Radiation Science and Technology
2021; 7(3): 47-52
http://www.sciencepublishinggroup.com/j/rst
doi: 10.11648/j.rst.20210703.11
ISSN: 2575-5935 (Print); ISSN: 2575-5943 (Online)

Detection of Activity Concentration, Dose Rate, Absorbed Dose and Effective Annual Dose of Radionuclide's Around Fertilizer and Pesticide Stores, Al-Jazeera Project in Sudan

Hafiz Fatelrahman Babeker Fadl Alla, Mahmoud Hamid Mmahmoud Hilo, Ahmed Al Hassan Alfaki

Department of Physics, Faculty of Science, Sudan University of Science and Technology, Khartoum, Sudan

Email address:

hafizfath@gmail.com (H. F. B. F. Alla), mahmoudhilo@gmail.com (M. H. M. Hilo)

To cite this article:

Hafiz Fatelrahman Babeker Fadl Alla, Mahmoud Hamid Mmahmoud Hilo, Ahmed Al Hassan Alfaki. Detection of Activity Concentration, Dose Rate, Absorbed Dose and Effective Annual Dose of Radionuclide's Around Fertilizer and Pesticide Stores, Al-Jazeera Project in Sudan. R*adiation Science and Technology*. Vol. 7, No. 3, 2021, pp. 47-52. doi: 10.11648/j.rst.20210703.11

Received: February 15, 2021; **Accepted**: March 26, 2021; **Published**: July 10, 2021

Abstract: This paper demonstrates the evaluation of radiological risk factors due to terrestrial radionuclides in soil, about the stores of pesticides and fertilizers for Al-Jazeera agricultural project in Al-Hasahisa, Sudan, to address the issue of the natural radioactivity of this area. Hence, levels of ^{226}Ra, ^{232}Th, ^{228}Ra, ^{40}K and 137Ci in the soil were calculated (by using germanium detector), and then the radiation risk parameters were calculated. its including radioactivity concentration Bq/kg, absorbed dose D, and effective annual dose E, its due to inhalation of radon (222Rn) and consumption of potassium (^{40}K), radium (^{226}Ra), radium (^{228}Ra), thorium (^{232}Th) and mean activity concentrations±deviation The norms for the five primitive radionuclides were, respectively, 268.98±5.22, 14.54±0.2, 15.31±1.54, 20.45±0.96, and 0.34±0.19 Bq kg^{-1}. This results somewhat normal distribution of the United Nations Scientific Committee on the Effects of Atomic Radiation. The results obtained indicate that some radiation risk factors appear to be unfavorable. The mean average absorbed dose±standard deviation (30.54±2.71) nGyh^{-1} was a slightly normal distribution of the average value of 30.54 nGy/ h, and the Average annual effective dose E (µSVyear^{-1})±standard deviation (37.48±3.32).) SVyear^{-1} was a slightly normalized distribution of the value of SVyear^{-1} its compared with the data of the United Nations Scientific Committee on the Effects of Atomic Radiation. The study focuses light on the demand to develop a comprehensive program for radiation protection in Sudan and in agricultural projects that constantly use pesticides and fertilizers for regulatory oversight.

Keywords: Activity Concentrations, Radiation Hazard, Soil, Stores of Fertilizer, Pesticides, Al Jazeera Agricultural Project

1. Introduction

Al-Jazeera Agricultural Project was established in 1925, the oldest project in Sudan and the largest irrigated farm in the world with an area of 2.2 million acres. The project runs across the states of the Aljazeera and the White Nile and Sinner along a length of 300 km. The project aims to exploit Sudan's share of the Nile water, transform the traditional agricultural area into modern agriculture, and raise the standard of living and health services by absorbing 15,000 farmers [1].

