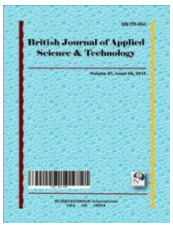

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Effect of Capital and Operating Cost on the Aggregate Production in Some Selected Quarries in North-Central Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author PAA drafted the questionnaires, performed the statistical analysis and drafted the first manuscript. Author MAG managed the literature searches and analyses of the study. Author ZOO designed the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study examines the effect of capital cost and operating cost on some selected quarries within North Central Nigeria.
Study Design: Survey design was used in designing the questionnaire used for collecting data from the selected quarries.
Study Area and Methodology: Twenty four quarries were selected in North- Central Nigeria for this study. Sixteen of these quarries were for commercial purposes while eight were for construction purposes. A total number of one hundred and fifty-five questionnaires were randomly distributed to the workers and managements of the various quarries to collect data on the quantity of granite rock blasted per month, cost of drilling accessories used, cost of explosives used, cost of maintenance of plant/equipment and cost of manpower. Net Present Value (NPV) and Internal Rate of Returns (IRR) were the two economic evaluation data analyses used for the study because they rely on the time value of money.

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Results: The result shows that Majok quarry, Cafon quarry, Rock bridge quarry, Academ quarry, Trans Engineering and Sinac granite quarry are not doing well as their internal rate of returns falls short of the annual internal rate of returns of 20%. This indicates that the companies could not break even as they failed to cover the average operating cost.
Conclusion: The study noted that it is not only huge capital cost that determine the production cost of aggregates, rather, such measures as the size of the jaw of the crushing plant, appropriate spacing and burden drilling plan are very important to guide against the extra operating cost of secondary blasting.

Keywords: Capital cost; operating cost; net present value; internal rate of returns.

1. INTRODUCTION

Quarries are classified as surface mining, which involves some basic cycle's operations such as excavation, drilling and blasting, loading, haulages from the quarry face to the crushing plant, crushing and maintenance of the machinery and equipment [1]. All these determine the success or failure of quarry operations. Drilling and blasting are the most important factors in quarry operations. Blasting is the principal method of rock breakage in mining and construction projects throughout the world. This may probably be due to its distinct advantages like economy, efficiency, convenience and ability to break the hardest of rocks [2]. With these two factors, a reasonable estimate can be made for the number of drills required and the cost implications [3]. If these operations are not successful, then the viability of the quarry becomes jeopardized. Also, Howard [4] noted that the development of production, utilization is very important in quarry operation which involves an overall job efficiency of 60%, a mechanical availability of 80% and an annual outage factor of 95%, yielding production utilization 46%. Peter [5] revealed that low overall job efficiency can occur when moving the drill from hole to hole and the low mechanical availability occurs when blast hole drill encounter rough usage. He therefore concluded that effort should be made to avoid secondary blasting and better primary blasting should be ensured since it increases the overall production of one ton of rock produced.

Opafunso [6] stated quarry project is a capital intensive investment with many uncertainties as a result of geologic condition, reserve estimations, severe problems in forecasting aggregate prices and production costs while Mainoma [7] noted that the overall economic viability of any quarry from a lender's point of view is mainly test through cash flow analysis. David [8] enumerated four important principles of an economic model for investment decisions which are; the incremental principle, the principle of time perspective, the opportunity cost principle and the discounting principle. Tobi [8] described these principles as the frameworks of economic analysis which interrelate the areas of quarrying, technology for drilling and blasting, the annual turnover, the capital investment required, the estimated operating costs, and the profitability criteria for the final investment decision. The evaluation of profitability of investment is the final analysis, which is measured by the difference between the summation of the present value of the expected proceeds over future years and the initial outlay invested today [9].

The objective of production schedule is to maximize the net present value and return on investment that obtained from the drilling and blasting, crushing and sale of aggregates from quarrying activities. Tijani [10] noted that an optimum production schedule in quarrying activities depends on two parameters. The first parameters are the stripping ratio associated with recovering the ore, the grade of that ore, and the physical location of that ore in respect to availability through time while the second parameters consist of costs associated with starting and maintaining the whole operation. The high risk and large capital expenditures, which are characteristics of the quarrying industry have made financial analysis as one of the crucial elements in the resource development process. In view of these facts, this study carried out comprehensive analyses of fixed and variable costs in some selected quarries with the aim of finding ways of reducing some of these costs and sustaining the profit maximization.

