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Environmental Radioactive Survey of Some Industrial Installations around Inshas Site

By

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ABSTRACT

Environmental samples, plant, soil and air were taken from some industrial installations near the Egyptian Reactor and measured radiometrically. The radioactive measurements were done using High Purity Germanium detector. The plants were ignited at 800 °C for 6 hours then the ash was counted. Radioactivity was detected in the air by environmental radiation monitoring system. Radioactive isotopes were recorded in some raw materials present in the studied three industrial installations. Such isotopes increase the level of radioactivity at the site. A plan to protect human being and his environment is proposed.

INTRODUCTION

A wide range of natural radioactivity is found in many raw materials such as clay, phosphates, and natural uranium mine [1]. There are industrial companies and agriculture land, which use many raw materials as a part of normal operational activities. Many companies concentrate the radioactivity of the raw materials, through some chemical processes, in either product or the waste. Every year a large amount of raw materials is used. Thus the amounts of radioactivity in the environment increase more and more and affect man and his environment [2]. The continuos increase in the use of such raw materials causes an expanding potential health hazard.

Upon the above mentioned issues, it was proposed to measure the radiation background at certain area around Inshas reactor up to 6 km., in diameter see Fig.(1), and to determine natural radioactivity in some nearby industrial installations which could contaminate the environment. The amount of each isotope should be assessed, in order to determine the dose received to human being and his environment.

