VARIATION IN WELL-HEAD GAMMA RADIATION LEVELS AT THE NIGERIAN PETROLEUM DEVELOPMENT COMPANY OIL FIELD, OLOGBO, EDO STATE, NIGERIA

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Abstract

Gamma radiation levels at the well heads in the Nigerian Petroleum Development Company Oil Field located at Ologbo in Edo State of Nigeria have been investigated using a Digilert 50 Radiation Geiger Muller Counter. The sites investigated include one heavy crude oil producing well (A), one light crude producing well (B) and a shut-down gas well. Diurnal measurements were made in the morning and afternoon periods on selected days during the dry and wet seasons between 2002 and 2004. The mean dose rate varies from one well head to the other. It is $(17.22 \pm 0.36) \times 10^{-12}$ μ Sv/hr at the heavy crude well head and much lower $(14.30 \pm 0.46) \times 10^{-12}$ μSv/hr for the light crude, while the shut down gas well gave $(17.26 \pm 0.46) \times 10^{-12}$ μSv/hr. It is found that the difference between the morning and afternoon radiation levels is within 68% significance level. The mean exposure rate for the dry season however seems to be consistently lower than that of the wet season. It was generally observed that the level of radiation around the well heads is less than 20×10^{-12} μSv/hr, which is in agreement with the International Atomic Energy Agency's standard on ionizing radiation background level.

***Key words**: Radiation, crude oil, radionuclide, contaminant, exposure*

Introduction

Petroleum is a naturally occurring liquid mineral deposited beneath the earth's surface. Its occurrence is sometimes accompanied with the existence of natural gas. Both the oil and the gas are generally contaminated with the radionuclides in the earth's crust. There are two broad based classes of natural radionuclide in the environment of the petroleum well-head, the cosmogenic and primordial nuclides. The cosmogenic radio nuclides include ^{3}H, ^{14}C, ^{22}Na and ^{24}Na which are mainly produced through the interaction of cosmic rays with the target atoms in the atmosphere. The main primordial radio nuclides are ^{40}K, ^{87}Rb and also ^{238}U and ^{232}Th together with their decay series.

All these provide the source of radiations such as α, β and γ often found in the petroleum matrix.

Contamination with radium is also known to be common in oil producing facilities, whereas contamination with radon and radon decay products is more prevalent in natural gas production also contributing to the production of α, β and γ radiations (Smith, 1987 and Gray, 1993). Radon concentration at the well has indeed been identified (U.N Scientific Report, 1977) to vary from one country to another as shown in Table 1. Also dissolved in the petroleum matrix are various cations such as barium, calcium and sodium and anions such as sulphate, chloride and bicarbonate. The levels of the cations and anions indeed vary over a wide range and their reactions with atoms also result in the production of α, β and γ radiations due to energy exchange.

Naturally occurring radioactive contamination in the environment can be detected by using a Geiger Muller Counter. Because the gamma radiations emitted by the various reactions are more penetrating and energetic than the α and β particles, the prevalence of γ radiation in the environment can be easily monitored.

The aim of this study is to investigate the gamma radiation levels in the environment of the oil wells in the Nigerian Petroleum Development Company

Oil field at Ologbo in Benin City, Edo State, Nigeria. It is believed that monitoring of petroleum contamination at the well head may help to unveil the possible health problems that may be posed to personnel as a result of hazardous radioactive concentrations.

Experimental method

Monitoring of the environmental radiation levels at the well-heads in the Nigerian Petroleum Development Company Oil Field at Ologbo in Edo State, Nigeria was carried out with a Digilert 50 nuclear radiation monitor [S.E. International, Inc., Summertown, U.S.A.] which contains a Geiger Muller tube capable of detecting , α , β and x-rays within the temperature range from -10 to 50 ° C. The sites investigated include one heavy crude oil producing well (A), one light crude oil producing well (B) and a shut-down gas well.

The monitor was placed at about 2.0m away from the well head and 1.0m above the ground. The instantaneous total count was recorded every fifteen minutes, while the cumulative count was monitored over a period of about 5 hours between 7 am and 12 noon for the morning session and between 1 and 6 pm for the afternoon session each day. Measurements were repeated for 6 selected days in each of the dry and wet seasons from 2002 to 2004. From the data, the mean count rate and the variation of count rate with time at each site were obtained.