2. METHODOLOGY

2.1 Description of the Study Area

Twenty four quarries were selected in North-Central Nigeria for this study as shown in Table 1.

Table 1. Names and locations of quarries sites

S/N	Quarry owner	State	LGA
1	Setraco Nig. Ltd	FCT	Bwari
2	Crushed Rock Industries ltd.	FCT	Bwari
3	Exsamines Nig. Ltd	FCT	Bwari
4	Majok Nig. Ltd	FCT	Bwari
5	Trans Eng. Nig. Ltd.	FCT	Bwari
6	ENL Company Ltd.	FCT	Bwari
7	SCC Nig. Ltd	FCT	Bwari
8	Gilmo Engineering Nig. Ltd.	FCT	AMAC
9	Alhaji Abdullah Gbojega	Niger	Chanchanga
10	Gold International Nig. Ltd	Niger	Chanchanga
11	Bulletine Construction Co. Ltd	Kogi	Lokoja
12	Sinac Granite Product Intl. ltd	Kogi	Ajaokuta
13	Julius Berger Nig. Plc	Kogi	Ajaokuta
14	Lubbox Limited	Kwara	Asa
15	Confidence Const. Co. Ltd.	Kwara	Asa
16	Aron Stones Limited	Kwara	Asa
17	Sarki & Adisa Co. Ltd	Kwara	Ilorin West
18	Cafon Ventures Nig. Ltd.	Kwara	Ilorin West
19	Mukan & Sons Nig. Ltd.	Plateau	Bassa
20	P.W. Nigeria Ltd.	Benue	Katsina Ala
21	Academ Const. Co Ltd	Benue	Katsina Ala
22	Just & Lawson Company Ltd.	Nasarawa	Nasarawa
23	Nasarawa Minerals Dev. Co. Ltd.	Nasarawa	Nas/Eggon
24	Rock Brigde Const. Ltd.	Nasarawa	Nas/Eggon

Sixteen of these quarries were for commercial purposes while eight were for construction purposes. Ten of the quarries were owned by the foreigners, while fourteen were owned by indigenous firm. Throughout the period of data collection for this study, five of the quarries were not in operation while ten were on skeletal operations and ten swere in continuous production.

Table 2. Average selling price for granite aggregates products

S/N	Sizes / Aggregates	Price / Tonne (N)
1	0 - 5 mm (Dust)	1,100
2	5 - 10 mm (3/8")	2,250
3	10 - 15 mm (1/2")	2,750
4	15 - 22 mm (3/4")	2,250
5	22 - 35 mm (1")	2,200
6	Crushed stone base	1,650
7	Hard core	1,650

2.2 Data Collection and Analysis

A total number of one hundred and fifty-five questionnaires were randomly distributed to the workers and managements of the various quarries to collect data on the quantity of granite rock blasted per month, cost of drilling accessories used, cost of explosives used, cost of maintenance of plant/equipment and cost of manpower. The data collected was used to determine the total variable cost and cost to produce a tonne of granite aggregate. Average selling price per tonne of granite aggregate was also collected as shown in Table 2.

Net Present Value (NPV) and Internal Rate of Returns (IRR) were the two economic evaluation data analyses used for the study because they rely on the time value of money. NPV and IRR were used to calculate the cash flows annuity for three years at 20% annual rate by using Equations (1) and (2). Also, the cost of producing one tonne of granite aggregate was calculated by using Equation (3).

$$NPV = R \times \frac{1-(1+i)^{-n}}{i} - \text{Initial Investment} \quad (1)$$

Where "NPV" is Net present value, "i" is rate of lending in % and "n" is the number of years

$$\text{IRR} = \{\text{LR} + (+\text{NPV})\}(\text{HR} - \text{LR}) \,/\, +\text{PV}^1 + \text{PV}^2 \quad (2)$$

Where, "IRR" is the internal rate of return, LR is Lower rate, HR is higher rate and +NPV is Positive NPV

$$CPTA = \frac{TVC}{NTP} \quad (3)$$

Where, CPTA is the cost per tonne of granite aggregate, TVC is the total variable cost and NTP is the number of tonne of granite aggregate produced.

