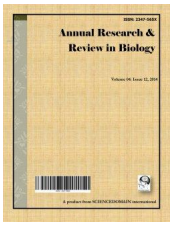

Annual Research & Review in Biology

18(4): 1-9, 2017; Article no.ARRB.36640
ISSN: 2347-565X, NLM ID: 101632869

Radiation Pollution and Cancer Risks in Sulaimaniyah and Ninawa Cities, Iraq

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Authors' contributions

This work was carried out in collaboration between all authors. Author SAM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FHS and BAA managed the analyses of the study. Author BAA managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2017/36640
Editor(s):
(1) Eugene A. Silow, Institute of Biology, Chair of invertebrate zoology and aquatic ecology Sukhe-Baator str., 5, Irkutsk, 664003, Russia.
(2) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.
Reviewers:
(1) Umar Afegbua Kadiri, Centre for Geodesy and Geodynamics, Nigeria.
(2) R. D. Mavunda, South Africa.
Complete Peer review History: http://www.sciencedomain.org/review-history/21423

Original Research Article

Received 5th September 2017
Accepted 10th October 2017
Published 16th October 2017

ABSTRACT

Pollution is the entry of contaminants into the environment or ecosystem which causes adverse change. The severe cases of radiation contamination lead to changes in DNA leading to genetic mutation, as happened in Hiroshima and Nakzaki in Japan and Chernobyl. Radioactive contamination in Iraq was resulted in the recent wars (1991-2015), because of uranium munitions. It is led to serious environmental and health disasters such as cancer, leukemia, and birth defects. The Iraqi Ministry of Environment has indicated that more than 300 sites in Iraq were polluted by mercury pesticides, heavy metals, polyol, chlorine, and depleted uranium, because of the abandoned weapons in some parts of Iraq from the remnants of the wars that have occurred in the Iraq.

Keywords: Radioactivity; DNA; pollution; uranium.

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1. INTRODUCTION

Pollutants can be a foreign substance or naturally occurring contaminants, then making land, water, air, dirty and not suitable to use or safe [1,2]. Radiation sources are divided into two main sources: natural source (natural radiation) and industrial source (industrial radiation) [3]. Natural radiation occurs spontaneously without humans, as there are elements in nature called radioactive isotopes (unstable) [4]. Which contains the excess energy produced by the protons and neutrons that form the nuclei of those elements, and when it reaches stability, it releases nuclear particles called alpha, beta and neutrons and electromagnetic radiation called gamma until it reaches the stage of stability, forming a stable nucleus of birth [5].

These elements are uranium and thorium, both of which are present in the outer crust of the Earth [4], and are also more concentrated in the volcanic rocks than in the sand rocks and also the crust contains ^{40}K [6]. Examples of natural radiation are also the rise of radioactive gases (^{222}Rn and ^{220}Rn) from the earth's crust and from buildings, especially concrete, as a result of the decomposition of radioactive materials [6,7]. Inhalation of the air that contains these gases affects the cells of the body [8]. Mineral water areas, black sand regions, and lava rocks are considered to be the most highly concentrated areas of radioactivity [9]. Radiation is artificial, which happens as a result of human action, where a man changes the neutron-proton (n:p) ratio of 1:1 for stable isotope into either 2:1 or 1:2 for unstable isotope in atoms and converts these atoms into a radioisotope. These operations occur in various nuclear research centers and atomic testing stations [10]. As nuclear reactors became 480 atomic reactors worldwide until 1992 [11]. As this radiation can be used peacefully in the field of medicine, energy generation, industry, agriculture, scientific research, and taking into account the safe ways to deal with it [12]. If these materials were used in the production of nuclear weapons and atomic bombs and did not follow precautions and security instructions in dealing with this type of radiation, they can destroy the environment and human together [13].

For example, increasing the concentration of naturally radioactive materials through various processes to extract the oil which increases the natural radiation in certain areas. This is observed in the oil-producing areas in Iraq where the cancerous diseases were spread [14], such as the city of Ninawa because of the major sites for the production of oil which has increased. This is a health hazard even in the neighboring regions, which requires finding the proper scientific methods to eliminate or minimize their impact. As well as the processes used to obtain nuclear fuel and enriching uranium and turn it into a paste using complex operations in the production of very massive amounts of depleted uranium which are disposed of as radioactive waste or are used in military operations, as happened in the war in Iraq of more than 20 years.

