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Estimation of Radiological and Toxical in Selected of Soil and Urine Samples in Babylon Governorate

A Thesis

Submitted to the Council of College of the Science/ University of Babylon in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Science/Physics.

By

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بسم الله الرحمن الرحيم

﴿فَتَعَالَى اللَّهُ الْمَلِكُ الْحَقُّ وَلَا تَعْجَلْ بِالْقُرْآنِ مِنْ قَبْلِ أَنْ يُقْضَى إِلَيْكَ وَحْيُهُ وَقُلْ رَبِّ زِدْنِي عِلْمًا﴾

صَدَقَ اللهُ العَلِيُّ العَظيم

(سورة طه: الآية ١١٤)

DEDICATION

To who taught me the success and patience for those who missed him in the face of difficulties and did not lower stay he fed with affection for my father

To the kindest woman with the most purest endless love in the universe, my mother

To my lovely sisters and brothers

To my husband who shared with me through thick and thin that the completion of my work would not have been possible without your support, and I hope that it will satisfy you

To my beloved country, Iraq

The fighters and martyrs of Iraq with all the love and appreciation.

Esraa

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CONTENTS

SUMMARY

In this study, the naturally radioactivity of ^{238}U, ^{232}Th and ^{40}K present in soil samples were measured in the Babylon governorate by using gamma- ray spectrometer NaI(Tl) was to evaluate health hazard of radiation and examination of the some metals lead (Pb), Nickel (Ni) and cadmium (Cd) to determine contamination in soil samples using the technique of Atomic Absorption Spectrophotometer (AAS). The examination of the urine samples is the preferable method for observing the inner exposure to toxic pollutants of Pb, Ni and Cd in human bodies. This study included two groups of male and female volunteers. The first group is cancer patients and the second is healthy. The urine samples were collected from cancer patients chosen from the hospitals in Babylon governorate, Iraq. Similarly, urine samples from the healthy group were collected from different regions in the Babylon governorate.

The averages of specific activity for ^{238}U, ^{232}Th and ^{40}K was (1.344±0.175, 8.322±0.416 and 209.886±3.237) Bq/kg, respectively. while, the equivalent radium, absorbed dose in air, effective annual internal dose and annual external dose were less than allowed limit.

For the results of some metals, the average values of Pb, Ni and Cd were (18.919, 81.043 and 0.202) mg/kg, respectively. All the result was higher than the permissible limit.

The average values of toxic element concentration (Pb, Ni, and Cd) in the urine samples from the cancer patients were 0.1902±0.028 mg/l, 0.0611±0.0149mg/l, and 0.0240±0.00313/l, respectively. In healthy individuals, the corresponding average values of toxic element concentration

(Pb, Ni, and Cd) in the urine samples were 0.0865±0.257mg/l, 0.027±0.0043mg/l, and 0.0135±0.0021mg/l, respectively. Accordingly, the average values of the toxic element concentration in urine samples of healthy volunteers were considerably lower than in the cancer patient group.

We conclude from this that the radioactivity was within the permissible limits globally and was safe for population. As for some metals, there was soil pollution in some areas.

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LIST OF ABBREVIATIONS/NOTATIONS

Symbol	Meaning
^{238}U	Uranium
^{232}Th	Thorium
^{40}K	Potassium
Pb	Lead
Cd	Cadmium
Ni	Nickl
Bq/kg	Becquerel/ kilogram
AAS	Atomic Absorption Spectrophotometer
FAAS	Flame Atomic Absorption Spectrophotometer
ppm	Parts per million
ETAAS	Electro thermal Atomic Absorption Spectrophotometer
ICP-OES	Inductively coupled plasma atomic emission spectroscopy
µg/L	micrograms /liter

mg/1	milligrams/ liter
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
TEC	Toxic Elements Concentration
µg/dL	micrograms /deciliter
^{3}H	Tritium
^{7}Be	Beryllium
^{14}C	Carbon
^{214}Bi	Bismuth
^{208}Tl	Thallium
Sv/Gy	Sievert/Gray
mSv/y	Milli Sievert /year
mg/m3	Milligram per cubic meter
^{o}C	Celsius
mm	Millimeter
kg	Kilogram
Co-60	Cobalt
Ba-133	Barium

Cs-137	Cesium
Na-22	Sodium
Mn-54	Manganese
keV	Kilo electron volt
ml	Milliliter
SPSS	Statistical Package of the Social Sciences
Ave ±SD	Average ±Standard Deviation
Max ±SD	Maximum ± Standard Deviation
Min ±SD	Minimum± Standard Deviation
mg/kg	Milligram per Kilogram
Std. Error	Standard Error
Sig.	Significant
df	Degrees of Freedom

Chapter One

General Introduction

1.1 Introduction

The radiation originates from a variety of sources, both natural and artificial. These include both cosmic radiation and environmental radioactivity from naturally occurring radioactive materials. Naturally, radioactivity is widespread in the earth environment, mainly in various geological formations and their disintegration products [1]. The natural radioactivity major sources are the nuclides of very long half-lives that have existed since the earth formation and nuclides produced via cosmic rays, such as (tritium ^{3}H, beryllium ^{7}Be and carbon ^{14}C) [2].The natural radionuclides of concern are mainly uranium(^{238}U), thorium (^{232}Th) and potassium (^{40}K) [3]. The level of naturally radioactivity concentration depends on local geological conditions and geographical location of the area. Long-term exposures to radioactivity and inhalation of radionuclides have serious health effects, such as cancerous disease. Nuclides radioactive exposure can cause lung diseases, pancreas, hepatic, bone and kidney cancers and leukemia [4].

On the other hand, there are some other pollutants within the surrounding environment are toxic. some metals pollution which it one of the problems that has received widespread around the world. The high impact on the atmosphere and nature of toxic elements justifies the increased interest in their monitoring. Heavy metals are inorganic contaminants that do not dissolve and become harmless products like organic pollutants, but remain and accumulate in the soil [5]. Concentrations of heavy metals are not stable and vary according to several variables in the environment, such as urbanization, climate change, industrial production, etc. Some elements involving lead (Pb), cadmium (Cd), and nickel (Ni) are generally toxic to both human and animal bodies [6,7] . Pb has carcinogenic properties by weakening both the respiratory and digestive processes and suppressing the immune system. This metal is particularly

damaging in kids. Due to its mutability and carcinogenicity Ni is accumulated mainly within the spinal cord and brain. Cd often simply accumulates in the circulatory system, the kidneys (especially the renal cortex), the lungs, and the heart and is toxic to bones and gonads. Inside the body, heavy metals are essential in small amounts but can be toxic in larger doses [8, 9].

Humans are exposure to heavy metals during air pollutant inhalation, drinking of contaminated water, exposure to contaminated soil, and industrial waste [10,11]. Measurements of radioactivity and toxic element concentrations in geological and biological samples provide an obvious picture of the radioactive and chemical contamination of the exposed persons.

1.2 Literature Review

1.2.1 Literature Review of Radioactivity

Hassan A. et al. (2011) [12] determined values of the activity concentrations (Bq/kg) for the radionuclides ^{238}U, ^{232}Th, and ^{40}K in Al-najaf Al-ashraf using Sodium Iodide Scintillation Detectors NaI(Tl). The measured levels of radiation background in this study from all investigated samples showed that the studied areas have normal levels of background radiation. The corresponding gamma radiation hazard indices, annual effective dose and gamma activity concentration index (Iγr) are below the acceptable limits.

Saleh I. H. (2012) [13] used gamma-ray spectroscopy, researchers assessed the radioactivity of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs in soil samples taken from the Macadam Peninsula in the Sultanate of Oman by using the high-purity germanium. For ^{238}U, ^{232}Th, and ^{40}K, the activity concentrations in the soil were (14.42, 9.95 and 158.21) Bq/kg, respectively.

Yousuf R. and Abullah K. (2013) [14] investigated natural radioactivity in soil samples obtained at five different depths from some towns in Iraq's Kurdistan Region's Suleiman governorate by using a NaI (Tl) detector. The average value of activity concentrations for ^{238}U, ^{232}Th and ^{40}K was (83.337, 19.147, and 284.86) Bq/kg respectively.

Ademola K. et al. (2014) [15] studied the specific activity of natural radionuclides ^{238}U, ^{232}Th, and ^{40}K in soil samples from the gold mining district of Itagunmodi (Nigeria) using NaI (Tl) detector for radiological hazard assessments. At the mining sites, the average activity concentrations of ^{238}U, ^{232}Th, and ^{40}K were (55.3± 1.2, 26.4 ± 2.7, and 505.1±7.1) Bq/kg, respectively.

Almayahi B. A. (2015) [16] used a NaI(Tl) detector to evaluate radioactive radionuclides of ^{238}U, ^{232}Th, and ^{40}K in a soil sample from the city of Najaf, Iraq. The average concentrations in the soil samples ranged (69.78±0.53, 125.63±0.47, and 1165.29±0.45 Bq/kg) for ^{238}U, ^{232}Th, and ^{40}K, respectively. The Raeq values of samples were lower than, 370 Bq/ kg recommended maximum levels of radium equivalents in soil.

Abojassim A. A. et al. (2016) [17] calculated the specific activates for ^{238}U ,^{232}Th and ^{40}K and radiation hazard indices in soil samples at Hattin complex in Babylon government using the NaI(Tl) detector. The average specific activity of (^{238}U, ^{232}Th, and ^{40}K) is (16.07±2.89, 9.60±0.954 and 271.42±11.60) Bq/Kg respectively. The radiation hazard indices calculated in this study found that the values were within the recommended values.

Karim M. S. et al. (2016) [18] used a NaI(Tl) detector to study the specific activity of natural radionuclides in soil samples collected from Babylon city. The results have shown that the average value of the specific activity, for ^{238}U was (15.485 Bq/kg), for ^{232}Th was the average value (15.505 Bq/kg), while for ^{40}K was (170.206 Bq/kg). It is found that hazard indices to be less than the allowed limits.

Hasan A. et al. (2017) [19] studied the specific activity of naturally radionuclides ^{238}U, ^{232}Th and ^{40}K in soil samples collected from different localities of the government departments of districts Qassim Babylon using NaI(Tl). Where the specific activity of ^{238}U, ^{232}Th and ^{40}K was found (15 ± 0.691, 45.46 ± 1.8265 and 277.685 ± 2) Bq/kg respectively. The average value of (Req) was found 102.239 Bq/kg. The radiation hazard indices which is lower than the safe limit.

Durusoy A. and Yildirim M. (2017) [20] based on the Nal(TI) detector studied the specific activity of ^{238}U,^{232}Th and ^{40}K in soil samples collected from Rize Province in the Black Sea region of Turkey. The average values of activity concentrations (24.5, 51.8, and 344.9) Bq/kg for ^{238}U, ^{232}Th, and ^{40}K respectively . The activities determined in this study were generally lower than average values from around the world.

Muttaleb M.K. et al. (2018) [21] studied of the radioactivity of soil samples in Amarah city, Maysan /Iraq using the detector NaI(Tl) to detect radionuclide (^{238}U, ^{232}Th, ^{40}K). Measurements, the average activity concentration of ^{238}U and ^{232}Th are lower than world averages, except ^{40}K. The mean absorbed dose

rate and the average annual effective dose equivalent due to naturally occurring radionuclides in this study is lower than the world averages.

Salman E. et al. (2019) [22] studied the radioactivity levels in the soil of Babylon governorate by using the NaI(Tl). The average specific activities (17.484 ±0.654, 37.091±1.005 and 315.613±3.198)Bq/kg for ^{238}U, ^{232}Th and ^{40}K respectively. The radiological hazards due to natural radionuclides within measurement allowable world.

Rejah B. et al. (2020) [23] used detector NaI(Tl) to study the specific activity of natural radioactive soil samples in various areas of the southern Al-Dora region, Baghdad governorate. The average activity concentrations of ^{238}U, ^{232}Th, and ^{40}K were found to be (38.22, 42.99, and 16.64) Bq/Kg respectively. The radiological hazard indices, including (Raeq), (D), (Hin) and (Hex), (AEDEin) and (AEDEex) and (Iγ) it was calculated and was less than the global values.

Oleiwi M. in 2021 [24] works a study of measurement radioactivity for Kutha district of Babylon governorate of soil samples using the NaI(Tl) detector. The average of radio activities of ^{238}U is (19.1565)Bq/ kg, while it is (54.501) Bq/kg for ^{232}Th and (179.578) Bq/kg for ^{40}K calculated values show acceptable values according to the standard levels.