3. RESULTS AND DISCUSSION

3.1 Results

The following results were generated from the data analyses: total variable cost, the cost to produce a tonne of granite aggregate and cash inflows for the period of three years as shown in Tables 3, 4 and 5.

3.2 Discussion

Fig. 1 shows the performance of the selected quarries. It was observed that Majok quarry, Cafon quarry, Rock bridge quarry, Academ quarry, Trans Engineering and Sinac granite quarry are not doing well as their internal rate of returns falls short of the annual internal rate of returns of 20%. This indicates that the companies could not break even as they failed to cover the average operating cost. It is not advisable for the firms to close down, even when the average variable cost could be covered at a loss would be minimized if the companies continue production. This is because if the companies close down, then, the business would still incur the capital cost which is unavoidable whether production continues or not. Meanwhile, if the price falls and the companies could no longer cover its variable cost, then it is advisable for the companies to close down. Otherwise, the companies will not only lose its capital cost but also part of its operating cost.

Figs. 2, 3 and 4 show the comparative analyses of total capital cost, total operating cost and total cost of producing one tonne of granite aggregate for each of the quarries. It was observed from the figures that Julius Berger quarry has the highest capital cost of N874, 000,000.00 and operating costs of ₦24, 573,344.00 and produces one ton of aggregate at an average cost of ₦386.00 while Rock Bridge with the lowest capital cost of ₦55, 000,000.00 and operating costs of ₦29, 760,000.00 produces one ton of aggregate at a whopping rate of N620.00 annually. Majok quarry produces one tonnage of aggregate at the highest operating cost of ₦900.00 with a capital cost of ₦85,000,000.00 while P.W. quarry with one of the highest capital cost of ₦755,000,000.00 produces one ton of aggregate at the lowest rate of ₦204.00. This shows that quarry with high operating costs will find it difficult to break even. This is the reason why Majok quarry with -16% of IRR cannot breakeven while Julius Berger and Gilmo quarries with 87% and 74% of IRR are doing well as a result of their very huge capital cost.

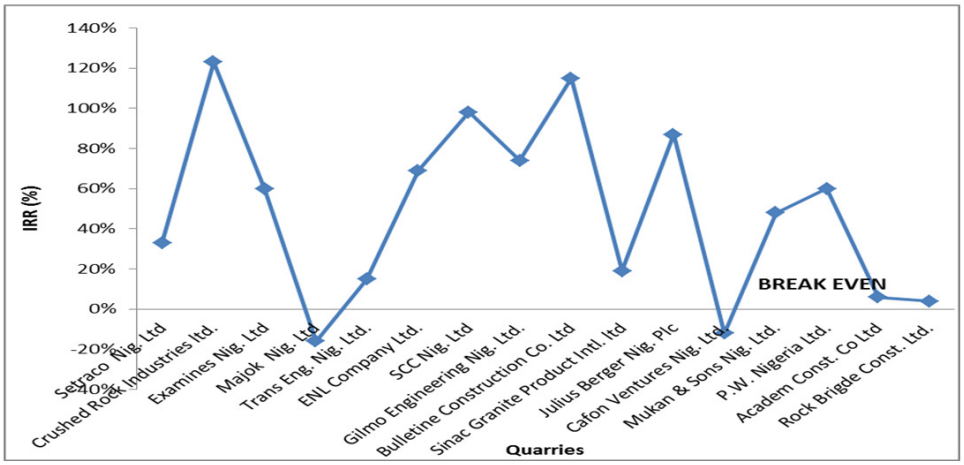

Fig. 1. Graph of comparative performance between successful and unsuccessful quarries