However, its negative impact makes it pollute the environment with pesticide residues in the living, human and animal environment. Pollution of human consumption of food, high incidence of acute and chronic poisoning and deaths due to pesticides, in addition to the high cost of pesticide control, especially in developing countries, Since phosphate fertilizers contain excessive amounts of radionuclide's and heavy metals, the use of prolonged mass can lead to a gradual contamination [2]. Ionizing radiation in the environment can be from natural or industrial sources, and industrial sources with the greatest extent in the use of chemicals that affect the environment of radioactive chemicals from pesticides and fertilizers, the people are exposed to ionizing radiation from radionuclides in the different types of natural source, Because of health risk associating with exposure to natural radionuclides, organizations such as the International, Local and International Radiation Protection Commission of the United

States Environmental Protection Agency (USEPA) -have standards and legislation to limit such exposure [3]. The annual effective dose worldwide for exposure to normal radiation is 2.4 m vs. [4]. However, the pesticides have negative and positive aspects, as they encouraged the introduction of agricultural investment doors, horizontal and vertical expansion, and a decrease in losses as a result of pests. Led to an abundance of agricultural food commodities for consumers, and also reduced erosion and dumping of soil erosion using herbicides as an alternative to the machine, the lack of clearly defined regulations for the management of soil animal waste and fertilizers the central government and provinces produce guidelines But these remain advisory and unenforceable [5]. Intensive use of the fertilizers can increase the amount of radionuclides in soil, groundwater and ingest ingestion by humans through the exposure pathways such as drinking water and food chain [6]. The main program carried out by a different radiation institute in order to build basic data on concentration of the radioactivity to be used as the reference in the event of any radiation incident, So many studies have been reported on the radioactivity and radiation dose of public exposure has been carried out in the different regions of Sudan for the cases in the northern region, the dose ranged from 44 to 53 nGy and the absorption rate and the annual effective dose ranged from 53 to 65 µsvy -1 [7]. In addition, another study found that the radiation uptake rate ranged from 7.1 to 84.6 nGy h^{-1} and the annual effective dose ranged from 8.7-103.7 µSvy^{-1} [8]. In the eastern Sudan the absorbed dose rate ranged from 24 to 48 with the average value of 38 nGy h^{-1}. In the central Sudan it is estimated that air intake dose at 1 m height is 31 to 47 nGy h^{-1} and annual effective dose is 6 to 47.8 Svy -1. In the western Sudan, a national environmental radiation monitoring program has been surveyed where the absorbed dose has found to be ranged from 500 to 7000 nGy h^{-1} [9]. Culture conservation by farmers or Non-governmental organizations that can promote these barely exist. There is however great potential for improving the efficiency of agricultural practices while maintaining productivity and reducing risks to the environment. For example, improving soil management, fertilizers, chemical fertilizers and irrigation can be more than matching crop requirements and reducing the risk of losses to air and water [5].

2. Surface Soil Quality

Considered soil factors and characteristics of the surface soil of the important components of agricultural environment. It supports the soil surface and subsurface to perform many of the functions of agriculture and human development. Understanding these factors would help to realize the values provided by our land and our land for mankind [10]. The environmental pollution and the food safety of the most important issues of our time. We have the effect of the soil and water pollution in particular, historically on the food which represents a significant threat to the human health safety, Although the current use of the pesticides is a less likely threat to the environment and the human than ever before but these adverse effects are still major long-term concern [11]. The good soil physical quality characterized by availability of soil airing and water and has feudal of a mechanical resistance to prolifration of roots [12] soil assessment is all ways conducted by farmers, and constantly in an agricultural view. Biological indicators have more effect on soil than other physical and chemical indicators. therefore, the quality of soil can be described mainly by its biological indicators. concequently, most aspect of demographic development in the world mainly depend on the soil quality, we need to provide sensitive and accurate tools to assess changes in soil quality in a short time scale. To assess changes in soil quality in the shortest possible period of time we need to provide sensitive and accurate tools [13], The potential productivity of the soil should have a useful tool for evaluating the effects of soil management and assisting officials through management decisions that improve crop production and soil management as required [12]. Considered soil factors and characteristics of the surface soil of the important components of agricultural environment. It supports the soil surface and subsurface to perform many of the jobs in agriculture, economic and human developments [10]. To assess soil management impacts and biological, chemical and physical soil health indicators of productive crops is a proactive process of soil quality assessment (SQ) [14]. The productive agricultural soil ecosystem refers to the soil quality because the surface of organic matter is necessary to combat soil erosion on the surface of the earth [15]. Volatility is determined by the soil, the main indicators of its own evaluation, and guidelines could be developed for the management, constraints, and requirements necessary to improve productivity can be identified