Hamid A. and Ali H. (2021) [25] studied the radioactivity levels of the naturally occurring radionuclides represented with ^{238}U, ^{232}Th, and ^{40}K for Surface and Deep Soils Salah al-Din Governorate using the NaI(Tl) detector.

In general, the results showed that the concentration of radionuclides in the surface soil is higher than that of the deep soil.

Rejah B. et al. (2021)[26] explain a studied of specific activity in soil samples for some areas in Al-Doura city in Baghdad Governorate using NaI(Tl) detector. The mean values of specific activity for ^{232}Th, ^{40}K in were 42.48 and 16.34 Bq/kg, respectively. All the health hazard indices were well below their global limits.

Ahmed A. and Farhan A. O. (2022) [27] studied the radioactivity of soil from various sites in the AL-Taimeem area in Al-Anbar province, by using NaI(Tl) detector. The results were less than recommended by the International Committee for Radiation Protection.

Akkurt I. et al. (2022) [28] claim natural radionuclides in soil samples from Cekmeköy-Istanbul, were measured with NaI(Tl) detector . Mean natural radioactivity and radiological parameter levels are calculated lower than the world average.

1.2.2 Literature Review of Toxic Elements

Afridi H.I. et al. (2008) [29] conduct a study to compare the level of toxic elements, (Pb) and (Cd), in biological samples (whole blood, urine, and scalp hair) of patients having diabetes mellitus type-2 age ranged (31–60) with those of age matched non-diabetics of both genders by using AAS. The concentration of understudy toxic metals was also high in blood and urine samples of diabetic mellitus patients but the difference was more significant in smoker diabetics mellitus patients.

Khwedim K. H. et al. (2009)[30] explored the levels of heavy metals (Cd, Ni and Pb) in the soil of Basra city- south of Iraq using also AAS technique. The average values were (39.4, 20.9 and 5.5)mg/kg for Pb,Ni and Cd, respectively. The results of this study showed heavy metals (Pb, Ni, and Cd) increasing to the west of Basra city.

Kadhim I.A. and Jawad S.T. (2010) [31] determined concentration of (Pb, Cd, Ni) of soil samples from Shattrah city using the (FAAS) . Values of concentration arranged [(171.6857, (12.27), (20.928) ppm] respectively, these results indicate that there was a high ratio of (Pb, Cd).

Gil F. et al. (2011) [32] determined the toxic elements concentrations of (Cd, Ni and Pb) in blood, urine, axillary hair and saliva from 178 individuals with occupational exposure to heavy metals and by using the AAS the results in urine samples was 0.25, 22.28, and 1.76 mg/1 respectively.

Habib H.R. et al. (2012) [33] studied the toxic elements (Pb, Cd and Ni) in some soil in Baghdad, Iraq by using the AAS. The contamination of Baghdad soil is responsible for the buildup of heavy metals with significant concentrations in contrast to worldwide average values in the Baghdad was (43, 19 and 172)ppm for Pb, Cd and Ni.

Todorovska N., et al. (2014) [34] determined concentration of Ni in human blood serum and urine by Electro Thermal Atomic Absorption Spectroscopy

(ETAAS) .the results of this study for urine samples with Ni concentrations in range of 0.5–2.5 µg/l .

Al-Hamzawi A.A. et al. (2015) [35] studied concentrations of Pb, Ni and Cd in urine and tissue samples of southern Iraqi cancer patients. were measured by using ICP-OES. The results showed the levels of toxic elements (Pb, Ni and Cd) in urine samples of the cancer patients group were (0.435, 0.217 and 0.115) mg/1, respectively.

Tang Sh. et al. (2016) [36] conducted a comparison of the levels of five heavy metals in human urine and sweat for healthy subjects, adult males selected from among sophomore undergraduates enrolled in Guizhou University using ICP-MS. The findings of this study shown that the Cd, and Pb levels excreted in urine were 0.001 ± 0.0007 and 0.03 ± 0.001µg/l respectively.

Khudhair A. F. et al. (2019) [37] determined the concentrations of trace elements in biological samples in Kerbala/ Iraq. Such an examination was achieved for urine samples of workers with different occupations and of different ages. The average concentrations of lead (Pb) were (0.1188 to 0.5067) ppm using the Flame Atomic Absorption Spectroscopy (FAAS) technique.

Al‑Hamzawi A. A. and Al‑Gharabi M.G. (2019) [38] determined the levels of heavy metals such as, Pb and Cd in soil samples collected from various residential, industrial, and agricultural areas of Al-Diwaniyah governorate in Iraq using the AAS technique, in order to determine the degree of pollution. The mean values of Pb and Cd in soil samples were 31.75

and 1.804mg/l, respectively. The permissible levels for Pb and Cd in the soils examined were generally exceeded.

Jindy J. et al. (2020) [39] studied soil contamination with heavy metals (Pb and Ni) in Zakho district, Kurdistan region - Iraq via the AAS technique. The concentration was found in the range of 0.541- 4.339 mg/l for Pb and 1.049 - 1.635 mg/l for Ni.

Rahman Z. (2020) [40] studied the concentrations of toxic elements like Pb, Ni and Cd in urine samples obtained from two groups: cancer patients and healthy people from the governorate of Al-Diwaniyah. The average toxic elements concentration Pb, Ni, and Cd in cancer patients' urine samples 0.402-0.037 mg/l, 0.261- 0.023 mg/l, and 0.105- 0.011 mg/l, respectively. The corresponding average values of TEC (Pb, Ni, and Cd) in urine samples of healthy people were 0.279-0.023 mg/l, 0.145 -0.013 mg/l, and 0.040-0.006 mg/l, respectively.

Saleh D.S. et al. (2021) [41] estimated the concentration of toxic elements Cd and Pb in the serum of diabetics and healthy people in Najaf city using the AAS technique. Results for this study showed the mean value concentration levels of Pb were within permissible range (0-10 µg/dL), in all groups, while the mean value concentration level of Cd was higher than the permissible range (0.030-0.121 µg/dL) according to WHO.

Khalaf E. et al. (2021) [42] studied the correlation between cancer and some toxic metals Cd and Pb in the whole blood, serum and hair of breast cancer patients in Basrah city , South Iraq. High concentrations of Cd and Pb were detected in whole blood.

Naji T.F. (2022) [43] determined heavy metals like Pb and Cd in serum samples collected from cancer patients and healthy people from Babylon governorate, Iraq. The findings revealed that healthy people's mean lead (Pb) concentrations (0.14001 ppm) were higher than those of cancer patients. The results demonstrate that cancer patients' mean cadmium (Cd) concentrations(0.0674 ppm) were greater than healthy people's.

1.3 Aims of the Work

The aim of this study is:

1. Calculate the specific activity of the natural radioactivity of ^{238}U, ^{232}Th, and ^{40}K in soil samples using the NaI(Tl) detector.

2. Measure the concentrations of toxic elements (Pb, Cd, and Ni) in urine samples of the cancer patients group and the healthy group by using Atomic Absorption Spectroscopy AAS.

3. Measurement of the concentrations of some metals in selected soil samples and estimation of pollution with toxic elements in the soil.

Chapter Two

Theoretical Part

2.1 Introduction

Toxicological contaminants are one type of the environmental pollution [35]. Natural radionuclides (^{238}U, ^{232}Th, and ^{40}K) are found in all elements of the environment, such as rock and soil. Furthermore, these radionuclides such as ^{238}U and ^{232}Th, disintegrate into other nuclides that are also radioactive, thus forming a decay chain. Natural and man-made radionuclides in the environment may enter the human body through inhalation and ingestion [44].

2.2 The Radionuclide Source

The assessment of the radiation doses from natural sources in humans is of particular importance because natural radiation is the largest contributor to collective dose of the world population. The radiation sources are classified into, natural and artificial [45]: primordial () [45]:

2.2.1 Natural Radiation

external sources of extraterrestrial origin (cosmic rays), terrestrial origin and internal radiation.

Cosmic rays, such as tritium (^{3}H), beryllium (^{7}Be), and carbon (^{14}C). Which are mainly produced through interaction of the cosmic rays with atoms in the atmosphere [46].

Terrestrial origin**,** these have half-lives very long which have been present on form the earth before about four billion years. The main primordial radionuclides are ^{40}K and the elements of the three radioactive series headed by ^{238}U, ^{232}Th and ^{235}U have existed in the earth crust throughout its history [47]. Internal radiation, comprising the naturally-occurring radionuclides which are taken into the human body by inhalation and ingestion [47].

2.2.2 Artificial Radiation

These are man-made radionuclides released into the environment through the testing of nuclear weapons, nuclear reactor accidents [47].

2.3 Radioactivity in Soil

People and their health depend on soil. It is a resource that can be used as a shelter as well as a source of food. Terrestrial radioactivity nuclides have been discovered at every stage of every area in the world, and they are dependent on the parent rocks that shape the soil. Natural radioactive materials account for the majority of radiation doses obtained by humans [48]. A lot of studies in the world measured the natural radioactivity level, such as ^{238}U, ^{232Th}, their decay products and ^{40}K in soil [49].

2.4 Gamma - Ray Interactions

There are three most important gamma ray interactions photoelectric effect, Compton scattering and pair production. These processes lead to the significant change of the original gamma-ray photon, both of the movement angle and the energy [50]

2.4.1 Photoelectric Effect

In this process a photon is absorbed by an atom and the energy is transferred to an ejected electron photoelectron which is ejected from the atom from one of its bound shells, and in the process the photon completely disappears.

2.4.2 Compton Scattering of Gamma Photon

The Compton scattering is a scattering of the incident gamma ray photon and an electron in the absorbing material. In the general case this is the dominant interaction of typical gamma-ray energies. In Compton scattering the

incident photon is deflected by angle θ with respect to its original direction [50].

2.4.3 Pair Production

This process, possible if the gamma-ray energy exceeds twice the rest mass of an electron that is 1.02 MeV.

2.5 Theoretical Calculations

This part shows the theoretical equations used to calculate specific activity and radiological hazards indices for the radioactivity of ^{238}U,^{232}Th and ^{40}K in soil.

2.5.1 Activity Concentration

The specific activity is calculated for (^{238}U) in terms of (^{214}Bi) with energy (1764 keV), as well as the specific activity of (^{232}Th) in terms of (^{208}Tl) using energy (2614 keV), and measuring the specific activity of ^{40}K with energy (1460 keV). The specific activity (A) of radionuclides in soil samples was obtained using the equation [51]:

$$A = \frac{\mathrm{Nn.a}}{\mathrm{I\gamma * \varepsilon * m * t}} \pm \frac{\sqrt{\mathrm{Nn.a}}}{\mathrm{I\gamma * \varepsilon * m * t}} \left[\frac{\mathrm{Bq}}{\mathrm{Kg}}\right] \quad (2\text{-}1)$$

where:-

$Nn.a$: area under the specified energy peak after back ground subtraction

$I\gamma$: is the gamma ray emission probability at each energy

m: mass of the soil sample

t: measurement time

ε: is the efficiency of the detector

2.5.2 Radium Equivalent Activity

The radium equivalent(Ra_{eq}) is used to evaluate the risk of concentration emitted by the activity of the radioactive elements ^{238}U, ^{232}Th and ^{40}K can be measured from equation [52] :

$$Ra_{eq}\left(\frac{Bq}{kg}\right) = A_U + 1.43\,A_{Th} + 0.077A_K \quad (2\text{-}2)$$

where: $A_U, A_{Th}, and\ A_K$ represents the specific activity of ^{238}U, ^{232}Th and ^{40}K respectively.

2.5.3 Absorbed Dose Rate

The absorbed dose (AD) can be measured in the air through radiation exposure so that the absorbed dose can be found in the body that is expressed in terms of the terrestrial nuclei as shown in the equation [53]:

$$AD\left(\frac{nGy}{h}\right) = 0.462\,A_U + 0.604A_{Th} + 0.0417A_K \quad (2\text{-}3)$$

Where: 0.462, 0.604, 0.0417 isotope conversion coefficients (^{238}U, ^{232}Th, ^{40}K).