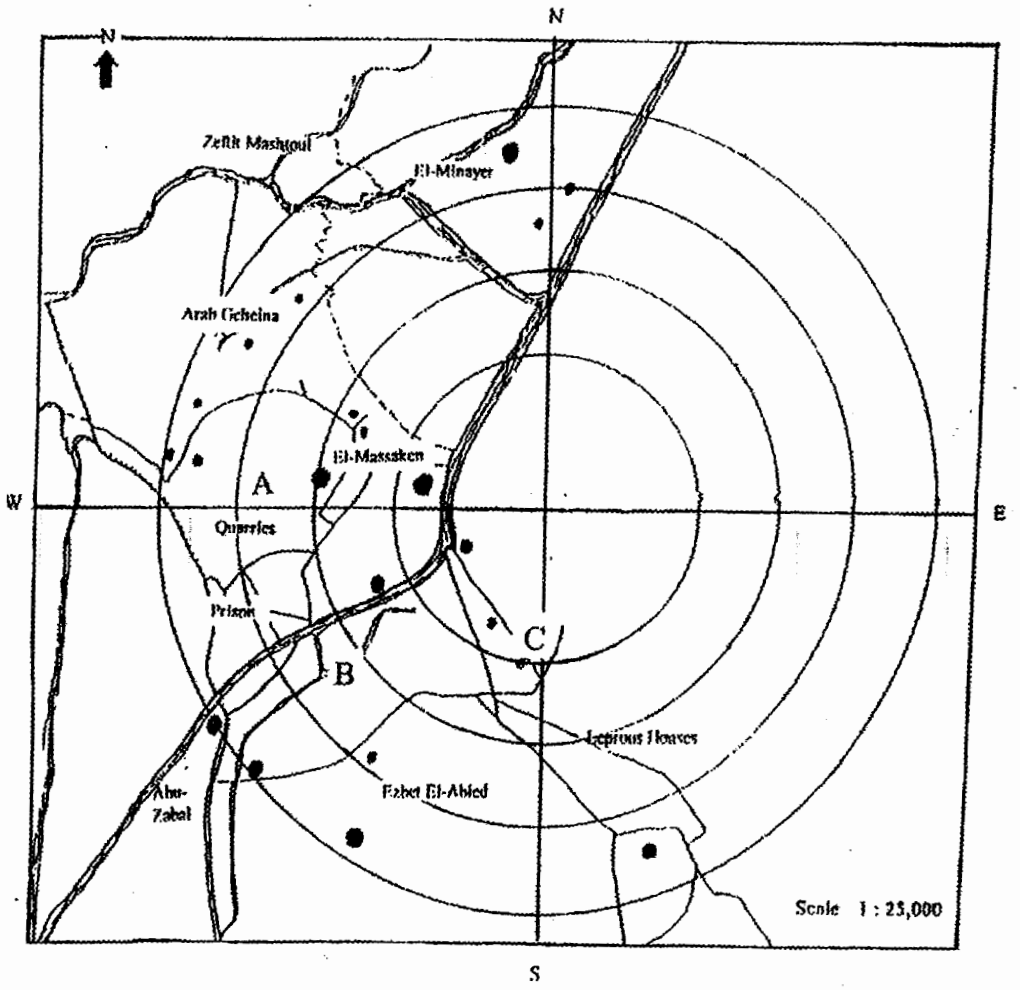


Fig. (1) Location map.

A : General company for quarrying.

B : Abu-Zabal fertilizers and chemical company.

C : Arab ceramic manufacturing company.

Equipment and Experimental Work

1- Equipment:

A-High purity Germanium detector:

The high purity germanium detector, Fig. (2), is a part of gamma ray spectrometer system. The high purity germanium detector includes (a) the detector, which converts the current to wave or pulses, has a diameter of 55.5mm., & length of 52.5mm.,where the samples are counted at distance of 5 mm. from the window of the detector, (b) Electronic units composed of preamplifier, which converts the pulse to small signal and an amplifier to converts the small signal to big one, (c) Multi channel analyzer to determine gamma energy maximum, and (d) a computer which is used for data processing and evaluation.

The detector consists of a germanium crystal suitably connected and mounted in a vacuum cryostat. The cryostat contains a pump to absorb gases and vapors outgasing from the various mounting materials. The crystal is cooled by inserting the cryostat in a dewar vessel filled with liquid nitrogen.

B- Environmental Radiation Monitoring:

The environmental radiation monitoring system is an integrated system consisting of a central computer and network for environmental radiation monitoring. The environmental radiation monitoring station has two Geiger Mueller types detectors (17.50" high, 15.25" and 8.38" deep). The contained, radiation measured system with high precision to assess quantitative gamma radiation levels of the environment .

2- Radiation calibration:

The high purity germanium detector was calibrated using gamma radiation emitted from a standard radionuclide source of activity 1.014 μCi in one liter Giffin sieved soil in 130G GA-MA Beaker [3]. An energy calibration curve, using the standard sources was drawn. Fig. (3) shows the relation between the number of energies and the number of channels. From the data of energy calibration curve, the efficiency can be determined for any isotope using Fig. (4). The standard source contains different isotopes given in Table (1):

