location / Diagram							
C C O M P O S I T I O N	Water Sample (Ions)						
	Magnesium	32.09	32.11	32.08	32.11	32.09	(mg/L)
	Manganese	0.94	0.95	0.93	0.95	0.94	Ppm
	Lead	0.228	0.226	0.227	0.227	0.228	Ppm
	Iron	1.035	1.036	1.037	1.036	1.035	Ppm
	Nickel	0.630	0.632	0.630	0.631	0.631	Ppm
	Sulphate	1279.00	1280.00	1280.00	1281.00	1279.00	(mg/L)
	Chloride	29.28	29.29	29.27	29.27	29.28	(mg/L)
	Soil Sample (Ions)						
	Magnesium	250.503	250.501	250.501	250.502	250.500	ppm
	Manganese	4.120	4.119	4.120	4.121	4.119	ppm
	Lead	1.061	1.060	1.062	1.062	1.061	ppm
	Iron	2.511	2.509	2.510	2.510	2.509	ppm
	Nickel	2.134	2.136	2.135	2.135	2.136	ppm
	Sulphate	224.01	224.02	224.00	224.00	224.01	(mg/ Kg)

4. 3. Monitoring Through Laboratory Equipment

Further parameter readings through laboratory work on of water quality are recorded in Table 3, i.e. test on dissolved sand sample.

Table 2. Mobile Water Quality Testing Using pH Meter.

Test on Mine Water Sample		Test on De-ionize Water Sample (standard)
Parameters	Average Values	Values
pH	7.2	7.0
Total Dissolved Solids	290 ppm	250 ppm
Temperature	28 °C	28 °C
Conductivity	580 micro-Siemens/cm	510 micro-Siemens/cm

Table 3. Mobile Water Quality Testing Using Multi-range Conductivity Meter.

Test on Dissolved Sand Sample	
Parameters	Average Values for
pH	6.4
Turbidity	32 NTU
Total Dissolved Solids	240 ppm.
Temperature	28 °C 470 micro-Siemens/cm
Conductivity	470 micro-Siemens/cm

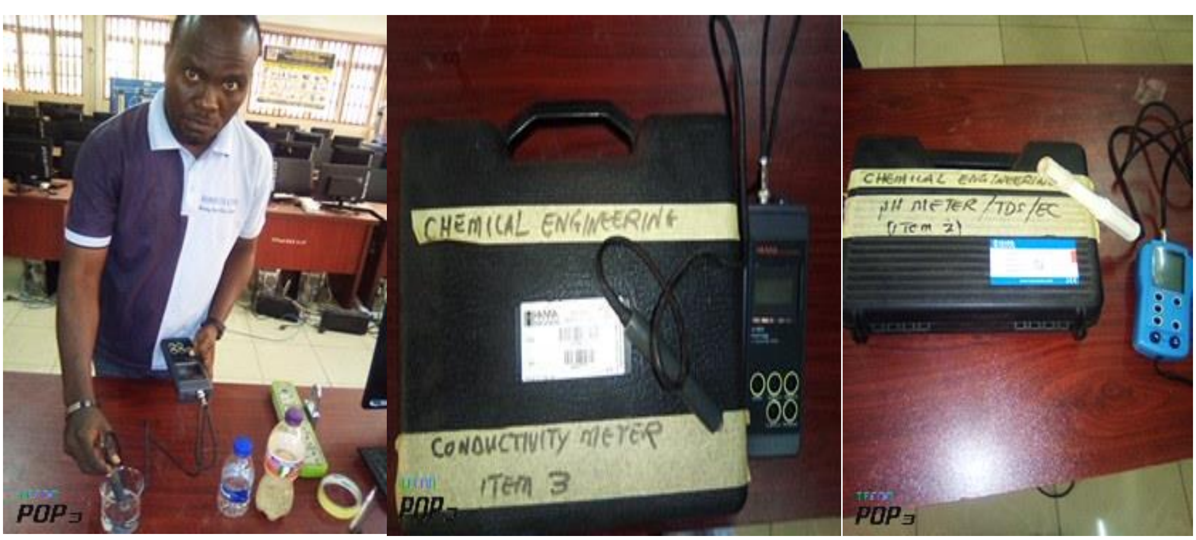


Figure 3. Mobile Water Quality Testing Using Hannah Instruments (i.e. pH Meter - code: HI9812-5) and (Multi-range Conductivity Meter - code: HI9033).

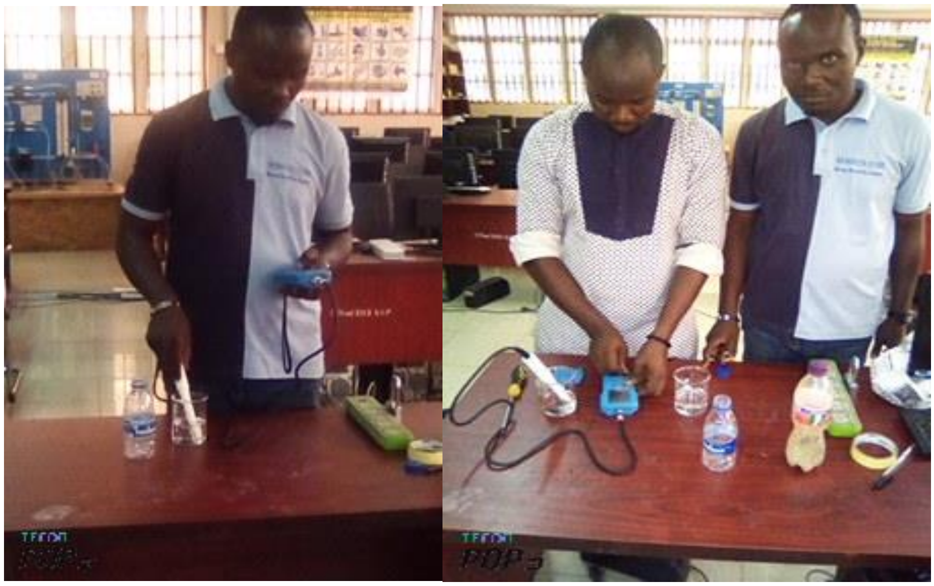


Figure 3(continue). Mobile Water Quality Testing Using Hannah Instruments (i.e. pH Meter - code: HI9812-5) and (Multi-range Conductivity Meter - code: HI9033).

