Radiation Detection and Heavy Metals Measurements in Powdered Blood Sample of Leukemia Patients

Zakariya A. Hussein

Department of Physics, Faculty of Science and Health, Koya University, Koya KOY45,
Kurdistan Region - F.R. Iraq

Abstract—**This research examines the measurements of radiation detection and heavy metals in blood samples of leukemia and health groups using CR-39 nuclear track detectors and X-ray fluorescence. The results show that the minimum and maximum values of uranium contents found in leukemia blood samples of male (18 years) and female (55 years) patients, respectively. The concentration of heavy metals (Pb, Cd, and Ni) and radium contents is higher in leukemia blood samples, as compared with their concentration in healthy blood samples.**

***Index Terms*–Uranium concentration, Heavy element, leukemia, CR-39, X-ray fluorescence.**

I. Introduction

Natural uranium consists of three radioactive isotopes in the following proportions ^{234}U ^{235}U, and ^{238}U, all of which are decayed through alpha- and beta-emissions (Abdulwahid, et al., 2020).

Once uranium enters the human body, the soluble part will reach the blood and accumulate to some degree in all organs. The major health concerns related to the presence of elevated levels of uranium are radiation effects and toxicity effects. As a heavy, metal uranium is toxic to humans and animals and, in addition, poses a potential health risk from external and internal radiation exposure (Konishi, et al., 2019).

Uranium (U) is a naturally occurring radioactive element or as a result of human activities. Plus, it is the heaviest ingredient that occurs in large quantities. On the other hand, its concentration is higher than other toxic elements and it is present in varying amounts in the environment (Zou, et al., 2011).

Uranium has side effects when inhaled or ingested. Studies involving humans and animals have shown that inhaled insoluble uranium particles can cause serious respiratory effects. According to the World Health Organization (WHO), approximately 2% of uranium that enters the body through ingestion is absorbed, but 98% is excreted through faces, and inhaled uranium can be absorbed into the blood by more than 20% (WHO, 2011).

Heavy metals enter the body through our food and beverages (ingestion), the air we breathe (inhalation), and less frequently through what we touch (absorption). Certain metals may pose health problems if they are present at high enough concentrations. Measuring heavy metals in the body may help to determine whether or not they are harmful (Kortei, et al.,2020; Hussein, 2019).

Toxic elements in the body could pose long-term health risks due to chemical toxicity and radioactivity, depending on the pathway and extent of exposure to toxic elements which are a serious threat to the human health (Buxton, et al., 2019). Exposure to toxic prolonged exposure to lead (Pb), chromium (Cr), cadmium (Cd), copper Cu, and nickel (Ni) can cause deleterious health effects in humans, namely, chronic inflammatory conditions and a higher risk for several cancers, cardiac, and pulmonary and neurological diseases. This scenario has been aggravated by erroneous human intervention that has significantly changed their natural cycle and balance, causing abnormal accumulation and environmental pollution (Isabel, Mariana and Mónica, 2016).

Heavy metals can be detected in human fluids such as blood. The most common samples used to test heavy metals are blood because they best represent the substance (Mohsen and Abojassim, 2019). Insoluble heavy metals build up toxins in the human body that affect human life. Metals such as Pb, Cd, Ni, and Cu are very venomous accumulative metals that pose serious risks to the environment (Jae, Jang and Yu, 2022; Tiange, et al., 2021). Heavy metals can be considered one of the main sources of many health problems, as some minerals replace others in the body and thus affect the organic process in the human body (Dler, et al., 2022; Mohammed and Ahmed, 2017).

Blood is the body fluid that is usually examined as far as trace elements are concerned. The amount of trace element entering the bloodstream after absorption into the gastrointestinal tract depends on how chemically bound it is in the food substance (Kim, et al., 2021; Basu and Kulkarni, 2014).

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Corresponding author's email: zakariya.hussein@koyauniversity.org

Heavy metals are metals that cannot be readily degraded and therefore build up in vital human organs. This condition causes different degrees of illness depending on acute and chronic exposure. Low condensation of weighty metals causes harm to humans and other living creatures. There is not yet an efficient mechanism to remove it from the body (Mahugija, Kasenya and Kiluiya, 2018; Nah, et al., 2018).

