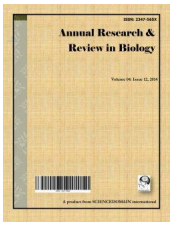

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Spatial and Temporal Variability of Environmental Radioactivity in Basra and Baghdad Cities, Iraq

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Authors' contributions

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

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ABSTRACT

Introduction: This research focused on study of the spatial and temporal variability of environmental radioactivity and impact of the pollution on the human health in Basra and Baghdad cities, Iraq.
Materials and Methods: Contamination is existence the contaminants in the natural environment, which is causing damage to it with a disturbance in the ecosystem. Contaminants are either foreign substances in the environment or natural substances but are exceeded the recommended levels. Pollution is not only associated with chemicals materials but also extends to various forms of energy, such as noise and thermal pollutions. Radioactive contamination is one of the most dangerous types of pollution on human's health. It has the ability to enter the human body and other organisms without warning. It is odorless, colorless, tasteless, and deadly. It was found in the air, water, soil.
Results: The food contaminations by the radioactivity result of using uranium munitions by the US

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military and its allies through the recent wars in Iraq (1991 to 2015). It was caused severe environmental and health disasters that led to cancer and increasing in the rate of birth defects.
Conclusions: Ministry of Environment (MOE) in Iraq has shown that over 306 sites were contaminated by mercury-containing pesticides and heavy metals such as phenol, chlorine, and depleted uranium, because of abandoned weapons in some the areas in Iraq.

Keywords: Radioactivity; Iraqi Ministry of environment; pollution; Hiroshima.

1. INTRODUCTION

The life was back to series of formation and transformations processes in several forms of the energy which is coming from sunlight [1,2]. There are two sources of the radioactive namely the normal and industrial sources [3-5]. Natural sources (U, Th series, and K) are coming from space (cosmic rays), soil, water, and air, these sources were existed around our world and in our bodies [6-8]. The concentration of natural radioactivity during the various operations of oil extraction was increased, this increasing was caused increase in the cancer cases in Iraq such as in Basra city [9-11]. There are high natural radiation rates in some regions of the world due to the several geological compositions in these areas [12]. Some radioactive materials were formed in the atmosphere because of interact of substances with their constituents, such as ^{14}C, which is formed through the interaction of cosmic rays with ^{14}N [13-15]. We can detect only gamma-ray directly and easily in the soil because of alpha and beta rays were absorbed. Which has low penetration range inside the external crust of soil. So the soil has priority for examination and investigation, especially the surface soil during the first days of contamination. The clay soil has the possibility of storage of radioactive materials more than sandy soil [4,5].

It is treated with simple scientific methods no need to take more measurements or high safeguard proceedings [3-5]. The industrial pollution of a wide range can be controlled only through the recommendations of international organizations in the radioactive field for reduce the health and economic risks [4]. During the past century, especially in the last decades, there was evidence to the radiation contaminants as found in Hiroshima, Nagasaki, Chernobyl. Also human exposure to industrial radioactive materials due to the fall down of dust from atomic bombs or emissions from nuclear energy [3,16]. ^{14}C, ^{40}K, ^{226}Ra, ^{210}U, and ^{90}Sr were found in the food and the human body [4,5]. The food contamination by the radiation materials leads to cancer. The environment can be polluted by pesticides and fertilizers, which is destructive for the health of organisms [17]. After opening the Iraqi borders with other countries to the traders after 2003 through the responsible authorities and the non-follow-up of the origin of imports without inspection of foodstuffs and production date led to increasing the cancer diseases [18]. The pollution through pesticides, sewage, and industrial led to increasing the concentration of lead, zinc, and iron in the plants such as vegetables and fruits [19,20]. The food exposes during the stages of industrialization to preservatives or polluting substances or to give the taste, smell, and flavor. All these substances have harmful effects on health when it has a high concentration. In addition to the effect of the components resulting from the process of packaging, storage, and cooling, which are caused serious damage to the human health [19, 20], as shown in Fig. 1.