Location of Wells	Radon Concentration p(Ci/L)
GERMANY	1 – 10
THE NETHERLANDS	1 – 45
NIGERIA	1 – 3
BRITAIN (North Sea)	2 – 4
USA	
(Colorado, New Mexico	1 – 100
(Kansas, Oklahoma	1 – 1,450
CANADA	
(Ontario)	4 – 800
(British Columbia)	390 - 540

Table 1: Radon Concentration in Natural Gas at the Well Heads (U.N. Scientific Committee Report on the Effects of Atomic Radiation: Sources and effects of Ionizing Radiation, N.Y, 1977

Results and discussion

The mean radiation dose rates obtained from the well-heads in the morning sessions were generally found to agree with those of the afternoons as they were within two standard deviations apart or 68% significance level. The average diurnal radiation level of 17.26 0.36 Sv/hr recorded at the well head A (Heavy crude) was found to agree with that of17.36±0.46μSv/hr obtained from the gas well head, while the two were found to be significantly higher than the radiation level of 14.30 0.14 Sv/hr recorded at the oil well head B (Light crude) [Table 2]. The high radiation level recorded at the heavy crude oil well head A and the gas well head indicates the higher level of radon in the environment of the well heads.

t was also observed generally that the average dose rates obtained in the wet season were consistently higher than those of the dry season [Table 3]. This may also be due to higher density of water vapour containing dissolved radon in the environment of the well heads during the raining season (Forks,1987).

Table 2: Diurnal radiation levels at the well heads in NPDC oil field at Ologbo, Edo State, Nigeria

Well Head	Dose rate $x10^{-2}$ μSv / hr		
	Morning 7.00am – 12.00 noon	Afternoon 1.00pm – 6.00pm	Average
Well A (Heavy Crude)	16.94 ± 0.08	17.51 ± 0.18	17.26 ± 0.36
Well B (Light Crude)	14.34 ± 0.16	14.26 ± 0.03	14.30 ± 0.14
Shut – down Gas well	17.45 ± 0.16	17.07 ± 0.50	17.36 ± 0.46

Radon 222 is a highly mobile naturally occurring radioactive gas produced by the radioactive decay of radium-226. From the radiological point of view, the only important isotope of radium is radium-226 which is known to have an average concentration of about 10^{-12} g/g (or 40 Bq/Kg) in the earth's crust (Gray, 1993). Contamination with radium has been recognized to be common in oil producing facilities, while contamination with radon and radon decay products are more prevalent in natural gas production and processing facilities (Sheppaard,1944). This is in line with the high radiation level obtained at the natural gas well head in our study.

Because radium is widely distributed in the earth's crust, radon is also widely distributed and once formed, radon is free to either dissolve in the crude oil matrix or migrate as a gas (Sheppard,1944; Gray,1993). Thus, migrating through the rocks and soil, radon is produced with the oil and natural gas at the well head. Also if present in sufficiently high concentration, radon can be distributed externally to storage vessels, pumps and other facilities. Figure 1 gives the radioactive decay paths of radium-226. This figure shows that radium produces gamma radiation in its decay path. The radiation was detected with a Geiger Muller Counter.

In Table 1, the radon concentration of natural gas at the oil well head in Nigeria is compared to those of some other countries of the world such as USA, Great Britain and Canada (UN Scientific Report,1977). It may be seen that the well head concentration of radon in Nigeria is extremely small compared to those elsewhere and particularly the USA and Canada where radon concentration constitutes enormous environmental problems requiring Government legislation for the control of naturally occurring radiation material (NORM) contamination in their petroleum industries.

Gamma rays are known to be highly penetrating and are part products of the radioactive materials containing radon which may be ingested or inhaled into the human body e.g. during repair and maintenance of facilities. If inhaled, the dust particles and aerosols containing radon may attach themselves to the lungs where gamma rays emitted in the decay may pose increased risk of lung cancer to personnel (Wittmore and McMillan,1983; Svec et al ,1976; Summerlin and Prichard, 1985; Harley and Pasternack, 1981)

In conclusion, it is pertinent to stress that the radiation levels recorded in the oil and gas well-head environment at the NPDC oil field in Ologbo, Edo State are well below the standard background radiation level of 20 ì Sv/hr recommended by the International Atomic Energy Agency (IAEA,1994). However, since radiation exposure in the environment may constitute serious hazard, especially to personnel, contaminated facilities and waste material problems must therefore be adequately recognized and addressed in the oil and gas industries..

Acknowledgment

We thank the Management of NPDC for granting us permission to have access to relevant facilities in their oil field at Ologbo, Edo State, Nigeria.