4. 4. Productivity / Income Economic Analysis

(i) During the Dry Season on Fanalou Quarry:

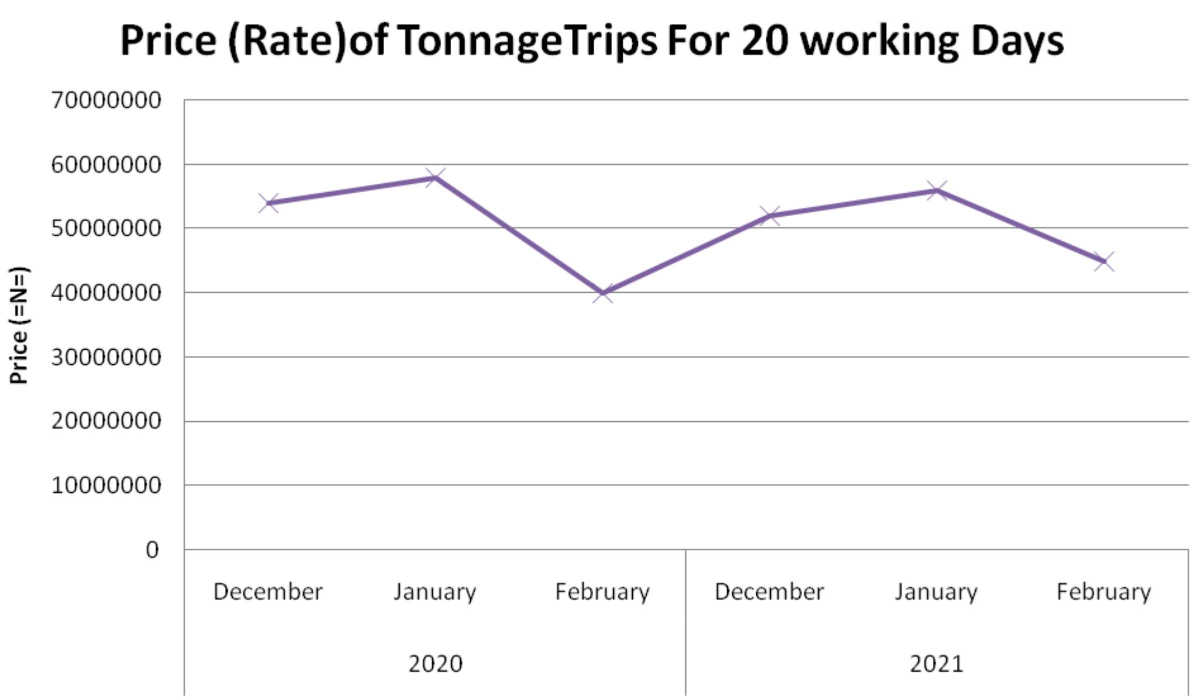


Figure 4. Price (Rate) of TonnageTrips For 20 working Days in Dry Season

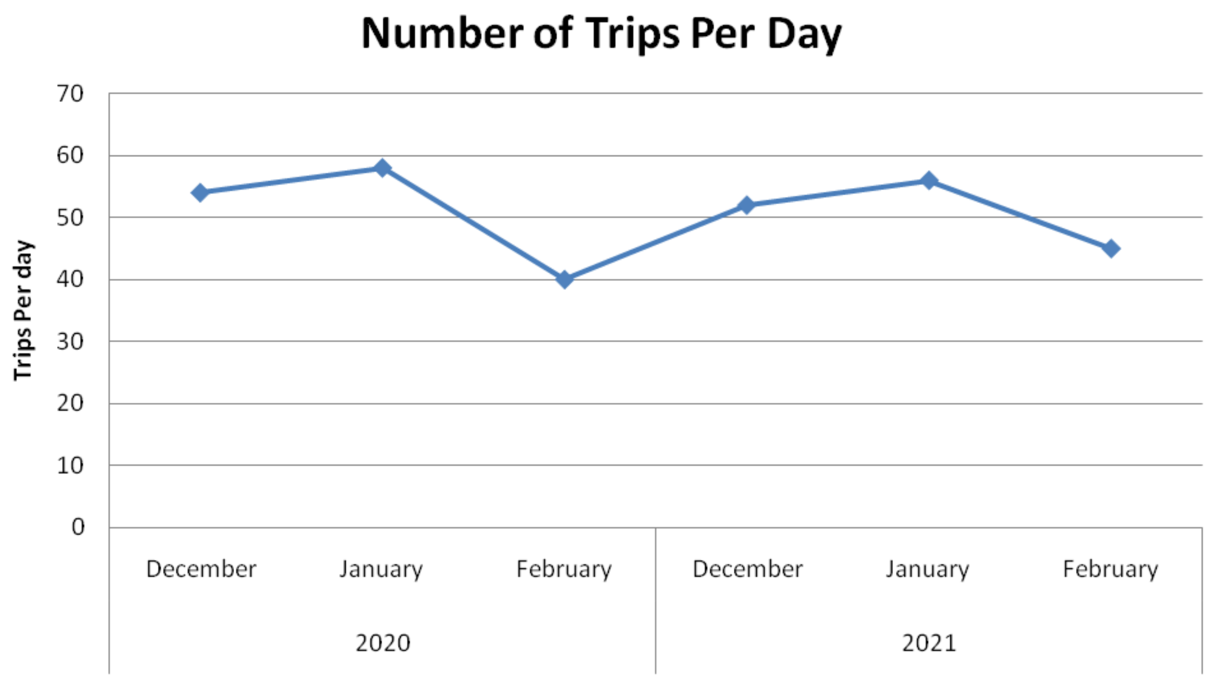


Figure 5. Number of Trips Per Day in Dry Season