Environmental pollution from toxic elements and the resulting long-term health effects are a great global health interest over the previous three decades, concerns about the effects of environmental pollution on public health have increased globally. Many health problems are linked to exposure to toxic elements, as people are exposed to toxic elements such as revolution (Ghorani, Riahi and Balali, 2016; Hussein, Jaafar and Ismail, 2013).

This study aims to detection the concentration of uranium and heavy metals (Pb, Cd, and Ni) in blood samples for leukemia patients and health groups at Erbil Governorate.

II. Materials and Methods

A. Samples Collection

The total number of blood samples for the leukemia patients and health group was 20 samples, female and male each one (ten samples). The blood samples for the leukemia patients group (ten samples) takes from the Nanakaly center of cancer in the Erbil governorate and the healthy group (ten samples) takes from the same governorate. The mean age of leukemia patients and health group is between 18 and 55 years. Blood specimens of 3 mL was taken from each leukemia patient and healthy groups were kept in the icebox (4°C) and then transfer to advance laboratories for heavy element analysis using the X-ray fluorescence (XRF) technique. Blood specimens were dried at 37°C for 5 h in an electrical laboratory oven (Adhraa, et al., 2019).

B. Reflection XRF

The spectrometry of XRF is the choice of generality petrologists and geochemists to obtain powder analysis (Ismail, Hussein and Sardar, 2020). This technique is intended for the speedy specific and specific investigation of great, minor, and trace components in a broad diversity of test types that do not require extensive training or experience on the part of the analyzer (Sergiusz, et al., 2021). To dry samples, the blood samples were heated with an electric heating incubator at 37°C for 6 h. The samples were placed in the chamber and measured with a 20 mm diaphragm under a vacuum (Rasha and Raghad, 2020). The spectrometer main unit consists of the sample chamber and the block unit. The chemical compositions of the samples were then measured from a computer program, as shown in Fig. 1.

C. CR-39 Nuclear Track Detectors

After collecting the blood samples from the patients and the healthy group, blood specimens were dried at 37°C for 5 h in an electrical laboratory oven (Hussein, 2015). The samples were put in the end of PVC tubes equipped with the nuclear track detector type CR-39 (Hussein, et al., 2013b). All detectors were steady at the top end of PVC tubes with a diameter of 1.5 cm and a length of 6 cm, as shown in Fig. 2, all tubes were stored for about 90 days in the Research Center of Physics Laboratory. The chemical etching method contained 6.25N of Na OH, distilled water, and a water bath was used for warming the etching at 70°C for 8 h. The detector is hung in Na OH by fixing the attached wire, on the cover or at the edge of the beaker, keeping the detector for the requisite time and the solution was shacked regularly during the time of etching (Adhraa, et al., 2019).

D. Calculation

To estimation of uranium concentration (ppm). We can obtain the uranium concentration in the samples by dividing W_U on the weight of the dry samples

$$C_U\left(ppm\right)=\frac{W_U}{W_S} \quad (1)$$

Also, we calculate the weight of uranium by equation (Elzain, 2014).

$$W_U=\frac{N_U A_U}{N_{av}} \quad (2)$$

Where, (N_U) is number of the sample at secular equilibrium can be obtained according to Podgorsak, 2005, A_U is the mass number of ^{238}U, and N_{av} is Avogadro's number.

III. Results and Discussion

Table I shows that the personal profile of patients, it is including location, age, and gender, also shows the results of uranium concentrations in blood samples for leukemia patients of Erbil governorate. The maximum and minimum uranium concentration in blood samples of leukemia patients was 1.15 ± 0.02 ppm for a female (55 years) and 0.12 ± 0.03 ppm for a male (18 years), respectively, and the average rate is 0.668 ± 0.28 ppm.