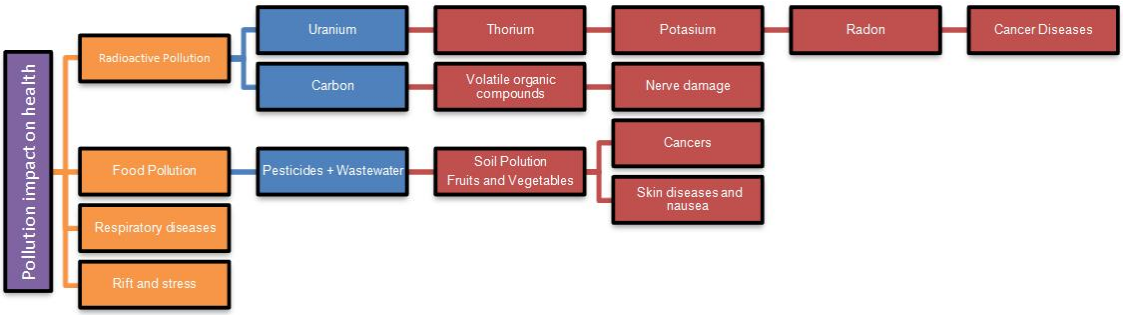

Fig. 1. Impact of the pollution on health [21]

Cancer is the main disease caused by food contamination. It means the growth and unlimited cell division, or the ability to divide the cells and destroy the neighboring tissues [22]. Cancer is an abnormal growth of the body tissue called tumor, so the tumor will occur in different types according to the tissue of the human. It shows weight loss, anorexia, and high body temperature. Cancer may result from infection by viruses, bacteria or parasites and usually occurs in animals and birds. Lung cancer was responsible for 28% of deaths and the most lethal of other types of cancer. The number of infected people in 2010 is expected to increase to more than 157,300 persons in the world among men and women [4,5].

Where the women were suffered from breast cancer more than lung cancer. The breast cancer began to decline after 1987, but still the most lethal in women and are expected to die about 40230 women in 2010 because of the breast cancer [20]. The prostate cancer is more common among men and the mortality is increasing with age (70 y) [22]. The colon cancer is the most common cancer in both men and women [23]. Whereas, pancreatic cancer is estimated to reaching of 4317 cases at the end of 2010. The brain cancer is an abnormal division of brain cells [24]. Lymphatic glands' cancer is growing in the lymphatic system and is divided rapidly and wildly [25,26]. Leukemia is the most common cancer among children (34%). This cancer has appeared in a large number of soldiers, who participated in the war against Iraq. Cancer of the stomach is a cancer spread in Iraq and takes the 7th rank of the number of infected [18,27]. The liver cancer was spread in Iraq and was ranked tenth among of the 10 cancer types [28].

1.1 Study Area

Iraq country was located between latitudes 29.05 and 37.23 to the north and longitudes 38.45 and 48.45 to the east. The study areas in this research were Baghdad and Basra cities, where the Baghdad is the capital of Iraq. The population of Baghdad, as of 2016, was 8,765,000, making it the largest city in Iraq. Basra is a governorate in the southern Iraq, bordering of Kuwait to the south and Iran to the east. The capital is the city of Basra as shown in Fig. 2.

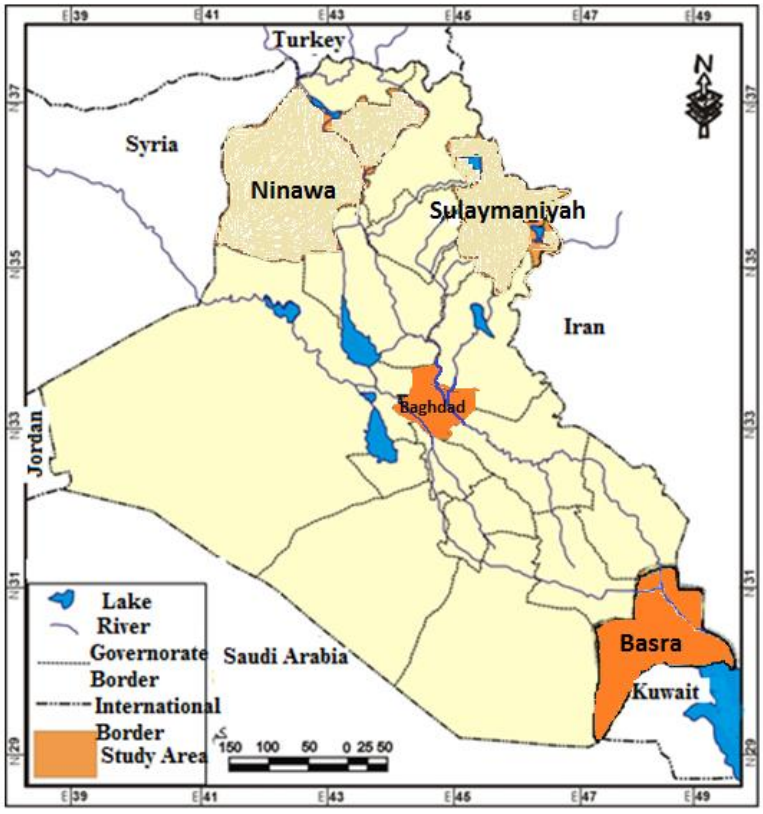

Fig. 2. Administrative Iraq's map. General Authority of Survey, 2010

2. STUDY HYPOTHESIS AND METHODS

We hypothesize herein that:

1. The successive wars in Iraq of the duration between 1991 to 2015 have an important role in the food pollution because of using the chemicals and radioactive materials.
2. Cancer was spread in Iraq because of food pollution by the chemicals and radioactive materials.
3. Radiation and chemical materials were distributed in areas surrounding of Basra and Baghdad during the second Gulf war at 1991 due to shelling by missiles and anti-tank bombs, which was coated with a layer of depleted uranium.
4. The impact of radioactivity in areas of Basra and Baghdad have clear value.
5. Cancer was increased in Basra because of production and extraction of oil, which is increasing radioactive materials concentration.
6. The pollution through pesticides, sewage, and industrial increases the concentration of lead, zinc, and iron in vegetables, fruits, and other plants.

Abhishek Bhandari, 2016 showed that colorectal cancer (CRC) found among young and adults in the USA [23]. Alasadi, 2015 showed that the pollutants in the different areas were at the recommended international levels [9]. The springs and quarries increase the background radiation dose rate in some locations were known as high-levels background radiation locations. The building materials in houses has the dose rate of background radiations [10]. The International Atomic Energy Agency (IAEA, 2005) was agreed to organize an international cooperative program for aid the Iraq country in this matter. The Iraqi Nuclear Facilities Dismantlement and Disposal Program were initiated by the U.S [24]. The fieldwork was conducted by a team from the US Uranium Research Center and international scientific institutions of some military operations areas of Iraq. The radioactive contamination in Baghdad and Basra was found. Where the level of contamination was reached of 10 times higher than the normal level.

3. RESULTS

A recent study on the Gulf war confirms that 33% of the war's remnants were rich by uranium oxides caused by the explosion of the tanks and armor. The level of radiation in plants and animals of 1996 in Basra was reached 14 times more than the recommended limits by the World Health Organization [25]. The rate of deformed birth in Iraq at the beginning of 1992 was increased with the increase of the cancer, especially in young who are more sensitive to the radiation than the adults. These casualties were occurred in soldiers from 1 to 106 cases of 1991 and 1996, respectively, especially leukemia. The cancer (1991 to 2011) was found to be 250146 injuries, as shown in Fig. 3. Whereas, leukemia was found to be 16729 injuries. The highest casualties were in males of 9590 cases because of the participation of soldiers in the war. The cancer was not restricted at bombed areas using depleted uranium, but it was included many areas, because the destruction of weapons in the Iraqi territory through a committee of international inspection and the Iraqi government led to the pollution of soil and water [26]. International Medical Research Center of Uranium showed that the radioactive contamination was widespread in all the cities of Iraq central and South in October 2003 dangerously, which is over 30,000 times higher than the recommended limit.

The most radioactive areas in Iraq were distributed of over 300 sites, but there were six sites more polluted. These sites were Mishraq in Ninewa city, where the sulfur and its compounds were concentrated. Khan Dhari site was located to the west of the city of Baghdad, which was the ethyl lead was concentrated. Awiridj site was located to the south of the city of Baghdad, where the heavy elements, phenol compounds, chlorine, and depleted uranium were concentrated. Qadisiyah site was located to the west of Baghdad and was contaminated by mercury pesticide. Kwersh site was contaminated by depleted uranium using in the weapons and military tanks. These sites have a significant influence on cancer in Iraq and are effect on DNA. The samples in this research were collected from Baghdad and Basra cities, where the majority of the remaining sites were contaminated by nuclear radiation [28]. Table 1 was showed the more injuries of breast cancer (264 cases) were in Basra of 939 cases (18.59%). Whereas, leukemia and lung cancers were 139 and 100 cases, respectively. The lower injuries were kidney cancer of 39 cases (2.75%) of the total cases.

Table 2 shows the cancer in the districts and aspects of Basra's city. The center of the city of Basra has the highest number of injuries of all

cancers. The breast cancer was 178 cases (67.42%) of the total number of 264 cases of this disease. The lowest number of injuries found to be 3 cases (1.14%) in FAO district. Colon cancer was found to be 76 cases in Basra's center and lowest injuries were 5 cases in FAO district, lung cancer was 47 cases in Basra's center and lower injuries were 1 case at FAO. The total number of cancer in Basra center was 545 (58.04%) and Zubair of 145 cases (15.44%). The lowest injuries were recorded in FAO of 13 cases (1.38%).