There are high rates of natural radioactivity in some regions of the world due to the different geological structure of those areas from other areas. Other natural sources are cosmic rays, which vary depending on the height of the place above sea level [3] and depending on the geographical location. The atmosphere is a protective barrier of that radiation, and some of the radioactive material is formed in the atmosphere as a result of the interaction of other substances with their components [15].

Sources of small-scale industrial radiation contamination can be treated in simple scientific ways and do not require high precautions [16]. There is a large-scale industrial pollution that cannot be controlled except through the recommendations of international organizations that are specialized in this field and require significant international cooperation to reduce health and economic risks [16]. Over the past decades, especially in the last century, there has been evidence such as Hiroshima, Nagasaki, and Chernobyl indicating radiation contaminants [5]. Human exposure to radioactive material from the fall of atomic dust from atomic bombs [17]. The radioactive materials found in food and inside the human body are natural, such as ^{14}C, ^{40}K, ^{226}Ra, and ^{90}Sr. Bacteria, fungi, and viruses are the cause of food contamination, food preparation methods, stages of manufacture, storage and distribution have become an important part of the increase of cancer by food [18]. Pollution by pesticides, sewage and industrial increases the concentration of lead, zinc, and iron, which is concentrated in vegetables and fruits [19], as shown in Fig. 1.

Cancer may result from a viral infection or bacteria or parasites and usually occurs in animals and birds, 12% of cancer occurs due to infection of viruses such as HPV, hepatitis, lymphoma, leukemia, and uterine cancer [21]. The study problems are: Do successive wars on

Iraq (1991-2015) have a role in radioactive and food contamination? Is the radiation and food contamination have an impact on cancer in Iraq? The most common cancer in Iraq is lung cancer,

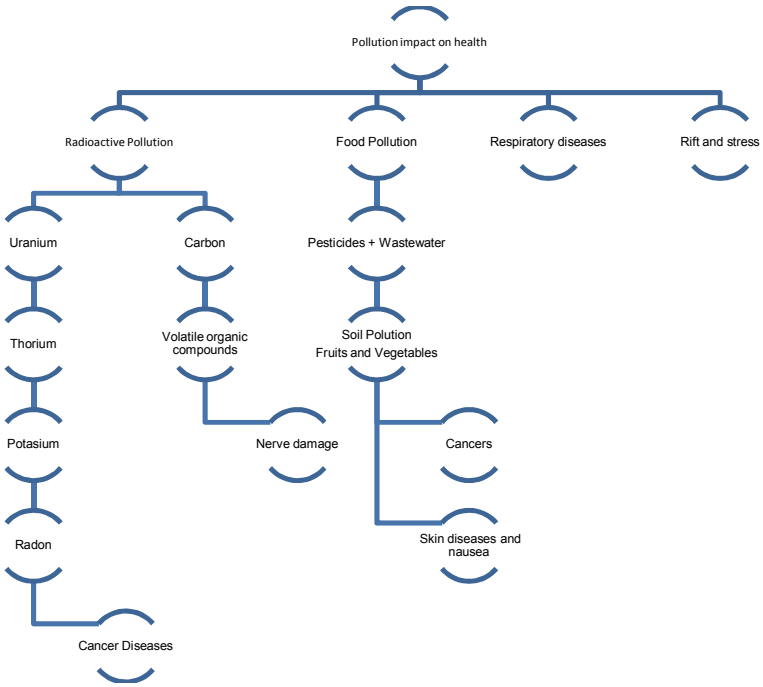

Fig. 1. Health pollution [20]