2.5.4 External and Internal Hazard Indices

External risk transactions (H_{ex}) and Internal Hazard index (H_{in}) can be calculated to measure the risk of gamma rays and related radiation. The following two equations were obtained based on the quality of radiation specific activity [54].

$$H_{ex} = \frac{Au}{370} + \frac{ATh}{259} + \frac{Ak}{4810} \quad (2\text{-}4)$$

$$H_{in} = \frac{Au}{185} + \frac{ATh}{259} + \frac{Ak}{4810} \quad (2\text{-}5)$$

2.5.5 Equivalent Annual Effective Dose (AEDE)

The estimated annual effective dose equivalent (AEDE) which is received by organs is calculated by using a conversion factor of (0.7 Sv/Gy), which was used to convert the absorbed rate to human effective dose equivalent with an outdoor occupancy of (20 %) [52]:

$$(AEDE)_{out}\,(mSv/y)=AD\,(\frac{nGy}{h})\times10^{-6}\times8760h\times0.2\times0.7(\frac{Sv}{Gy}) \quad (2\text{-}6)$$

2.5.6 Gamma Index (Iγ)

It is a coefficient used to calculate the risk arising from the gamma radiation associated with natural radionuclides. I_γ for the studied soil samples was computed by equation[52] :

$$I\gamma = \frac{Au}{150} + \frac{ATh}{100} + \frac{Ak}{1500} \quad (2\text{-}7)$$

2.6 Toxic Elements

Heavy metals are compounds that are required by living organisms in certain amounts, but when present in excessive concentrations, they become toxic and have an adversely impact on the ecosystem[55]. Because of their high atomic weight and a density greater and due to the long biological half-life long, these elements accumulate in the organs of the human body [56]. Heavy element exposure has increased in humans and other organisms as a result of their recent use, particularly in industrial areas. These elements are communicated to humans through natural sources, such as the earth's crust, where they are naturally found and then transferred to water and air by erosion. Other human activities include industrial waste dumping, oil

extraction, manufacturing, residential waste disposal, hospitals, Pb-containing fuel combustion, and mining. These components are difficult to decompose and accumulate in the human body, they cause many health problems and these elements in the present study are included (Pb, Cd, and Ni)[55]:

2.6.1 The Lead

Lead is a naturally occurring silver metal that was found in various quantities in the earth's crust and one of the earliest metals discovered [57]. Pb's properties like softness, high malleability, low melting point and corrosion resistance have resulted in its widespread usage in different industries like automobiles, paint. Pb is regarded as a potent occupational toxin and its toxicological manifestations are well known. The non-biodegradable nature of lead is the prime reason for its prolonged persistence in the environment [58].

Human exposure to Pb occurs through various sources like inhalation of Pb polluted dust particles, leaded gasoline, industrial processes such as lead smelting and coal combustion, lead-based paints, lead containing pipes or lead-based solder in water supply systems and battery recycling. There is no such level of Pb that appears to be necessary or beneficial to the body and no “safe” level of exposure to lead has been found. Pb toxicity is a particularly insidious hazard with the potential to causing irreversible health effects. It is known to interfere with a number of body functions and it primarily affects the central nervous, hematopoietic, hepatic, and renal systems producing serious disorders [59].

2.6.2 The Cadmium

Cadmium is a toxic element that has the ability to accumulate in living organisms, and it's concentration of the body increases with age [60].Cadmium

is a relatively rare element, that is not naturally free, but is associated with the minerals of other materials such as lead and copper, which are the most cadmium - containing metals. Cd is often found near sites of metal mining and refining, production and application of phosphate fertilizers, waste incineration, and disposal.

The main routes of exposure to Cd are through inhalation of air, cigarette smoke, and food ingestion. Cadmium may also be transported as a particle or vapor for long distances in the atmosphere, depositing on soil and water surfaces. Cd binds strongly to organic matter where it is immobilized in soil and taken up by plant life and agricultural crops. Since tobacco leaves accumulate Cd from the soil, regular use of tobacco-containing products is a common route of human cadmium exposure [61].

2.6.3 The Nickel

The Ni is a lustrous and hard, silvery-white metal. Ductile is the 24th element in order of natural abundance [62]. It is widely distributed in the environment. Natural sources of atmospheric Ni include dusts from volcanic emissions and the weathering of rocks and soils. Human exposure to Ni occurs primarily via inhalation and ingestion [63]. In industrialized regions and large cities, atmospheric Ni concentrations are related to fly-ash from burning fossil fuels in power plants. Cigarette smoking can further increase inhaled nickel. Another source of human Ni exposure is dietary where some foods, especially plant foods. In 1990, the International Committee on Ni carcinogenesis in man suggested that respiratory cancer risks are primarily related to exposure to soluble Ni concentrations above 1 mg/kg. Exposure to Ni compounds can produce a variety of adverse effects on human health. Ni allergy in the form of contact dermatitis is the most common reaction [64].

The toxic element pathway in the human's bodies is shown in figure (2-1).

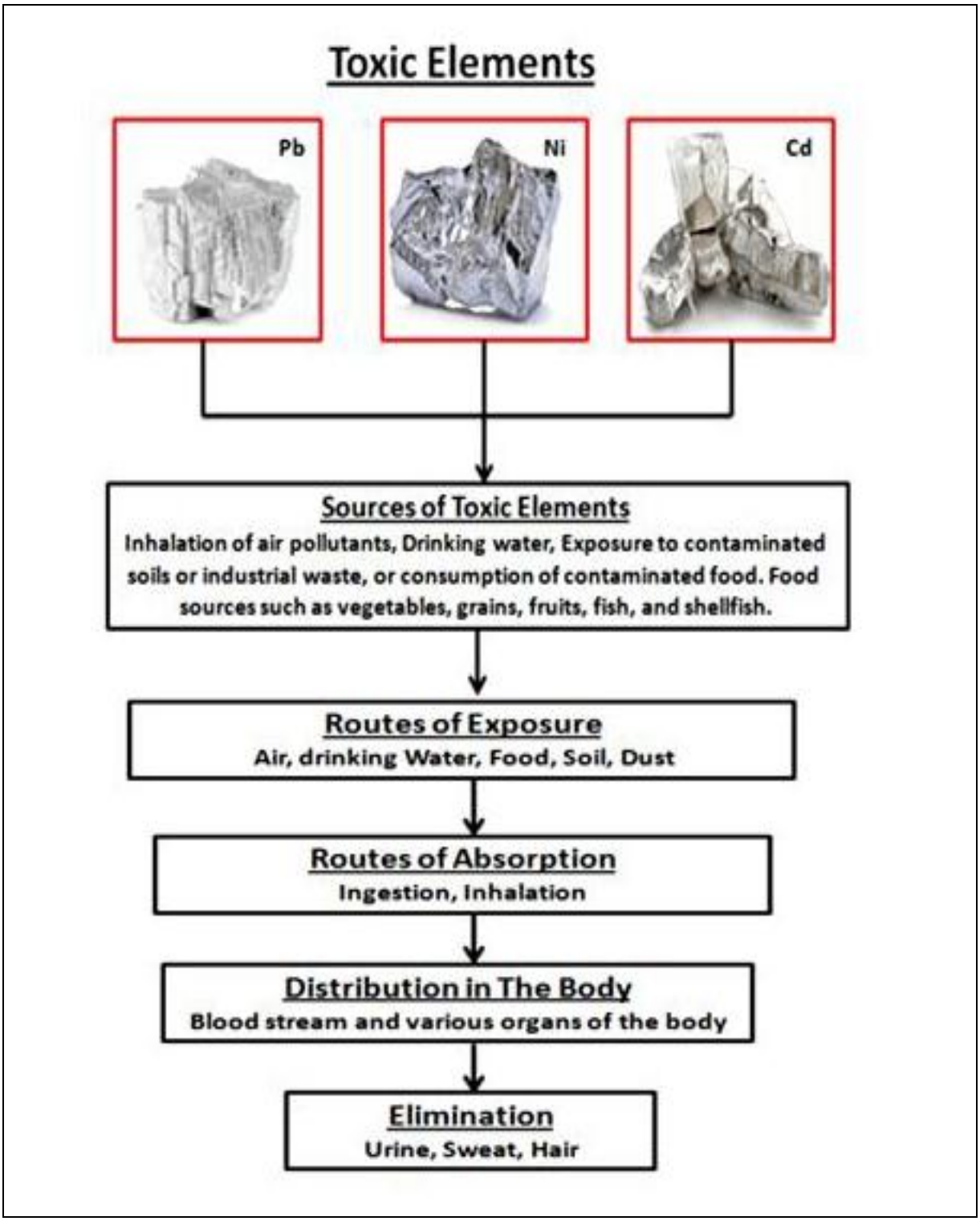

Figure 2.1: The routes of exposure to toxic elements [40].

2.7 Health Effects of Heavy Metals

The normal way of exposure to heavy metals is through polluted soil, air and food. Pollution caused by heavy metals has negative effects on the individuals' health and the environmental balance [65].

The natural environment is characterized by the delicate balance that exists between its various elements, the effects of this change will paper, for example, industrial areas, climate change and this balance between the components is called (environmental balance) and that any change. Any undesirable change in the elements of the environment resulting from human activities that cause harm to human health and living organisms is considered environmental pollution.

In biological systems, heavy metals have been reported to affect cellular organelles and components.

Toxic elements in the human body transfer through the bloodstream into the various organs of the body [66]. Many epidemiological studies consider these toxic elements as possible effects carcinogens on humans and animals in general. The studies have shown that heavy metals can cause cancer diseases [67].

2.8 Heavy Metals in Soil

Soil is a crucial component of rural and urban environments, and in both places land management is the key to soil quality. urban soil as a soil material having anon - agricultural, man - made surface layer more than 50cm thick, that has been produced by mixing, filling, or by contamination of land surfaces in urban and suburban areas. The characteristics of urban soil are vertical and spatial variability, absence of soil structure leading to compaction, modified soil reaction (in most cases higher pH values), low organic matter content, restricted aeration and water drainage, high content of anthropic materials,

modified soil organisms population and activity. When considering different kinds of soil pollutants, heavy metals are especially dangerous because of their persistence and toxicity[68].

Soil act as a sink for heavy metals through sorption, complexation, and precipitation reactions. Due to proximity to humans, accumulation of harmful substances in urban soils is of grat concern. There are two main sources of heavy metals in soil:

(1) Naturally background, which represents the heavy metal concentration derived from parent rocks.

(2) Anthropogenic contamination, including agrochemicals organic amendments, animal manure, mineral fertilizer, sewage sludge and industrial wastes[69].

Chapter Three

Experimental Part

3.1 Introduction

This chapter includes a description of the study area, collecting and preparing the samples, description of the devices used to examine the samples, materials and the methods used in the present study.

This study deals with the practical part by collecting samples consisting of soil to measure radiological and toxical element concentrations as well as urine samples. These samples are prepared for measurement using different techniques, as shown in the figure work plan (3-1).

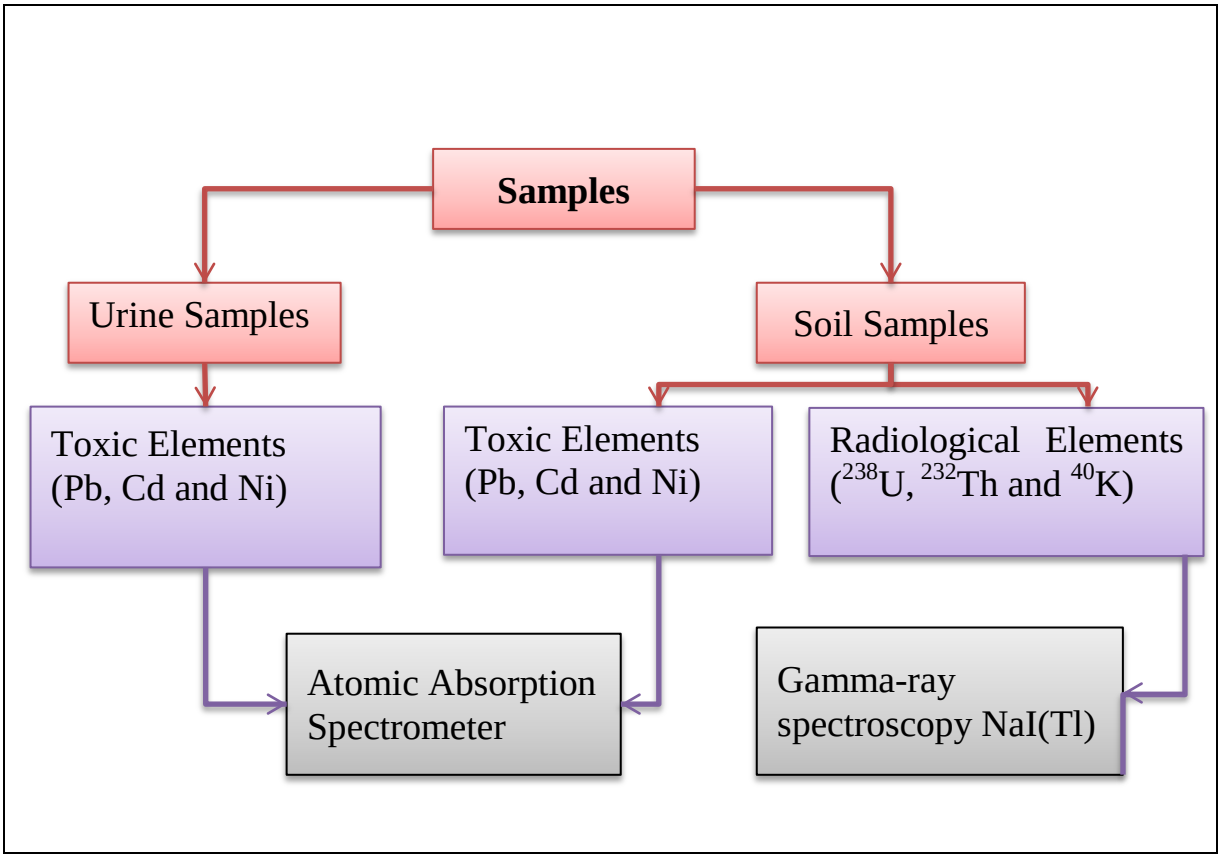

Figure 3.1: Flow chart of the study.