Table II shows the range value for uranium concentration of blood samples for the healthy group varied from 0.014 ± 0.002 ppm to 0.072 ± 0.008 ppm. The average value of uranium concentration in blood samples for leukemia patients is higher than the healthy group, as shown in Fig. 3, and this finding is in agreement with those of other researchers (Al-Hamzawi, Jaafar and Tawfiq, 2015).

Table III represents the average value of uranium concentration in the blood samples of male and female leukemia patients and healthy groups. From this table, the average value of uranium concentration of male and female leukemia patients group is 0.57 ± 0.03 ppm and 0.76 ± 0.02 ppm, respectively, while the average value of uranium concentration of male and female for the healthy group is 0.026 ± 0.08 ppm and 0.039 ± 0.05 ppm, respectively. The results showed that the average values of uranium concentration for female leukemia patients and healthy groups are higher than those for males. This is because the total blood volume in females is 4–5 L, while in

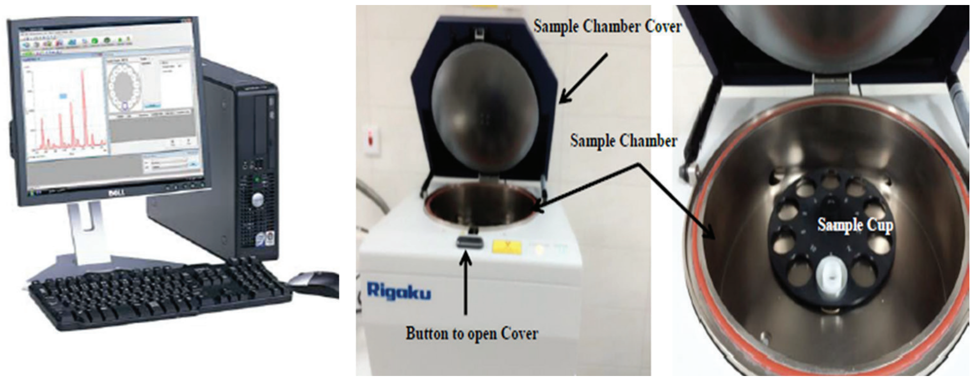

Fig. 1. X-ray fluorescence illustrates the sample chamber with their computer program.

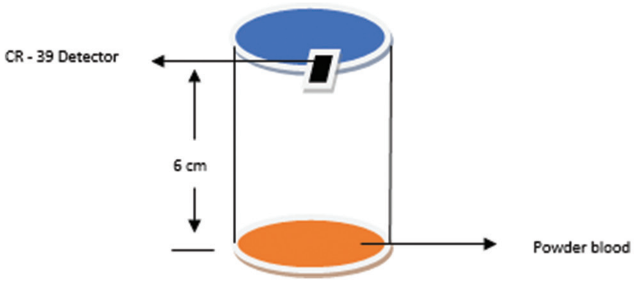

Fig. 2. Diagram of container for measuring uranium concentrations.

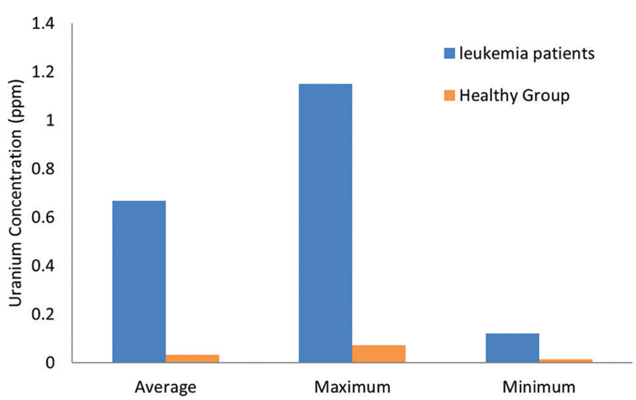

Fig. 3. Comparison of the uranium concentration between the leukemia patient and healthy groups.

males is 5–6 L (Basu, and Kulkarni, 2014). Results showed statistically significant in the uranium concentration with regard to gender in both groups ($p < 0.05$).

The heavy elements (Pb, Cd, and Ni) are investigated in the blood of 20 volunteers including ten samples for each leukemia patient and healthy group using the XRF technique. The heavy elements in blood samples for both groups are concise in Tables IV and V.

