ANALYSIS AND MEASUREMENT OF OCCUPATIONAL EXPOSURE TO NATURALLY OCCURRING RADIOACTIVE MATERIALS

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ABSTRACT

One of the most important topics in resent years in the field of radiation protection is the naturally occurring radioactive materials (NORM) and technologically enhanced naturally occurring radioactive materials (TE-NORM). Both International Atomic Energy Agency and European Commission in general and oil producing countries are taking active part in it. Recently two impartial documents were issued by the IAEA, namely (Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological options for Mitigation) and (Application of the concepts of exclusion, exemption and clearance) in 2004.

NORM comprises radionuclides associated with the ^{238}U and ^{232}Th decay chains as well as ^{40}K. These radionuclides are very long lived and have some progenies that are long lived, such as ^{226}Ra, in oil industry.

Ceramic floor or wall tiles, commonly used in domestic decoration such as sitting rooms, bath rooms and kitchen, get their sanitary white appearance and guard against corrosion from zircon sand ($ZrSiO_4$) added to the glaze as an emulsifier. Zircon contains some natural radionuclides whose industrial exposure should be regarded as occupational.

In the present work attention was referred to (Analysis and Measurement of occupational Exposure to Naturally Occurring Radioactive Materials) which are produced at several sites in Egypt.

U-238 and its series, and Th-232 and its series as well as K-40 are the most important radionuclides among TE-NORM. Different techniques such as (high-purity germanium HPGe, CR-39 track detectors, survey meters, thermoluminenscence TLD)

dosimeters and theoretical approach were used for activity and dose estimation.

Part I**: Petroleum Samples**

1- Elemental Analysis Results.

Elemental measurements were performed by using ICP-MS device of Joel plasmaxy type. Trace elements of the samples were resolved by Neubliz technique. The data showed the presence of stable and unstable elements with low and high intensity.

2- Measurements by Different Instruments

The ambient dose equivalent rate in μ Sv/h from contaminated piles and pipes at petroleum field was measured by using gamma ray survey meter at various distances from these piles and pipes. Other measurements in laboratory by contamination monitor, in addition to relative reading by inspector and γ-ray survey meter were done to measure the ambient dose equivalent rate of samples taken from petroleum field

Different aluminum and lead filters were used for estimating beta-range in aluminum and effective energy for the investigated TE-NORM of oil samples respectively.

3- Measurements by Gamma Spectroscopy

The average activity concentrations (Bq/kg) of the natural occurring radionuclides of ^{238}U, ^{232}Th and ^{40}K in oil samples were estimated using gamma spectrometer.

4- Measurements by Track Detectors

CR-39 track detectors were used to estimate the Track density, Exhalation rate, mass of exhalation rate and the effective radium content for TE-NORM of petroleum samples.

5- Measurements by TLD

TLD-100 & TLD-700 commercial dosimeters were being used as personnel dosimetry of petroleum field workers of the petroleum industry in Egypt, during the period 1999-2003. 37 personal TL-badges were regularly distributed in addition to other badges as required for certain operations. This investigation indicated no violation of the occupational annual limit.

6- Estimation of Dose Rate and Annual Effective Dose

It is found that the total absorbed dose rate arising from sludge sample was about 3.699 μGy/h. The total absorbed dose rates in air outdoors calculated for scales and soils samples ranged from (0.118 to 8.788) μGy/ h with a mean value of 2.54 μGy/ h and from (1.383 to 1.667) μGy/ h with a mean value of 1.525 μGy/ h respectively.

The total Annual Effective dose outdoors estimated for petroleum samples such as sludge was about 5.177 mSv and for scales and soils from (0.164 to 12.30) mSv with a mean value of 3.55 mSv and from (1.936 to 2.333) mSv with a mean value of 2.134 mSv, respectively

Part II: Zircon for Ceramic Industry and Consumer Product

1- Measurements by Different Instruments

Measurements in laboratory by contamination monitor, in addition to relative reading by inspector and γ-ray survey meter were done to measure the ambient dose equivalent rate of samples taken from ceramic industry and consumer product.

2- Measurement by Gamma Spectroscopy

The average activity concentrations (Bq/kg) of the naturally occurring radionuclides of ^{238}U, ^{232}Th and ^{40}K in zirconium and

consumer product samples were estimated by using HPGe gamma spectrometer.

3- Measurements by track detectors

CR-39 track detectors were used to estimate the Track density, Exhalation rate, mass of exhalation rate and the effective radium content for NORM of zirconium and consumer product samples respectively.

4- Estimation of Dose Rate and Annual Effective Dose

The total absorbed dose rates as well as the total annual effective dose exposure were estimated arising from ceramic industry and consumer products.

