Quest Journals
Journal of Software Engineering and Simulation
Volume 2 ~ Issue 5 (2014) pp: 01-05
ISSN(Online) :2321-3795 ISSN (Print):2321-3809
www.questjournals.org

Research Paper

Environmental Impact Assessment of Coal Mining Activity in Enugu Metropolis, Enugu State, Nigeria

Awalla, C.O.C
Department of Geology and Mining Faculty of Applied Natural Sciences Enugu state University of Science and technology, Agbani Enugu State, Nigeria Phone no: 08037433314.

Received 08 March, 2014; **A**ccepted 17 May, 2014 © The author(s) 2014. Published with open access at **www.questjournals.org**

ABSTRACT:- It is very necessary to undertake baseline study of the Environmental Impact Assessment (EIA) of the coal mining activity on the future development and management of the natural environment and resources of Enugu metropolis. Geologically, the Enugu coal mine area is underlain by the Enugu Shale (Campanian), Mamu Formation (Lower Maestrichtian) and Ajali Sandstone (Middle Maestrichtian). Of the three formations, Mamu Formation is the most important with respect to coal occurrence and mining. Both Mamu Formation and Ajali Sandstone are affected by Late Cretaceous tectonism leading to fissures like faulting, folding and fracturing of the rock materials. The interconnectivity of these fissures between Mamu Formation and Ajali Sandstone helps to encourage the free flow of water to the surface of the hill cuts along Enugu-ninth mile expressway at all seasons (ie perennial). Coal mining activity exposes the overburden and mine spoils to oxidation. Coal deposits are commonly associated with pyrite and marcasite (FeS_2). This is stable below water table, because when water table lowers, it is oxidized. Oxidation of pyrite produces sulphuric acid which pollutes the water. The p^H values for Onyeama, Okpara, abandoned Iva valley coal mine and Ogbette coal preparatory mine are 2.8, 2.30, 6.10 and 6.30 respectively. The low p^H values and corrosive mine waste water greatly increase leaching actions and total dissolved solids (TDS) content of the water. Augmentation of water supply from coal mines water after treatment of p^H and iron contents with lime and aeration or filtration respectively will mitigate the potential risks of handdug well interference and land subsidence that could arise from over utilization of over-concentrated boreholes network in the area.

KEYWORDS*:-* Coal Mine. Mamu Formation, Enugu Shale, Ajali Sandstone, Oxidation, Pyrite Internnectivity.

I. INTRODUCTION

The most prominent feature at Enugu metropolis is the Udi plateau. The plateau is a cuesta running north-south with a bold east –facing escarpment and gentle dipping slopes. There are many seepages, springs, and streams on the foot of most of the hills and ridges. At the mines, most of the seepages, springs and stream emanate directly from the perennial flood water from the coal mines.

From the oldest to youngest formation at the Enugu coal mines, the area is underlain by the Enugu Shale (Campanian), Mamu Formation (Lower Maestrichtian) and Ajali Sandstone (Middle Maestrichtian) (Fig. 1) Thus, stratigraphically of the three formations, the Ajali Sandstone overlies Mamu formation which in turn overlies Enugu Shale. The Mamu Formation is the most important geological formation with respect to coal formation, occurrence and mining. The Mamu Formation underlies Ajali Sandstone (aquiferous unit), but both are generally affected by late Cretaceous tectonism leading to fauting, folding and fracturing of the rock materials.

Department of Geology and Mining Faculty of Applied Natural Sciences Enugu state
University of Science and technology, Agbani Enugu State, Nigeria Phone no: 08037433314.