3.2 Study Area

Babylon is a governorate in central Iraq. It is located 90 km south of Baghdad. Babylon is located at longitude coordinates of 44° 10' 8.99" east and at latitude coordinates of 32° 50' 6.59", it's unquestionably one of the most important archaeological sites in the world. It has an area of 5,119 square Kilometres, with an estimated population of 2,241,638 people in 2021.The economy of Babil relies mainly on agriculture. The importance of the agriculture sector in Babylon stems from the fact that Euphrates river provides a plentiful amount of water for irrigation, making the land arable [70]. Figure (3-2) shows the district of Babylon Governorate and Table (3-1) shows the sites studied and the name of the regions.

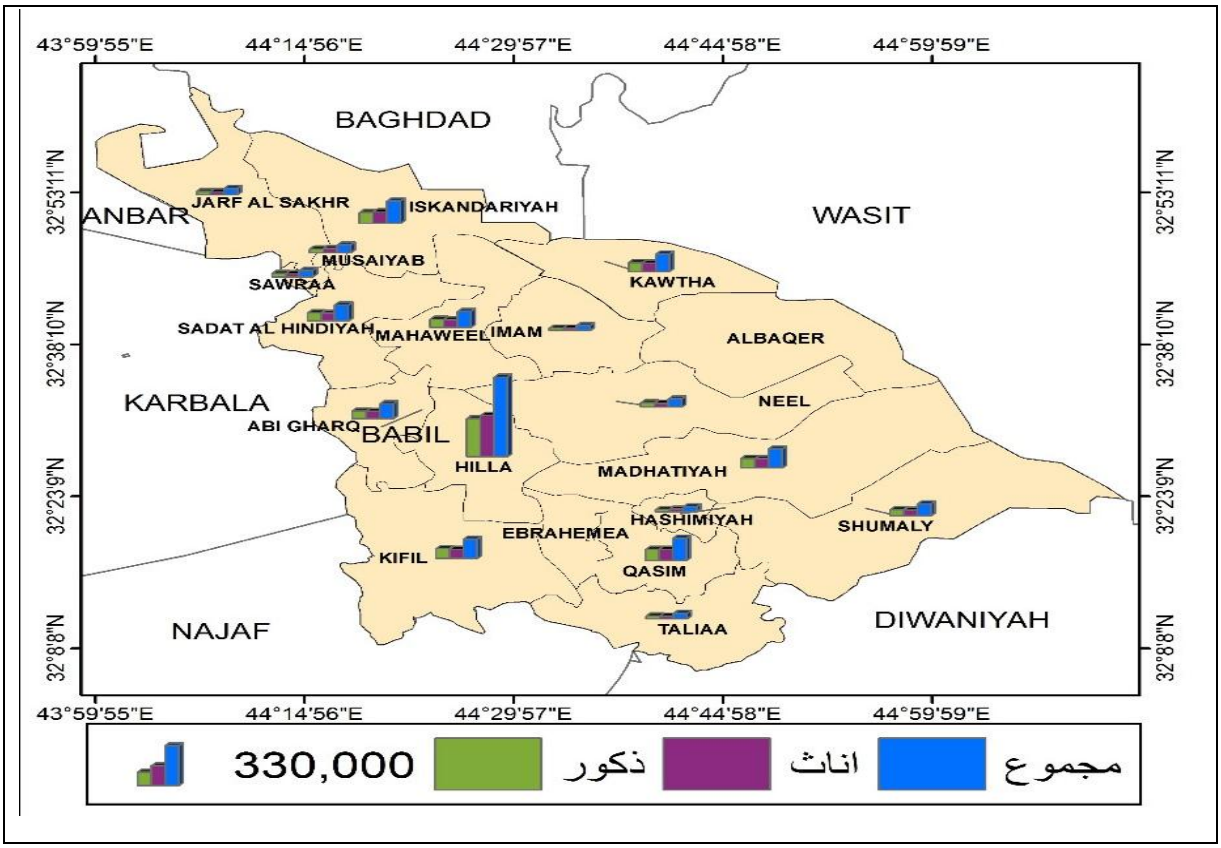

Figure 3.2: Map of Babylon governorate.

Table 3.1: The names of regions and coordinates of samples.

No.	Region	Samples	Coordinates	
			Latitude (N)	**Longitude (E)**
1	Alkifl	1	32°12'26.8"	44°22'11.9"
		2	32°13'27.6"	44°20'59.6"
		3	32°13'51.4"	44°22'52.5"
2	Al Iskandariyah	4	32°50'29.6"	44°19'35.1"
		5	32°51'59.1"	44°20'39.2"
		6	32°53'35.7"	44°21'05.6"
3	Al Mahaweel	7	32°44'20.2"	44°24'20.0"
		8	32°39'10.2"	44°24'04.0"
		9	32°36'09.2"	44°24'52.0"
4	Sadat Al Hindiyah	10	32°40'44.1"	44°15'07.5"
		11	32°38'04.4"	44°16'48.2"
		12	32°42'56.7"	44°15'09.9"
5	Al Musayab	13	32°45'35.5"	44°16'49.1"
		14	32°46'59.4"	44°17'32.1"
		15	32°47'01.6"	44°17'00.4"
6	Al Neel	16	32°32'32.9"	44°30'09.1"
		17	3232'36.9"	4433'00.2"
		18	32°33'05.1"	44°34'15.0"
7	Al Qasim	19	32°18'23.2"	44°40'30.3"
		20	32°16'17.3"	44°41'25.7"
		21	32°18'10.3"	44°40'57.2"
8	Abi Gharq	22	32°31'03.4"	44°22'49.3"
		23	32°32'00.9"	44°20'11.9"
		24	32°30'51.9"	44°21'51.5"
9	Al Imam	25	32°39'58.1"	44°30'39.2"
		26	32°40'23.7"	44°29'53.7"
		27	32°39'29.9"	44°28'22.0"
10	Al Shumaly	28	32°20'37.9"	44°50'03.3"
		29	32°19'26.2"	44°55'30.7"
		30	32°19'07.7"	44°54'15.1"
11	Al Hilla	31	32°48'86.5"	44°45'51.8"
		32	32°29'51.1"	44°24'54.6"
		33	32°26'41.2"	44°26'56.5"
12	Al Madhtiyah	34	32°24'10.5"	44°38'58.1"
		35	32°23'51.9"	44°40'25.8"
		36	32°24'07.3"	44°41'28.0"

13	Al Hashimiyah	37	32°21'35.8"	44°37'24.9"
		38	32°20'49.7"	44°39'33.7"
		39	32°22'49.7"	44°39'45.0"
14	Al Ebrahmea	40	32°23'21.4"	44°32'05.0"
		41	32°23'08.3"	44°31'17.1"
		42	32°22'32.4"	44°32'05.8"
15	Al Taliaa	43	32°13'10.6"	44°42'16.6"
		44	32°10'27.1"	44°43'35.9"
		45	32°1138.2"	44°42'08.2"

3.3 The Prepared Samples

After collecting the samples for 15 various locations in the Babylon governorate. The soil samples taken from a depth of 10-20 cm, are located a long way from the human trespassing. It cleans these samples and dries them in an electric oven at 100 ^{o} C for 2 hour to remove moisture from the samples[71]. To obtain homogeneous samples, the soil is grind and filtered by a diameter clamp (1mm) and then put (1kg) in a Marinelli beaker and stored for a month to obtain radiation balance [72].

3.4 Gamma-Ray Spectroscopy

Gamma-ray spectroscopy is used in this study, which it consists of a NaI (Tl) detector (a scintillation detector) of (3"×3") crystal dimension coupled with MCA (multi-channel analyzer). This particular detector is designed with ORTEC Components, Inc. MCA contains a 4096 channel connecting with ADC (Analog to Digital Convertor) through interface [73]. Gamma-ray spectroscopy measurements are analyzed by MAESTRO-32 software, as shown in figure (3-3).

Figure 3.3: Gamma-ray spectroscopy.

3.5 NaI(Tl) detector

The scintillation detector of iodide sodium activated with Thallium NaI(Tl), consists of two basic parts: the scintillator material and the photomultiplier tube. The scintillator material is (inorganic) at size (3"x3").

It is characterized by the production of photons (scintillation) when they absorb nuclear radiation and they are fed with Thallium, whose presence is necessary for the activation process to occur. The photon is usually produced by removing the excitation that occurs in the material after absorbing the nuclear radiation [74].

As for the photomultiplier facing the crystal, it consists of a cathode and a number of diynodes. The resulting photon in the crystal when it falls on the photocathode leads to the production of an electron, and then the diodes amplify the number of electrons produced from the photo cathode which is reacted with the scintillation [75].

3.6 Energy Calibration for NaI(Tl)

The purpose of the energy calibration process is to determine the position of the incident photon energy for each channel. This is done using standard sources that contain well-known peaks of energy.

When selecting these sources for calibration purposes, it takes into account the wide range of energies of the elements of the model spectrum to be detected.

For energy calibration, the following standard sources are used: (^{60}Co, ^{133}Ba, ^{57}Co, ^{137}Cs, ^{22}Na, ^{54}Mn, ^{109}Cd) and the energy between (1332.5-88) keV.

Table (3-2) shows the value of energy for standard sources and figure (3-4) represents the relationship between the energy of the standard sources and the corresponding channel number for each power value.

Table 3.2: Energy and channel number for standard sources used for calibration

Source	Energy (keV)	Channel number
^{60}Co	1173.228	141
^{60}Co	1332.494	159
^{54}Mn	834.838	102
^{137}Cs	661.6	82
^{22}Na	511.006	64
^{22}Na	1274.5	153
^{109}Cd	88	11
^{133}Ba	81	10

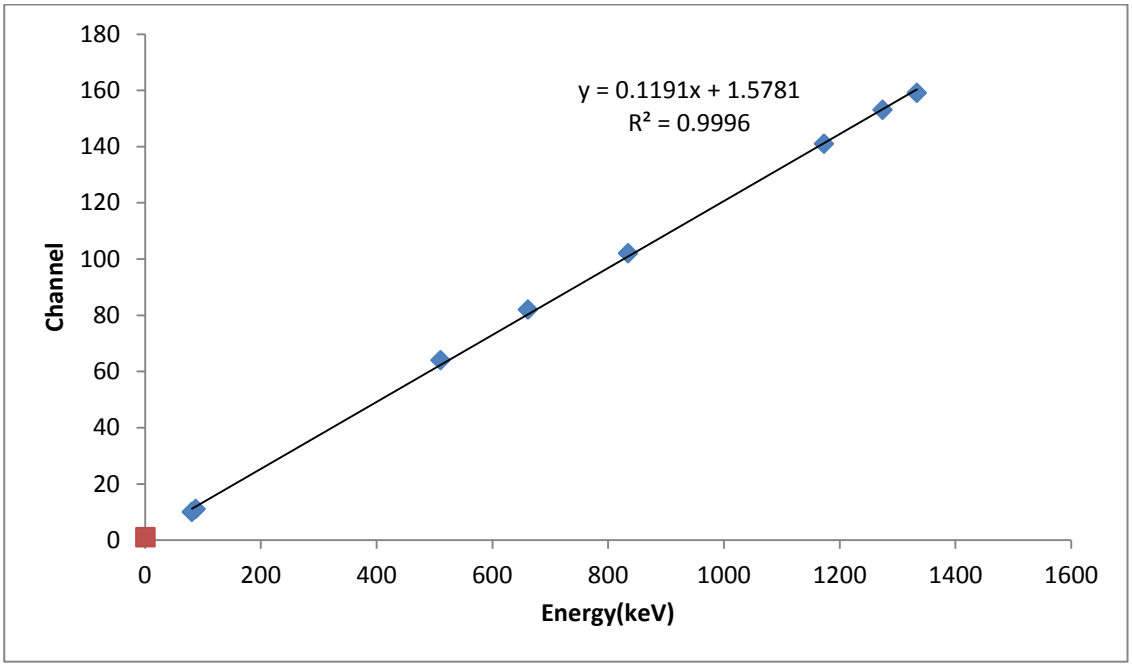

Figure 3.4: The relationship between energy and channel number for NaI(Tl).