Site. Good understanding of the volatility of the soil, The task of crop production capabilities because it allows decision-makers and farmers to apply more rational agricultural techniques. This rational crop management techniques include the application of fertilizers to produce higher crop yields as well as to reduce the risk of nutrient loss [16]. Cuts represent human origin in soil health, the individual components of the quality of the soil, a source of concern environmentally urgent. A conference was held on "soil health: biological management component of the quality of the soil, Helping to raise awareness of great importance and benefit on soil components and are considered as indicators of soil quality and health as it happened in the United States in November 1998, The indicators of soil quality and health must be understandable and useful to the officials of the lands and they have the final decision on soil quality. The living organisms visible such as earthworms, insects, and mold has historically met this standard. Finally, indicators must be easy and inexpensive to measure, but need to know the complexity of measuring the classification of organisms in the soil [17] To determine preventive measures against agricultural pollution of water systems, it is necessary to prevent and measures from the competent authorities to fertilize the soil in permissible and non-polluting proportions of the soil [18] There is a modern assessment of soil quality on the basis of many biological characteristics, not just a few of them, which lead to the complexity of the systems and the unclear results on which the assessment of soil quality is based [19, 20].

3. Material and Methods

3.1. The Study Area

Fertilizers and pesticides stores are located in Al-Jazeera agricultural project west of Al-Hassa city, and in Qureshi station, 4 km north of Al-Hassa city. These stores are located on an area of about 2 kilometers from the land, and the number of these stores about eight stores very large area of one store 40 m in 120 and at a height of approximately six meters, and the distance between each Jabalon and the other approximately 20 meters, These stores have a wall from the north and south side only, but from the west side and the way does not have a wall, as well as there are some residential areas very close to them as a Qurashi station located 500 meters from these stores in the south-west of these stores, while the other residential areas farther compared In Qurashi Station Area, There are also some random places that are almost adhered to these stores and used for food and tea vendors for the workers of these stores and those who cross the road, and owners of heavy vehicles located in that place.

3.2. Preparation of the Samples

80 soil samples were randomly taken from four locations in a direction north, south, east and west for pesticide and fertilizer stores for Al-Jazeera agricultural project near Al-Hasahisa city in Al-Jazeera state, Sudan, using Oker soil sampling device (20 -25) cm deep in Samples were taken from different locations of the earth to obtain stable natural soil approximately 200 meters for each direction from the source. 0.5 kg was taken for each sample from the four sides of the source. A homogeneous powdery powder was obtained to classify and sort the samples [21]. Samples were then placed with half a kilogram Marinelli beakers, and its obtain a secular balance between the thorium and radium contents in all samples and their daughters, all cups were sealed tightly for approximately 28 days [22].

3.3. Instruments

The high-purity germanium detector is of the type, it is coaxial and works with an efficiency of 37%, it is multi-channel in the analysis, and there are 16384 channels made by a company Baltic Scientific Instrument Company with specific energy equivalent to 1.95 kilovolts for each line of energy, as for the precise energy for cobalt 60, which is equivalent to 1332.52 photons produced at the source. Calibration quality control was performed using standard reference materials for soil by the International Atomic Energy Agency - 226 and the International Atomic Energy Agency - 375. Accordingly, the operating system was calibrated and accordingly the concentration of natural radioactivity is approved by the International Atomic Energy Agency [23].

3.4. Samples Analysis

80 soil samples weighing 500 g were collected from different areas of the fertilizer and pesticide stores of Al-Jazeera Agricultural Project in Al-Hasahisa area. The samples were crushed and screened and placed in plastic cans and were closed tightly for a period of four weeks to get rid of the radon element. The germanium detector was calibrated by investigation by collecting spectra data from standard sources with energies ranging from 0.25 to 2.62 MeV. Then, the energies at the top of the number of different spectra were recorded for every 900 seconds, and the values of the energies were compensated in mathematical equations to obtain the concentration of the elements in the sample.

