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Environmental Impact Assessment of Steam Injection Mining Method of Agbabu Bitumen Deposit

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Abstract: An environmental impact of steam injection mining method applicable to Agbabu bitumen deposit was studied. Steam injection tests were carried out on the deposit. The environmental pollutants evolved from the tests were evaluated with respect to their source, impact, monitoring or detection and control. The results of the analysis indicated that steam injection method would control the contaminated water in the mining of Agbabu bitumen deposit.

Key words: Bitumen deposit, steam injection, environmental impact, gas

INTRODUCTION

According to Akande and Akinbinu (2005) bitumen as one of the mineral resources is a general term for group of mineral composed of mixture of hydrocarbon that are in carbon disulphide. The Agbabu bitumen deposit is located about 10 km south of Ore, Ondo State, soluble Nigeria and covers an area some 55 km long and averages 4.5 km wide as shown in Fig. 1. The bitumen deposit occur between longitude 4^0 30^1-50 00^1 E and latitude 6^0 37^1-60 30^1 N. According to Adegoke (1980) detailed investigation carried out by the Geological Consultancy Unit of Obafemi Awolowo University, Ile-Ife in the area between 1979 and 1980 involving the drilling of

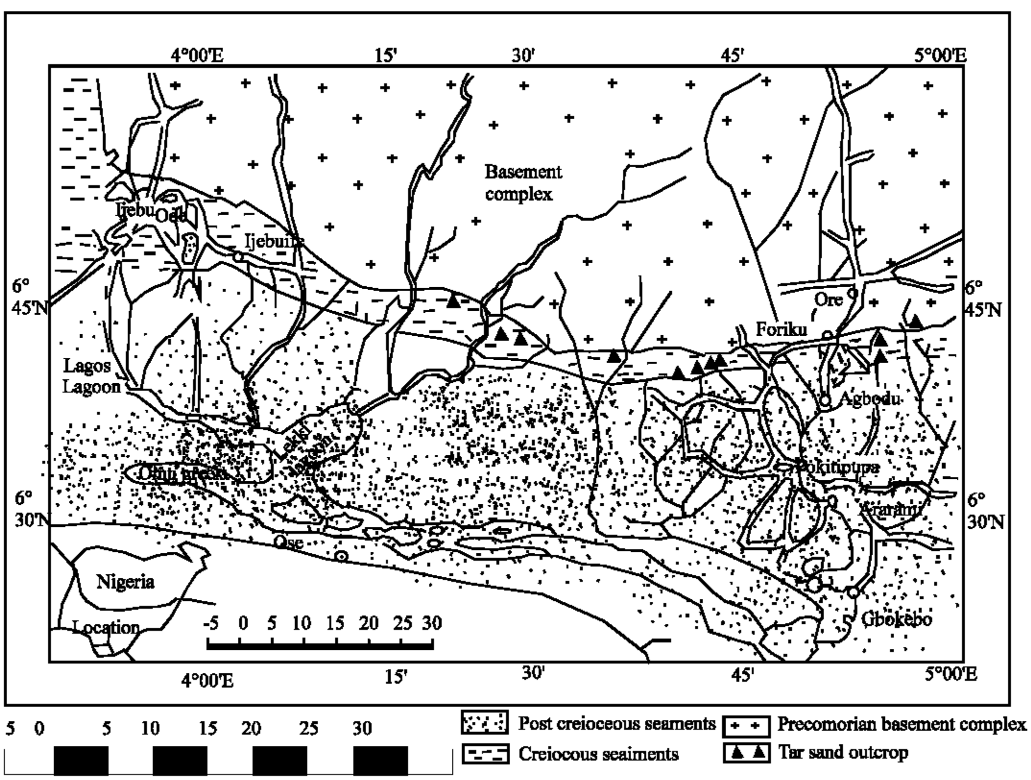

Fig 1: Location map of the study area

40 boreholes (including BH 25) confirmed the presence of 1.8×10^9 million tonnes of bitumen in place. The bitumen area is in the rain belt of Nigeria where the mean monthly precipitation is up to 142.8 mm. Its known rainfall is up to an average of 140 days in a year of 365 days.

The recovery of bitumen from areas where the overburden depth is greater than 100 m require the use of *in situ* technologies such as steam injection (Hicks and Probstein, 1982). The steam injection process is characterized by injection of steam into the reservoir in order to modify the properties of bitumen and ensure its mobility for production.

The need to utilize all the available workable bitumen deposits thoroughly and efficiently results in adverse environmental impacts on land, air and frequently on human health and biological resources (Osemenam, 1991). This calls for rational methodologies to elucidate the nature and scale of impacts from the proposed development of Agbabu bitumen deposit using the steam injection to specify the available ameliorative measures and their technical and economic consequences and the means to clarify the likely consequences of any decision under consideration (Burkill *et al*., 1984).

Hence, it becomes necessary to study each of the environmental pollutants separately to identify its source, impact, detection or monitoring and control in order to determine the method that is more environmental and project safety conscious.