The average concentration of heavy elements of the leukemia patients (Pb, Cd, and Ni) was found 12.32 ± 1.2 ppm, 3.61 ± 0.2 ppm, and 5.17 ± 0.8 ppm, respectively. From Table V average concentration of heavy elements of the healthy groups (Pb, Cd, and Ni) was found 6.67 ± 0.26 ppm, 1.39 ± 0.04 ppm, and 2.04 ± 0.085 ppm, respectively.

The result shows that heavy elements (Pb, Cd, and Ni) are higher in the leukemia patients than in the healthy groups and element (Pb) value for leukemia patients and healthy groups is higher than (Cd and Ni) elements, as shown in

TABLE I
Uranium Concentration in Blood Samples of the Leukemia Patients

Sample	Gender	Age (year)	Location	Uranium concentration in (ppm)
1	Male	18	Daratu	0.12±0.03
2	Female	20	Kaznazan	0.32±0.04
3	Male	22	Shaqlawa	0.38±0.01
4	Female	23	Mergasor	0.56±0.02
5	Female	45	Hanara	0.88±0.05
6	Male	26	Soran	0.74±0.09
7	Female	54	Maxmur	0.92±0.02
8	Male	30	Choman	0.82±0.04
9	Male	28	Soran	0.79±0.03
10	Female	55	Heran	1.15±0.02
	Average			0.668±0.28
	Maximum			1.15±0.02
	Minimum			0.12±0.03

TABLE II
Uranium Concentration in Blood Samples for Healthy Group

Sample	Gender	Age (year)	Location	Uranium Concentration in (ppm)
1	Male	44	Daratu	0.034±0.004
2	Female	48	Kaznazan	0.018±0.007
3	Male	55	Shaqlawa	0.072±0.008
4	Female	36	Mergasor	0.026±0.004
5	Female	29	Hanara	0.024±0.005
6	Male	33	Soran	0.015±0.009
7	Female	25	Maxmur	0.022±0.006
8	Male	27	Choman	0.014±0.002
9	Male	52	Soran	0.064±0.008
10	Female	40	Heran	0.042±0.001
	Average			0.033±0.006
	Maximum			0.072±0.008
	Minimum			0.014±0.002

TABLE III
The Average Uranium Concentration in Blood Samples for Males and Females

Groups	Gender	Uranium concentration (ppm)	p-value
leukemia patients group	Male	0.57±0.03	0.001
	Female	0.76±0.02	
Healthy group	Male	0.026±0.08	0.001
	Female	0.039±0.05	

TABLE IV
HEAVY ELEMENTS CONCENTRATIONS IN BLOOD SAMPLES OF THE LEUKEMIA PATIENTS

Sample	Gender	Age (year)	Pb	Cd	Ni	Smoking Habited
1	Male	18	10.55	3.12	4.67	S
2	Female	20	11.28	3.24	4.86	N
3	Male	22	10.55	3.52	5.08	N
4	Female	23	11.78	3.65	5.12	S
5	Female	50	9.28	3.06	4.98	S
6	Male	26	8.92	2.66	3.88	N
7	Female	54	15.12	4.22	5.88	S
8	Male	30	14.92	3.98	5.78	S
9	Male	28	12.87	3.92	5.04	N
10	Female	55	18.82	4.78	6.42	S
	Average		112.32±1.26	3.61±0.2	5.17±0.8	
	Maximum		18.82	4.78	6.42	
	Minimum		8.9	2.66	3.88	

TABLE V
HEAVY ELEMENTS CONCENTRATION IN BLOOD SAMPLES FOR HEALTHY GROUPS

Sample	Gender	Age (year)	Pb	Cd	Ni	Smoking habited
1	Male	44	4.92	0.84	0.98	N
2	Female	48	5.34	0.92	1.22	N
3	Male	55	5.84	1.61	2.42	N
4	Female	36	6.08	1.27	2.48	N
5	Female	29	7.94	2.12	2.82	N
6	Male	33	6.44	1.68	2.34	N
7	Female	25	10.12	2.22	2.78	N
8	Male	27	7.33	1.84	2.38	N
9	Male	52	8.62	1.12	1.92	N
10	Female	40	4.15	0.32	1.12	N
	Average		6.67±0.26	1.39±0.04	2.04±0.085	
	Maximum		10.12	2.22	2.82	
	Minimum		4.15	0.32	0.98	