Figure 1. *Map of stores of fertilizer and pesticides Al-Jazeera agricultural project.*

4. Computation of Radiation Hazard Parameters

4.1. Soil Activity Concentration

In order to discover the activity in the soil sample, the lower limit of this activity must be known, and the lowest readings of the activity of the elements in the sample were as follows: 2.7 for radium-26, 9.2 for thorium-232, 0.2 for potassium-40, and this was done with the mathematical relationship attached below [3]

$$Ac\left({}^{Bq}\!/_{kg}\right) = Cn\Big/P_{\gamma}\,M\varepsilon \qquad (1)$$

if it was:

Pɣ=the absolute transmission probability of the specified rays

Cn=net count rate below the corresponding peak

e=Detector efficiency at specified ray-power

Ac=the concentration of radionuclide activity in a sample

Soil (Bq / kg)
M=mass of soil sample (kg)

4.2. Calculation of Measurement of the Radioactivity Concentration of the Absorbed Dose Rate for the Stores of Fertilizer and Pesticides

The concentration of radioactivity is calculated from the conversion of the incident rays to a material from a radioactive body after the material absorbs this radiation and results in the absorbed dose nGy/h per Bq/kg for the following elements 40 K, ^{232}Th and ^{226}Ra which are 0.0414, 0.623 and 0.461, respectively, and the absorbed dose can be calculated The kidney is in the air by applying the above factors in the equation below (2) (UNSCEAR, 2008).

$$D(nGy/h)=(0.461A_{Ra})+(0.623A_{Th})+(0.0414A_K) \quad (2)$$

The concentration of radioactivity can be described by unit (Bqkg-1) of the elements of potassium, radium and thorium in soil samples as follows: A_K, A_{Ra}, $A_{Th,}$ [21].

4.3. Calculate the Effective Annual Dose (E)

The estimation of the effective annual dose rates from the stores of fertilizer and pesticides, when converting the absorbed dose into the effective annual dose, a conversion factor of 0.7SvGy-1 and an external occupancy factor of 0.2 must be present. These factors were established by (UNSCEAR, 2008) and on this basis the effective annual dose is calculated in unit Sv/y with the relationship below. (3) [21]

$$E(\mu Svy^{-1})=D(nGh^{-1})\times 24h\times 365.25day\times 0.2\times 0.7SvG/y\times 0.001 \quad (3)$$

5. The Results and Discussion

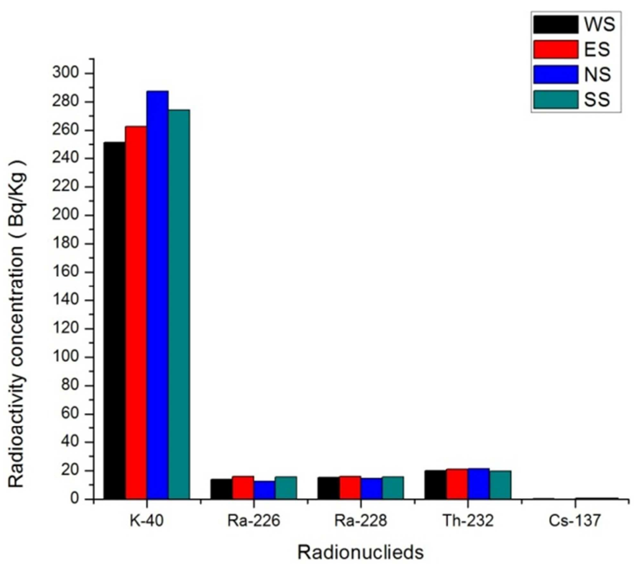

Figure 2. *The activity concentration of the natural radionuclide's ^{40}K, ^{228}Ra, ^{226}Ra, ^{232}Th, ^{137}Cs Soil samples were measured around fertilizer and pesticide stores for this work.*

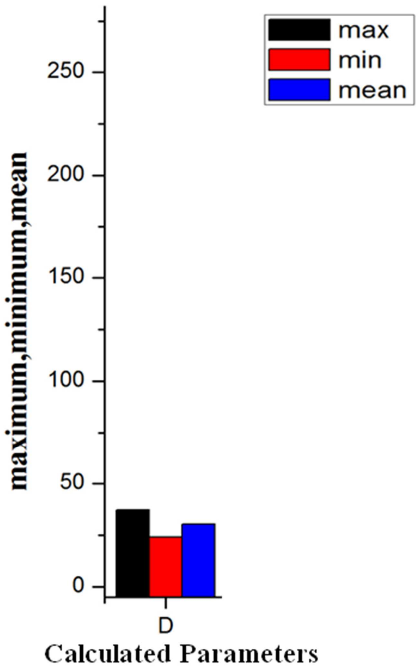

Figure 3. *The statistical figure showing the risk index for effective annual dose E (µSv/y) and absorbed dose D (nGy/ h).*