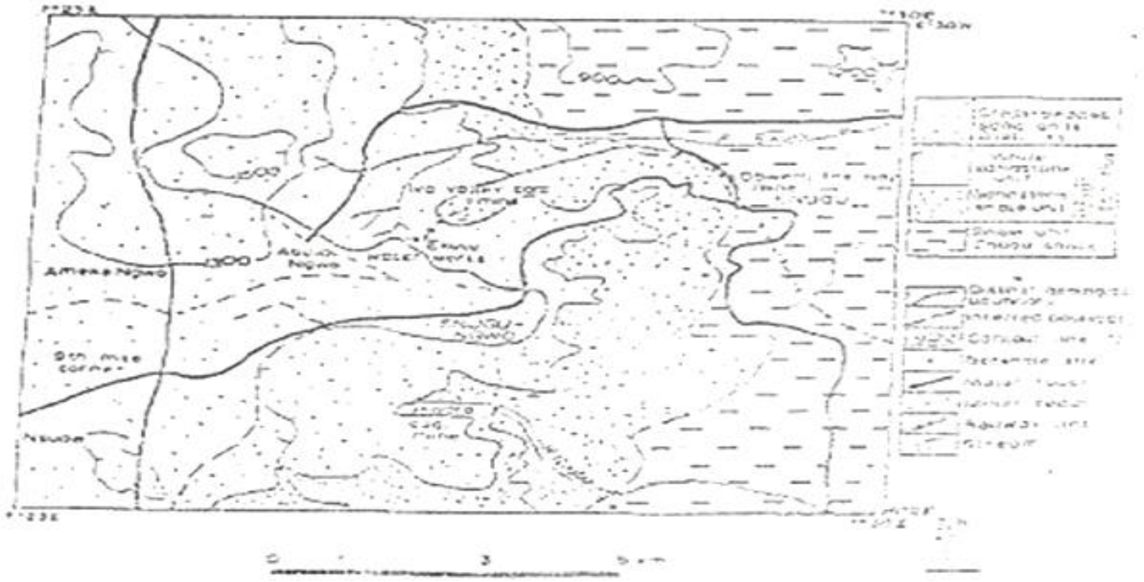

Fig. I: Physiographic and geological map of the area (Ezeigbo and Ezeanyim, 1993)

The faults and fractures that are encountered in the mine tunnels are clearly and easily discernible inside the coal mines and on the outcrops of the Mamu Formation, such as those on the hill-cuts along the Enugu- Ninth Mile expressway. The fractures continue through the Ajali Sandstone to the surface. Hence, this phenomenon encourages the perennial flow of water at almost all the sides of the hill-cuts.

Enugu Shale (which underlies Mamu Formation) was deposited under shallow marine environment. It consists of light grey to dark grey shale, mudstone and intercalations of sandstone and sandy-shale. Mamu Formation was deposited under paralic conditions (Kogbe, 1976). Its lithology is heterogeneous, fine to medium grained sandstone, shale, carbonaceous shale and coal seams. In Enugu, five coal seams occur within the Mamu Formation but the third coal seam with workable thickness of more than 1.5m is (currently) mined. The formation is highly fractured and it is about 395m thick (Ezeigbo and Ezeanyim, 1993). Generally, the bedding is irregular, and truncation of bedding occurs due to slumping, and contemporaneous erosions is common (de Swardt and Casey, 1961).

The general dip of Mamu Formation, which is also the dip of the coal seams is 2^o South West direction (Diala, 1984). Down dip outflow in the unconfined aquifer is intercepted by the Ninth mile borehole field. The ultimate result of groundwater development is the shifting of the regional groundwater divide Westward (Fig. 2), (Uma, 1992).