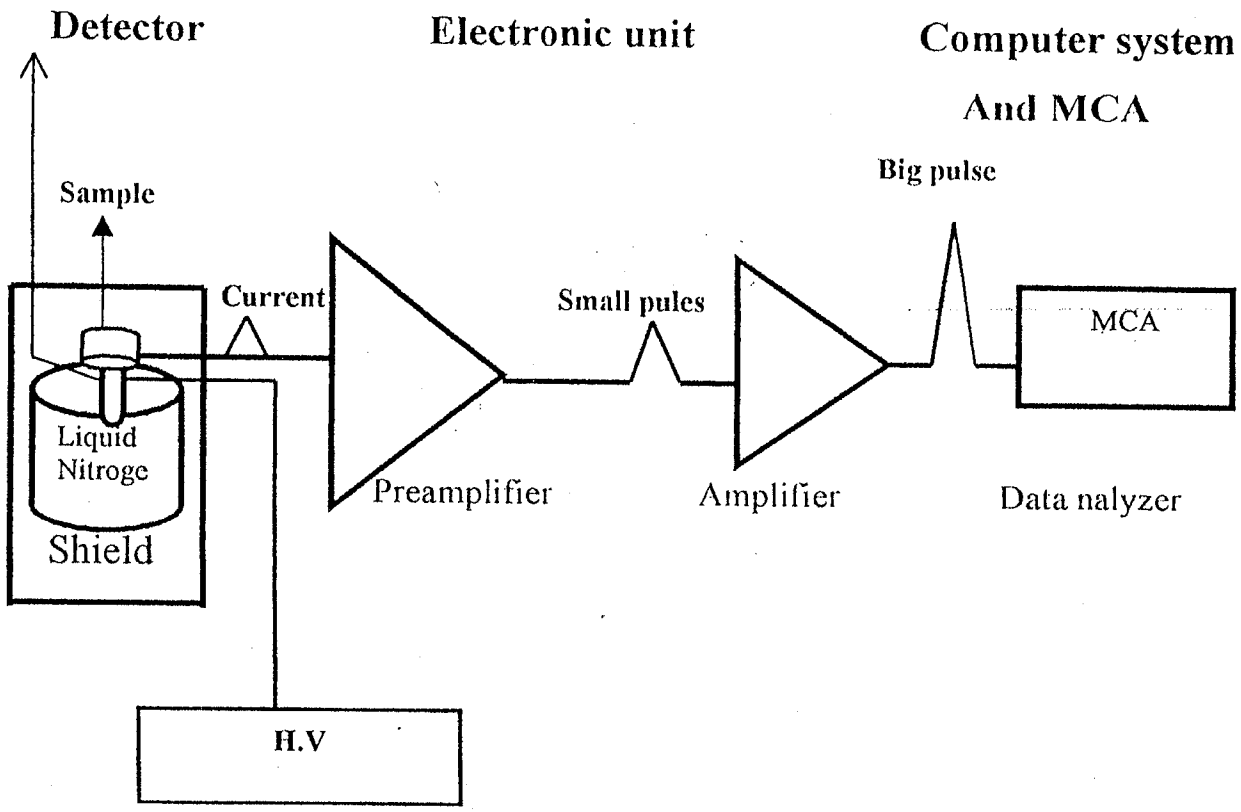


Fig. (2) Schematics of electronics system for a High purity Germanium Detector.

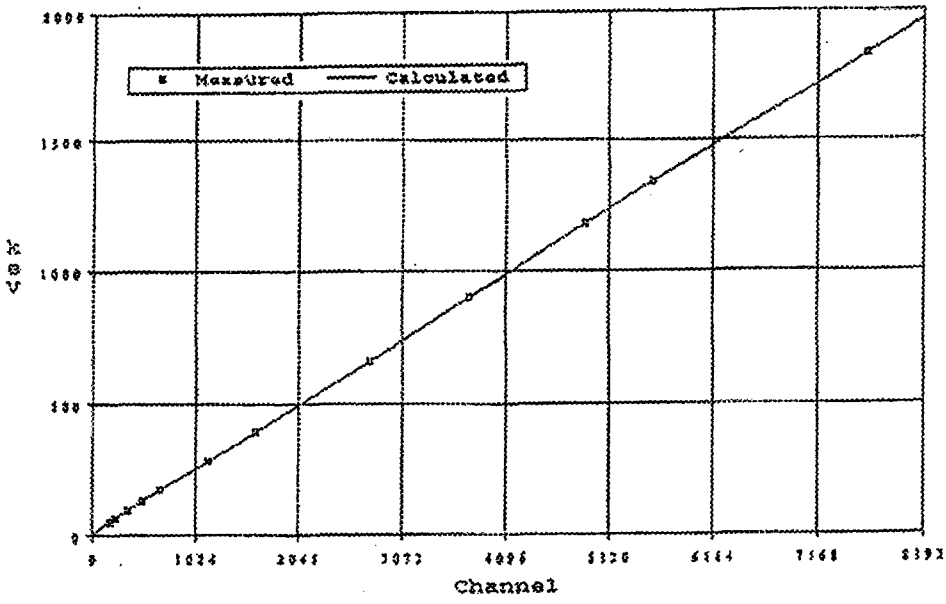


Fig. (3) Energy Calibration Curve.