3.7 Efficiency Calibration

The efficiency calibration is performed by acquiring a spectrum of the calibration standard for (500 second). The net count rate is determined at the photo peaks for all the energies to be used for determination of the efficiency calibration. The equation below was used to calculate efficiency (ε) [70]:

$$\varepsilon = \frac{Nn.a}{A * I\gamma * t} \times 100\% \qquad (3\text{-}1)$$

$Nn.a$: area under the specified energy peak after background subtraction

$I\gamma$: is the gamma ray emission probability at each energy

A: Activity of source of measured time

t: Measurement time

The radionuclides are used for the efficiency calibration tabulate in Table (3-3) The efficiency curve is obtained by plotting the detection efficiency of Na(Tl) as a function of energy. The calibration curve is shown in figure (3-5).

Table 3.3: Standard sources with energies known and efficiency.

Isotopes	Energy (keV)	Efficiency %
Co-60	1332.5	0.009262
Mn-54	834.8	0.074325
Cs-137	661.6	0.071227
Na-22	1274.5	0.027025
Cd-109	88	3.19249
Ba-133	383.7	0.78565
Co-57	136.6	2.47295

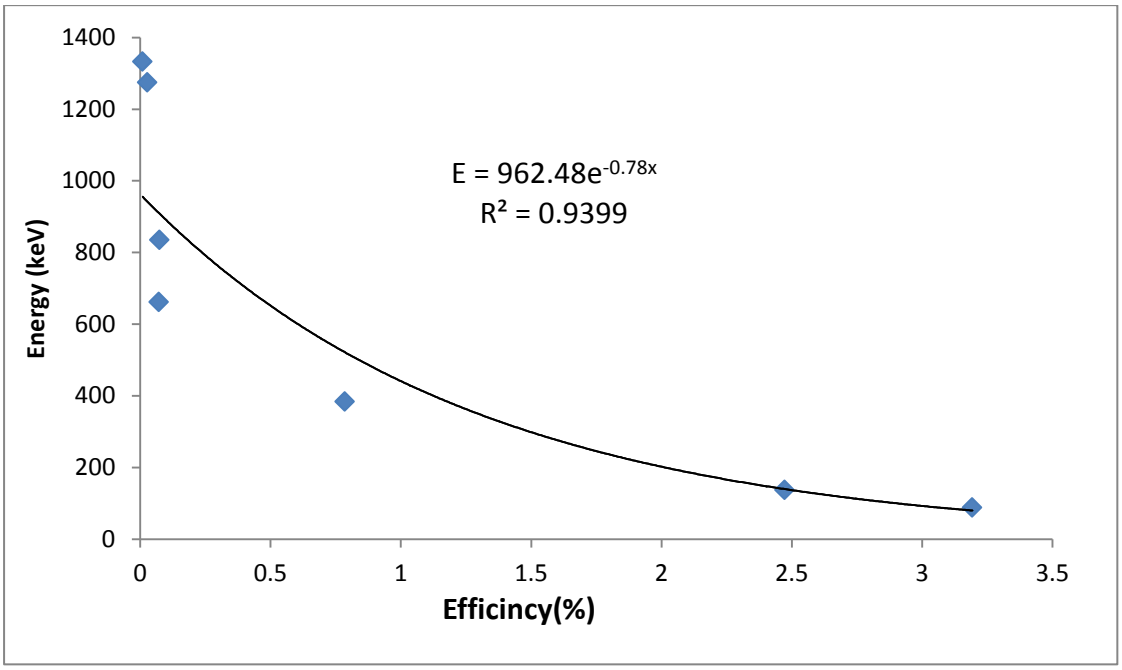

Figure 3.5: The relationship between efficiency and energy.

Figure (3-5) shows the relationship between efficiency and energy, it can be found the efficiency in ^{238}U (^{214}Bi), ^{232}Th (^{208}Tl) and ^{40}K as seen in Table (3-4).

Table 3.4: The values of efficiency for isotopes ^{238} U (^{214}Bi), ^{232}Th (^{208}Tl) and ^{40}K.

Isotopes and Daughter	Energy (keV)	Ɛ %
^{40}K	1460	0.03011
^{238}U	1764	0.02143
^{232}Th	2614	0.00106

3.8 Background and Samples Measurement

Before conducting any measurement of the radioactivity of any samples, it is necessary to measure the radioactive background of the detection system for the possibility of the presence radioactive source or polluting materials that become a source of radiation in addition to the natural radioactivity of the walls of the laboratory itself. The background is one of the most critical influences on the measurement the background spectrum was measured by a 1-liter plastic container on the detector and counting at the same time for sample measurements (12000 second). The research laboratory in the Physics Department College of the Science University of Babylon.

Environmental samples of low-level radioactivity are often measured in Marinelli Beakers specially designed to provide better detection sensitivity. Full Energy Peak Efficiency variations are observed in this geometry for different sample types this is due to self-attenuation effects, see figure (3-6) for Marinelli Beaker photo and a drawing of its dimensions respectively**.**

Figure 3.6: Photo of Marinelli beaker and the design of its geometry.

The 1-liter Marinelli beaker, made of polypropylene material manufactured by Amersham, is used. The precision with which the activity can be determined by this Marinelli geometry is limited by the effect of self-absorption, for which correction must be made. To calculate the specific activity for each sample, the net area under the corresponding peaks in the energy spectrum is computed by subtracting the count due to background sources from the net area of a certain peak using the maestro-32 data analysis package. At low gamma energies which have poorly-separated photo-peaks, the measuring of the specific activity concentrations is possible at well separated photo-peaks at high energies, as that obtained in our results from the

gamma rays emitted by the progenies of ^{238}U and ^{232}Th, which are in secular equilibrium with them, while ^{40}K was estimated directly by its gamma-line of 1460 keV.

3.9 Measurement of Heavy Metals

The measurement of heavy metals (Pb, Ni and Cd) is discussed in the subsequent sections.

3.9.1 Collected samples

In the current study, 60 samples of human urine are collected from males and female volunteers in Babylon Governorate. The urine samples have been taken from two groups including patients of cancer group and healthy group. The cancer patients group was collected from the Babylon oncology center. Similarly, the healthy group was collected from different regions of the governorate. Each sample is kept at 4°C using an ice box, with the code of the sample until the time of analysis. The age, gender and smoking habits of volunteers are taken into consideration are revealed in Table (3-5).

Table 3.5: Demographic characteristics of the two groups participating in the study

Classification	Cancer patients group	Healthy group
Males number	16	16
Females number	14	14
Smokers number	11	8
Age range (years)	11-81	10-78
Males average age (years)	53.06	51.62
Females average age(years)	46.06	43.6
Average age total (years)	50.1	48

The independent variables in this study are the demographic variables of the participants such as gender, health status, smoking habit, and age.

3.9.2 Sample Digestion

The dried soil samples, weighing 1 g in containers are digested by adding 20 ml of 65% nitric acid (HNO_3) and placed on a hot plate at a temperature of 80^{o}C, when the red vapors stop appearing added 10ml of perchloric acid ($HClO_4$) [38] . The samples were then heated until the dark color turned light, then the contents are cooled and diluted with 25 ml of warm distilled water and the sample was filtered using a filter sheet and the sample is collected with a volume of 100 ml in a special containers as show in figure (3-7).

As for digestion of urine samples, the experimental method is the urine samples with (8 ml) were mineralized in (4 ml) of nitric acid HNO_3 (65 %) in addition to one ml from hydrogen peroxide H_2O_2 (30 %). The urine samples were first digested using heating at 200 °C for 1 hour. All urine samples have been cooled at room heat after the digestion process [35]. The samples of urine were completed with distilled water (100 ml) and filtered using Whatman filter paper, which washed with water and acid and dry in advance. Figure (3-8) show the urine samples after digestion.

Figure 3.7: Preparing the soil for digestion

Figure 3.8: The urine samples.

3.9.3 Atomic Absorption Spectrophotometer

The Atomic Absorption Spectrophotometer (AAS) is a technique for determining a wide range of heavy metals in liquid samples. It can measure parts per billion of a gram and analyze and determine the concentrations of more than 62 different metals in various materials such as (Pb, Cd and Ni). In environmental testing, it can measure the concentration of heavy elements in soil, as for clinical analysis, AAS can test for toxic elements in urine.

In terms of operation, the AAS method is, mainly, based on determining the amount of radiation absorbed by the chemical element of interest and hence, measuring its concentration. Atoms of different elements absorb characteristic wavelengths of light. AAS is equipped with a detector that can compare the light wavelengths transmitted by the sample with the wavelengths of light that are passed through it [76].

Analyzing a sample to see if it contains a concentration of a particular element using lamp from that element. For example with lead, a lamp containing lead emits light from excited lead atoms that produce the right mix of wavelengths to be absorbed by any lead atoms from the sample.

In AAS, the sample is atomized by converted into ground state free atoms in the vapors state and a beam of electromagnetic radiation emitted from excited lead atoms is passed through the vaporized sample. The greater number of atoms there is in the vapor, the more radiation is absorbed.

Physically, a photon is emitted with a certain amount of energy E when electrons transfer within an atom. Since every atom has a unique electron configuration, it has a distinct pattern of wavelengths at which it will absorb energy [77]. This property allows a qualitative analysis of a sample to be made and hence its concentration can be determined. The concentration is calculated based on the Beer- Lambert law [78]. The figure (3-9) shows the components of this technique. The technique used in this work of Flame Atomic Absorption Spectrophotometer.

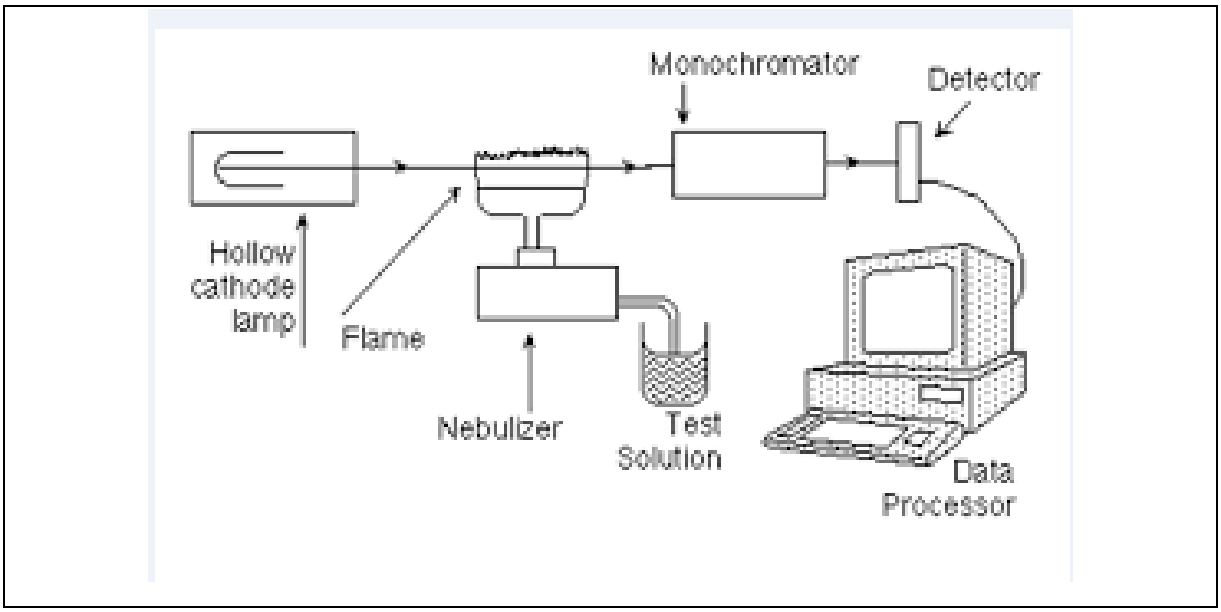

Figure 3.9: Components of atomic absorption spectrophotometer [79].