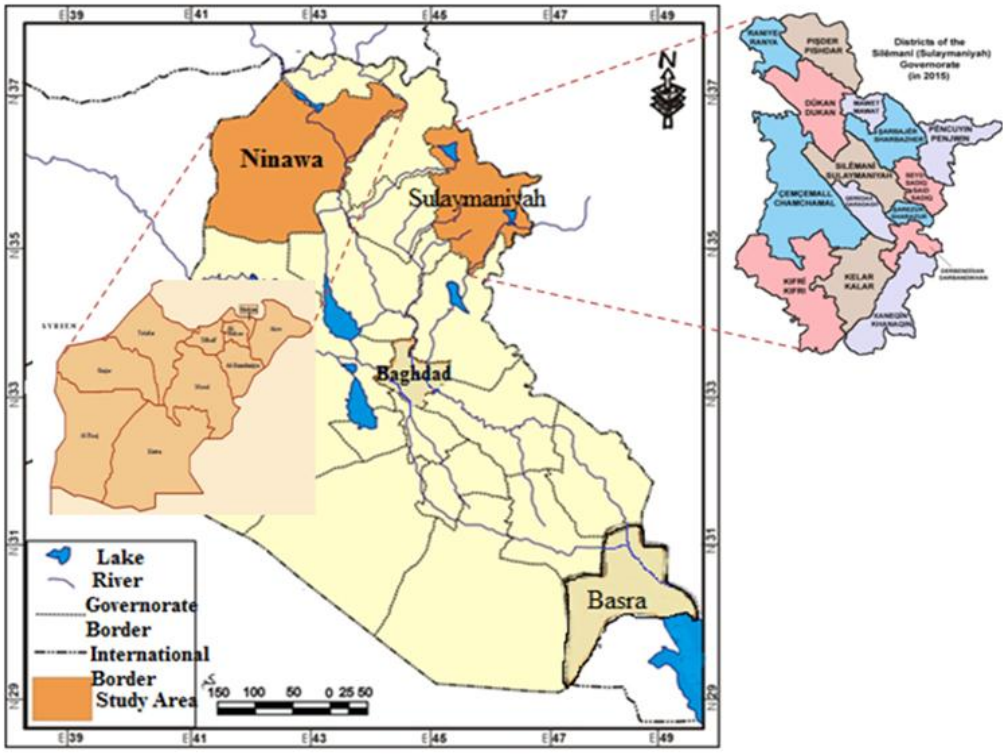

Fig. 2. Administrative Iraq's map (Scale of 1: 1,000,000)

Source: design of authors based on iraq's administrative map, general authority of survey, 2010

breast cancer, prostate cancer, colon cancer, pancreatic cancer, brain cancer, lymph cancer, leukemia, stomach cancer, liver cancer.

2. MATERIALS AND METHODS

2.1 Study Area

Iraq is a federal parliamentary republic according to the Constitution of Iraq and consists of eighteen provinces and its capital in Baghdad. Iraq is one of the countries of West Asia, which overlooks the Arabian Gulf. It is bordered to the south by Kuwait and Saudi Arabia, to the north by Turkey, to the west by Syria and Jordan and from the east by Iran. It is a member of the League of Arab States, the Organization of the Islamic Conference and OPEC. Iraq's latitude and longitude are 33° 00' N and 44° 00' E. Ninawa is a province in northern Iraq and its center in Mosul, which is Iraq's second largest city and is 465 km away from Baghdad. Sulaymaniyah is located in the northeast of Iraq, bordered to the east by the Iranian border, to the south by Diyala province, to the west by the oil-rich province of Kirkuk, to the north of the Iranian border and by Erbil, as shown in Fig. 2.

2.2 Study Hypothesis and Methods

1. The wars in Iraq have an important role in the food pollution.
2. Food pollution by the chemicals and radioactive materials.
3. The relation of radioactive contamination during the recent wars (1991 to 2015) and cancer distribution in Iraq based on the data from the Ministry of the Environment.
4. The impact of the radioactive contamination in Iraq on the health of Iraqis.
5. Link the increase in cancer cases in Iraq to the depleted uranium used in the war in Iraq.

3. RESULTS AND DISCUSSION

A recent study confirms that 33% of the remnants of the Gulf War is rich in uranium oxides resulting from the explosion of tanks and armor. In 1996, the level of radiation in plants and animals in Basra was 14 times higher than the recommended level of safety by the World Health Organization [22-24]. Cancer patients from 1991 to 2011 were found to be 250146 cases, as shown in Table 1. Where the leukemia was 16729 cases. The International Medical Center for Uranium Research [25] shows that radioactive contamination in 2003 is widespread in all the cities of Central and South Iraq at a dangerous level and more than 30,000 times higher than the permissible limit [26]. Pollution was not limited to areas that were bombed but included remote areas.