Part III**: Theoretical Approach**

1- Man Exposure in Field

The absorbed dose at 1m above-contaminated soils with NORM is theoretically estimated for 20 m x 20 m site. These estimations were preformed by deriving several formulas for various specific mass densities of soil and different expected important radionuclides e. g. ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs. Successful attempt was done to derive 56 numerical formulas with approximate mathematical treatment of specific dose rate at site containing pile and/or pipe of NORM. Usually they are computed by the aid of complex Monte Carlo computer codes; such as MCNP of Los Alamos, GENT of CERN and Monte Carlo of Nuclear Technology Lab., Aristotle University. Thereafter, three computer programs were constructed, tested and developed to solve those aforementioned formulas.

الملخص العربي

إحدى أهم المواضيع في تَستاءُ من سَنَواتِ في حقلِ حمايةِ الإشعاعِ الطبيعيونُ الذين يَجِدونَ موادَ مُشعّةً طبيعية وحَسّنوا يَجِدونَ موادَ مُشعّةً تقنياً طبيعياً (معيار تي إي). كلتا الوكالة الدولية للطاقة الذرية والمفوضية الأوربية عُموماً ودول منتجة للنفط تَأْخذُ جزءَ نشيطَ فيه. مؤخراً وثيقتان نزيهتان أُصدرتَا مِن قِبل الوكالة الدولية للطاقة الذرية. يعني (مدى التلوّثِ البيئي مِن قِبل طبيعياً حَدَث مادّةِ مُشعّةِ (معيار) وخيارات تقنية للتخفيفِ) وتطبيق مفاهيمِ الاستثناء وإستثناءِ وترخيص في 2004.

يَشْملُ المعيارُ radionuclides إرتبطَ ب238 يو و232 إنحطاط Th يُقيّدُ بالإضافة إلى 40 كُي. هذه radionuclides يَعِيشُ لمدة طويلة جداً وعِنْدَهُ بَعْض السُلالاتِ تلك لمدة طويلة مَعيشة، مثل Ra 226، في صناعةِ النفط.

الأرضية الخزفية أَو بلاط الحائطِ، مستعمل عموماً في الزينةِ المحليةِ مثل غرفِ الجلوس وحمّاماتِ ومطبخِ، يَحْصلُ على ظهورِهم الأبيضِ الصحي ويُحاذرَ مِنْ التآكلِ مِنْ رملِ الزرقونِ (ZrSiO 4) أضافَ إلى الصقيلِ كمستحلب. يَحتوي الزرقونُ بَعْض radionuclides الطبيعي الذي تعرّضها الصناعي يَجِبُ أَنْ يُعتَبرَ مهني.

في إنتباهِ العملِ الحالي أُشيرَ إليه (تحليل ومقياس التعرّضِ المهنيِ لإيجاد الموادِ المُشعّةِ طبيعياً) الذي أنتجَ في عِدّة مواقع في مصر.

يو -238 وسلسلته، و232-Th وسلسلته بالإضافة إلى كُي -40 radionuclides الأكثر أهميةً بين المعيارِ تي إي. التقنية المختلفة مثل (نقاوة عالية germanium إتش بي جي إي، كاشفات مسارِ سي آر -39، أمتار مسح ، thermoluminenscence تي إل دي) dosimeters ونظرة نظرية إستعملا لتقديرِ الجرعةَ والنشاطَ .

جزء (1) عينات نفطِ

1 - نَتائِج تحليلِ عنصريةِ.

المقاييس العنصرية أدّيتْ بإستعمال آي سي بي الآنسة أداةِ نوع جويل plasmaxy. عناصر أثرِ العيناتِ حُلّتْ بتقنيةِ Neubliz. شوّفتْ البياناتُ حضورَ العناصرِ الرسميةِ المستقرّةِ والغير مستقرةِ بكثافةِ الإرتفاعَ والمستوى الواطئَ.

2 - مقاييس بالآلاتِ المختلفةِ

نسبة مكافئِ الجرعةِ البيئيةِ في Sv /h مِنْ الأكوامِ والأنابيبِ الملوثةِ في حقلِ النفطِ كَانَ مُقاس بإستعمال مترِ مسحِ شعاعِ الغاما في المسافاتِ المُخْتَلِفةِ مِنْ هذه الأكوامِ والأنابيبِ. المقاييس الأخرى في المختبرِ مِن قِبل مراقبِ التلوّثِ، بالأضافة إلى قراءة نسبيةَ مِن قِبل المفتشِ ومترِ مسحِ الشعاعِ عُمِلا لقيَاْس نسبةِ الجرعةِ البيئيةِ المكافئةِ للعيناتِ أُخذتْ مِنْ حقلِ النفطِ

الألمنيوم المختلف والمرشحات الرئيسية إستعملا لتَخمين مدى البيتا في الألمنيومِ والطاقةِ الفعّالةِ لتَحرّيا معيارَ تي إي مِنْ النفطِ يَختبرانِ على التوالي.