The device consists of Radiation Source (Cathode Tube), the energy source by atomizer, monochromater and detector[79].

The AAS technique is developed in the nineteenth century, its modern form was enormously enhanced during the 1950s by Alan Walsh and a team of Australian chemists [76]. The AAS model used in the present study is (AA-7000 SHIMADZU, Japan) and it is shown in Figure (3-10).

Figure 3.10: Atomic Absorption Spectrophotometer.

3.9.4 Calibration Curve for Heavy Metals (Pb, Cd and Ni)

The AAS process also requires a calibration curve, which will help determine the concentration of the element you are testing for based on previous measurements of it at known concentrations.

The measuring instruments known as a spectrometer is calibrated for the specified element. Once the sample is fed into the instrument, it will

show up on the instruments calibration curve according to the law of diluting[80]:

$N_1 * V_1 = N_2 * V_2$ (3-2)

Where:

N_1: is the concentration of solution before dilution (ml/L).

V_1: is the volume of solution.

N_2: is the concentration of dilute solution (after more solvent has been added).

V_2: is the volume of the dilute solution.

The concentrations of heavy elements are determined in the U- science laboratory in Al-Diwaniyah governorate.

3.10 Instrument Information

Optics parameters of lead

Socket: 6

Lamp Current Low (Peak)(mA): 10

Wavelength (nm): 283.3

Slit Width (nm): 0.7

Lamp Mode: BGC-D_2

Atomizer/Gas Flow Rate Setup

Fuel Gas Flow Rate (L/min): 2.0

Support Gas Flow Rate (L/min): 15.0

Flame Type: Air-C_2H_2

Burner Height (mm): 7

Burner Lateral Pos. (pulse): 0

Burner Angle (degree): 0

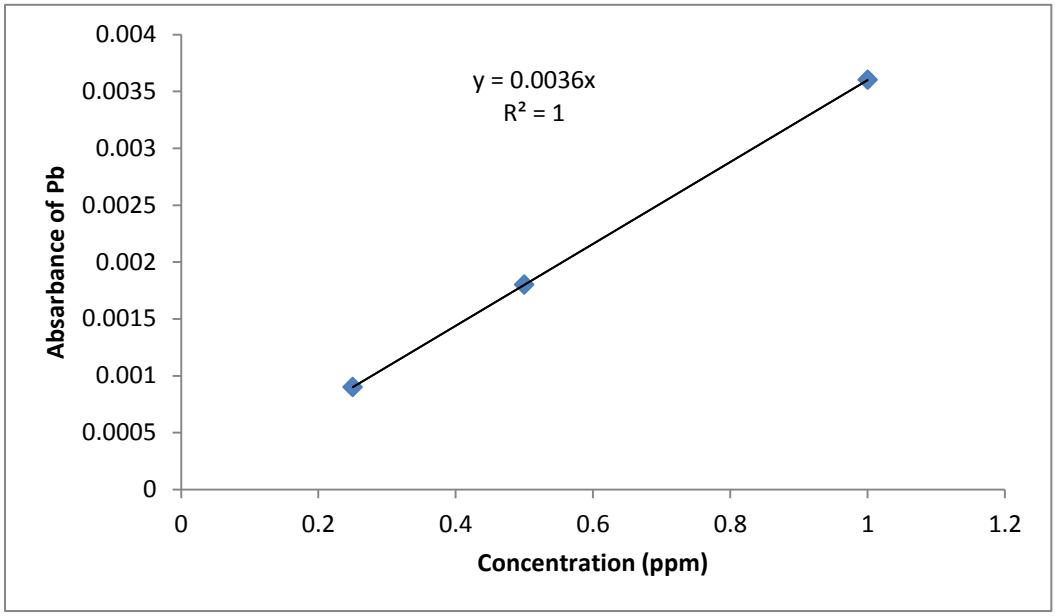

Figure 3.11: Calibration curve of element Pb.

Optics Parameters of cadmium

Socket: 4

Lamp Current Low (Peak)(mA): 8

Wavelength (nm): 228.8

Slit Width (nm): 0.7

Lamp Mode: BGC-D_2

Atomizer/Gas Flow Rate Setup

Fuel Gas Flow Rate (L/min): 1.8

Support Gas Flow Rate (L/min): 15.0

Flame Type: Air-C_2H_2

Burner Height (mm): 7

Burner Lateral Pos. (pulse): 0

Burner Angle (degree): 0

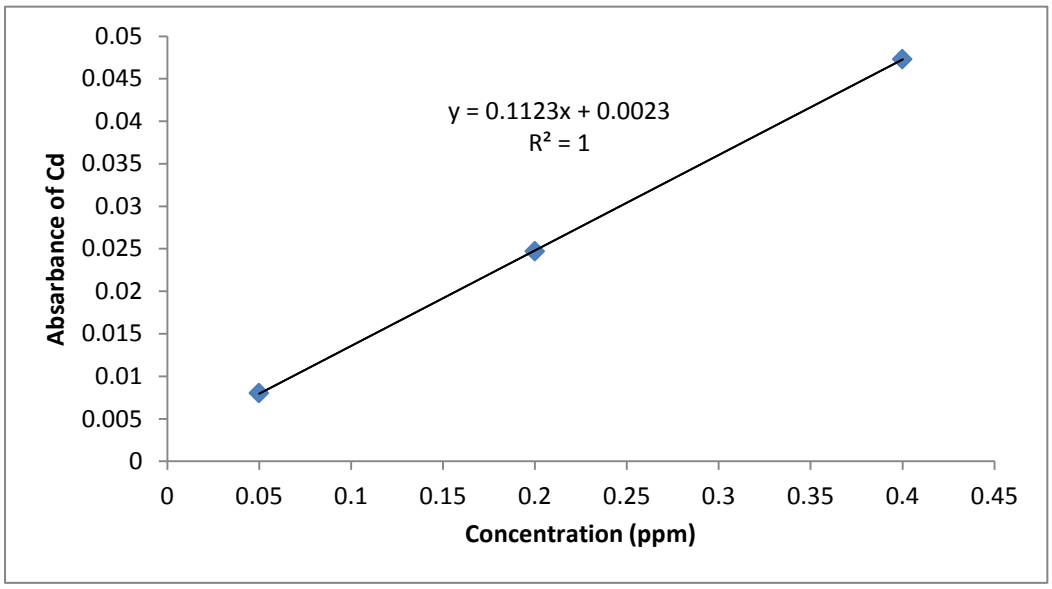

Figure 3.12: Calibration curve of element Cd.

Optics Parameters of Nickl

Socket: 1

Lamp Current Low (Peak)(mA): 12

Wavelength (nm): 232.0

Slit Width (nm): 0.2

Lamp Mode: BGC-D_2

Atomizer/Gas Flow Rate Setup

Fuel Gas Flow Rate (L/min): 1.6

Support Gas Flow Rate (L/min): 15.0

Flame Type: Air-C_2H_2

Burner Height (mm): 6.5

Burner Lateral Pos. (pulse): 0

Burner Angle (degree): 0

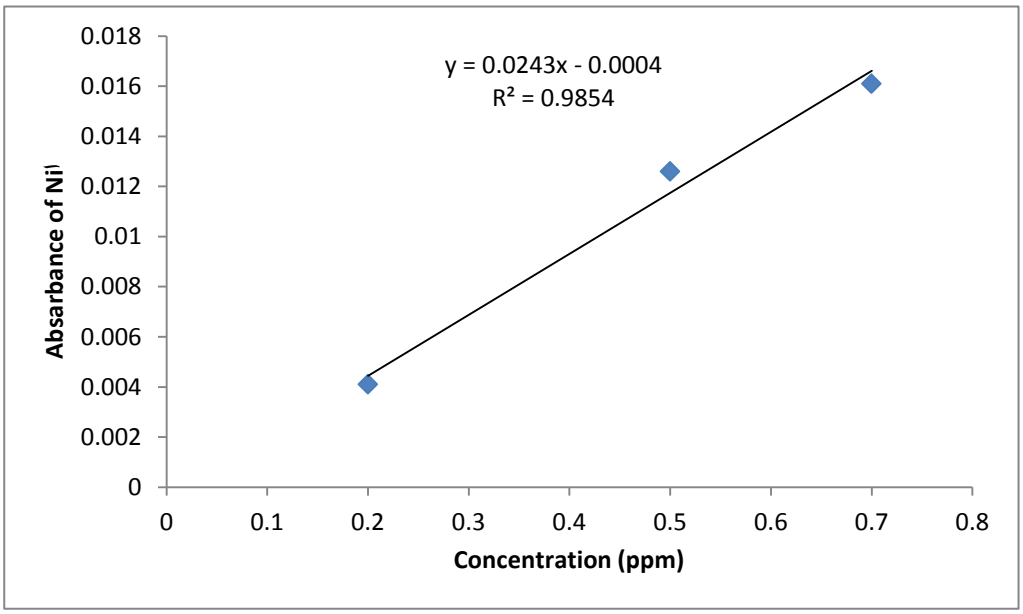

Figure 3.13: Calibration curve of element Ni.

3.11 Statistical Analysis

The results are divided into two group cancer patients, healthy individuals and analyzed by using; a.statistical package of the social sciences (SPSS) program. Independent Multi-ANOVA has been used to calculate the significance of the probability level. The results obtained for the cancer group were compared with the results of the healthy group using various tests to determine the significance of probability level of each the analyzed parameters.

Chapter Four

Results and Discussion

4.1 Introduction

This chapter explains the results of radiological and toxicological detection in soil samples and human urine conducted in this study. First, the activity concentrations using a NaI(Tl) detector and distributions of natural radionuclides in soil samples collected were investigated to assess the environmental radioactivity and characterization of radiological hazard and measuring the concentrations of toxic elements in urine and soil using the AAS technique.

4.2 Specific Activity

The ^{238}U, ^{232}Th and ^{40}K concentrations in soil samples are from 15 different areas in Babylon governorate. The results of natural radioactivity are presented in Table (4-1).

Table 4.1: Specific activity for ^{238}U and ^{232}Th, and ^{40}K.