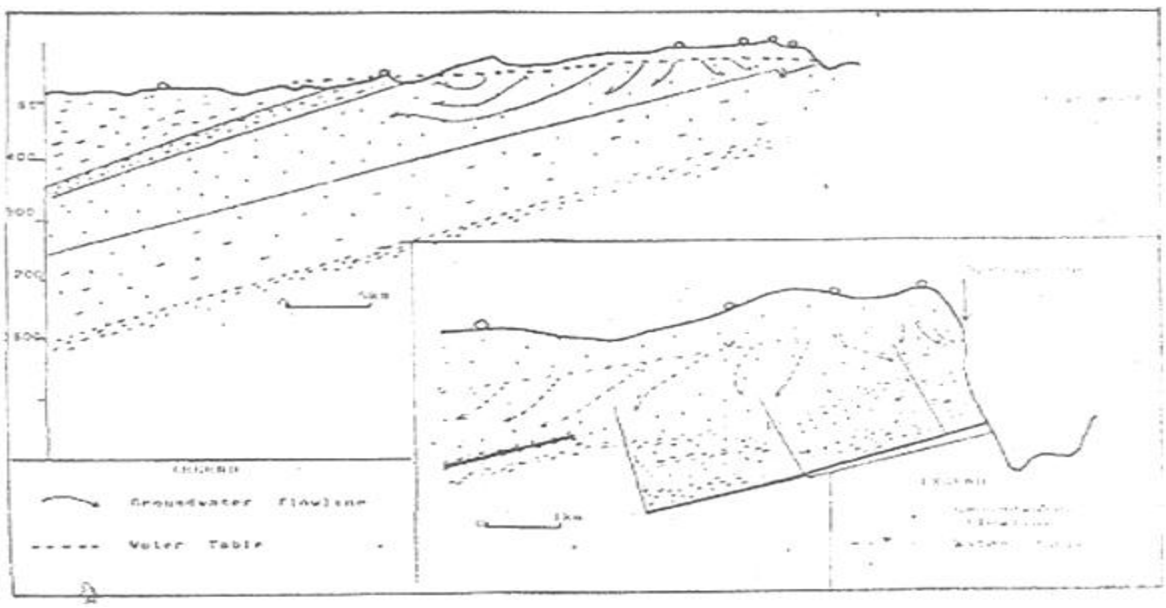

Fig 2: Conceptual models of groundwater flow pattern in the area showing regional trends, whereas inset shows detailed flow patterns in the coal mining area (Uma, 1992)

II. RESULT, DISCUSSION AND QUALITY OF COAL

The coal within the Mamu Formation is bituminous and has high sulphur content. The shale within the Mamu Formation has also large quantities of sulphur stains in addition to high concentration of pyrite (FeS_2) flakes. Pyrite (FeS_2) can be called fool's gold, as the colour is brass yellow with hardness 6 – 6½. It is an important ore of sulfur; and sometimes mined for the associated gold or copper (Dictionary of geological terms, 1976). Pyrite (FeS_2) is the most widespread sulphide mineral. It can be found as an accessory mineral in igneous rocks, in hydrothermal ore veins, contact metamorphic deposits, and anaerobic sediments. Mamu Formation exhibits cyclic sequences with five coal seams.

Sandy horizons (from greater than 5m, but less than 15m thick) within the Mamu Formation constitute the confined aquifers. Stratigraphic logs reveal two to three prominent sandy horizons up to the base of the No. 3 coal seam. These aquiferous horizons are separated by thick intercalations of shale, coal seams and sandstone which form aquitards. The cumulative thickness of sandy beds (aquifers) up to no. 3 coal seam ranged from 12.5m to 70m with an average of 35m. The 35m is the effective thickness of the confined aquifer. The hydraulic properties (T and K) of the confined aquifer occur by direct infiltration from rainfall at the escarpment where sandy units are exposed at the earth surface and by vertical flow from the overlying unconfined aquifer through the connecting fractures.

One of the major problems hindering the supply of potable water to Enugu and environs is the acid mine drainage pollution caused by coal mining activity. The mine water is polluted within the sumps in the floor of the long walls. The sumps act as oxidation chambers where groundwater from the fractures is mixed and subsequently reacted with sulphur-rich solutes released by coal mining activity.