More injuries were breast cancer of about 1343 cases (23.01%) of the total cases of cancer (3936 cases) in Baghdad as shown in Table 3. Nervous and brain cancers were found to be 449 cases (7.69%) and lung cancer was 434 cases. Whereas the lowest cases were about 146 cases (2.50%) of thyroid of the total cases.

Table 4 shows that the highest injuries were concentrated in Baghdad and in the Rusafa district, compared with other districts and areas. Whereas the breast cancer was 410 cases (30.53%) in Rusafa. The lowest injuries were in Tarmiya of about 2 cases. Nervous and brain were found to be 165 cases in the Rusafa district and 2 cases in the district of Tarmiya. Lung and bronchial cancers were 111 cases in the Rusafa and 3 cases in the Tarmiya. The total number of cancer was found in Rusafa in Baghdad about 1,222 (28.54%) of 3931 cases. While, Karkh, Adhamiya, Kadhimiya, Mahmudiyah, and Tarmiya were 959, 516, 366, 141, and 13, respectively [27].

4. DISCUSSION

4.1 Radioactivity in the Study Area

1. Affect people who are directly exposed to this radiation, which leads to the cancer or the death.
2. Slow death will occur for the people who living in areas far from nuclear radiation.
3. The deformities will appear on future generations.
4. Long-term adverse effects can be caused by the air pollution, which is extends to the pollution of rainwater, and there is a radioactive rain that can cause deterioration of rivers, lakes, groundwater, and plants.
5. The contaminated agricultural crops will consume by the human
6. The animals' meat and milk will have contaminated by radioactive materials.
7. The contaminated materials by radiation coming from other countries are one of the indirect effects on us although we are geographically far from nuclear material.

The highest number of breast cancer was concentrated in the capital Baghdad due to the war on Iraq, which is similar to the Hiroshima. The radioactive materials that causes cancer is a real risk which is cannot be ignored or overlooked as it began to spread dramatically. International treaties for the reduction of radiation pollution and foods contamination (do not meet the international standards) have been proposed [29-35].

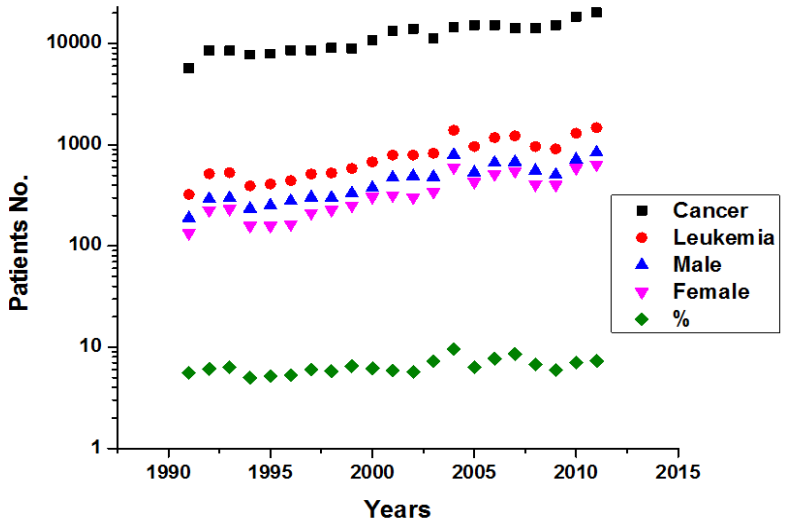

Fig. 3. Cancer and leukemia in Iraq (1991 to 2011) for all ages [27]

Table 1. Cancer in Basra (2011) [27]

Cancer code	Cancer type	Cases no.	%	Percentage relative to 100,000 cases
C1	Breast cancer	264	18.59	10.42
C2	Leukemia	139	9.79	5.49
C3	Lung and Bronchus	100	7.04	3.95
C4	Cancer of Lymph Glands	90	6.34	3.55
C5	Nervous System and Brain	85	5.99	3.36
C6	Urinary Streams	81	5.70	3.20
C7	Stomach	51	3.59	2.01
C8	Colon	49	3.45	1.93
C9	Pancreas	41	2.89	1.62
C10	Kidney	39	2.75	1.54
	Total	939	66.13	37.07
	Total Number (Cases of Remaining)	1420	100	56.06

Table 2. Cancer in Basra, 2011 [27]

