Radiological Impact of Geo-Pilot Plant after Decontamination

Dr.Yousif M. Zayir Al-Bakhat
Fouzey H. kitah
Decommissioning Center of Destroyed Nuclear Facilities (IDC)
Ministry of Science and Technology

Abstract

The Geo-Pilot plant had been designed and constructed in 1989 in the center of Baghdad at high population residence sector to protect the hydrated yellow cake from uranium Ore. The final radiological survey is performed on the Geo-Pilot Plant to demonstrate compliance with the appropriate release criteria. The field measurements were performed on a systematic grid of 404 cells. The samples of soil were collected and analyzed in the radioanalytical laboratory. The results of laboratory analysis satisfy the exclusion criteria established by the International Atomic Energy Agency(IAEA). The dose received by the decommissioning workers range from 0.25 – 0.42 µSv /y, which satisfy the occupational dose limit regulated by the IAEA of 20 mSv/y and 1mSv/y for public.

The environmental impact of the use of the site for industrial scenario has been investigated using RESRAD computer code. The results indicate that the Geo-Pilot Plant meets the release criteria after dismantling, since none of the individual measurements or health risk assessment results exceed any of the established guidelines.

Key words:- Release of site, Geo-pilot plant, Criteria of release ,RESRAD

Introduction

The Geo-pilot plant was established in 1989 for treating uranium ore to obtain hydrated yellow cake. The plant was constructed by the State Company of Geological Survey and Mineral Investigation, on area about 500m^2 in the center of Baghdad near the headquarter of the company. The plant consists of six operating units which have specific functions for treating uranium ore. The plant has been operated for a limited and discrete periods. The available information shown that the product was 2-3 Kilo of hydrated yellow cake.

The purposes of the final status survey are [1, 2, and 3]:

- Demonstrate that the Geo-Pilot Plant meets the established release criteria.
- Provide an input for dose/ risk assessment.
- For radiological protection of workers, general public and environment from harmful of radiation due to exposure to: dose rates, contamination levels of individual radionuclides activities [4,5].

Materials and Methods

A- Field Measurements for Geo-Pilot Plant

Two kinds of in-situ measurement were used in relation to characterization; which are:

- Dose rate measurements
- Radioactive contamination measurements

Field measurements were performed using hand – held radiometer types:

- RADIgam model (2000) S.N (0183) code (76687) GM detector for measuring Dose rate in μSv/hr, contamination (α +β+ Y) in (cps) with probe model (SABG-15), Code (75287), S.N. (7163) and,
- RadEye – model (42506/7120)), with NaI (Tl) detector, response from 30 keV to 5 MeV, unit in (μSv/hr) and in (cps), Thermo Scientific – Germany.
- CAB instrument model 18351 probe model SAB-70 CANBERRA scintillation counter for measuring contamination in cps for α, β, and α + β.
- Ludlum Model 44-9 G-M Pancake, is a portable microprocessor-based digital scalar/ rate meter 2 in*2, designed for use with scintillation, G-M and proportional detectors unit (in R/hr, Sv/hr, or cps).

B- Laboratory Measurements

Fifty-five samples were collected and measured to determine the concentration of radionuclides by using gamma-spectrometry system (HPGe) detector, of Eff. 40%,& resolution 2.0 KeV based on Co-60 of energy 1.332 MeV. The analyses were conducted using Genie-2000 software [6,7] in the impacted areas.

C- Impacted areas are classified according to the extent of contamination into one of three classifications [8, 9, and 10]:

- Class 1 Areas: Areas that have radioactive contamination above the derived concentration guidance level (DCGL).
- Class 2 Areas: Areas that have radioactive contamination, but not expected to exceed the DCGL.
- Class 3 Areas: Any impacted areas that are not expected to contain any residual radioactivity.