TABLE VI
HEAVY ELEMENT IN BLOOD FOR MALES AND FEMALES OF LEUKEMIA PATIENTS GROUP

Elements	Statistical rate	Male	Female
Pb	Minimum	8.9	18.28
	Maximum	14.92	28.9
	Mean±standard error	11.41±2.82	25.13±3.18
	$p<0.05$-(0.001)		
Cd	Minimum	2.66	3.06
	Maximum	3.98	4.78
	Mean±standard error	3.44±0.22	3.79±0.65
	$p<0.05$-(0.001)		
Ni	Minimum	3.88	4.67
	Maximum	5.78	6.42
	Mean±standard error	4.89±0.14	5.45±0.12

$p<0.05$

Fig. 4. The heavy elements concentrations in the blood of leukemia patients are increased by inhalation of airborne dust particles and exposure to radioactivity released and taking a radiation dose.

In addition, Fig. 5 appears that the rate of Pb in blood is 59% and is higher than that of Cd, and Ni, because the majority of lead concentrations found in the environment are the result of human activities. Lead pollution at the local level results from emissions from cars using leaded gasoline, lead is still used in gasoline in many Middle Eastern countries, including Iraq. This result is consistent with another investigator in another country (Khoder, Al Ggamdi and Shiboob, 2012; Stojsavijevic, et al., 2020).

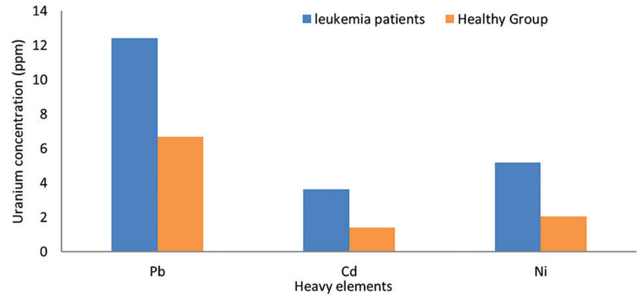

Fig. 4. Comparison heavy elements for leukemia patients and healthy groups.

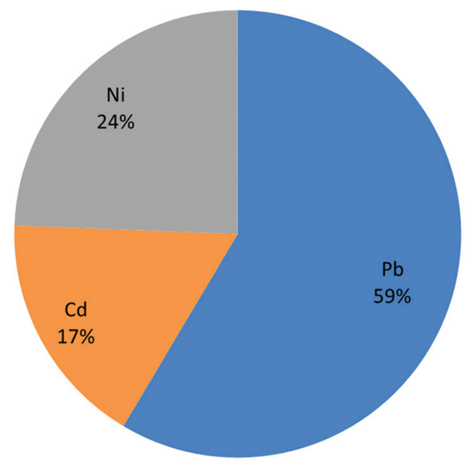

Fig. 5. The rate heavy element in leukemia patients.

Table VI appears the average value of the heavy elements in the blood of male and female leukemia patients group, in this table, the average rate of heavy elements (Pb, Cd, and Ni) of the male leukemia patients group is11.41 ± 2.82 ppm, 3.44 ± 0.22 ppm, and 4.89 ± 0.14 ppm, respectively. Furthermore, in this table, the average value of the heavy elements (Pb, Cd, and Ni) of the female leukemia patients group is 25.13 ± 3.18 ppm, 3.79 ± 0.65 ppm, and 5.45 ± 0.12 ppm, respectively. The results should compare with other articles obtained that the rate amount of heavy element for the male group is lower than for the female group. This is because the volume of the total blood in males is higher than, while in females, and also differences in red blood cell hemograms. Results showed statistically significant in the heavy metals concentration with regard to males and females in both groups $p < 0.05$.