Table 3. Monthly cash flows of the quarries

S/N	Quarries	Quantity of rock produced (tonne)	Royalty (N25/ton) (N)	Cost of drilling accessories (N)	Cost of explosive (N)	Cost of equipment maintenance (N)	Cost of man power (N)	Total variable cost (N)
1	Setraco Nig. Ltd.	60,000	1,500,000	1,270,316	15,385,850.00	6,843,834.00	1,460,000.00	26,460,000.00
2	Crushed Rock Industries Ltd.	48,912.50	1,222,813	650,320	2,771,161.04	10,896,400.00	2.366.172.71	15,540,693.54
3	Examine Nig. Ltd.	21,008	525,200	392,906	2,324,275.69	9,506,855.49	1,565,824.10	14,315,061.28
4	Majok Nig. Ltd.	23,333	583,325	802,125	10,232,150.00	6,900,000.00	3,065,725.00	21,583,325.00
5	Trans Eng. Nig. Ltd.	34,043	851,075	464,882	9,607,200.00	5,000,000.00	1,268,735.00	17,191,892.00
6	ENL Company Ltd.	81,000	2,025,000	4,383,190	12,774,150.00	7,331,960.00	1,782,660.00	28,296,960.00
7	SCC Nig. Ltd.	47,236	1,180,900	438,680	2,374,381.33	12,969,016.63	1,842,146.00	18,805,123.96
8	Gilmo Engineering Nig. Ltd.	50,375	1,259,375	398,530	2,463,280.00	11,800,110.86	1,200,170.00	17,121,465.86
9	Bulletine Construction Co. Ltd.	12,480	312,000	280,184	2,029,336.93	3,566,018.97	828,965.70	7,016,505.60
10	Sinac Granite Production Intl. Ltd.	35,000	875,000	995,740	7,009,820.00	6,840,560.00	1,635,000.00	17,356,120.00
11	Julius Berger Nig. Plc	63,601.20	1,590,030	810,368	8,327,518.00	14,369,800.70	1,065,654.54	26,163,371.24
12	Cafon Ventures Nig. Ltd.	35,200	880,000	773,118	7,016,100.00	15,460,782.00	3,150,000.00	27,280,000.00
13	Mukan & Sons Nig. Ltd.	45,000	1,125,000	1,170,084	7,232,096.00	6,875.000.00	2,092,821.00	11,620,001.00
14	P.W. Nigeria Ltd.	80,229	2,005,725	780,668	6,862,400.00	6,657,749.04	2,040,000.00	18,346,542.04
15	Academ Const. Co Ltd.	55,000	1,375,000	780,668	7,009,820.00	16,896,400.00	1,625,000.00	27,686,888.00
16	Rock Brigde Const. Ltd.	48,000	1,200,000	1,398,466	12,466,010.00	11,120,000.00	4,775,524.00	30,960,000.00

Table 4. Cost of producing a tonne of granite aggregate

S/N	Quarries	Cost of granite aggregate/ton (N)	Total capital cost (N)	Total operating cost (N)
1	Setraco Nig. Ltd	416	610,000,000	25,000,000
2	Crushed Rock Industries Ltd.	341	660,000,000	16,340,810
3	Examines Nig. Ltd	656	320,000,000	13,789,865
4	Majok Nig. Ltd	900	85,000,000	21,000,000
5	Trans Eng. Nig. Ltd.	480	250,000,000	16,340,817
6	ENL Company Ltd.	320	310,000,000	25,920,000
7	SCC Nig. Ltd	373	401,000,000	17,624,636
8	Gilmo Engineering Nig. Ltd.	319	523,610,000	16,042,090
9	Bulletine Construction Co. Ltd	537	200,000,000	6,704,551
10	Sinac Granite Product Intl. Ltd	510	75,000,000	17,850,000
11	Julius Berger Nig. Plc	386	874,000,000	24,573,344
12	Cafon Ventures Nig. Ltd.	750	110,000,000	26,400,000
13	Mukan & Sons Nig. Ltd.	386	122,000,000	17,370,000
14	P.W. Nigeria Ltd.	204	755,000,000	16,340,817
15	Academ Const. Co Ltd	473	401,000,000	26,311,888
16	Rock Brigde Const. Ltd.	620	55,000,000	29,760,000