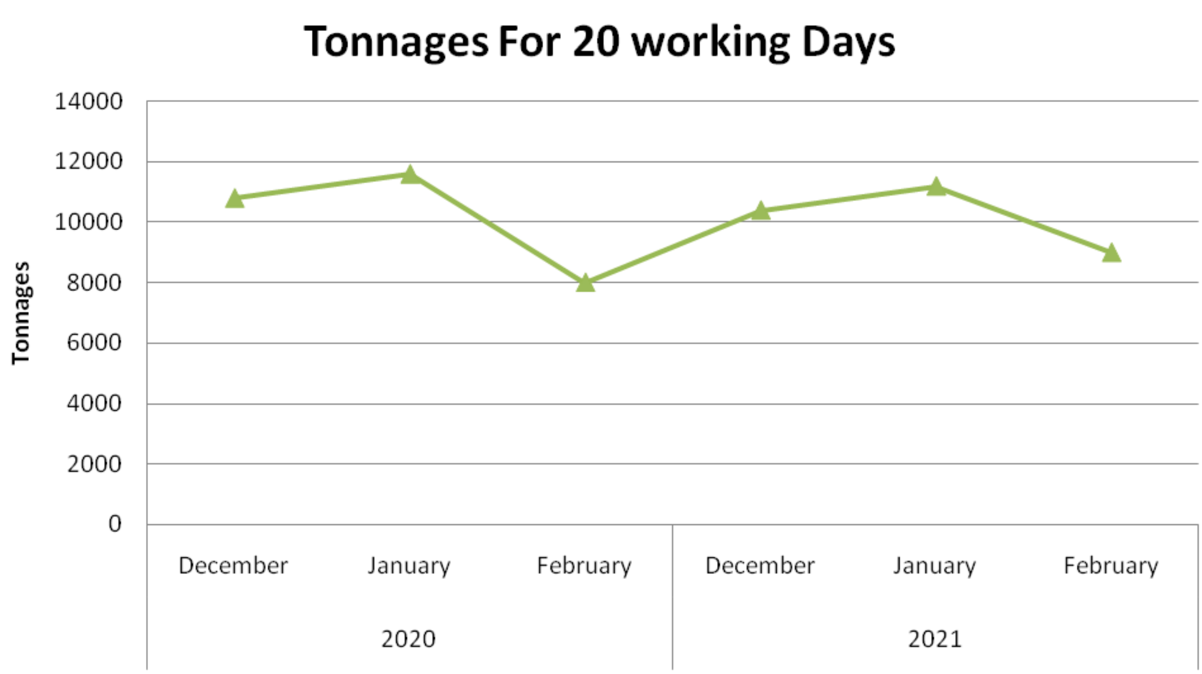


Figure 6. Tonnages for 20 working Days in Dry Season

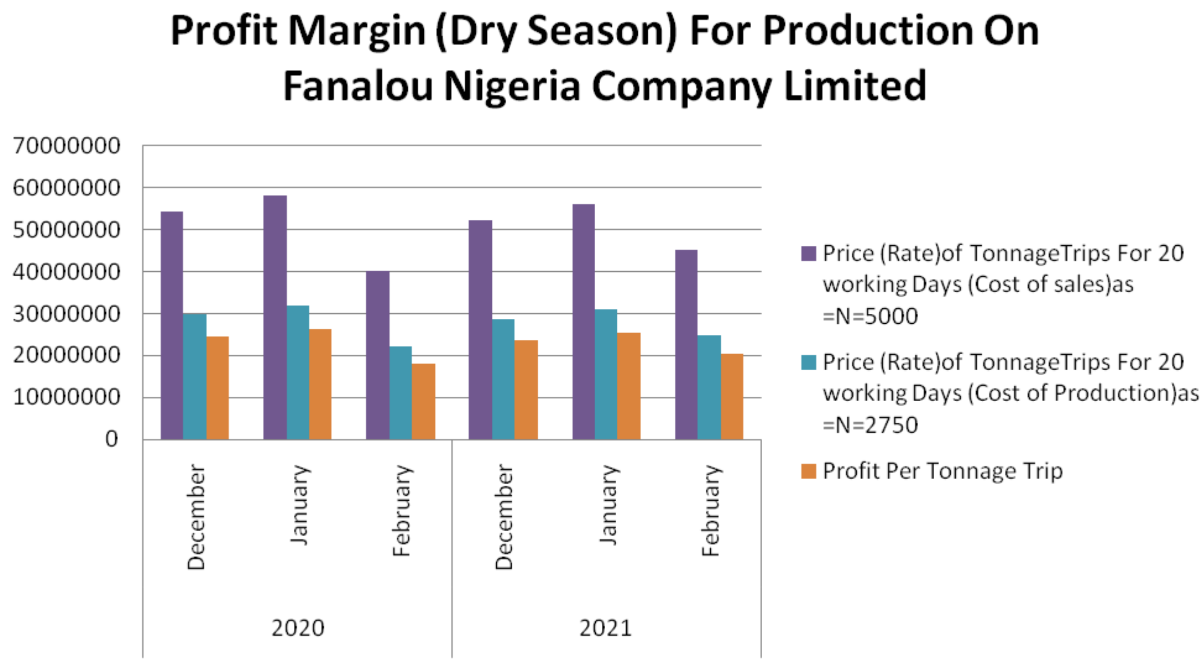


Figure 7. Profit Margin (Dry Season) For Production On Fanalou Nigeria Company Limited

(ii) During the Rainy Season on Fanalou Quarry:

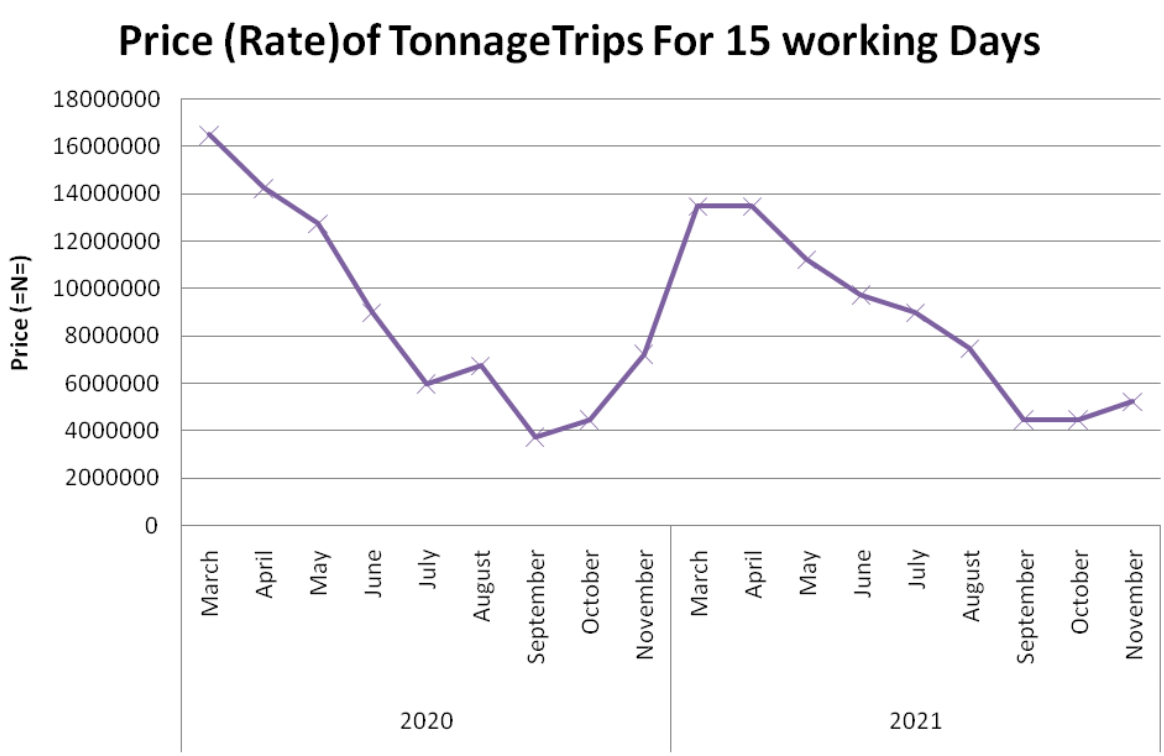


Figure 8. Price (Rate) of Tonnage Trips For 15 working Days in Rainy Season

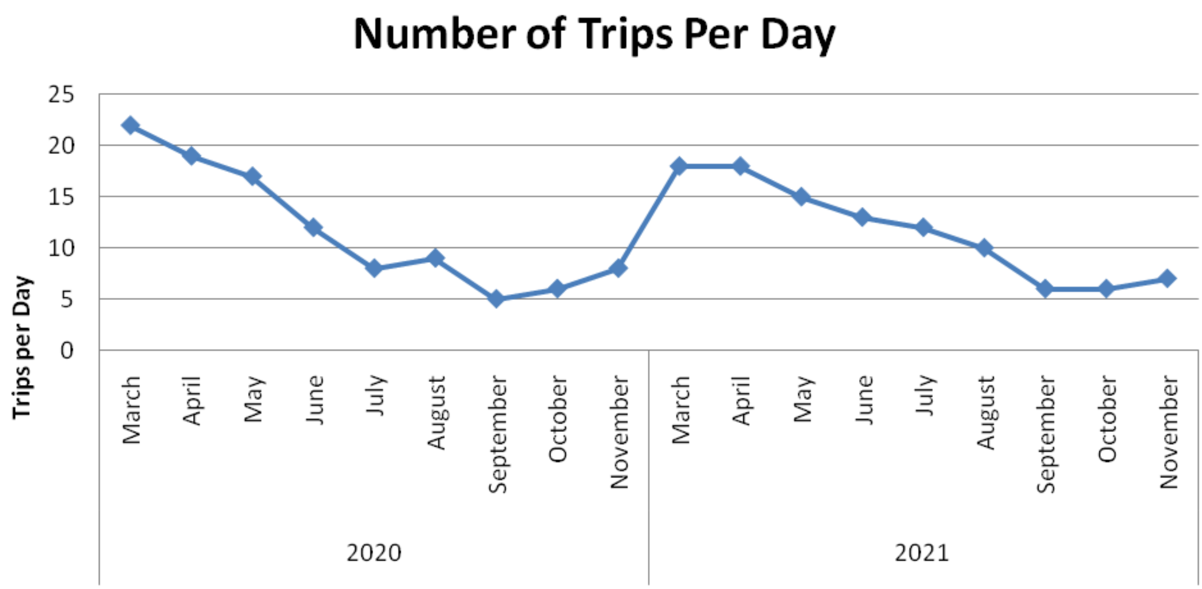


Figure 9. Number of Trips Per Day in Rainy Season

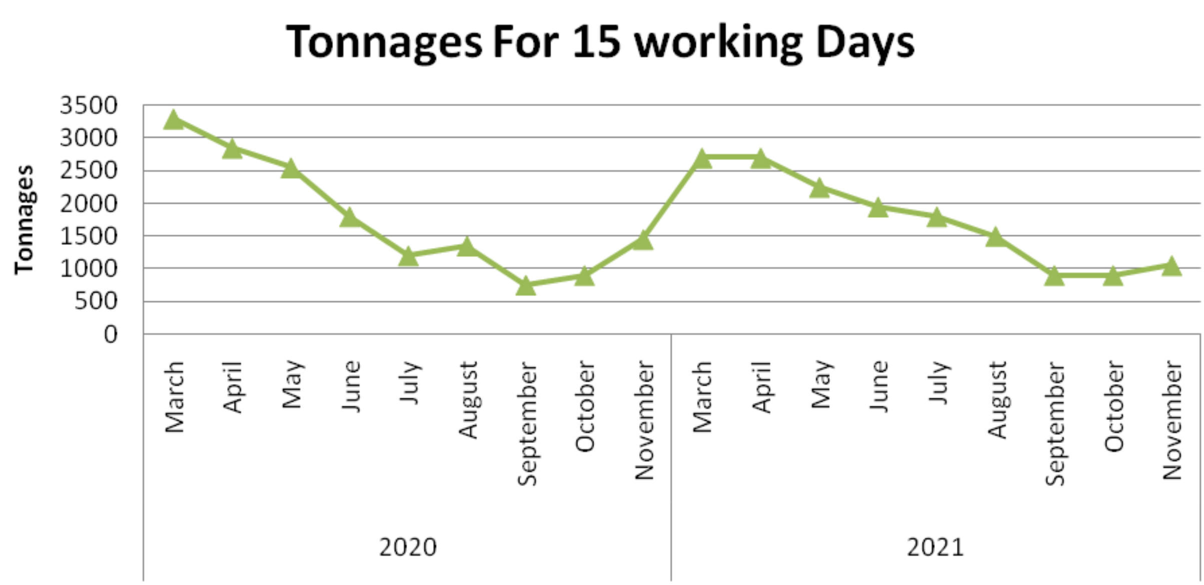


Figure 10. Tonnages for 15 working Days in Rainy Season

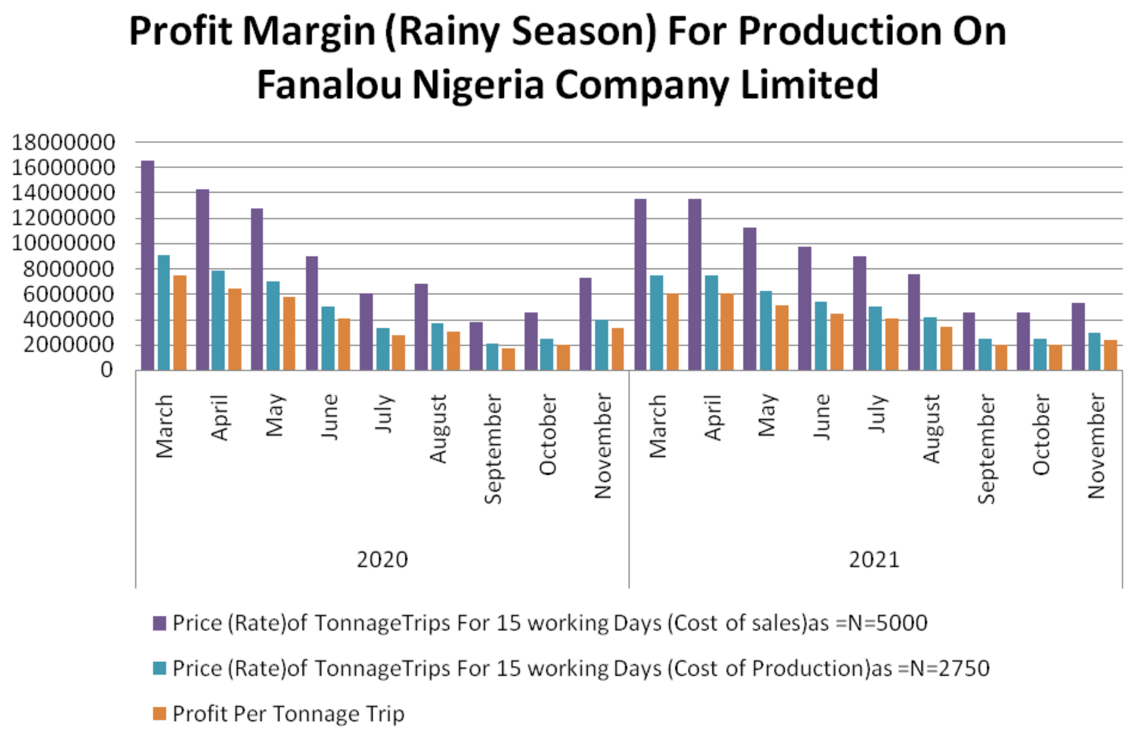


Figure 11. Profit Margin (Rainy Season) For Production On Fanalou Nigeria Company Limited