IV. CONCLUSIONS

In this research, the uranium concentration and heavy elements (Pb, Cd, and Ni) were measured in blood samples of leukemia patients and healthy groups in the Erbil governorate. The results obtained show that uranium concentrations in the blood samples of the leukemia patients group are higher than those of the healthy group. Heavy metals can be considered one of the main causes of many health problems. The result shows that the heavy elements rate in blood was higher in the leukemia patients than in the healthy groups. The result also obtained that the average rate of the heavy element (Pb, Cu, and Ni) in the blood samples from female leukemia patients is highest than males. The statistical results approved that the uranium concentration and heavy metals significantly changes ($p < 0.05$) with gender type in both groups.

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References

Abdulwahid, T.A., Alsabari, I.K., Abojassim, A.A., Mraity, H.A. and Hassan, A.B. 2020. Assessment of concentrations of alpha emitters in cancer patients blood samples. *SYLWAN 164,* 183, pp. 242-246.

Adhraa, B.H., Ahmed, A.M., Hussein, A.A. and Ali, A.A. 2019. Determination of alpha particles levels in blood samples of cancer patients at Karbala Governorate, Iraq. *Iranian Journal of Medical Physics*, 16(1), p. 41-47.

Al-Hamzawi, A.A., Jaafar, M. and Tawfiq, N. 2015. Concentration of uranium in human cancerous tissues of Southern Iraqi patients using fission track analysis. *Journal of Radioanalytical and Nuclear Chemistry*, 303, 1703-1709.

Basu, D. and Kulkarni, R. (2014). Overview of blood components and their preparation. *Indian Journal of Anaesthesia*, 58(5), p. 529.

Buxton, S., Garman, E., Darten, T., Schlekat, E., Taylor, M. and Oller, A. 2019. Concise review of nickel human health toxicology and ecotoxicology. *Inorganics Journal*, 7(7), pp. 89-93.

Dler, A., Ismail, A.H., Hashim, A.T. and Hussein, Z.A. 2022. Measurement of the trace element concentration in some livestock and poultry bone samples using X-ray fluorescence. *ZANCO Journal of Pure and Applied Sciences*, 24(12), pp. 67-73.

Elzain, A. 2014. Measurement of Radon-222 concentration levels in water samples in Sudan. *Advances in Applied Science Research*, 5(2), pp. 229-234.

Ghorani, A., Riahi, Z. and Balali, M. 2016. Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of Research in Medical Sciences,* 21(4), pp. 1-12.

Hussein, Z.A. 2015. Measurement of indoor radon concentration in dwellings of Koya using nuclear track detectors. *International Journal of Science and Research (IJSR)*, 4, pp. 2465-2467.

Hussein, Z.A. 2019. Assessment of natural radioactivity levels and radiation hazards of soils from Erbil Governorate, Iraqi Kurdistan. *ARO-The Scientific Journal of Koya University*, 7(1), pp. 34-39.

Hussein, Z.A., Jaafar, M.S. and Ismail, A.H. 2013. Measurements of indoor radon-222 concentration inside Iraqi Kurdistan: Case study in the summer season. *Nuclear Medicine and Radiation Therapy*, 4(1), pp. 1-4.

Hussein, Z.A., Jaafar, M.S., Ismail, A.H. and Battawy, A.A. 2013. Radon exhalation rate from building materials using Passive Technique Nuclear Track Detectors. *International Journal of Scientific & Engineering Research*, 4(7), pp. 1276-1282.

Isabel, S., Mariana, S. and Mónica, E. 2016. Kidney cancer. Heavy metals as a risk factor. *Porto Biomedical Journal*, 1(1), pp. 25-28.

Ismail, H.A., Hussein, Z.A. and Sardar, P.Y. 2020. Investigation a relation between radioactivity concentrations of 40 Potassium (40K) in tooth and the various ethnic groups and its impacts on the rate of tooth damage. *Environmental Nanotechnology, Monitoring & Management*, 14, pp. 100385.