3 - مقاييس بالغاما Spectroscopy

تجمعَّات النشاطِ المتوسطةِ (Bq / كيلوغرام) الحَدَث الطبيعي radionuclides 238 يو، 232 Th و40 كُـي فـي عينـاتِ الـنفطِ تخمـينَ الـذي يَسـتعملُ Ge صـافي جـداً. غامـا كاشـفِ spectrometer.

4 - مقاييس بكاشفاتِ المسارِ
كاشفات مسارِ سي آر -39 كَانتْ تُستَعملُ لتَخمين كثافةِ المسارَ، نسبة تبخّرِ، كتلة نسبةِ التبخّرِ ومحتوى الراديومِ الفعّالِ للمعيارِ تي إي مِنْ عيناتِ النفطِ.
5 - مقاييس مِن قِبل تي إل دي
تـي إل دي -100 وتـي إل دي -700 تجـاري dosimeters كَانـتْ مسـتعمل للمـوظفي dosimetry لعُمّالِ حقلِ نفطِ الصناعة النفطيةِ (النسبة الثابتة) في مصر. أثناء الفترةِ 1999-2003 37 شارات شخصية تي إل وُزّعتْ بإنتظام بالأضافة إلى شاراتَ أخرى كما هو مطلوب لبَعْض العملياتِ. هذا التحقيقِ ما أشارَ إلى أي إنتهاكِ الحدِّ السنوي المهني.

6 - تقدير نسبةِ الجرعةِ والجرعةِ الفعّالةِ السنويةِ
نسبة الجرعةِ المُنغَمِسةِ الكليّةِ بالإضافة إلى تعرّضِ الجرعةِ الفعّالِ السنوي الكليِّ خُمّنَ منشأ عن حقلِ النفط خُمّنَ.

جزء (2) zirconium للصناعةِ الخزفيةِ والمنتج الإستهلاكي
1 - مقاييس بالآلاتِ المختلفةِ
مقاييس في المختبرِ مِن قِبل مراقبِ التلوّثِ، بالأضافة إلى قراءة نسبيةً مِن قِبل المفتشِ ومترِ مسحِ الشعاعِ عُمِلا لقيَاْس نسبةِ الجرعةِ البيئيةِ المكافئةِ للعيناتِ أَخذتْ مِنْ الصناعةِ الخزفيةِ والمنتج الإستهلاكي.
2 - مقياس بالغاما Spectroscopy
تجمعَّات النشاطِ المتوسطةِ (Bq / كيلوغرام) الحَدَث الطبيعي radionuclides 238 يو، 232 Th و40 كُي في zirconium وعينات منتج إستهلاكي خُمّنا بإستعمال غاما إتش بي جي إي spectrometer.
3 - مقاييس بكاشفاتِ المسارِ
كاشفات مسارِ سي آر -39 لإستعملتْ تخمينَ كثافةِ المسارَ، نسبة تبخّرِ، كتلة نسبةِ التبخّرِ ومحتوى الراديومِ الفعّالِ لمعيارِ zirconium ومنتج إستهلاكي يَختبرانِ على التوالي.
4 - تقدير نسبةِ الجرعةِ والجرعةِ الفعّالةِ السنويةِ
نسبة الجرعةِ المُنغَمِسةِ الكليّةِ بالإضافة إلى تعرّضِ الجرعةِ الفعّالِ السنوي الكليِّ خُمّنَ منشأ عن الصناعةِ الخزفيةِ والمنتج الإستهلاكي خُمّنَ على التوالي.
1 - نظرة نظرية
إنّ الجرعةَ المُنغَمِسةَ في 1 m فوق التُرَبِ الملوثةِ بالمعيارِ يُخَمّنُ نظرياً لـ20 m x 20 m موقع. هذه التقديراتِ شُكّلتْ بقيادة سيارة عِدّة صيغ للكثافاتِ الجماعيةِ المعيّنةِ المُخْتَلِفةِ مِنْ التربةِ وe radionuclides مهمة متوقّعة مختلفة. Ra 226 .g، Th 232، 40 كُي و137 Cs. المحاولة الناجحة عُمِلتْ لقيَاْدَة 58 صيغةً عدديةً بالمعالجةِ الرياضيةِ المتطوّرةِ التقريبيةِ بدقّة مِنْ نسبةِ الجرعةِ المعيّنةِ في الموقعِ تَحتوي كومةً و/ أَو إنبوب المعيارِ. حَسبتْ عادة بمساعدةِ رموزِ حاسوبِ مونتي كارلو المعقّدة؛ مثل إم سي إن بي مِنْ Los Alamos، سيد سي إي آر إن

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ABSTRACT

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