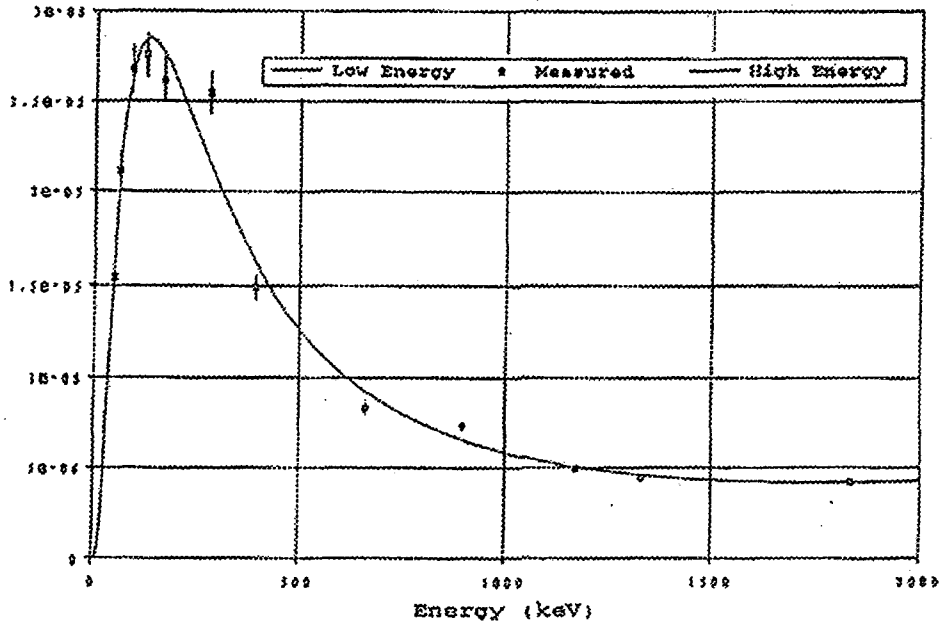


Fig. (4) Efficiency Calibration Curve.

Table (1): Isotopes in standard source.

Isotope	Gamma energy (KeV)	Half life
Pb_{210}	46.5	22.3 year
Am_{241}	59.5	432 year
Cd_{109}	88	462.6 day
Co_{57}	122	271.79 day
Ce_{139}	166	137.64 day
Hg_{203}	279	46.595 day
Sn_{113}	392	115.09 day
Cs_{137}	662	30.0 year
Y_{88}	898	106.63 day
Co_{60}	1173	5.2714 year
Co_{60}	1332	5.2714 year
Y_{88}	1836	106.63 day

3- Analysis of Samples:

The chemical analysis of samples, as given by each company, is as follows; Aswan clay composed of L.O.I: 9.18%, SiO_2:54.96 %, Al_2O_3 :25.30% , Fe_2O_3:2.40%, CaO: 1.28%, MgO:0.41%, SO_3:0.16%, K_2O: 0.72%, Na_2O: 0.19%, TiO_2: 1.71%. The analysis of phosphate raw materials is as follows; H_2O: 1.15%, CaO: 46.50, P_2O_5: 25.0%, MgO: 0.42%, Fe_2O_3: 1.56%, Al_2O_3 :1.6%, SiO_2:12.6%, F:2.3%, SO_4:2.0%, Cl:250 ppm, and combined H_2O:0.5%. Organic mater and CO_2 is 6.6%.

4- Calculation of specific activities:

For the determination of the efficiency factor, accumulation of any energy spectra should be calculated for a predefined counting system using a standard for each radionuclide of interest at the desired source to detector geometry. The efficiency factor can be determined by the following equation [4]:

$$e_{(i,E)} = \frac{[N_{(i,E)} - B_{(E)}]}{A_{(i)}\, I_{(E)}} \qquad (1)$$

Where:

$e_{(I,E)}$ represents the photopeak efficiency for the radionuclide(i)at full energy (E),

$N_{(E)}$ is the net counting rate of full energy peak,

$B_{(E)}$ is the net background counting rate at the energy (E),

$A_{(i)}$ is the calculated activity in Bq. of respective radioisotope in the reference standard used for the radionuclide (I) and

$I_{(E)}$ is the intensity of emitted energy (E).