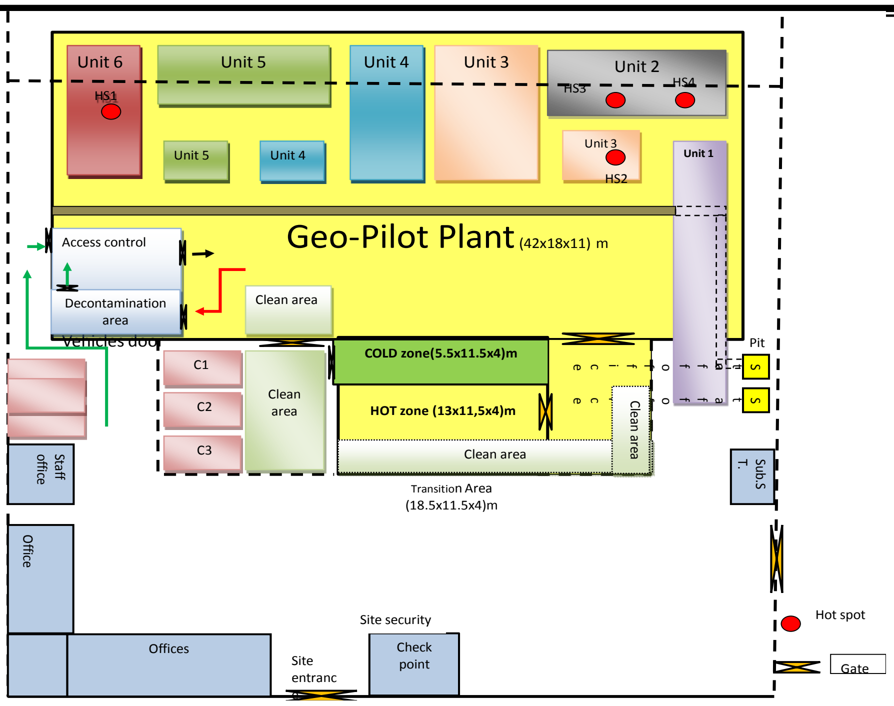


Fig.-1 Survey Units Classification

Radiological Risk Assessment

RESRAD (short of RESidual RADioactivity) (On-site) Version 6.5 (2009) computer code is used for estimating radiation doses and human health risks from radioactive contamination due to decommissioning of facilities and future site users after release. This software tool was developed by Argonne National Laboratory, under the joint sponsorship of the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC) [11]. The following exposure pathways are taken into account for the dose and risk assessment:

- External exposure.
- Internal exposure from ingestion and inhalation pathways.

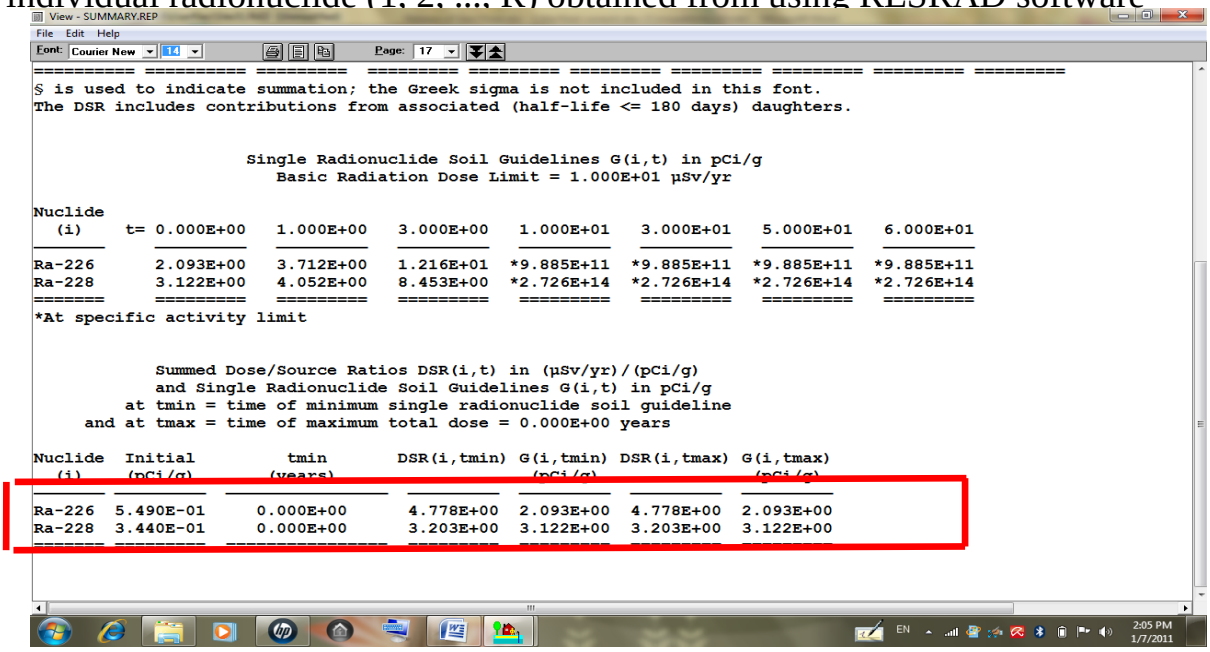
Results and discussion:

Contaminated spot in sector 2 after dismantling of centrifuge had been identified during the characterization survey, for α+β count rates range from 2.2 – 3.7 cps (measured using CAB monitor, B.G. = 0.5 cps). The radiological contamination on this spot were removed during the decontamination process, the results of twenty-four readings were applied at each grid as determined statistically. None of the measurements exceed the acceptable limit of twice the natural background level after dismantling.