Table 2 showed that the highest number of breast cancer was found in Sulaimaniyah of about 190 (17,24%) of the total number of injured (752). Colon cancer was about 104 and lung cancer was 95. While the lowest number was in lymphoma 34 (3.09%).

Sulaymaniyah city center has the highest number of breast cancer of 172 cases (90.53%), While the lowest number was in lung cancer in Halabja district (one injury). There was one injury in the city of Kalar in the lung, urinary tract and prostate cancers. In the districts of Penjwin and Chamchamal, there was only one injury in leukemia. In Sahl Rania, one injury was found in the blood, nervous system, urinary tract and prostate cancers. Sulaymaniyah city center has the highest number of cancer of about 671 cases (89.23%). Halabja district has 19 injuries (2.53%) and Penjwin district had 3 injuries (40%) (Table 3).

Table 4 illustrated that the highest number of breast cancer found in Ninawa, about 331 injured (17:39) of the total number of casualties in Ninawa. The highest number of cancer in Ninawa was in breast cancer of about 331 cases (17.39%) of the total number of cancer in Ninawa of about 1329 injuries. Whereas lung cancer was found to be 231 cases (12.14%), and leukemia 143 cases (7.51%). Liver cancer about 58 injured (3.05%) was less cancer in Ninawa.

Table 5 indicated that The number of cases of breast cancer in the center of Mosul was about 252 cases (76.13%) of the total number of injuries. The lowest number of breast cancer recorded in the urban district (one injury). Lung cancer recorded 174 injuries in the center of Mosul and the least casualties were in the urban district (one injury). The blood cancer recorded about 104 injuries in the center of the city of Mosul and the least injury was about two injuries in the districts of Telafar and Aqra. The total number of cases of all types of cancers was 976 cases. The number of cancer was about 1326, 128, 71, 46, and 35 in Ninawa, Telafar, Hamdaniya, Tilkaif, and Sinjar. The lowest number of injuries was recorded in Sheikhan and urban of about 14 injuries.

Table 1. Cancer and leukemia in Iraq (1991 to 2011) for all ages [27]

Year	Cancer	Leukemia	Male	Female	%
1991	5720	323	189	134	5.6
1992	8526	517	292	225	6.1
1993	8471	530	298	232	6.3
1994	7785	392	234	158	5.0
1995	7948	410	252	158	5.2
1996	8630	443	279	164	5.3
1997	8592	515	303	212	6.0
1998	9033	527	300	227	5.8
1999	8936	584	333	251	6.5
2000	10888	679	375	304	6.2
2001	13332	790	474	316	5.9
2002	13985	792	491	301	5.7
2003	11248	823	482	341	7.3
2004	14520	1392	796	596	9.6
2005	15172	964	535	429	6.35
2006	15226	1176	665	511	7.72
2007	14213	1226	677	549	8.6
2008	14180	960	555	405	6.77
2009	15251	908	506	402	5.95
2010	18482	1302	715	587	7.04
2011	20278	1476	839	637	7.28
Total	250146	16729	9590	7139	6.69

Table 2. Cancer patients in Sulaimaniyah, 2011 [27]

Cancer code	Cancer type	Cases no.	%	Percentage of 100000 cases
C1	Breast cancer	190	17,24	10.11
C2	Colon	104	9.44	5.53
C3	Lung and Bronchus	95	8.62	5.05
C4	Leukemia	78	7.08	4.15
C5	Nervous System and Brain	57	5.17	3.03
C6	Urinary Streams	53	4.81	2.82
C7	Prostate	52	4.72	2.77
C8	Stomach	50	4.54	2.66
C9	Thyroid	39	3.54	2.08
C10	Cancer of Lymph Glands	34	3.09	1.81
	Total	752	68.24	40.01
	Total Number	1102	100.00	58.64

Table 3. Cancer patients in Sulaimaniyah (2011) [27]