The efficiency calibration curve is then plotted as a function of energy (or a function of channels), where the highest part will be of higher efficiency than the lower part. The absolute activity of an unknown source can be calculated. The following equation is used in calculating the absolute activity of such a source:

$$A_{(i)} = \frac{[N_{(i,E)} - B_{(E)}]}{e_{(i,E)}\, I_{(E)}} \qquad (2)$$

The total counts under each photopeak were computed automatically using Multi Channel Analyzer and software through integrating the area which is bounded by the peak and straight line base connecting the two corresponding base points. After necessary correction for the background readings, the count rates are determined by dividing the integrated beak area by the counting time. The absolute activity for each peak is then obtained by equation 2.

RESULTS AND DISCUSSION

The radiation background of the studied site was measured. The surveyed area included three industrial installations namely, Arab Ceramic Manufacturing Company, Abu-zabal Fertilizers and Chemical Company, General Company for Quarrying. Each industrial installation has an area of about 6-8 km^2. Radiometric gamma survey of the three sites showed that the gamma radiation was high. The range of the background is 182 Bq/kg. Samples from the environment of the three industrial installations (sand, plant and water) were measured using HpGe detector.

The background was also measured. Results in Fig. (5) show the gamma spectra of the B.G and the environmental samples. The gamma spectra showed several peaks at energies : 46.4, 63.1,74.6,77.0,92.2, 143.6,185.6, 238.5, 241.1, 294.7, 352.3, 583.9, 610.2, 769.1, 912.8, , 936.0, 970.0, 1122, 1240, 1462, 1768,(KeV).

The activity in Bq is calculated in both B.G and environmental samples. Results showed that the environmental samples contain different radioactive isotopes. The activity in Bq of different radionuclides found in the samples, which were collected from the three different industrial installations is giving in Table (2). The calculated activity in the normal sample (sand), lies within the permissible level (360 Bq/kg)[1] agreed by the International Atomic Energy Agency (IAEA). However, the activities of other samples, which were taken from the industrial installations, remarkably exceed the permissible limits as indicated in Table (2).

Measurements of radioactivity in air were done using Environmental Radiation Monitoring system . The air was monitored directly during the day. The obtained results are given in Fig. (2). The analysis of data showed that the gamma activity was maximal during the day and minimal during the night. The activity was increased for certain days where the nuclear reactor was operated.

The chemical analysis of the raw materials showed the presence of 25.04 % phosphate. Phosphate is found in nature mixed with some naturally occurring radioactive material namely U^{238} [5]. Based on these facts and according to the analysis of decay of U^{238}, several isotopes could be detected. The radioisotopes that might be found in the raw materials of the three industrial installations are; Pb^{212}, Pb^{214}, Th^{234}, K^{40}, Tl^{208}, and Bi^{214}. Kr^{90}, Xe^{138} and I^{131} might be found.

In conclusion, the obtained results assured that the three industrial installations use raw materials, which contain natural radioactive isotopes. The level of radiations emitted at such industrial installation exceeds the proposed limit (360Bq/kg) of the International Atomic Energy Agency,IAEA[1],. This Level of radiations increases more during the normal operation of the reactor.

Release of radioactive isotopes to the environment, from the normal operation of the reactor and raw materials used in some nearby industrial installations, causes the exposure of the inhabitants and workers to ionizing radiations.

To protect the environment from such radiations, the discharged radioisotopes from the reactor and nearby industrial installation should be controlled. Therefore an environmental monitoring plan should be implemented in accordance with the regulatory body .