CC	Basra		Khasyib		Zubair		Qurna		FAO		Shatt Al-Arab		Madaanh		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
C1	178	67,4	7	2.65	36	13.6	13	4.92	3	1.14	13	4.92	14	5.30	264	100
C8	76	54.6	13	9.35	18	12.9	8	5.76	5	3.60	6	2.27	13	4.92	139	100
C3	47	47.0	8	8.00	21	21.0	7	7.00	1	1.00	6	2.27	10	3.79	100	100
C2	45	50.0	6	6.67	18	20.0	7	7.78	1	1.11	4	1.52	9	3.41	90	100
C5	44	51.7	7	8.24	18	21.1	8	9.41	0	0	4	1.52	4	1.52	85	100
C6	45	55.6	2	2.47	13	16.0	11	13.5	1	1.23	3	1.14	6	2.27	81	100
Prostate	29	56.8	1	1.96	9	17.6	2	3.92	0	0	1	0.38	9	3.41	51	100
C7	30	61.2	6	12.24	3	6.12	3	6.12	2	4.08	3	1.14	2	0.76	49	100
Thyroid	28	68.2	3	7.32	5	12.2	0	0	0	0	2	0.76	3	1.14	41	100
C4	23	58.9	2	5.13	4	10.2	4	10.2	0	0	1	0.38	5	1.89	39	100
Total	545	58.0	55	5.86	145	15.4	63	6.71	13	1.38	43	16.29	75	28.41	939	100

Table 3. Cancer in Baghdad, 2011 [27]

Cancer code	Cancer type	Cases no.	%	Percentage relative to 100,000 cases
C1	Breast cancer	1343	23.01	19.03
C2	Nervous System and Brain	449	7.69	6.36
C3	Lung and Bronchus	434	7.44	6.15
C4	Urinary Streams	313	5.36	4.43
C5	Leukemia	302	5.17	4.28
C6	Colon	282	4.83	4.00
C7	Cancer of Lymph Glands	260	4.45	3.68
C8	Skin	206	3.53	2.92
C9	Stomach	171	2.93	2.42
C10	Thyroid	146	2.50	2.07
	Total	3936	66.92	55.34

Table 4. Cancer in Baghdad (2011)

CC	Rusafa		Adhamiya		Sadr City		Karkh		Kadhimiya		Mahmudiyah		Abu Ghraib		Madain		Tarmiya		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
C1	410	30.53	210	15.64	196	14.59	347	25.84	97	7.22	33	2.46	23	1.71	25	1.86	2	0.15	1343	100
C2	165	34.81	72	15.19	68	14.35	82	17.30	52	10.97	15	3.16	7	1.48	11	2.32	2	0.42	474	100
C3	111	25.58	37	8.53	67	15.44	97	22.35	58	13.36	29	6.68	12	2.76	20	4.61	3	0.69	434	100
C4	83	26.52	33	10.54	62	19.81	65	20.77	36	11.50	17	5.43	4	1.28	11	3.51	2	0.64	313	100
C5	70	23.18	43	14.24	61	20.20	68	22.52	27	8.94	16	5.30	9	2.98	7	2.32	1	0.33	302	100
C7	81	28.72	34	12.06	31	10.99	83	29.43	31	10.99	8	2.84	7	2.48	7	2.48	0	0.00	282	100
C6	73	28.08	23	8.85	50	19.23	66	25.38	20	7.69	9	3.46	11	4.23	6	2.31	2	0.77	260	100
C8	54	26.21	28	13.59	39	18.93	53	25.73	19	9.22	7	3.40	4	1.94	2	0.97	0	0.00	206	100
C9	35	20.47	22	12.87	33	19.30	52	30.41	15	8.77	6	3.51	3	1.75	4	2.34	1	0.58	171	100
C10	40	27.40	14	9.59	23	15.75	46	31.51	11	7.53	1	0.68	7	4.79	4	2.74	0	0.00	146	100
Total	1122	28.54	516	13.13	63	16.03	959	24.40	366	9.31	141	3.59	87	2.21	97	2.47	13	0.33	3931	100

5. SOME SOLUTIONS AND RECOMMENDATIONS

1. Design map of all areas which it has a high radioactive contamination in Iraq to prevent the access to it or the housing and agriculture.
2. The establishment of hospitals for the treatment of cancer, which is began to increase in the recent times.
3. Contracting with international companies of treating the cancer.
4. Early identification of breast cancer through the periodic examination.
5. Call the international media about areas affected by nuclear radiation or other pollutants.

6. CONCLUSIONS

The radiation and food contaminations have a major role in the spread of cancer in Iraq. The cancer was widely increased in Baghdad and Basra cities. The leukemia was increased among the children and also among the soldiers, who has participated in the battles. Leukemia was found to be in the men more than in the women. Breast cancer was found to be more than in the other cancers in the study area. The distortion cases were increased due to increased of radioactive contamination, particularly in the city of Basra.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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