The activity was found to concentrate radionuclide's in units of Becquerel per kilogram of elements of potassium 40, radium 226, thorium 232 and cesium 137, as well as radium 228, which were naturally produced in soil samples from residential areas near stores of fertilizers and pesticides in Al-Jazeera agricultural project. The activity concentrations of the soil samples varied its range of ^{40}K, ^{226}Ra, ^{228}Ra, 232 Th and ^{137}Cs vary from 232 - 321.75 Bq/ kg for 40 K, 11.6 - 18.33 Bq/ kg for ^{226}Ra, 6.7 - 24.05 Bq/ kg for ^{228}Ra, 14.43 - 27.98 Bq/ kg for ^{232}Th, 0 - 1.37 Bq/ kg for ^{137}Cs.

The soil samples showed the concentration of activity in the range Specific to each element, and the average activity concentration in this study was 268.98 Becquerel / kg for the element potassium, 14.54 Becquerel / kg for the element radium 226, 15.31 Becquerel / kg for the thorium element, and the average radioactivity concentration of the above elements was compared with the global readings of the average radioactivity concentration and were as follows 400 Becquerel / kg for potassium, 35 Becquerel / kg for radium 226, 30 Becquerel / kg for thorium, compared with the report of the United Nations Scientific Committee on the Effects of Atomic Radiation [23]. The average values of the radioactivity concentration in this study of the radioactive samples that appeared in the soil appear to be very small compared with the United Nations report and some previous studies. There are some phenomena for the values of radionuclide activity, such as potassium 40, which is naturally produced from the remains of fertilizers and pesticides, plant residues and animal wastes in the soil in the study area, and given the soil samples in which fertilizers, pesticides, industrial fertilizers and other agricultural and animal wastes are abundant, which leads to a change in the concentration of radionuclide activity in them. In this study, the rate of absorbed dose of radionuclide's was obtained as well as the calculation of the average annual effective dose of the radioactive elements that appeared in soil samples which are ^{40}K, ^{226}Ra, ^{228}Ra, ^{232}Th and ^{137}Cs. The dose absorbed in the air was in the range between 10.7 to 156.4 nGy/ h, when its mean was 56.9 nGy/ h, according to the report of the United Nations Committee on the Effects of Atomic Radiation. The calculated of the absorbed dose rate values±deviations (SD) of 30.54±2.71 nGy/ h. In the study area, it was found that the average values obtained are much less than the average global values permitted by the UN committee that is concerned with the effects of radiation. the absorbed dose around the residential areas near the stores of fertilizer and pesticides, Al Jazeera agricultural project. The annual effective dose were determined to be average of 42.70 from 115.49 µSv /year with an average of 37.48±3.32 µSv/ year. And minimum 29.4 µSv year-1, and maximum 45.72 µSv year-1. It turns out that most of the values for the effective annual dose rate are much less than the permissible limit set by the International Committee for Radiation Protection by one mSv per year.

6. Conclusion

In the conclusion of this research, the concentration of radioactivity of radium nuclides 226, radium 228, terium 232 and cesium 137 around the stores of fertilizers and pesticides for the Al-Jazeera agricultural project in Hasahisa area was less than the average global natural levels for all radionuclide's, as well as the average for calculating the absorbed dose in this study, which is less than the average global value of the International Committee For the prevention of atomic radiation, as well as the average absorbed dose rate and the annual dose effect rate for this study is very small compared to the global average, and this indicates that the distribution of radionuclide's in soil samples for that area is a normal distribution.

In order to protect human health and the environment from the harmful effects of radionuclide's that result from the imposed use of fertilizers and pesticides on the soil, the supervisory authorities in the field of radiation protection must develop devices in the field and raise awareness of the optimal use of fertilizers and not overuse them.

References

[1] Chandrajith, Rohana, et al. "Natural radionuclides and trace elements in rice field soils in relation to fertilizer application: study of a chronic kidney disease area in Sri Lanka. J" Environmental Earth Sciences (2010): 60.1, 193-201.

[2] Chauhan P, Chauhan RP, Gupta M. Estimation of naturally occurring radionuclides in fertilizers using gamma spectrometry and elemental analysis by XRF and XRD techniques. Microchemical J. (2013), 106: 73-8.

[3] IDRISS, Hajo, et al. Environmental impact assessment of natural radioactivity around a traditional mining area in Al-Ibedia, Sudan. Archives of environmental contamination and toxicology, 2016, 70.4: 783-792.