The shales of the Mamu Formation contain pyrite flakes and sulphur stains. The mine water contain iron and magnesium as major cations, but the major anion is sulphate. Thus, the water-type is mainly magnesium-sulphate type. The water that is not directly influenced by mining activity has bicarbonate as major anion (Tab.1). The acid mine drainage water in the Enugu coal mining area contains high iron, high magnesium, high sulphate, high total dissolved solids (TDS) and low p^H. The mine water is acidic and thus corrodes mining and plumb equipment.

Table 1: Summary of Hydrochemistry of Enugu Coal Mines. (Ezeigbo and Ezeanyim 1993)

Constituent	Range (mg/1)		Average concentration	No of samples
	Max	Min.		
Ca^{2+}	24.05	1.60	6.04	32
Mg^{2+}	158.08	6.08	31.94	32
$Na^+ + K^+$	20.88	3.52	7.13	30
SO^{2-}_4	420.00	14.80	136.39	32
SO^{2-}_3	0.60	2.20	1.38	19
CT^-	17.37	1.99	4.86	32
$HCO_3 + CO^{2+}_3$	80.50	3.40	31.25	32
Free O_2	8.00	1.50	4.00	50
Free CO_2	230.00	4.00	51.68	30
Total Fe^{2+}	25.76	8.40	8.94	32
TDS	715.00	8.50	195.15	80

These ions are highly toxic to man, plants and aquatic life, and thus render the water unfit for human drinking and agriculture; and unusable for other domestic and industrial purposes. The acidity of the streams does not support plants and animal life living in the water and thus the re-establishment of this life will require several months (Hert, 1985). Due to high acidity of the soil nutrients, natural vegetation is scarce or absent where coal (mine) wastes deposit exist. Therefore, plant growth failures are usually associated with extreme acidity which characterised most coal (mine) wastes and which must be moderated before any pant nutrient balances or seeding method are attempted (Smith and Sobek, 1978).

Faults reactivation is most prevalent due to high fluid withdrawal from the highly faulted Mamu Formation. Fault reactivation is a potential hazard.

Faults reactivation is most prevalent due to high fluid withdrawal from the highly faulted Mamu Formation. Faults reactivation is a potential hazard, because of the highly fractured and faulted nature of the formations of the Enugu coal mine environment. Freeze and Cherry (1979) reported cases of subsidence initiated by the withdrawal of fluids from aquifers. The influences of both effective and fluid pressures encourage the occurrence of subsidence. Hence, subsidence is very prevalent along Enugu-ninth mile expressway. Effective pressure is reduced by fluid pressure, but dewatering reduce fluid pressure which causes effective pressure to increase. The increase in effective pressure is accompanied by reduction in void ratio or settlement. If the pore water pressure is reduced significantly, effective pressure will be appreciable and the resulting decrease in void ratio will cause subsidence.

The burning or incineration of mine spoils produce noxious gases like carbon dioxide (CO_2), hydrogen sulphide (H_2S), cabon monoxide (CO), methane (CH_4) and oxides of sulphur and nitrogen. Thus, mine spoil waste burning which is common in Enugu coal mines, especially during dry season is an oxidative reaction. However, noxious gases can also be produced from burning of mine materials like fire extinguishers, hose conduits, conveyor belts and hydraulic fluids.

Other sources of air pollution are dust, and air emissions from blasting, excavation and operation of coal preparatory mines. The air emissions from blasting and excavation cause miners disease called pneumosoneosis, while coal preparatory plants produce important noxious gaseous pollutants like carbon dioxide, carbon monoxide, sulphur dioxide; and oxides of nitrogen and sulphur.