Sample No.	Sampling Regions	Specific Activity (Bq/Kg)		
		^{238}U	^{232}Th	^{40}K
S1	Al-kifl	18.07±0.303	8.101±0.420	215.718±2.37
S2		9.307±0.187	13.843±0.289	159.32±2.024
S3		4.57±0.122	7.099±0.391	203.29±2.303
S4	Al Iskandariyah	8.806±0.135	11.768±0.196	208.61± 2.333
S5		8.846±0.144	7.55±0.406	145.796±1.951
S6		22.18±0.225	10.790±0.197	202.197±2.297
S7	Al-Muhaweel	3.651±0.091	14.137±0.155	187.053±2.209
S8		17.382±0.199	14.762±0.567	227.759±2.438
S9		5.031±0.112	12.795±0.247	207.236±2.326
S10	Saddet al Hindiyah	10.520±0.155	8.589±0.113	207.393±2.327
S11		4.507±0.109	7.205±0.219	203.241±2.303
S12		8.001±0.135	9.564±0.457	190.943±2.232
S13	Al-musayab	5.711±0.114	21.79±0.689	248.073±2.545
S14		9.144±0.146	23.472±0.775	187.288±2.211
S15		9.122±0.158	13.930±0.308	291.525±3.447

S16	Al Neel	13.97±0.188	14.291±0.588	359.637±3.828
S17		12.84±0.230	15.750±0.373	307.707±3.541
S18		6.861±0.139	20.527±0.705	353.604±3.796
S19	Al Qasim	8.13±0.143	13.707±0.576	251.211±3.199
S20		10.42±0.162	19.542±0.293	387.150±3.972
S21		7.101±0.140	17.469±0.290	273.304±3.337
S22	Abi Gharq	6.864±0.136	8.662±0.458	398.604±4.030
S23		10.42±0.162	7.521±0.427	255.736±3.228
S24		10.16±0.160	9.632±0.483	330.248±3.668
S25	Al Imam	7.11±0.134	11.771±0.207	288.834±3.431
S26		10.092±0.166	7.424±0.424	326.579±3.648
S27		15.214±0.196	9.608±0.482	342.598±3.736
S28	Al Shumaly	10.67±0.164	17.106±0.644	369.012±3.878
S29		26.17±0.257	13.539±0.573	309.052±3.549
S30		5.397±0.188	13.955±0.309	284.269±3.403
S31	Al Hilla	4.092±0.166	11.768±0.534	379.027±3.930
S32		18.55±0.217	6.721±0.403	325.642±3.643
S33		6.09±0.124	14.464±0.329	440.833±4.238
S34	Al Madhtiyah	6.19±0.125	6.504±0.191	347.204±3.771
S35		3.846±0.268	17.761±0.656	405.493±4.065
S36		5.160±0.234	9.390±0.477	287.002±3.420
S37	Al Hashimiyah	8.507±0.298	8.856±0.463	355.927±3.808
S38		9.65±0.156	10.603±0.507	311.171±3.561
S39		5.085±0.113	8.468±0.453	299.065±3.491
S40	Al Ebrahmeh	6.439±0.249	17.324±0.648	377.653±3.923
S41		19.82±0.224	8.807±0.462	352.055±3.788
S42		8.567±0.255	14.291±0.588	343.332±3.740
S43	Al Taliaa	7.287±0.241	13.976±0.582	329.962±3.667
S44		3.567±0.118	6.187±0.387	309.786±3.553
S45		12.211±0.237	9.591±0.295	302.734±3.512
Ave ±SD		**9.592±0.179**	**12.233±0.416**	**209.886±3.237**
Max ±SD		**26.17±0.257**	**23.794±0.755**	**440.833±4.238**
Min ± SD		**3.567±0.118**	**6.187±0.387**	**145.796±1.951**
Global limit[82]		**33**	**45**	**420**

The maximum value specific activity of ^{238}U is (26.17±0.257 Bq/kg) in Al Shumaly (29), while the minimum value is (3.567±0.118Bq/kg) in Al-Taliaa (44) as illustrated in figure (4-1). It is found that the average of these values is **(**9.592±0.179Bq/kg).

As for ^{232}Th the maximum value specific activity is (23.794±0.755 Bq/kg) Al-musayab (14), while the minimum value is (6.187±0.387 Bq/kg) in Al-Taliaa (44) and the average values found (12.233±0.416 Bq/kg) shown in the figure (4-2).

The specific activity values of ^{238}U and ^{232}Th differed in the study area due to the variation of environmental structures. The radioactivity in soil is dependent on the radioactivity of the rocks that produced it (the origin of soil) as well as the total activities that happened during the formation of the soil.

For a specific activity of ^{40}K, the maximum value is (440.833±4.238 Bq/kg) in Al Hilla river (33), which is due to the presence of phosphate fertilizers in this agricultural region, whereas the minimum value specific activity was (145.796±1.951 Bq/kg) in Al Iskandariyah (5) and the average values is (209.886±3.237 Bq/kg) shown in the figure (4-3).

It should mention that the potassium content of soil varies depending on the soil type and increases in some agricultural areas due to the use of phosphate fertilizers that contain potassium compounds. Pesticides and chemical fertilizers with radioactivity are among the important sources of soil pollution [21].

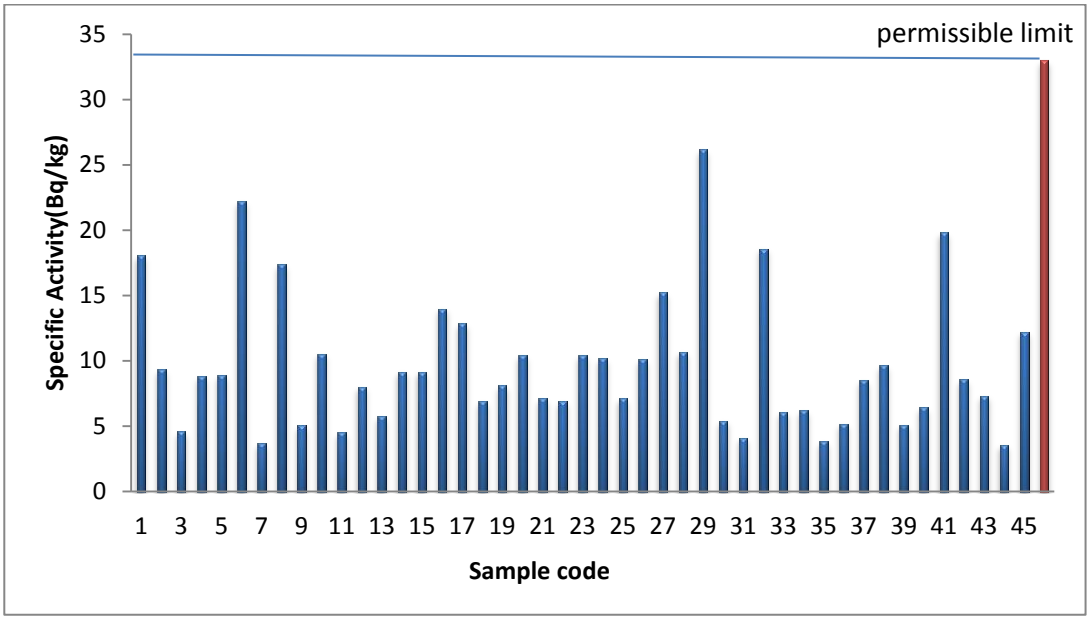

Figure 4.1: The specific activities of ^{238}U.

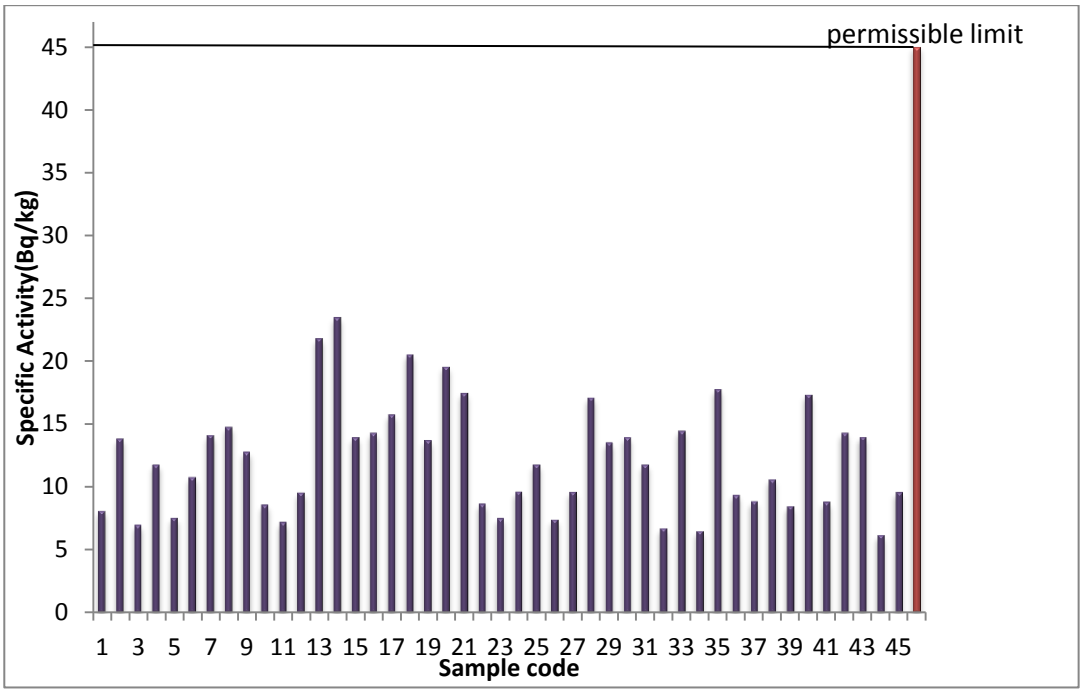

Figure 4.2: The specific activities of ^{232}Th.

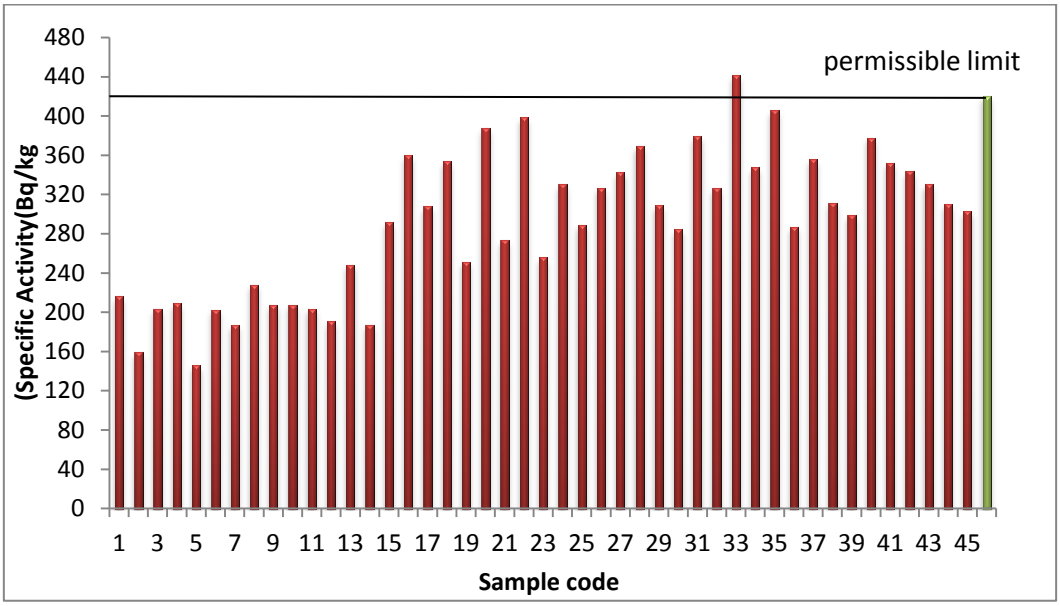

Figure 4.3: The specific activities of ^{40}K.

4.2.1 Comparison of Results with Other Studies

Table (4-2) shows a comparison between the specific activity of radionuclide in soil samples obtain in the current study and those in other studies.

The average values of specific activity of ^{238} U, ^{232}Th and ^{40}K in the current study are less than Nigeria, Turkey, Iraq's - Kurdistan and Iraq-Najaf. This is due to the different locations from which the samples were taken.

Table 4.2: Comparison of the specific activity of radionuclides in different countries and local studies to the current study of soil samples.

Country	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Refs.
Iraq- Babylon/Kuth	19.1565	54.501	179.578	[24]
Iraq- Babylon/Qassim	15 ± 0.691	45.46± 1.82	277.68 ± 2	[19]
Iraq- Babylon	15.485	15.505	170.206	[18]
Iraq- Babylon/Hittin	16.07±2.89	9.60±0.95	308.24±11.06	[17]

Iraq- Baghdad	38.22	42.99	16.64	[23]
Iraq-Najaf	69.78±0.53	125.63±0.47	1165.29±0.45	[16]
Iraq's - Kurdistan	83.337	19.147	284.86	[14]
Turkey	24.5	51.8	344.9	[20]
Sultanate Oman	14.42	9.95	158.21	[13]
Nigeria	55.3 ± 1.2	26.4 ± 2.7	505.1± 7.1	[15]
Iraq- Babylon	9.592±0.179	12.233±0.416	209.88±3.237	Present Work
Worldwide	33	45	420	[82]

4.3 Radiation Hazards

In order to assess the health effects, the radiation hazards such as radium equivalent activity (Ra_{eq}), Absorbed dose rate(AD)(nGy/h), External (H_{ex}) and Internal(H_{in}) Hazard Indices, annual effective dose (AEDE) indoor, outdoor& total dose (mSv/y) and Gamma Index (Iγ) were calculated. The values have shown in Tables (4-3).

Table 4.3: The Hazard indices in this work.