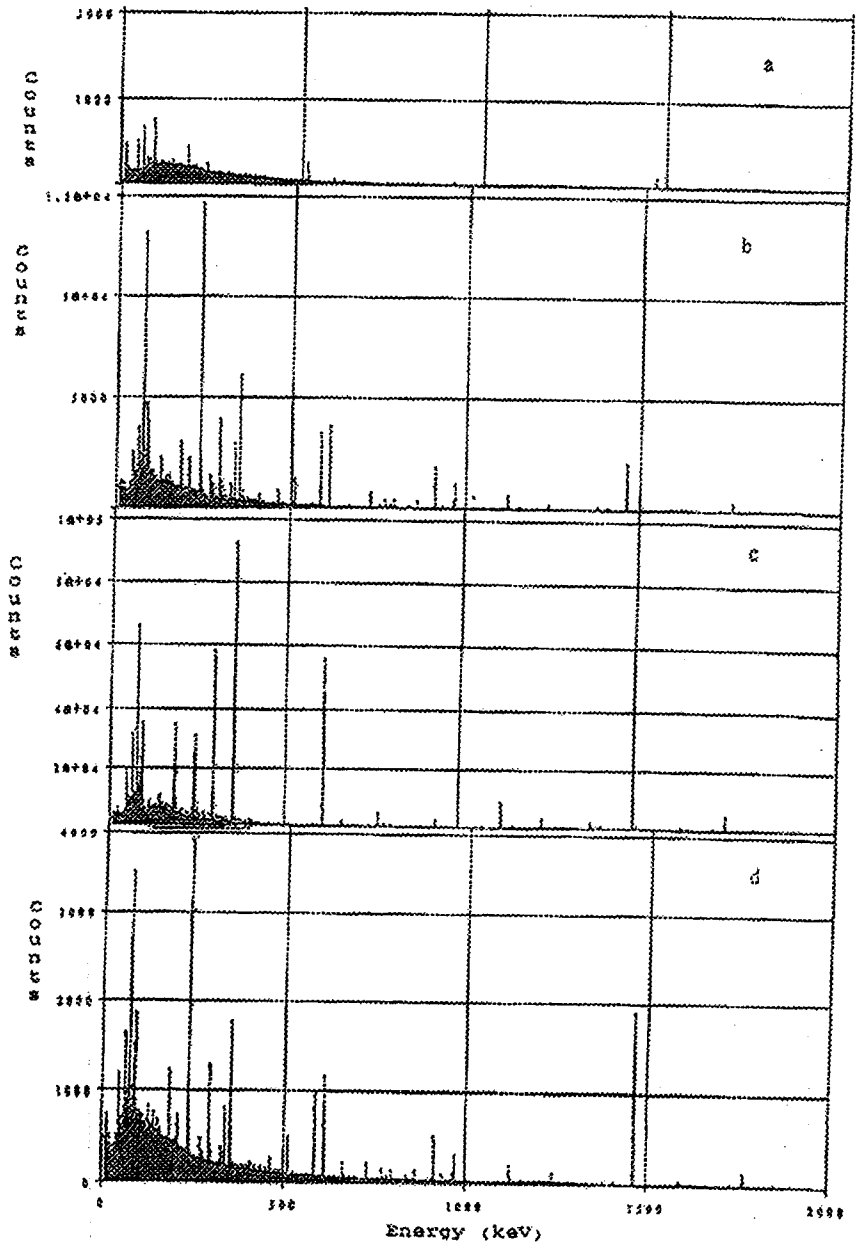
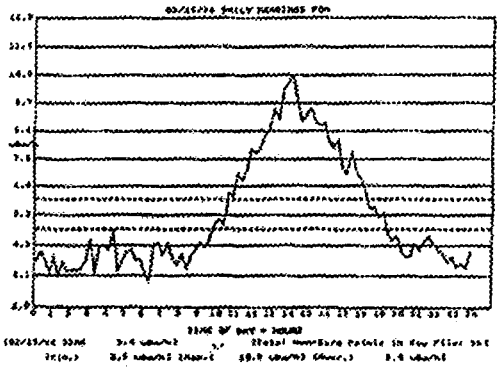