Results of total annual dose received by an individual using RESRAD are (3.7µSv/y) which is below dose limit of occupational regulated by the IAEA (20 mSv/y) and risk assessments related shown in Figures (3). As well as according to Unity Rule represented by equation below [12, 13, and 14]:-

$$\sum_{r=1}^{R} \frac{C_r}{DCGL_r} \leq 1 \quad \text{.....(1)}$$

Where C_r : radionuclides concentration DCGL guideline value for each individual radionuclide (1, 2, ... R) obtained from using RESRAD software



View - SUMMARY.REP

File Edit Help

Font: Courier New 14 Page: 17

$ is used to indicate summation; the Greek sigma is not included in this font.
The DSR includes contributions from associated (half-life <= 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 1.000E+01 µSv/yr

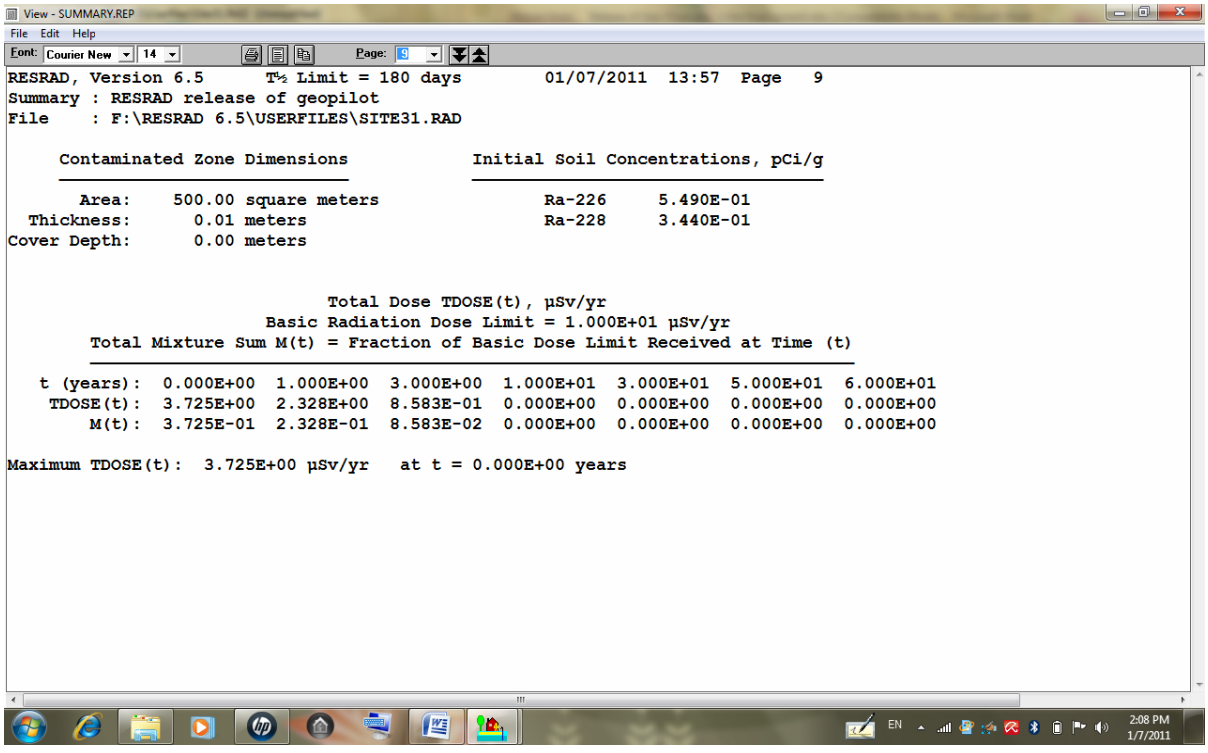
Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	5.000E+01	6.000E+01
Ra-226	2.093E+00	3.712E+00	1.216E+01	*9.885E+11	*9.885E+11	*9.885E+11	*9.885E+11
Ra-228	3.122E+00	4.052E+00	8.453E+00	*2.726E+14	*2.726E+14	*2.726E+14	*2.726E+14