4. 5. Combined Seasons for Number of Trips per Day and Total Tonnage per Day

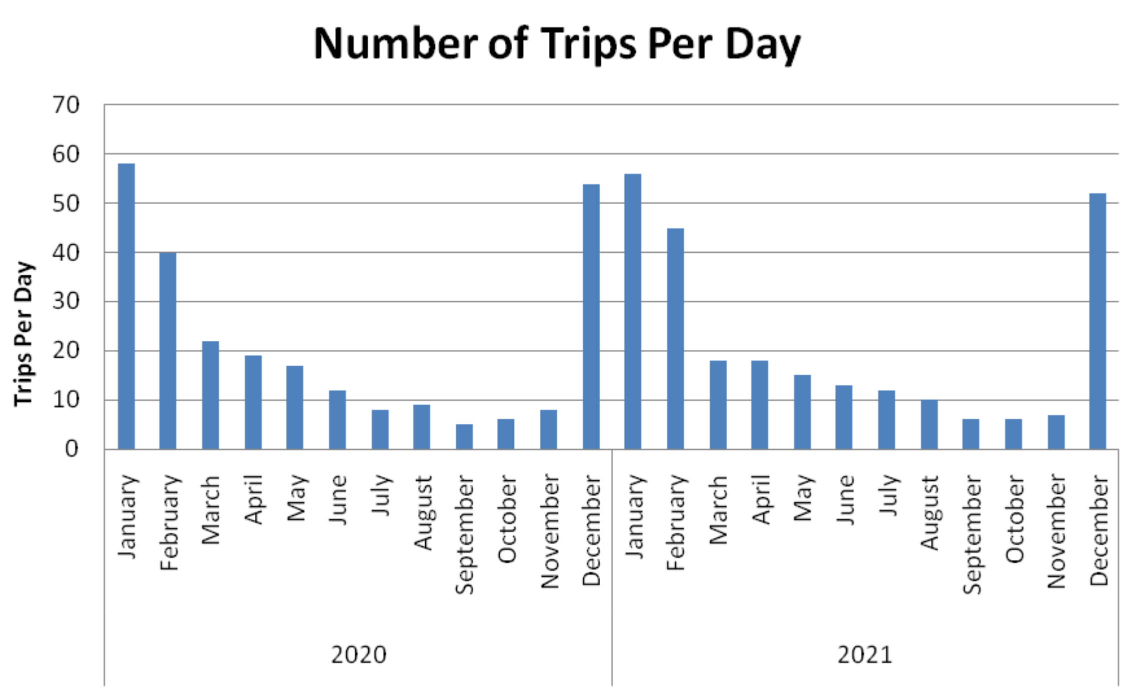


Figure 12. Number of Trips per Day for Combined Seasons

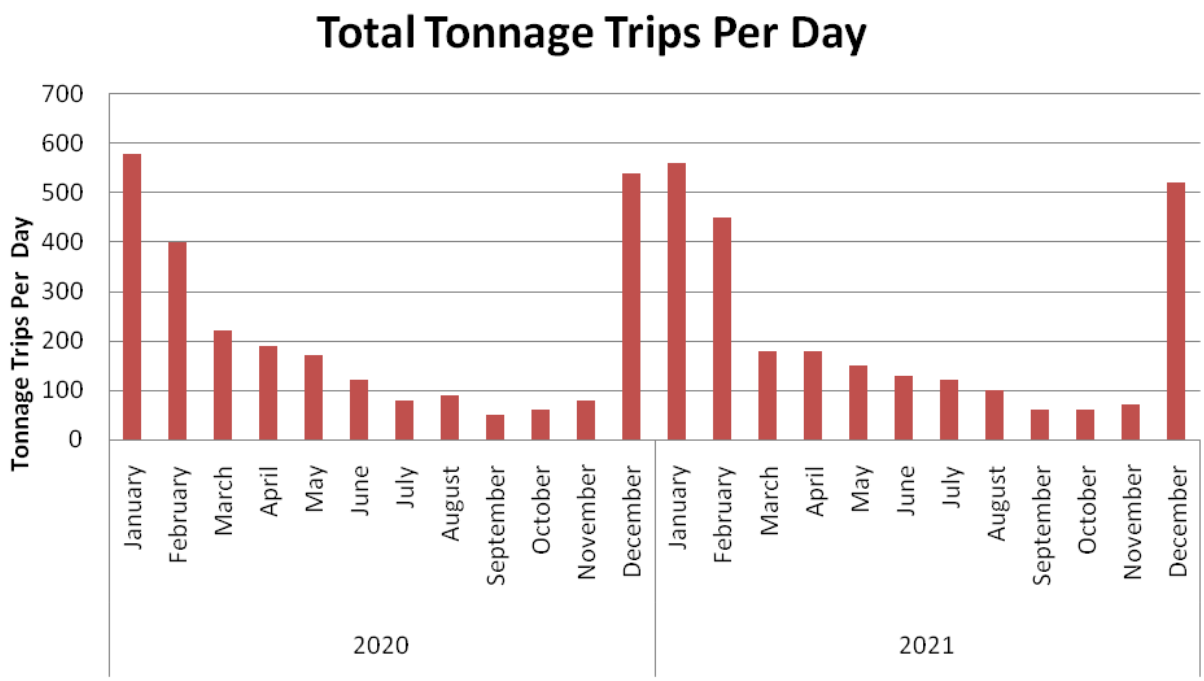


Figure 13. Total Tonnage Trips Per Day for Combined Seasons

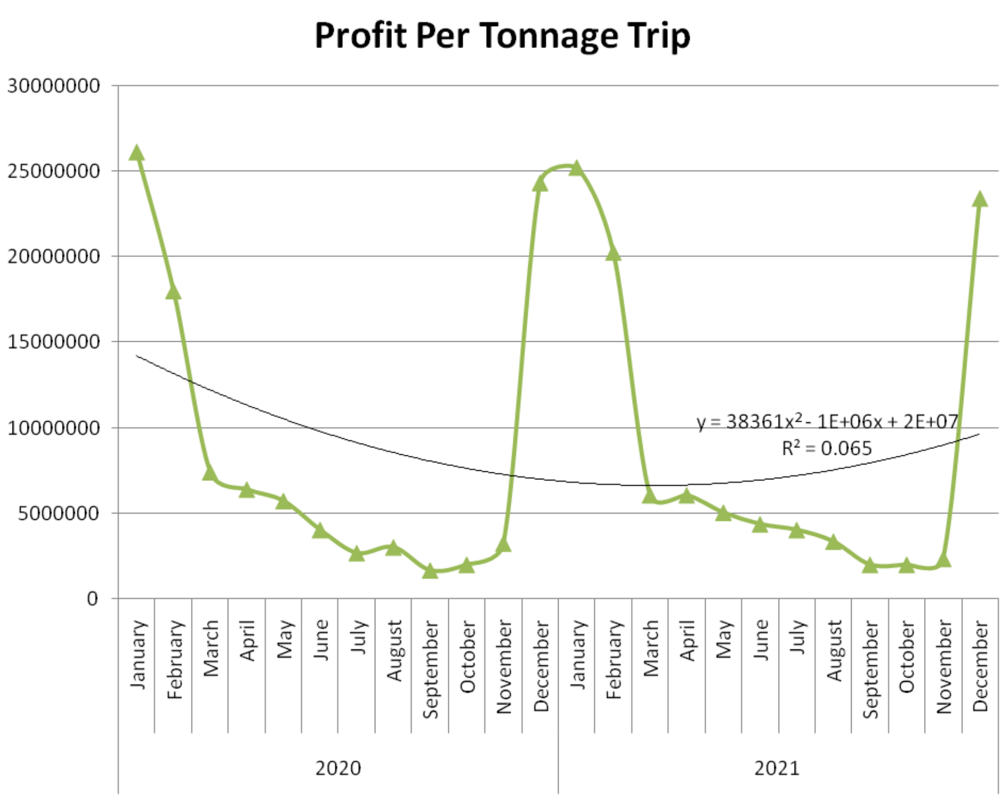


Figure 14. Profit Per Tonnage Trip For Combined Season

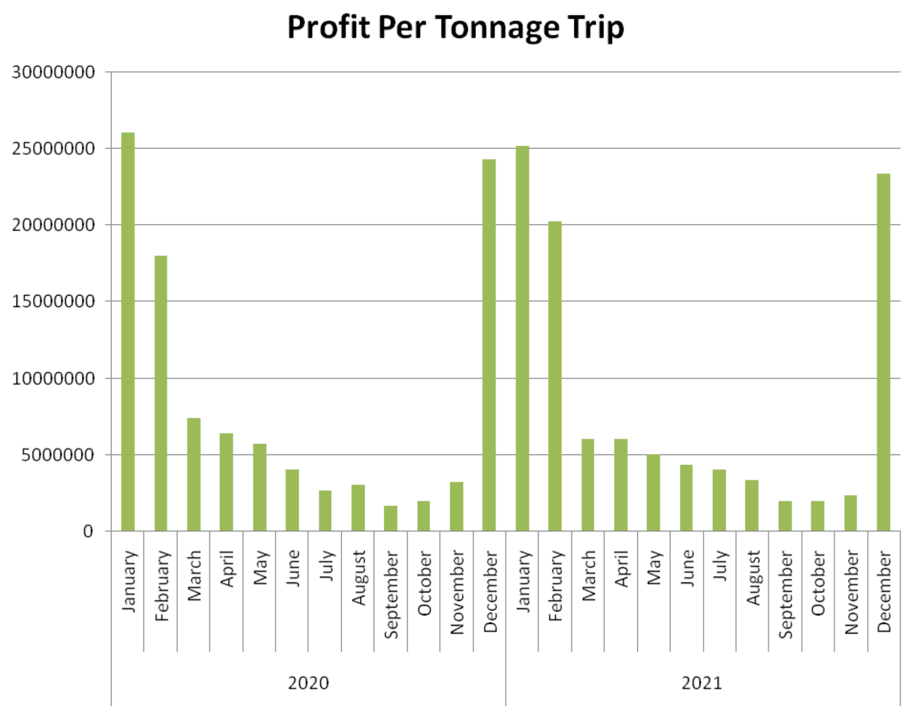


Figure 14(continue). Profit Per Tonnage Trip For Combined Season

4. 6. Compare Seasons for Number of Trips Per Day and Total Tonnage Per Day

(a) Number of Trips per Day and Total Tonnage per Day in Rainy Season

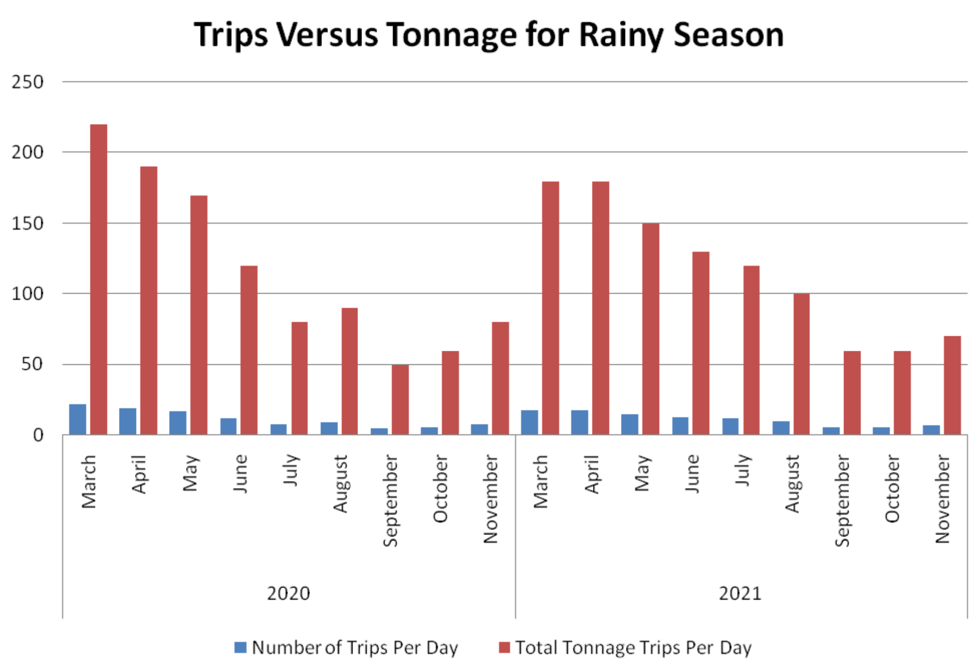


Figure 15. Trips versus Tonnage for Rainy Season

(b) Number of Trips per Day and Total Tonnage per Day in Dry Season

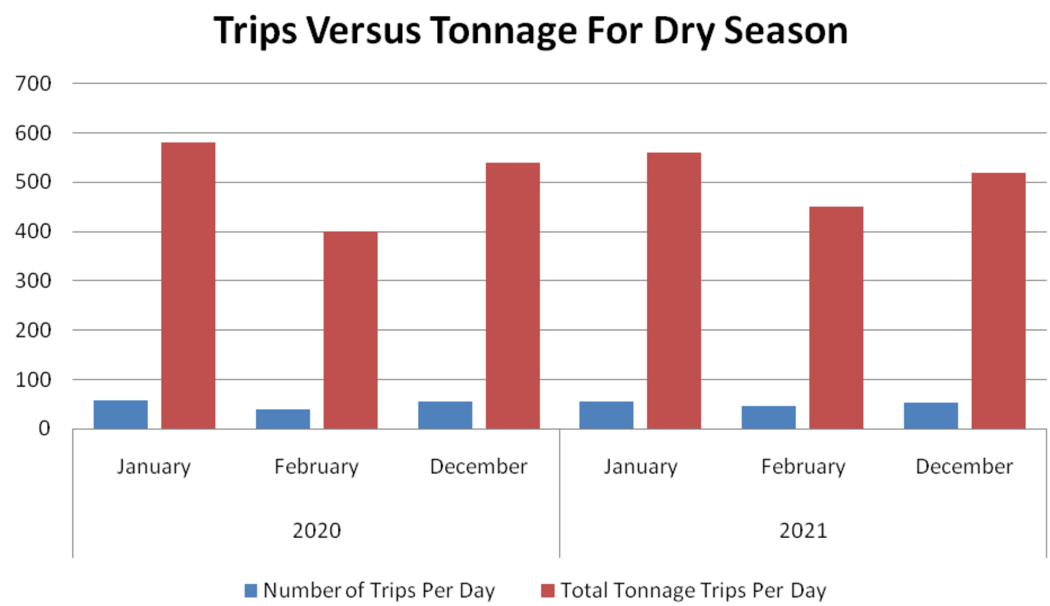


Figure 16. Trips versus Tonnage for Rainy Season

Table 4. Annual Profit Turn-over for Two (2) years.

Year	Month	Profit Per Tonnage Trip For Dry season (=N=)	Profit Per Tonnage Trip For Rainy season (=N=)	Annual Profit
2020	January	26,100,000		
	February	18,000,000		
	March		7,425,000	
	April		6,412,500	
	May		5,737,500	
	June		4,050,000	
	July		2,700,000	
	August		3,037,500	
	September		1,687,500	
	October		2,025,000	
	November		3,262,500	

	December	24,300,000		
	TOTAL	**68,400,000**	**36,337,500**	**104,737,500**
2021	January	25,200,000		
	February	20,250,000		
	March		6,075,000	
	April		6,075,000	
	May		5,062,500	
	June		4,387,500	
	July		4,050,000	
	August		3,375,000	
	September		2,025,000	
	October		2,025,000	
	November		2,362,500	
	December	23,400,000		
	TOTAL	**68,850,000**	**35,437,500**	**104,287,500**

5. DISCUSSION