Table 3: Seasonal variation in radiation levels at the well heads in NPDC oil field at Ologbo, Edo State, Nigeria

Well Head	Mean Dose Rate $x10^{-2}$ µSv / hr			
	Season	Morning	Afternoon	Average
Well A (Heavy Crude)	Wet	17.00 ± 0.23	17.69 ± 0.42	17.35 ± 0.31
	Dry	16.88 ± 0.31	17.32 ± 0.31	17.10 ± 0.31
Well B (Light Crude)	Wet	14.50 ± 0.69	14.57 ± 0.50	14.53 ± 0.55
	Dry	14.18 ± 0.28	14.28 ± 0.33	14.23 ± 0.25
Shut down Gas well	Wet	17.57 ± 0.50	17.27 ± 0.28	17.42 ± 0.41
	Dry	17.63 ± 0.48	16.57 ± 0.28	17.10 ± 0.42

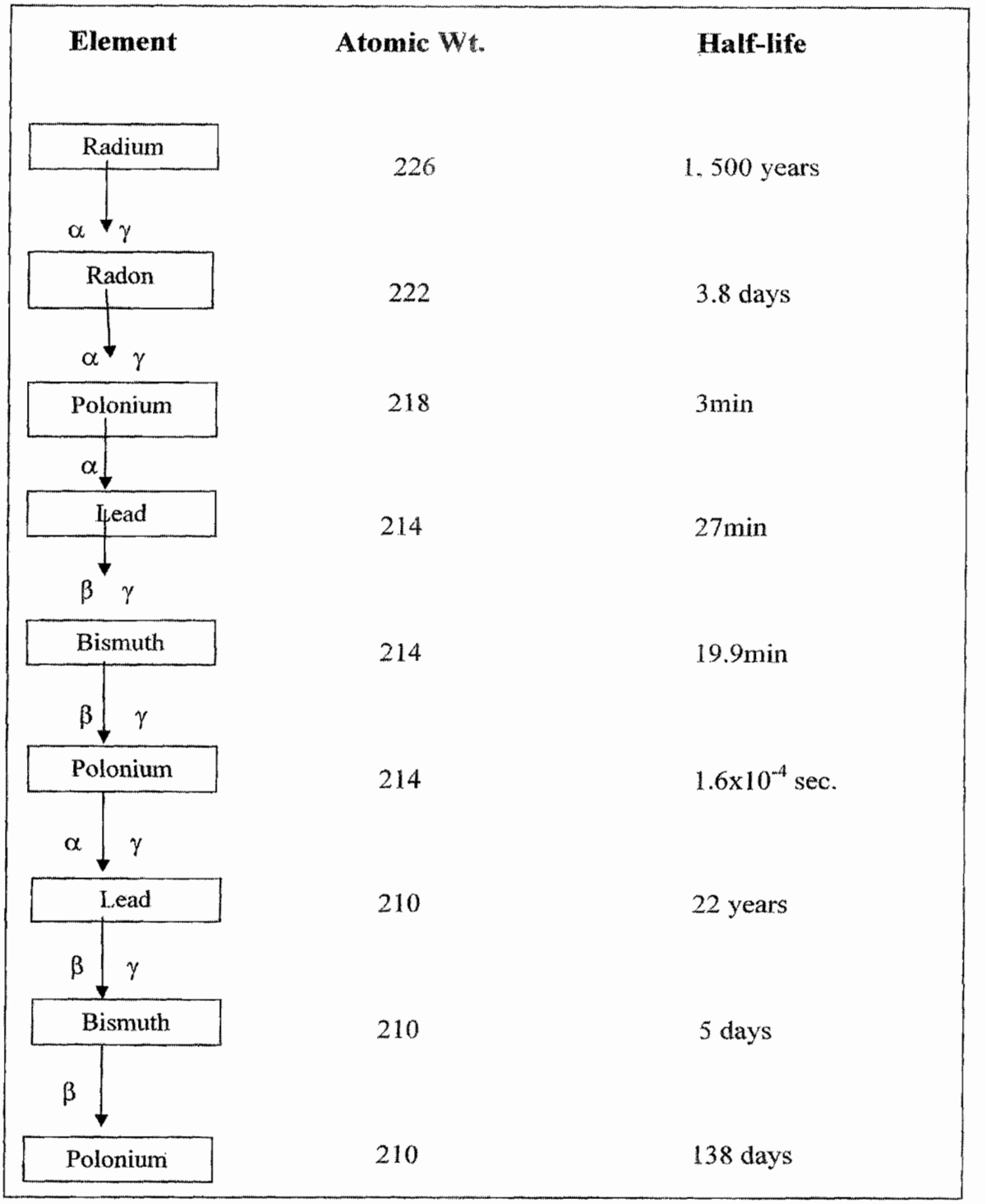

Fig 1: **Decay of radium-226 and its daughters**

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