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (µSv/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ra-226	5.490E-01	0.000E+00	4.778E+00	2.093E+00	4.778E+00	2.093E+00
Ra-228	3.440E-01	0.000E+00	3.203E+00	3.122E+00	3.203E+00	3.122E+00

Figure (2) Represented the Maximum TDOSE



View - SUMMARY.REP

File Edit Help

Font: Courier New 14 Page: 9

RESRAD, Version 6.5 T½ Limit = 180 days 01/07/2011 13:57 Page 9
Summary : RESRAD release of geopilot
File : F:\RESRAD 6.5\USERFILES\SITE31.RAD

Contaminated Zone Dimensions
Area: 500.00 square meters
Thickness: 0.01 meters
Cover Depth: 0.00 meters

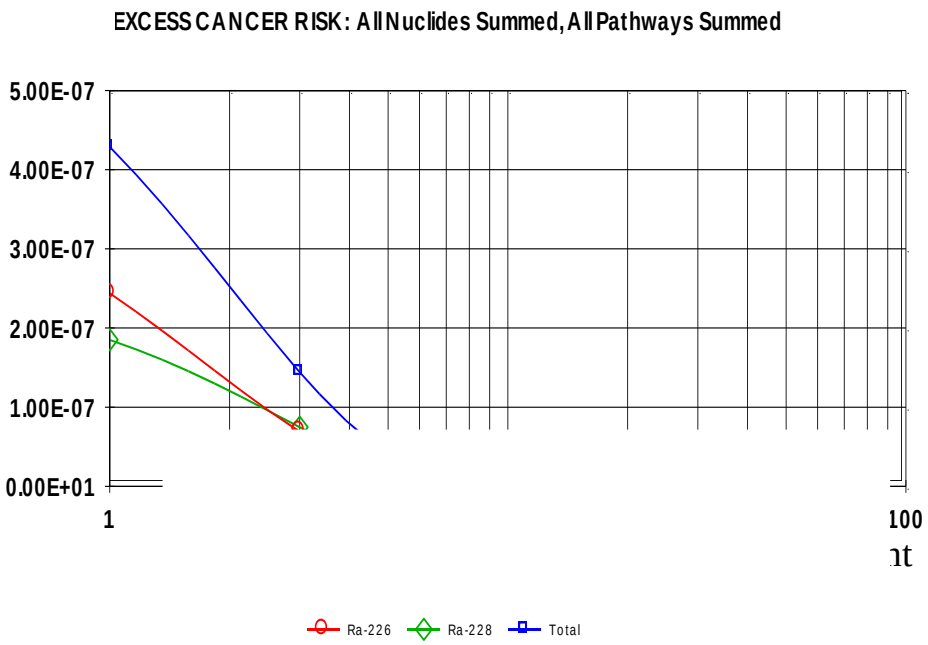
Initial Soil Concentrations, pCi/g
Ra-226 5.490E-01
Ra-228 3.440E-01

Total Dose TDOSE(t), µSv/yr
Basic Radiation Dose Limit = 1.000E+01 µSv/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	5.000E+01	6.000E+01
TDOSE(t):	3.725E+00	2.328E+00	8.583E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
M(t):	3.725E-01	2.328E-01	8.583E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Maximum TDOSE(t): 3.725E+00 µSv/yr at t = 0.000E+00 years

Figure (3) Single Radionuclide Soil Guideline



Conclusion

The results of final radiological characterization after dismantling of Geo-Pilot plant site indicate that:

- A total of 9696 field measurements were performed on a systematic grid of 404 cells in the Geo-Pilot Plant.
- The measurements of background at Geo-Pilot plant after dismantling are: The minimum and maximum contamination levels are (0.25 – 0.78) cps using CAB monitor.
- Dose rates (0.06 – 0.07) µSv /h using Ludlum Meter
- No individual measurements exceed twice the B.G using CAB and Ludlum monitors after dismantling.
- Radiological risk assessment by using RESRAD software are based on the maximum activity concentrations in soil sample for Ra-226 and Ra-228 of about (20.32, 12.75) Bq/Kg respectively . The radiological impacted due to exposure pathways indicated that the Geo-pilot plant could be released for industrial use [13] - Decontamination were implemented for that hotspot and the site now within the B.G level of contamination and exposure dose rate [14].
- The probability of cancer risk lifetime from total doses due to radionuclides present is 4 workers from 10.000.000 might be affected as in figure (4).
- From formula(1) and figure(3) which is describe the Single Radionuclides Soil Guideline , the sum of fraction below one which (equivalent 10 µSv/yr) and this mean that TEDE (Total Effected Dose Equivalent) which equal to 3.7 µSv/yr below 10 µSv/yr.
- Comparison these results with the regulatory limits indicates that the site comply with the IAEA release criteria of site (10µSv/y) for unrestricted use [10, 13].