CC	Sulaymaniyah		Halabja		Panjwin		Sahl Rania		Dukan		Derbandikhan		Chamchamal		Kalar		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
C1	172	90.5	4	2.11	2	1.05	3	1.58	0	0	0	0	2	1.05	7	3.68	190	100
C2	91	87.5	5	4.81	0	0	3	2.88	0	0	0	0	2	1.92	3	2.88	104	100
C3	86	90.5	1	1.05	0	0	2	2.11	2	2.11	0	0	3	3.16	1	1.05	95	100
C4	69	88.4	2	2.56	1	1.28	1	1.28	0	0	0	0	1	1.28	4	5.13	78	100
C5	46	80.7	4	7.02	0	0	1	1.75	0	0	0	0	4	7.02	2	3.51	57	100
C6	50	94.3	0	0	0	0	1	1.89	0	0	0	0	1	1.89	1	1.89	53	100
C7	46	88.4	2	3.85	0	0	1	1.92	0	0	0	0	2	3.85	1	1.92	52	100
C8	45	9.0	0	0	0	0	2	4.00	0	0	0	0	0	0	3	6.00	50	100
C9	33	84.6	1	2.56	0	0	2	5.13	0	0	0	0	1	2.56	2	5.13	39	100
C10	33	97.0	0	0	0	0	0	0	0	0	0	0	0	0	2	2.94	34	100
Tot.	671	89.2	19	2.53	3	0.40	16	2.13	2	0.27	0	0	16	2.13	25	3.32	752	100

Table 4. Cancer in Ninawa (2011) [27]

Cancer code	Cancer type	Cases no.	%	Percentage relative to 100000 cases
C1	Breast cancer	331	17.39	10.12
C2	Lung and Bronchus	231	12.14	7.06
C3	Leukemia	143	7.51	4.37
C4	Nervous System and Brain	137	7.20	4.19
C5	Colon	108	5.68	3.30
C6	Cancer of Lymph Glands	104	5.47	3.18
C7	Stomach	94	4.94	2.87
C8	Urinary Streams	61	3.21	1.86
C9	Thyroid	59	3.10	1.80
C10	Liver	58	3.05	1.77
	Total	1329	69.68	40.53
	Total Number	1903	100	58.17

Table 5. Cancer in Ninawa (2011) [27]

CC	Mosul		Hamdaniya		Tilkaif		Sinjar		Telafar		Sheikhan		Elhoudhar		Akre		Baaj		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
C1	252	76.13	22	6.65	16	4.83	7	2.11	23	6.95	3	0.91	1	0.30	4	1.21	3	0.91	331	100
C2	174	75.32	15	6.49	6	2.60	2	0.87	23	9.96	5	2.16	1	0.43	3	1.30	2	0.87	231	100
C3	104	72.73	5	3.50	2	1.40	5	3.50	19	13.29	0	0.0	2	1.40	2	1.40	4	2.80	143	100
C4	94	68.61	4	2.92	4	2.92	1	0.73	22	16.06	2	1.46	3	2.19	2	1.46	5	3.65	137	100
C5	86	79.63	5	4.63	2	1.85	2	1.85	9	8.33	1	0.93	0	0.0	2	1.85	1	0.93	108	100
C6	71	68.27	10	9.62	6	5.77	2	1.92	8	7.69	0	0.0	4	3.85	1	0.96	2	1.92	104	100
C7	68	72.34	1	1.06	3	3.19	8	8.51	7	7.45	1	1.06	2	2.13	1	1.06	3	3.19	94	100
C8	40	65.57	3	4.92	4	6.56	3	4.92	7	11.48	0	0.0	1	1.64	0	0.0	3	4.92	61	100
C9	43	72.88	2	3.39	2	3.39	4	6.78	5	8.47	2	3.39	0	0.0	0	0.0	1	1.69	59	100
C10	44	75.86	4	6.90	1	1.72	1	1.72	5	8.62	0	0.0	0	0.0	0	0.0	3	5.17	58	100
Total	976	73.60	71	5.35	46	3.47	35	2.64	128	9.65	14	1.06	14	1.06	15	1.13	27	2.04	1326	100

4. CONCLUSIONS

Radiation contamination in food and water has a major role in cancer diseases in Iraq. Cancer diseases were found to be increased in Sulaymaniyah and Ninawa cities, Iraq. Leukemia among children and soldiers who participated in the battles was increased. Leukemia found to be in males more than females. Although the danger of radiation contamination in water and food is very low, the effects of the nuclear crisis are sure to be felt for next years.

ACKNOWLEDGEMENT

The authors acknowledge the financial support of the Kufa and Baghdad Universities, Iraq

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/21423