The design and preparation of the disposal site for mine spoil wastes (ie tailings) should be carefully carried out to reduce the amount of air and water available to the spoils to the lowest minimum by compaction. This highly compacted clayed soil helps to mitigate oxidation reactions. Detailed dewatering scheme limits flooding of the mines. Larger diameter pipes may be laid to drain the enormous volume of mine water. The drainage pumps at Onyeama mine discharge about 19,636 m^3/day and would need emergency services to cope with sudden flood of water into the tunnels when major fractures are intercepted. The quantiy of mine water inflow from surface sources or rapid infiltration of rain water to underground working will depend on transimisivity (T) of the formations, dimensions of the fractures, hydraulic head, thickness of the protection layers etc. The largest water inflows correspond with the area of higher rainfall (Raphael and David, 1993)

The agricultural land devegetation due to mine soil wastes can be reduced by blending alkaline overburden materials and agricultural limestone with acidic spoil to neutralize the acid before seeding the area. Fault reactivation can be reduced by the control of groundwater withdrawal, but can be difficult as long as mining activity continues, unless highly fractured and faulted zones are selected for mining. Air pollution can be reduced by avoiding the burning of mine spoil wastes. When exhaust fumes are released into the air, it is very difficult to control the amount of polluted air that is released into the atmosphere.

In order to develop and improve mining activity, the underground water requires lowering of the piezometric levels and depressurization of the underlying aquifers. Mining activity includes metalliferous mining, coal mining, salt mining, industrial and ornamental rocks mining, quarrying, sand and gravels extraction. Most often, the aquifer is the deposit itself, while in others it is more or less isolated by protective layers, which can be above or below the aquifers and can accumulate large reserves of water or receive resource by direct infiltration or can be in contact with the surface water. In large aquifer system, it is necessary to carry over-exploitation of the aquifer systems and extraction of large volumes of water with different rate of flow from one mine to another.

Generally, the development of surface and underground mines workings below the phreatic level changes the hydraulic gradient, and thus affects the surface water and groundwater flow configurations and regimes. Flow of water can be induced towards the mining excavation and thus requires pumping large quantity of water that creates extensive and prolonged cone of depression. Therefore, hydrogeological, environmental and economic effects require an appropriate water management strategy in order to reduce socio-economic impacts of mine dewatering.

The mine water management involves the avoidance of high risk of inrush which invariably attracts high cost that can make the mining venture economically unviable. Thus, mine water management has difficulties derived from the physical environment, mining activity, technical, social-economic and political factors. Mine water drainage can modify the water balance in the region.

To compensate cost and to met demand and supply of water, the pumped mine water can be used for different purposes like non-conventional hydrogeological resources. It can be integrated into the surface runoff. For example, mine water drained from the Enugu coal mines was used for water supply to the surrounding towns and villages as major source of water supply, as well as for land irrigation and industrial use in the mines. The mine water management, when adequately implemented can be used artificially to recharge Ajali aquifer, especially in areas without constant yield. The mine water in the Onyeama, Okpara, and Ogbette coal preparatory mine (Tab.2) can be partly used in fish-hatchery, especially if the people are properly informed and educated on the need and how to implement the whole fishery programmes.

Table 2: Hydrochemical data of Enugu Coal Mine groundwater (Ezeigbo and Ezeanyim, 1993)

Geochemical parameters	Onyeama mine	Okpara mine	Iva valley mine	Ogbette coal preparatory mine
P^H	2.80	2.30	6.10	6.30
Colour (Platinum, Cobalt	5.00	10.00	20.00	6.30
Electrical conductivity (homs) u/cms	700.00	1550.00	110.00	800.00
Total hardness (mg/I	100.00	100.00	80.00	-
Silica as $SiO_{2\ (mg/I)}$	30.00	30.00	7.50	12.50
Nitrate (mg/I)	1.20	1.11	0.13	1.02
Total iron (mg/I)	8.40	25.76	1.70	6.40
Sulphide (mg/I)	1.40	-	1.80	-
Sulphate (mg/I)	310.00	420.00	58.00	174.00
Magnesium (mg/I)	185.08	85.12	12.16	111.87
Sodium (mg/I)	6.95	10.33	4.40	-
Potassium	9.46	2.19	2.35	-
Calcium (mg/I)	4.00	6.41	4.01	3.21
Chloride (mg/I)	10.42	1.99	-	8.93
Phenolp acidity	124.00	320.00	10.00	10.00
Total Alkalinity	20.00	16.00	80.00190.00	90.00
Total Dissolved Solids	330.00	785.00	65.00	515.00
Free Carbondioxide	230.00	38.00	8.00	68.00
Bicarbonate	16.00	9.60	65.00	80.50