[4] Bai H, Hu B, Wang C, Bao S, Sai G, Xu X, Zhang S, Li Y. Assessment of Radioactive Materials and Heavy Metals in the Surface Soil around the Bayanwula Prospective Uranium Mining Area in China. International journal of environmental research and public health. (2017), 14 (3): 300.

[5] Smith, Laurence, et al. "Mitigation of diffuse water pollution from agriculture in England and China, and the scope for policy transfer. J " Land Use Policy (2017): 61, 208-219.

[6] Hassan NM, Chang BU, Tokonami S. Comparison of Natural Radioactivity of Commonly Used Fertilizer Materials in Egypt and Japan. Journal of Chemistry. (2017), 2017: 1-9.

[7] Einas H. O., SalihI and A. Khatri Sam., GIS mapping and assessment of terrestrial gamma-radiation in Northern state, J. Radiation Protection Dosimetry. (2012), 3 (151): 1-11.

[8] Wisal B. Hassan., Habbaniand F. I and Shaded I. A., Investigations of environmental radioactivity in the northern state of Sudan, Sudan Journal of Science. (2013), 2 (5). 83-93.

[9] Fadol N, Salih I, Idriss H, Elfaki A, Sam A. Investigation of natural radioactivity levels in soil samples from North Kordofan State, Sudan. Research Journal of Physical Sciences. (2015), 3 (7): 1-7.

[10] Usman S. Surface soil factors and soil characteristics in geo-physical milieu of Kebbi State Nigeria. Eurasian Journal of Soil Science. 2016 Jan 1; 5 (3): 209-20.

[11] Lu Y, Song S, Wang R, Liu Z, Meng J, Sweetman AJ, Jenkins A, Ferrier RC, Li H, Luo W, Wang T. Impacts of soil and water pollution on food safety and health risks in China. Environment international. 2015 Apr 1; vol 77: 5-15.

[12] Tormena CA, Karlen DL, Logsdon S, Cherubin MR. Corn stover harvest and tillage impacts on near-surface soil physical quality. Soil and Tillage Research. 2017 Mar 31; vol 166: 122-30.

[13] Bastida F, Zsolnay A, Hernández T, García C. Past, present and future of soil quality indices: a biological perspective. Geoderma. 2008 Oct 31; 147 (3-4): 159-71.

[14] Karlen DL, Stott DE, Cambardella CA, Kremer RJ, King KW, McCarty GW. Surface soil quality in five 51 idwestern cropland Conservation Effects Assessment Project watersheds. Journal of soil and water conservation. 2014 Sep 1; 69 (5): 393-401.

[15] Franzluebbers AJ. Soil organic matter stratification ratio as an indicator of soil quality. Soil and Tillage Research. 2002 Jul 1; 66 (2): 95-106.

[16] Min XI, Bingzi ZH, Xiying HA, ZHANG J. Soil quality in relation to agricultural production in the North China Plain. Pedosphere. 2015 Aug 1; 25 (4): 592-604.

[17] Doran JW, Zeiss MR. Soil health and sustainability: managing the biotic component of soil quality. Applied soil ecology. 2000 Aug 1; 15 (1): 3-11.

[18] PAVLIDIS, George; TSIHRINTZIS, Vassilios A. Environmental benefits and control of pollution to surface water and groundwater by agroforestry systems: a review. Water resources management, 2018, 32.1: 1-29.

[19] Paz-Ferreiro J, Fu S. Biological indices for soil quality evaluation: perspectives and limitations. Land Degradation & Development. 2016 Jan; 27 (1): 14-25.

[20] Jorge Paz-Ferreiro, Shenglei Fu. "Biological Indices for Soil Quality Evaluation: Perspectives and Limitations", Land Degradation & Development, 2013.

[21] UNSCEAR (United Nations Scientific Committee on the Effect of Atomic Radiation) (2008) Sources and effects of ionizing radiation. Report to the General Assembly, New York, United Nation.

[22] DIAB, H. M., et al. Evaluation of natural radioactivity in a cultivated area around a fertilizer factory. Journal of Nuclear and Radiation physics, 2008, 3.1: 53-62.

[23] UNSCEAR. (2000). Sources and effects of ionizing radiation. United Nations scientific committee on the effects of atomic radiation. New York, USA: United Nations Publication.