MATERIALS AND METHODS

Agbabu borehole number 25 was prepared for trial cyclic steam injection test. Casing of 84 m length and 0.14 m diameter was installed. Two perforations of 2 m each were made in the casing at length 70-72 and 76-78 m in the lower bituminous horizons (Fig. 2). A high pressure saturated steam was injected into the reservoir through the annulus between tubing and casing. The well was supplied by an 80% air quality movable type steam generator with maximum capacity of 8 ton h^{-1}. The steam was shut off and well sealed in for a period of 10 h. The heat generated penetrated a sufficiently broad zone around the well. The well was then opened and a mixture of water and bitumen flow into the well and was withdrawn to the surface by pumping (Fig. 2). The well was shut in and plugged 16 h later. The produced bitumen and water were separated in the laboratory. The produced water was analyzed for possible contaminants. Wastes from the exhaust of boilers of the steam generator were also analyzed for nitrogen dioxide, sulphur dioxide and other pollutants.

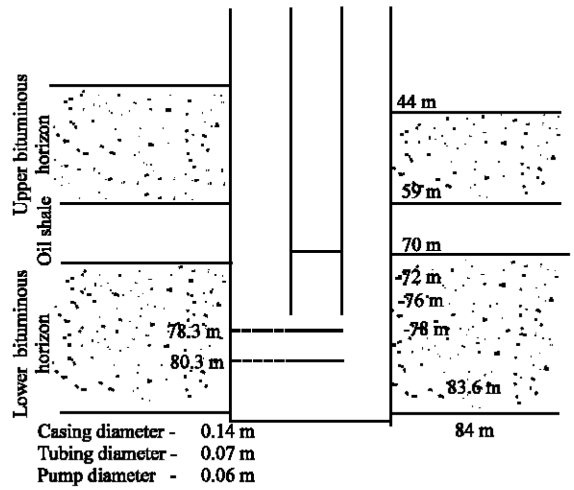

Fig. 2: Agbabu BH 25

RESULTS AND DISCUSSION

0.639 tons of steam was injected during the steam injection test. 0.0755 m^3 and 0.271 m^3 of bitumen and water respectively were produced. This production resulted in water-oil ratio of 3.6. Analysis of the exhaust fumes of the steam generator shows that sulplur dioxide is produced from crude-oil fuel combustion in the steam generator, nitrogen dioxide is produced at the exhaust of boilers of the steam generator, hydrogen sulphide gas is produced from strata gas and strata water and the produced water is found to contain contaminants classified as organic, inorganic, sediments and thermal pollutants. Table 1 shows the result of average gas analysis and Fig. 3 presents the graph of bitumen and produced water with respect to time. By analysis, exhaust gases comprising 90% Nitrogen, carbon dioxide and steam were produced at the combustion tube discharge. The produced water was found to contain contaminants classified as organic, inorganic and sediments.

Sulphur dioxide: The sulphur dioxide produced during steam injection process affect human respiratory track, causing irritation and increasing air way resistance which consequently may lead to death from bronchitis, pneumonia and allied troubles. It has adverse effect on vegetation. It contributes to acid rains and cause extensive damage to buildings and sculptural materials. The magnitude of sulphur dioxide generated is determined using modified West-Gaeke spectrophotometric method and the concentration of the gas must not exceed 0.50 ppm. The sulphur dioxide is controlled either by removal of sulphur dioxide from flue gas or removal of sulphur from the fuel before burning or the use of low-sulphur fuel.

Table 1: Results of average stabilized period gas analysis

Component	Volume %
Carbon dioxide	14.47
Oxygen	0.14
Nitrogen	80.79
Carbon monoxide	3.5
Argon	1.10

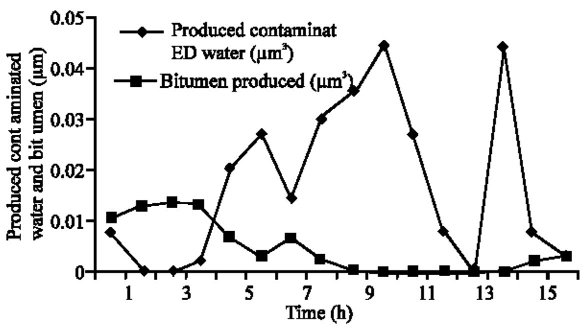

Fig. 3: The graph of bitumen and produced water

Nitrogen dioxide: The nitrogen dioxide produced causes respiratory problem ranging from coughing to aggravation of asthma. It contributes to acid rain causing direct damage to structures and plants and changing the natural acid/base balance of rivers and lakes. The magnitude of the Nitrogen dioxide is determined using the standard chemiluminescence's method. Its tolerance must not exceed 0.25 ppm. The nitrogen dioxide is controlled through the use of low-nitrogen oxides burners on steam generator or by nitrogen oxides removal from stack gas using chemical sorption process.