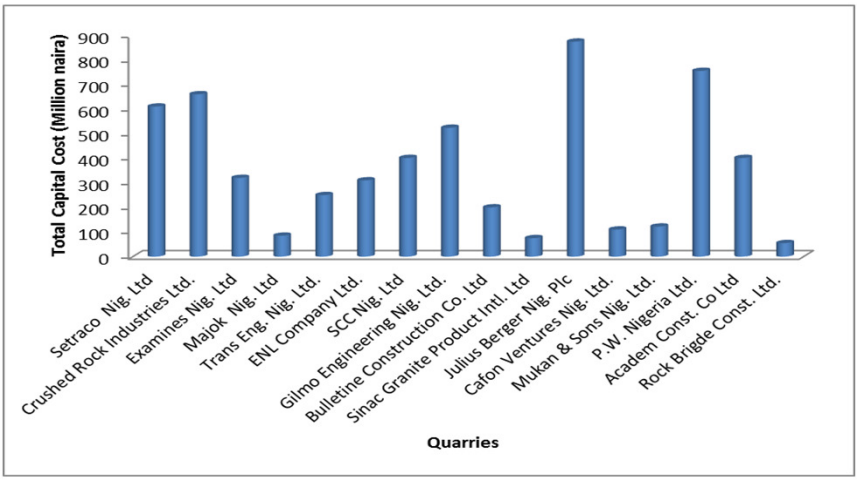

Fig. 2. Comparative of total capital cost of the quarries

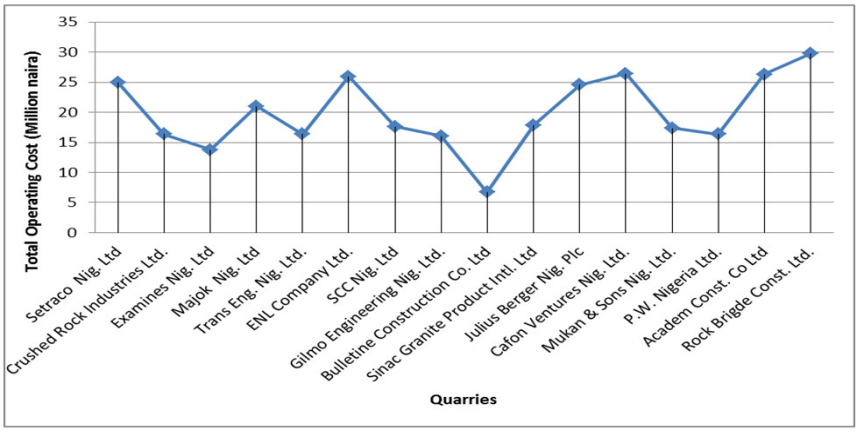

Fig. 3. Comparative analyses of total operating cost of the quarries

Table 5. Cash Inflow for the period of three year at 20% annual rate

S/N	Name of quarries	Initial investment	Year 1 (N)	Year 2 (N)	Year 3 (N)	IRR (%)	NPV (N)
1	Setraco Nig. Ltd	-610,000,000	350,000,000	350,000,000	350,000,000	33	737,268,518.52
2	Crushed Rock Ind. Ltd	-660,000,000	890,000,000	890,000,000	890,000,000	123	1,874,768,518.52
3	Examine Nig. Ltd.	-320,000,000	255,000,000	255,000,000	255,000,000	60	537,152,777.78
4	Majok Nig. Ltd.	-85,000,000	20,000,000	20,000,000	20,000,000	-16	42,129,629.63
5	Trans Eng. Nig. Ltd.	-250,000,000	110,000,000	110,000,000	110,000,000	15	231,712,962.96
6	ENL Company Ltd.	-310,000,000	270,000,000	270,000,000	270,000,000	69	568,750,000.00
7	SCC Nig. Ltd.	-401,000,000	450,000,000	450,000,000	450,000,000	98	947,916,666.67
8	Gilmo Engineering Nig. Ltd.	-523,610,000	480,000,000	480,000,000	480,000,000	74	1,011,111,111.11
9	Bulletine Const. Co. Ltd.	-200,000,000	255,000,000	255,000,000	255,000,000	115	537,152,777.78
10	Sinac Granite Prod. Intl. Ltd.	-75,000,000	35,000,000	35,000,000	35,000,000	19	73,726,851.85
11	Julius Berger Nig. Plc	-874,000,000	900,000,000	900,000,000	900,000,000	87	1,895,833,333.33
12	Cafon Ventures Nig. Ltd	-110,000,000	28,000,000	28,000,000	28,000,000	-12	58,981,481.48
13	Mukan & Sons Nig. Ltd.	-122,000,000	85,000,000	85,000,000	85,000,000	48	179,050,925.93
14	P.W. Nigeria Ltd.	-755,000,000	600,000,000	600,000,000	600,000,000	60	1,263,888,888.89
15	Academ Const. Co Ltd.	-410,000,000	150,000,000	150,000,000	150,000,000	6	315,972,222.22
16	Rock Brigde Const. Ltd.	-55,000,000	20,000,000	20,000,000	20,000,000	4	42,129,629.63