From Table 1, the mean concentration of ionic contamination for five (5) production mine pit locations was considerably analyzed for the water and soil samples collected from the Fanalou mine pits (see Figure 3) using Atomic Absorption Spectrophotometer (AAS) Test. These metallic amounts pose a threat to pump-set during mine pit drainage, and to the environment of the host-community at large.

The conductivity test carried out using the pH Meter on water samples indicated a pH of 7.2; total dissolved solid of 290 ppm and conductivity of 580 micro-Siemens/cm (see Table 2); while that of carried out using the Multi-range Conductivity Meter dissolved soil samples shows pH of 6.4; total dissolved solid of 240 ppm; conductivity of 470 micro-Siemens/cm and turbidity of 32 NTU (see Table 3). The implication of these dissolved sediments causes problems for pumps that are used in draining water out of the mine pits in the form of:

(i) premature failure of equipment by abrasion of pump components , hereby increasing maintenance overhead costs;

(ii) cavitations, i.e. unnecessary noise, uncontrolled vibrations, failure of seal bearing, erosion of impeller, unexpectedly high power consumption, unimaginable fluid viscosity, clogging of strainers and filters, blockages to hoses and pipings;

(iii) undue trapping of fluids between impeller and its housing, at very high velocity causing drop in pressure and frictional losses; and

(iv) corrosion damages done to the casing of the pumps slowly and gradually, i.e. pitting corrosion (Amosu, 2021).

In Table 4 and 5, productivity / income economic analysis was observed during the dry and rainy seasons on Fanalou surface mines; considering the assumptions of 30 maximum trips for 15 working days during for the rainy season (Figure 8, Figure 9 and Figure 10), and 60 maximum trips for 20 working days during the dry season (Figure 4, Figure 5 and Figure 6).