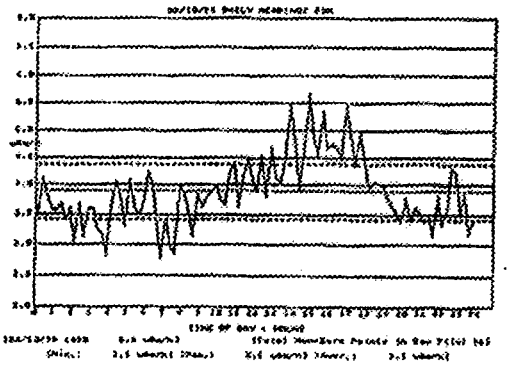
Fig. (5) Gamma spectra of environmental samples taken from:
a-Background.
b-Arab ceramic manufacturing company.
c-Abu-zabal fertilizers and chemical company.
d-General company for quarrying.

Table (2) : Radiometric measurements of energy, activity and corresponding isotope.

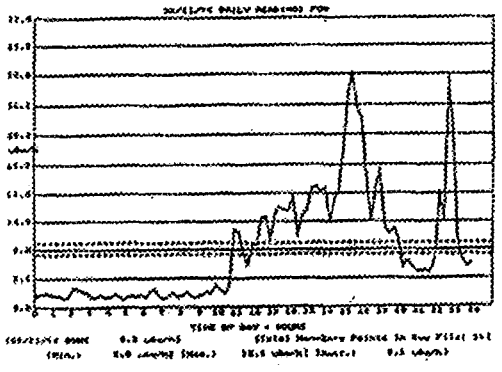
Energy (KeV)	Isotope	Intensity (I)	Efficiency (ε)	B.G Count/sec	Normal Sample (Bq/kg)	General Company for Quarrying Sample (Bq/kg)	Fertilizers & Chemical Company Sample (Bq/kg)	Arab Ceramic Company Sample (Bq/kg)
912.2	Ac^{228}	25	6.39E-5	25	1.6	2.9	6.8	4.0
936.0		3	6.23E-5	18	1.4	1.6	4.2	21.9
63.1	Bi^{214}	3.9	2.1E-4	660	7.2	11.9	5.0	240.0
610.0		47	E-4	33	1.3	2.3	9.2	74.0
769.0		5	7.73E-5	27	1.0	-	7.6	24.9
1122.0		17	5.2 E-5	13	1.3	2.2	7.8	26.1
1173.0	Co^{60}	100	9.28E-5	14	-	-	-	-
1333.0		100	9.28E-5	9	-	-	-	-
662.0	Cs^{137}	85	9.18E-5	25	-	-	-	-
1462.0	K^{40}	11	4.33E-6	103	74.2	455.6	187.0	138.0
46.4	Pb^{210}	4	1.59E-4	504	5.7	12.7	12.5	186.0
238.5		47	2.38E-5	240	16.1	31.7	133.6	38.1
74.4	Pb^{214}	6.2	2.4E-4	295	15.1	-	16.0	31.5
77.0		10.7	2.46E-4	254	13.2	-	12.8	27.9
241.6		4	2.36E-5	232	10.0	60.3	15.2	23.6
294.6		19	2.07E-5	114	17.4	29.8	16.6	24.1
352.3		36	1.79E-5	90	10.2	27.0	107	898.9
186.0	Ra^{226}	3.2	2.69E-4	427	4.2	9.2	5.2	246.6
92.3	Th^{234}	5.6	2.68E-4	724	0.6	-	2.2	7.3
143.6		9.7	2.83E-4	223	1.0	-	3.2	8.7