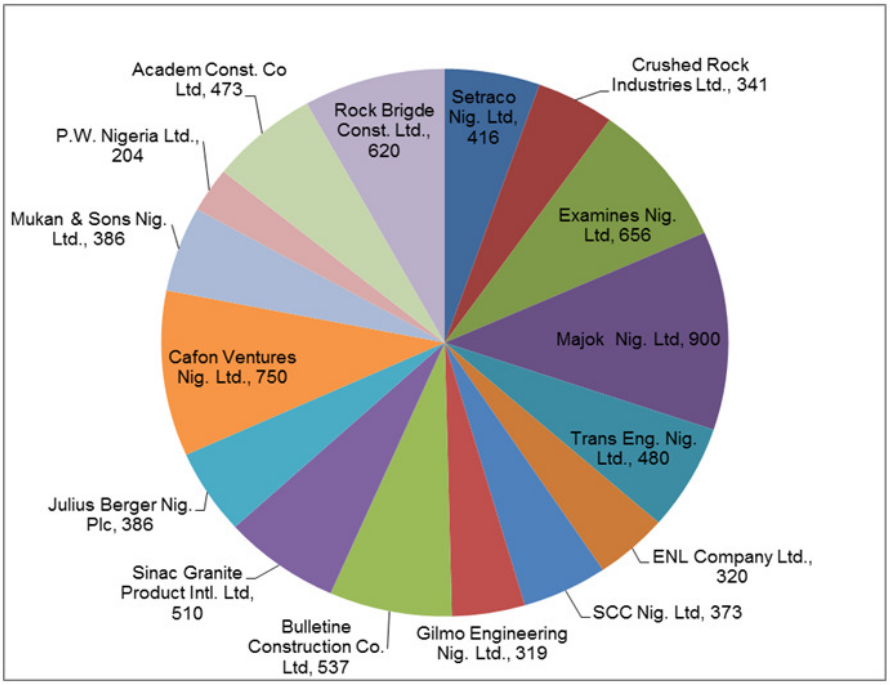

Fig. 4. Comparative analyses of total cost of producing one tonne of granite aggregate

4. CONCLUSION

The study noted that it is not only huge capital cost that determine the production cost of aggregates, rather, variable costs such as explosives and explosive accessories cost, cost of drilling and cost of equipment maintenance which are equally determined by the blast design (size of the jaw of the crushing plant, appropriate spacing and burden drilling) are very important to guide against extra operating cost of secondary blasting. The study, therefore recommended that all the unsuccessful quarries should invest more and increase their capital cost so that the operating costs will be drastically reduced. Technical procedures (such as holes diameter, water conditions, burden, spacing, bench height, rock structure, desired shape of the muck pile, size and type of handling and crushing equipment and of course, the type of explosives used and the kind of ignition) which dictate by the condition of the deposit should be strictly followed before setting up quarry operation in order to guide against the high rate of aggregate production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Holmberg R. Explosives and blasting techniques, (A.A. Belkema). 2003;5-200.
2. Ajaka EO, Adesida PA. Importance of blast-design in reduction of blast-induced vibrations. Int. J. Sci., Tech. and Society. 2014;2(3):53-58.
3. General Books LLC staff, Quarrying; quarries, Queenston, Ontario, Dalkey quarry, Tyndall stone and Lengenbach quarry, (Cave dicusa). 2010;1-26.
4. Hartman HL. Introductory mining engineering. Wiley India Limited; 2007.
5. Pearse GE. Rock blasting aspects on theory and practice. Mines and Quarry Engineering; 1955.
6. Opafunso ZO, Ajaka EO. Application of geographic information system (GIS) to solid mineral resources information management. Pakistan Journal of Science Industrial Research. 2003; 47(3)240.
7. Mainoma MA, Aruwa SAS. Principles and practice of managerial finance. Oxford; 2008.

8. David GA. Misuse of monte carlos simulations in NPV analysis, Mining Engineering Book 47, (Britain). 1995;75-79.
9. Tobi J, Brainard W. Asset markets and the cost of capital in economics progress, private values and public policies, (Amsterdam, Netherlands: North–Holland). 1977;25-28.
10. Tijani MN, Loehnert EP. Exploitation and traditional processing techniques of brine Salt in parts of the Benue trough, Nigeria. Int. J. Miner Process. 2004;4(74): 157–167.

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