References

1. IAEA," characterization of radioactivity contaminated sites for remediation purpose", IAEA-TECDOC-1017, IAEA, Vienna, 1998.
2. IAEA," radiological characterization of shutdown nuclear reactors for decommissioning purposes", T.R series No. 389, IAEA, Vienna, 1998.
3. IAEA, "Quality measures for the characterization process" Douglas G. draper presentation, IAEA, technical meeting on characterization for the Iraqi nuclear facilities decommissioning project, 23-27 July 2007, IAEA, Vienna.
4. IAEA, "the characterization survey" Douglas G. draper presentation, IAEA, technical meeting on characterization for the Iraqi nuclear facilities decommissioning project", 23-27 July 2007, IAEA, Vienna.
5. IAEA, "characterization data collection experience EWN" Axel Backer EWN Gmbh, IAEA, technical meeting on characterization for the Iraqi nuclear facilities decommissioning project", 23-27 July 2007, IAEA, Vienna.
6. IAEA, "measurement of radio nuclides in food and the environmental', A guide book, T.R. series No. 295, IAEA, Vienna, 1989.
7. IAEA, "Standard format and content for safety related decommissioning document", safety series No. 45, IAEA, Vienna, 2005.
8. IAEA, "characterization of radioactive waste forms and packages"T.R. series No. 383, IAEA, Vienna, 1997.
9. Predisposal management of high level radioactive waste,WS-G-2.6, 2003.
10. Application of the Concepts of Exclusion Exemption and Clearance, IAEA, safety guide No. RS-G-1.7, 2004.
11. C.Yu et al."Data Collection Handbook to Support Modeling Impact of Radioactive Material in Soil. Argonne IL" April 1993.
12. IAEA-TECDOC-1092 (Generic Procedure from Monitoring in a Nuclear or Radiological emergency)
13. 'Release of Sites from Regulatory Control on Termination of Practices, Safety Guide No.WS-G-5.1, IAEA, Vienna (2006).
14. International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

المترتبات الاشعاعية لمنشأة المسح الجيولوجي بعد ازالة التلوث الاشعاعي

محسن زاير البخات

فوزي حسن كاطع د. يوسف

وزارة العلوم والتكنولوجيا – بغداد

مركز تصفية النشأت النووية المدمرة في العراق

الخلاصة:-

تم تصميم وبناء منشأة المسح الجيولوجي في عام 1989في مركز بغداد ذات الكثافة السكانية العالية وصممت لانتاج الكعكه الصفراء من اليورانيوم المستخرج من المنجم التابع لوزارة الصناعة والمعادن.

تم اجراء مسح اشعاعي نهائي باستخدام الاجهزة الحقلية ضمن مخطط شبكي يتكون من 404 خلية لتحديد مستوى التلوث والتعرض الاشعاعي للمنشاة بعد التفكيك وازالة التلوث الاشعاعي للمناطق الملوثة، اضافة الى قياس وتحليل نماذج التربة باستخدام المنظومات المختبرية الثابتة وكانت النتائج مطابقة مع المحددات العالمية لاطلاق لمنشآت والمحددة من قبل الوكالة الدولية للطاقة الذرية.

- ان معدل الجرع المستلمة من قبل العاملين تتراوح بين(0.25-0.42) مايكرو سيفرت / سنة وهي أقل من الحدود المسوح بها للعاملين والمحددة من الوكالة الدولية للطاقة الذرية والبالغة (20) ملي سيفرت/سنة و (1) ملي سيفرت/ سنة للسكان.
- ان المترتبات الاشعاعية البيئية للمنشأة تم تحليلها باستخدام البرنامج العالمي RESRAD اشارت نتائج التحليل والتقييم للمخاطر الصحية للسكان اقل من الحدود المسموح بها وعليه تم اطلاق المنشاة للاستخدامات الصناعية .

الكلمات الدالة / اطلاق الموقع ، منشأة المسح الجيولوجي ، ظاهرة الاطلاق ، برنامج RESRAD