An abandoned mine can be used as a large water reservoir that can be integrated into water resources management. For example; in India, abandoned mines are used as water reservoir for water supply and cooling of thermal plants, especially during the Monsoon season, when surface water flow is extremely turbid (Banerjee and Shylienger, 1978). However, mine water can require pre- treatment when it must be used for explosives; due to the presence of iron and ammonia, and other heavy metals.

III. CONCLUSION

The environmental impact assessment of coal mining activity in Enugu metropolis and environs is very important and thus must be carried out at regular intervals. Hence, the unavoidable environmental problems are enumerated. Besides the rapid remarkable growth in population, industrialization, agricultural activity, mining activity, and employment opportunity in Enugu metropolis and environs, the environmental problem include water contamination, air pollution, faults reaction and devegetation. Air pollution, which is the least problem, endangers the health of mine workers and people within the vicinity of the mine areas.

The effects of the acid mine water drainage on vegetation can be controlled by proper disposal of coal spoil wastes and acid mine water, while revegetation can be effected by seeding after blending alkaline overburden materials and agricultural limestone with acid spoil to cause in-place neutralization of the acid.

REFERENCES

[1]. Banerjee, S.P and Shylienger, S.P. 1978. Mine drainage problems in India Coalfields with special reference to the problems in Jharia Coalfield. SIAMOS, 781: 2744 Granada.
[2]. De Swardt, A.M.J. and Casey O.P. 196-. The coal resources of Nigeria: Geol. Surv. Nig.Bull. No. 28 Diala, H.N. 1984. A review of some of the future problems and possible solutions
[3]. Facing the Nigerian coal Industry. Paper presented at 20th Annual Conf. Nig. Mining and Geosc. Society, Nsukka.
[4]. Dictionary of Geological Terms, 1976. Anchor Books Edition, U.S.A. 472 pp.
[5]. Ezeigbo, H.I. 1988. Geological and Hydro geological influences on the Nigeria Environment. Water Resources (NAH), vol. 1, No 1, P.37-43.
[6]. Ezeigbo, H.I. and Ezeanyim, B.N. 1993. Environmental pollution from coal mining activities in the Enugu area, Anambra State, Nigeria. Mine water and the Environment, Vol. 12, p. 53-62.
[7]. Freeze, R.A. and Cherry, J.A.1979. Groundwater. Prentice Hall Inc. Englewood, California.
[8]. Hert, O.H. 1985. Practical control measures to reduce acid mine drainage. Pro. 13th
[9]. Industrial Waste Conf. Engineering Bull. Purdue University, Extension Dept. Lafayette, Indiana, P. 189-193.
[10]. Kogbe, C.A. 1976. Paleogeographic History of Nigeria from the Albian Time. In Kogbe C.A.(ed), Geology of Nigeria. Elizabethan Publ.Co, Surulere, Lagos, P. 237-252.
[11]. Raphel, F.R. and David, F.L.1993. Mine water, Drainage mine water and the Environment. Vol. 12,p. 107-130.
[12]. Smith, R.M. and Sobek, A.A. 1978. Physical and chemical properties of overburdens spoil wastes, and new soils. In Reclamation of drastically disturbed lands. Schaller, F.W. and Sutton, P. (ed), ASA, CSSA, SSSA, Madison, Wisconsin. P.149-172.
[13]. Uma, K.O. 1992. Origin of Acid mine Drainage in Enugu Environ. Geol. Water sci, vol. 20.No 3, p. 1818-194.