If the cost of production is pegged at two thousand, seven hundred and fifty thousand naira per tonne (2750 naira per tonne), and production sales at five thousand naira per tonne (5000 naira per tonne) for both seasons, the profits incurred for the rainy season stands as thirty-six million, three hundred and thirty-seven thousand, five hundred naira (36,337,500 naira) in the year 2020 and thirty-six million, one hundred and twelve thousand, five hundred naira (36,112,500 naira) in the year 2021 (see Table 8 and Figure 11); while the profit made for the dry season stands as sixty-eight million, four hundred thousand naira (68,400,000 naira) in the year 2020, and sixty-eight million, eight hundred and fifty thousand naira (68,850,000 naira) in the year 2021 (see Table 8 and Figure 7).

Also, the calculated cumulative annual profits stands as one hundred and four million, seven hundred and thirty-seven thousand, five hundred naira (104,737,500 naira) for the year 2020 and one hundred and four million, nine hundred and sixty-two thousand, five hundred naira (104,962,500 naira) for the year 2021 (see Table 8).

The profit margin for both seasons indicates that production is greatly reduced during rainy season than in the dry season. Also less sales or losses are incurred during the rainy seasons, all round the year. Rain also disrupt the other mining cycle such as drilling, blasting, hauling and loading.

6. CONCLUSIONS

This field research work focuses on Fanalou Nigeria Company Limited, which is a surface mine or quarry in Ikpeshi, Nigeria. This quarry like any other produces continuous water influx from the underground seepages, surface run-off and atmospheric precipitation whose impacts is felt on production. This company stands to tackle the menace and challenges of monitoring it, especially in terms of its metallic concentration, in order to avert or prevent eventual mine abandonment.