Hydrogen sulphide gas: The hydrogen sulphide gas produced during steam injection process constitute toxic health hazard to employees and occasionally lead to death. It contributes to acid rain, cause tarnishing in metals, paint peeling, soil acidity and damage to aquatic life. The magnitude of hydrogen sulphide gas produced is determined by UV molecular adsorption method or by detector tube and the concentration of the gas is kept within 10ppm thresh hold limit value. The impact is controlled either by prevention of exposure of employees or by removal of the gas using iron sponge process or stret ford process.

Produced water contaminants: Anaerobic conditions created by rotten algae from organic contaminants present health hazard to living organism. Bitumen spill have direct toxic effects on marine organisms including sublethal effects such as reduced growth of marine plants, physiological changes in molluscs, reduce breeding success and community changes. Bitumen slick if ingested produce toxic effects on marine and fresh water organisms and also pose aesthetic problem along shorelines. The inorganic pollutants kill living organism in the water bodies. The acids and alkalis discharge are fatal to fish and destroy aquatic life. Sediments in the produced water increase turbidity and reduce the amount of sunlight available to green water plants. The sediments cause thickening of fish quills and lead to asphyxiation of the fish and also interfere with spawning sites and decrease the amount of food available for fish. Thermal pollution of the bodies has deleterious consequences for aquatic inhabitants as it increases the toxicity of some chemical pollutants present in the fresh water.

The minimum acceptable receiving water quality is monitored by routine determination of the corresponding water quality parameter to each of the produced water contaminants. The produced water contaminants impacts are controlled by incorporation of water treatment plant with water recycling facilities into the steam injection. However, the steam injection process promote thermal pollution since the cooling water abstracted for the steam generator is not totally relieved of its heat by the cooling towers before discharge into water bodies.

Water requirements/groundwater impact: The water requirements for the steam injection come from the water bodies around and ground water. The water-oil ratio value of 3.6 implies that for every barrel of bitumen produced, 3.6 barrel of water is release as waste. This result in handling large volumes of water throughout the protect life. According to Mainland (1984) bottom water influx and the existence of gas or vapour filled space in the reservoir when reservoir temperature is raised also contributes to the high level of waste generated. To reduce the impact on water bodies and ground water, the water requirements for steam generation should come from non-potable saline water source existing near the border between Ondo and Delta State of Nigeria and recycled produced water which is separated from the produced bitumen. However, there is need to guard against leakages during its transportation in order to prevent pollution.

Wastewater generated by this method enters aquifer fissures at specific points or through general seepage from overlying soils and through careless discharge of pollutants directly into groundwater via boreholes or wells. The higher the amount of waste generated at the surface, the greater the risk of groundwater pollution. Nitrates, pathogens, toxic organic compounds and heavy metals, which are dangerous to human health, are discharge into the groundwater. The groundwater impact controlled is by discouraging deep well water disposal method for excess produced water and by treating, the produced water adequately before its disposal with closely monitoring by relevant governmental health agencies.

CONCLUSION

The environmental impacts of steam injection methods of mining the Agbabu bitumen deposit have been duly analyzed. Evaluation has shown that the steam injection method of mining the Agbabu bitumen deposit would be good with respect to environmental consideration as the method corroborate the following environmental protection measures:

- Minimization of groundwater impacts by use of minor volumes of fresh groundwater for domestic uses at central plant site.
- Minimization of air emissions.
- Minimization of water pollution through the generation of smaller possible quantity of waste.
- Minimization of water requirements.

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The environmental impacts of large-scale mining projects involving. these metal ores are the subject of this Guidebook. The Guidebook does not discuss the mining of ores that are extracted using strip mining methods, including aluminum (bauxite), phosphate, and uranium. The Guidebook also does not discuss mining involving extraction of coal or aggregates, such as sand, gravel, and limestone. 1.1 phases of a mining project. There are different phases of a mining project, beginning with mineral ore exploration and ending with the post-closure period.Â The first way in which proposed mining projects differ is the proposed method of moving or excavating the overburden. What follows are brief descriptions of the most common methods. 1.1.3.1 Open-pit mining. Changes in the practice of Environmental Impact Assessment (EIA) and advances in information technology have greatly expanded the range of tools available to the EIA practitioner. For example, map overlay methods, originally pioneered by McHarg (1971), have evolved into sophisticated Geographic Information Systems (GIS).Â The objective is to select an array of methods that collectively will meet assessment needs. Of the variety of techniques and methods available, only a few are applicable to developing countries. The latter are described here. Mining and heavy metal pollution: Assessment of aquatic environments in Tarkwa (Ghana) using multivariate statistical analysis. Journal of Environmental Statistics, 1(4), 1â€“13. Boening, D. W. (2000).Â Evaluation of the Status of heavy metal pollution of soil and plant (Chromolaena odorata) of Agbabu bitumen deposit area, Nigeria. American-Eurasian Journal of Scientific Research, 5(4), 241â€“248. FAO/WHO.