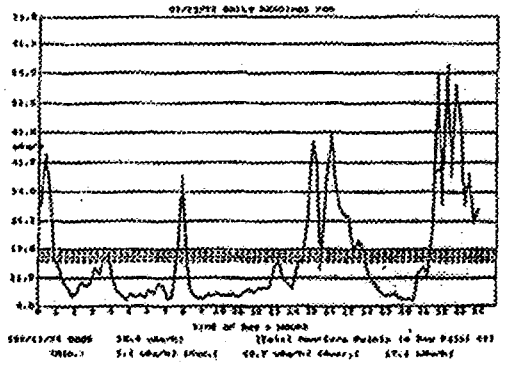


Sunny

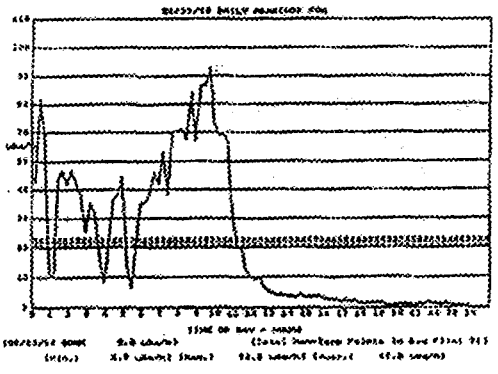


Cloudy

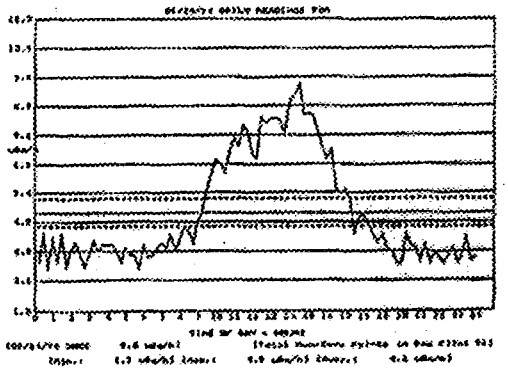




Reactor working



Reactor working



Sunny

Fig. (6) Activity measurements of air during 24 hr of Inshas environmental site.

To protect the inhabitants and workers, the radioactivity should be calculated as term source which is defined as the time dependent rate of radionuclide release from the facility to the environment [6]. Source term must account for the quantity of radionuclides found on the site, physical and chemical forms of radionuclides, leach rate.... etc. Once the concentrations of radionuclides have been determined in each environmental medium of concern, the dose to an individual can be calculated using pathways and dosimetery calculations and model. Pathway models convert environmental concentration to radionuclides intake rate for a person. Pathways can include ingestion of water or foodstuffs or inhalation of air borne contaminations [8]. The goal of pathways and dosimetery calculations is to calculate the effective whole body dose and doses to the individual organs for maximally exposed person. Many data are required for these models. For example guidance on appropriate food consumption rates, inhalation rate, bioaccumulation factors, atmospheric transport by Gaussian model should be taken into account. Thus the dose received to a person could be determined.So one can put the suitable measures that limit or mitigate the impact of the calculated dose.

It can be recommended that a model based on different pathways, such as infiltration, climatic condition, term, food chain, and dosometry, should be established to assess the dose.

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قياس إشعاعي بيئي لبعض المنشآت الصناعية في منطقة مفاعل أنشاص

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تم قياس المستوى الإشعاعي لبعض المنشآت الصناعية بموقع مفاعل أنشاص. أخذت عينات من البيئة مثل التربة والنبات والهواء من داخل وخارج المنشآت الصناعية بموقع أنشاص. تم حرق النبات عند درجة حرارة ٨٠٠ °م وتم قياس الرماد الناتج . . استخدمت فى عمليات القياس جهاز الجيرمانيوم عالي النقاوة واستخدم جهاز رصد المستوى الإشعاعي لتحديد المستوى الإشعاعي فى الهواء . وجدت تعيين بعض النظائر المشعة فى المواد الأولية المستخدمة فى كل مصنع. تم اقتراح برنامج وخطة لحماية الإنسان والبيئة المحيطة فى هذه المناطق.