This project considers the situations that surround the monitoring of mine water from the quarry and five (5) pit mines, using status of metallic concentrations in them, as well as the economic profit incurred per tonnage of ores tripped out on sales after production. By and large, apart from some caution to be taken concerning avoidance of cavitation for pumping unit used for mine pit drainage, the ionic amount in the individual mine pit is a potential threat to pumping operation and to the environment.

It is therefore recommended that water should be treated to neutralize the ionic concentrations before been pumped into the water channels that leads to the host-commumity (Amosu and Adeosun, 2021), and the appropriate materials that can withstand cavitation and corrosion should be chosen for the best pump-set selected for mine pit drainage. Also, in order to remain in business, all efforts should be doubled into profit-making during the dry seasons, since the rainy season is a burden to mine production.

References

[1] Adriano D.C., Wenzel W.W., Vangronsveld J. and Bolan N.S. (2004): Role of Assisted Natural Remediation in Environmental cleanup. *Geoderma* 122: 121-142

[2] Agomuo M. S and Egesi N. (2016): Petrology and Structural Geology of Ikpeshi and its Environ of Igarra Schist Belt South-western Nigeria. *International Journal of Science Invention Today*, 5(4), 303-319

[3] Ajibade, A.C. and Wright J.B., (1988): Structural Relationship in the schist Belts of North Western Nigeria; Precambrian geology of Nigeria. *A publication of Geological Survey*, Pp 103-109

[4] Amosu C.O. (2021): Mechanism of Corrosion in Production Wells using Stainless Steel: Review. *Indian Journal of Environment Engineering,* Volume – 1, Issue - 1, Pp. 25-32. DOI:10.35940/ijee.A180

[5] Amosu C.O.and Adeosun T.A.(2021): Waste Minimization In Segilola Gold Mine Project, Osun State; Department of Mineral and Petroleum Engineering Yaba College of Technology, Lagos, Nigeria. *Quest Journals - Journal of Research in Environmental and Earth Sciences,* Volume 7 , Issue 4, pp 06-17

[6] Hamid A., Mushtag A., Nazir R., Asghar S. (2017): Heavy Metals in Soil and vegetables Grown with Municipal wastewater in Lahore, Bangladesh. *J. Sci Ind Res* 52 (4): 331-336. Doi: 10: 3329/bjsir.v52i4.34821

[7] Idris G. N., Asuen G. O.and Ogundele O. J.(2014): Environmental Impact on Surface and Ground Water Pollution from Mining Activities in Ikpeshi, Edo State, Nigeria. *International Journal of Geosciences*, 2014, 5, 749-755

[8] Kimberly, M.F.H. and William, H. :(1999). Trace metals in Montreal urban soils and the leaves of Teraxacumofficinale. *Canadian Journal of Soil Science,* 79, pp. 385-387

[9] Kozan E. And Liu S.Q. (2017): An Operational Level Multi-Stage Mine Production Timetabling Model for Optimally Synchronising Drilling, Blasting and Excavating Operations. *International Journal for Mineral Reclamation Environment* 31(7): 457-474. https://doi.org/10.1080/17480930.2016.1160818

[10] Martínez-Sánchez M.J., Navarro M.C., Pérez-Sirvent C., Marimón J., Vidal J. and García-Lorenzo M.L. (2008): Assessment Of The Mobility Of Metals In A Mining-Impacted Coastal Area (Spain, Western Mediterranean). *J Geochem Explor.* 2008; 96: 171-182

[11] McGrath S.P., Zhao F.J., Lombi E., (2001): Plant Rhizosphere Process Involved Phytoremediation of Metal-Contaminated Soils. *Plant Soil*, 232 (1/2): 207-14 p.

[12] Nasrabadi T., Nabi Bidhendi G.R., Karbassi A.R. and Mehrdadi N. (2010): Partitioning of Metals In Sediments Of The Haraz River (Southern Caspian Sea Basin). *Environ Earth Sci* 59: 1111-1117

[13] Obasi I.O., Nnorom P.C., Nzeakor F.C. and Nwaogu D.C. (2019): Profit Analysis of Poultry Production and marketing in Okigwe L.G.A. of Imo State, Nigeria – Implication

for Employment Generation. *International Journal of Marketing and Communication Studies* Vol. 4, No. 1.

[14] Odeyemi, I.B (1976): Prelimnary report on the field relationship of the Basement Complex rocks around Igarra, Midwest Nigeria, In Geology of Nigeria, Pp 59 – 63. Elizabeth Pub Lagos.

[15] Ozdemir B. and Kumral M. (2019): A System-wide Approach to Minimize the Operational Cost of Bench Production in Open-cast Mining Operations. *Int J Coal Sci Technol*, 6(1): 84-94. https://doi.org/10.1007/s40789-018-0234-1

[16] Saliu M.A. and Komolafe K. (2014): Investigating the Effect of Dolomite Exploitation on Groundwater Condition of Ikpeshi, Akoko – Edo, Edo State, Nigeria. *Journal of Earth Sciences and Geotechnical Engineering*, vol. 4, no. 3, 137-147

[17] Singh S. And Narendrula R. (2006): Factors Affecting The Productivity of Loaders in Surface Mines. *Int J. Min Reclam Environ* 20(01): 20-32

[18] Tarzia M., De Vivi B., Somma R., Ayuso R.A., McGill R.A.R. and Parrish R.R. (2002): Anthropogenic versus natural pollution – an environmental study of an industrial site under remediation (Naple, Italy). *Geochemistry: Exploration, Environment, Analysis*, 2, 45-56

[19] Ulrich, D., W. Brockbank, D. Johnson, and Younger, J. (2007). Human resource competencies: Responding to increased expectations."Employment Relations Today 34(3), pp.1-12

[20] Umoru T.A. et al (2021): Determination of Elemental Composition and Trace Elements in Limestone Deposit in Ikpeshi, Edo State, Nigeria. *IRE Journals,* Volume 5 Issue 1

[21] Weisz M., Polyak K. and Hlavay J. (2000): Fractionation Of Elements In Sediment Samples Collected In Rivers And Harbors At Lake Balaton And Its Catchment Area. *Microchem J.* 67: 207-217

[22] Woodruff, S. and Dack, S.: (2004). Analysis of risk from mercury contamination at the Khimprom Plant in Kazakhstan. *I Journal of Land Contamination & Reclamation*, 12 (3), pp. 213-218

[23] Yu K.C., Tsai L.J., Chen S.H. and Ho S.T. (2001): Correlation Analyses Binding Behavior Of Heavy Metals With Sediment Matrices. *Water Res.* 35 (10): 2417-2428

[24] Zayernyuk V.M., Mukhomorova I.V., Zabaikin I.V., Egorova E.N. And Seifullaev B.M. (2017): Analysis of The Current State And Prospects of The Gold Mining Industry In Russia, *Espacios,* Vol. 38 (No. 58), Page 24