Jae, M.L., Jang, S.S. and Yu, K.K. 2022. Red blood cell deformability and distribution width in patients with hematologic neoplasms. Clinical Laboratory, 68(10), pp. 11-14.

Khoder, M., Al Ggamdi, M.A. and Shiboob, M.H. 2012. Heavy metal distribution in street dust of urban and industrial areas in Jeddah, Saudi Arabia. *Journal of King Abdulaziz University: Metrology, Environment and Arid Land Agricultural Sciences*, 142(588), p. 1-4.

Kim, S.H., Yang, H.O., Hyun, C.A., Joo, H.S. & Chang, S.S. (2021). Levels of blood lead and urinary cadmium in industrial complex residents in Ulsan. *Annals of Occupational and Environmental Medicine,* 29(1), p. 26.

Konishi, T., Kodaira, S., Itakura, Y., Ohsawa, D. and Homma S. 2019. Imaging uranium distribution on rat kidney sections through detection of alpha tracks using CR-39 plastic nuclear track detector. *Radiation Protection Dosimetry*, 183, pp. 242-246.

Kortei, N., Korley, K., Alice, K., Papa, A., Nana, B. and Manaphraim, M. 2020. Potential health risk assessment of toxic metals contamination in clay eaten as pica (geophagia) among pregnant women of Ho in the Volta Region of Ghana. *BMC Pregnancy and Childbirth*, 20(1), p. 160.

Mahugija, J., Kasenya, Z. and Kiluiya, K. 2018. Levels of heavy metals in urine samples of school children from selected industrial and non-industrial areas in Dar es Salaam, Tanzania. *African Health Sciences*, 18(4), pp. 1226-1235.

Mohammed, R. and Ahmed, R., 2017. Estimation of excess lifetime cancer risk and radiation hazard indices in southern Iraq. *Environmental Earth Sciences Journal,* 76(3), pp. 76-80.

Mohsen, A.A. and Abojassim, A.A. 2019. Determination of alpha particles levels in blood samples of cancer patients at Karbala Governorate, Iraq. *Iranian Journal of Medical Physics*, 16(1), pp. 41-47.

Nah, E.H., Suyoung, K.S., Cho, M. and Han, I.C. 2018. Complete blood count reference intervals and patterns of changes across pediatric, adult, and geriatric ages in Korea. *Annals of Laboratory Medicine*, 38(6), pp. 503-511.

Podgorsak, E. 2005. Basic radiation physics. In: Radiation Oncology Physics: A Handbook for Teachers and Students. IAEA, Vienna, pp. 1-7.

Rasha, S.A. and Raghad, S.M. 2020. Assessment of uranium concentration in blood of Iraqi females diagnosed with breast cancer. *Radiation and Environmental Biophysics*, 60(6), pp. 96-201.

Sergiusz, Ł., Marcin, C., Alicia, F., Jack, B., Robert, S. and Andrzej, S. 2021. Breast cancer-epidemiology, risk factors, classification, prognostic markers, and current treatment strategies-an updated review. *Cancers (Basel)*, 13(17), pp. 25-29.

Stojsavijevic, A., Liiljana, V., Branislav, R., Slavica, B., Mariia, G. and Dragan, M. 2020. Assessment of trace metal alterations in the blood, cerebrospinal fluid and tissue samples of patients with malignant brain tumors. *Scientific Report*, 10(4), pp. 124-128.

Tiange, L., Mingyu, Z., Mohammad, R., Xiaobin, W., Stefanie, H., Cuilin, Z. and Noel, T. 2021. Exposure to heavy metals and trace minerals in first trimester and maternal blood pressure change over gestation. *Environment International*. 53(6), pp. 72-76.

WHO. (2001). Depleted Uranium Sources, Exposure and Health Effects. Technical Report, World Health Organization, Geneva.

Zou, W., Bai, H., Zhao, L., Li, K. and Han, R. 2011. Characterization and properties of zeolite as adsorbent for removal of uranium (VI) from solution in fixed bed column. *Journal of Radioanalytical and Nuclear Chemistry*, 288, 779-788.