Sample No.	$Ra_{(eq)}$ (Bq/Kg)	AD(nGy/h)	H_{ex}	H_{in}	Iγ	AEDE (msv/y) Outdoor
S1	46.265	22.253	0.1249	0.1738	0.3076	0.1091
S2	41.370	19.540	0.1117	0.1368	0.3360	0.0239
S3	30.247	14.941	0.0816	0.0940	0.2396	0.0183
S4	41.698	20.076	0.1126	0.1364	0.2735	0.0246
S5	30.868	14.855	0.0833	0.1072	0.2692	0.0182
S6	53.179	25.379	0.1436	0.2035	0.3804	0.0311
S7	38.236	18.251	0.1032	0.1131	0.3173	0.0223
S8	56.029	26.695	0.1513	0.1983	0.4016	0.0327
S9	39.285	18.911	0.1060	0.1196	0.2997	0.0231
S10	38.772	18.842	0.1047	0.1331	0.2915	0.0231
S11	30.459	15.031	0.0822	0.0944	0.2293	0.0184
S12	36.381	17.598	0.0982	0.1198	0.3143	0.0215
S13	55.978	26.517	0.1511	0.1665	0.3808	0.0325

S14	57.130	26.610	0.1542	0.1789	0.4900	0.0326
S15	51.490	25.022	0.1390	0.1637	0.4398	0.0306
S16	62.094	30.326	0.1677	0.2054	0.4411	0.0371
S17	59.056	28.544	0.1594	0.1941	0.4788	0.0350
S18	63.443	30.662	0.1713	0.1898	0.4184	0.0376
S19	47.074	22.743	0.1271	0.1490	0.4493	0.0278
S20	68.176	33.094	0.1841	0.2122	0.4470	0.0405
S21	53.127	25.526	0.1434	0.1626	0.4877	0.0313
S22	49.943	25.172	0.1348	0.1534	0.3028	0.0308
S23	40.868	20.149	0.1103	0.1385	0.3648	0.0247
S24	49.364	24.447	0.1333	0.1607	0.3566	0.0299
S25	46.183	22.639	0.1247	0.1439	0.3828	0.0277
S26	45.856	22.891	0.1238	0.1511	0.3699	0.0280
S27	55.334	27.282	0.1494	0.1905	0.4435	0.0334
S28	63.546	30.940	0.1716	0.2004	0.4482	0.0379
S29	69.328	33.386	0.1872	0.2579	0.4993	0.0409
S30	47.241	23.013	0.1275	0.1421	0.4282	0.0282
S31	50.106	25.004	0.1352	0.1463	0.3620	0.0306
S32	53.235	26.323	0.1437	0.1939	0.4847	0.0322
S33	60.718	30.178	0.1639	0.1804	0.4167	0.0370
S34	42.226	21.377	0.1140	0.1307	0.3766	0.0262
S35	60.467	29.715	0.1632	0.1736	0.3945	0.0364
S36	40.687	20.183	0.1098	0.1238	0.3655	0.0247
S37	48.578	24.272	0.1311	0.1541	0.3527	0.0297
S38	48.773	24.018	0.1317	0.1577	0.3697	0.0294
S39	40.222	20.079	0.1086	0.1223	0.3703	0.0246
S40	60.292	29.481	0.1628	0.1802	0.4508	0.0361
S41	59.523	29.307	0.1607	0.2143	0.4491	0.0359
S42	55.440	27.150	0.1497	0.1728	0.4200	0.0332
S43	52.680	25.805	0.1422	0.1619	0.3948	0.0316
S44	36.268	18.408	0.0979	0.1075	0.2874	0.0225
S45	49.234	24.221	0.1329	0.1659	0.3712	0.0297
Ave.	**49.477**	**24.152**	**0.1336**	**0.1595**	**0.3812**	**0.0314**
Max	**69.328**	**33.386**	**0.1872**	**0.2579**	**0.4993**	**0.1091**
Min	**30.247**	**14.855**	**0.0816**	**0.0940**	**0.2293**	**0.0182**
Global limit[1]	**370**	**55**	**≤ 1**	**≤ 1**	**≤ 1**	**1**

The highest value of radium equivalent (Ra_{eq}) is (69.328Bq/kg) in sample No. (29) and the minimum value is (30.247Bq/kg) in sample No.(3), either the average value of radium equivalent (Ra_{eq}) is (49.477Bq/kg). From these results, the equivalent activities of radium were less than 370 Bq/kg. while the highest value of Absorbed dose rate(AD) is (33.386nGy/h) in a sample (29) and the minimum value is (14.855nGy/h) in a sample (5), either the value rate of absorbed dose (AD) is (24.152nGy/h) and less than global permissible limit 55(nGy/h)

The calculated highest value of the external hazard index (Hex) is (0.1872) in sample No.(29) and minimum value is (0.0816) in sample No.(3) with an average value of 0.1336. Also the internal hazard index (Hin) found that its highest value is (0.2579) in sample No.(29) and the minimum value is(0.0940) in sample No.(3), and an average value is (0.1595).

After measuring the Gamma Index (Iγ), it is found that its highest value is (0.4993) in sample No. (19) and the minimum value is (0.2293) in sample No. (11) and the average value are (0.3812). As for the annual effective dose (AEDE) (outdoor) measurement finds that its highest value is (0.1091 mSv/y) in sample No. (1) and the minimum value is (0.0182 mSv/y) in sample No. (5) at either of these rates the annual effective dose is (0.0314mSv/y).

Pesticides and chemical fertilizers with radioactivity are among the most important sources of environmental pollution.

Since the occurring radioactive materials are more concentrated with the increase in human activities, such as miming oil and gas production, which is the cause of risks of radioactive pollution or radioactive waste, the values the hazard indices vary from one region to another.

4.4 Concentrations of Heavy Metals in Soil Samples

The concentration of (Pb, Cd and Ni) in soil samples in areas of Babylon governorate as presented in Table (4-4).

Table 4.4: Concentrations of heavy metals in soil.

Sample No.	Sampling Regions	Concentration of Toxic Elements (mg/kg)			Area Description
		Pb	Cd	Ni	
S1	Al Hilla	21.102	0.361	144.006	Industrial
S2	Al Shumaly	19.391	0.180	37.876	Heavy Traffic Densities
S3	Al Madhtiyah	23.384	0.257	22.431	Agricultural
S4	Al Qasim	22.813	0.206	100.865	Industrial
S5	Al Hashimiyah	21.673	0.670	19.319	Residential
S6	Al Ebrahmea	22.817	0.025	148.248	Car garage
S7	Al Neel	17.680	0.206	18.254	Agricultural
S8	Al Taliaa	8.547	0.001	18.884	Residential
S9	Al Mahaweel	15.821	0.412	112.355	Main Street
S10	Al-Musayab	28.517	0.283	175.331	Electrical power plant
S11		25.095	0.002	194.821	Fuel station
S12		9.914	0.015	147.16	Residential
S13	Al Iskandariyah	14.828	0.249	85.599	Agricultural
S14		18.251	0.014	40.896	Industrial district
S15		10.266	0.004	33.391	Main Road
S16	Alkifl	24.524	0.026	156.732	Brick Factory
S17		21.307	0.206	15.167	Commercial markets
S18	Sadat Al Hindiyah	15.399	0.386	26.267	Agricultural
S19		17.106	0.103	87.686	Main Street
S20		19.962	0.439	35.582	Residential
Ave.		**18.919**	**0.202**	**81.043**	
Max.		**28.517**	**0.670**	**194.821**	
Min.		**8.547**	**0.001**	**15.167**	

Global limit[33]		**10**	**1**	**40**	

The calculated Pb ranged from all sites was between 8.547 to 28.517mg/kg with a rate value of 18.919 mg/kg. where the value of Pb concentrations was high in soil samples, which is higher than its average in global soils (10 mg/kg). The increased content of Pb in industrial and commercial areas densely populated is associated with the fact that Iraqi vehicular traffic system is still using lead to improve the octane rate of gasoline. In addition, the highest value of Pb was in the electrical power plant in Al-Musayab, where, the products of fuel combustion can cause soil pollution in the nearby areas.

The Cd detected value in the selected locations varies from 0.001to 0.670 mg/kg with an average value of 0.202 mg/kg and observed to be within the permissible limit globally (1mg/kg). Anthropogenic activities such as wastewater irrigation, sludge, fertilizer, and solid waste from different industries can all increase the amount of Cd in the environment.

As for Ni, rescored high values which are ranging from 15.167 to 194.821 mg/kg in Al-Musayab (fuel station) with an average value of 81.043 mg/kg. The determined world mean for Ni in uncontaminated soil is 40mg/kg. We note the high concentration of Ni in the industrial area, as well as the electric power plant, fuel plant and brick factory, which constitute a major source of pollution to surrounding areas, in addition to the environmental services represented by the dumping of sewage and the accumulation of waste in soil which leads to its decomposition and increased concentrations of heavy metals.

4.4.1 Comparison with Other Studies

We note from Table (4-5) concentrations rates of Pb and Cd in Babylon were higher than present work, the reason is that the locations from which the samples were taken may differ for that Baghdad, Basra, Shattrah city, Diwaniyah and China were higher than this work. As for average the concentration of Ni in our study, the result is higher than the average concentration in Baghdad, Basra, Shattrah city and China.

The difference in these results is due to the contamination of some areas with toxic elements or the pollution of industrial areas.

Table 4.5: Comparison between the concentrations of the heavy metals in soil with different studies to the current study.

Country	Pb	Cd	Ni	Refs.
Iraq-Babylon	201.4	2.2	49.1	[77]
Iraq- Baghdad	113.98	0.54	80.44	[81]
Iraq-Basra	39.4	20.9	5.5	[30]
Iraq-Shattrah city	171.68	12.27	21.5	[31]
Iraq- Baghdad	43	19	172	[33]
Iraq- Diwaniyah	31.75 ± 2.65	1.804 ± 0.43	-	[38]
China	28.6	0.148	27.8	[83]
Iraq-Babylon	18.919	0.202	81.043	Present Work

4.5 Concentration of Toxic Elements in Urine Samples

Using the SPSS program, the general statistical indicators of data for Pb, Cd and Ni are obtained for two groups of healthy and patients. Table (4-6) shows the concentration Pb, Ni and Cd in urine samples of the healthy individuals.

Table 4.6: Concentrations of toxic elements in urine samples for the healthy group.

Sample Code	Pb (mg/l)	Ni (mg/l)	Cd (mg/l)
H1	0.0139	0.0008	0.0014
H2	0.0281	0.001	0.0109
H3	0.0311	0.004	0.0153
H4	0.0362	0.0211	0.0179
H5	0.0561	0.0241	0.0113
H6	0.0167	0.0011	0.005
H7	0.0278	0.005	0.0075
H8	0.025	0.0583	0.0082
H9	0.0417	0.0976	0.0221
H10	0.0306	0.039	0.0098
H11	0.0355	0.011	0.0086
H12	0.0525	0.0225	0.0141
H13	0.0405	0.0095	0.0029
H14	0.0564	0.0129	0.0058
H15	0.0444	0.0594	0.0076
H16	0.0494	0.0336	0.0425
H17	0.0194	0.017	0.0142
H18	0.0547	0.0122	0.0193
H19	0.522	0.0299	0.0495
H20	0.0111	0.041	0.0017
H21	0.0832	0.021	0.0023
H22	0.412	0.0504	0.0109
H23	0.0222	0.0254	0.0076
H24	0.0441	0.0341	0.0033
H25	0.552	0.0747	0.0423
H26	0.05	0.0191	0.0095
H27	0.0581	0.0127	0.0117
H28	0.0391	0.0679	0.0153
H29	0.0913	0.0169	0.0079
H30	0.0502	0.0108	0.0209
Mean± Std. Error	**0.0865±0.257**	**0.027±0.0043**	**0.0135±0.0021**
Minimum	**0.01110**	**0.00080**	**0.0014**
Maximum	**0.552**	**0.09760**	**0.0495**
Global limit[11]	**0.1**	**0.025**	**0.02**

The maximum, minimum and average value of Pb in urine samples healthy group is 0.552 mg/l, 0.0111 mg/l and 0.865±0.257 mg/l, respectively, as shown in figure (4-4). Concentration of Ni ranged between 0.0008 to 0.0976 mg/l with rate value 0.027±0.0043 mg/l illustrated in figure (4-5).

Figure (4-6) shows the concentration of Cd ranged from 0.0014 to 0.0495 mg/l and an average of 0.0135±0.0021 mg/l.

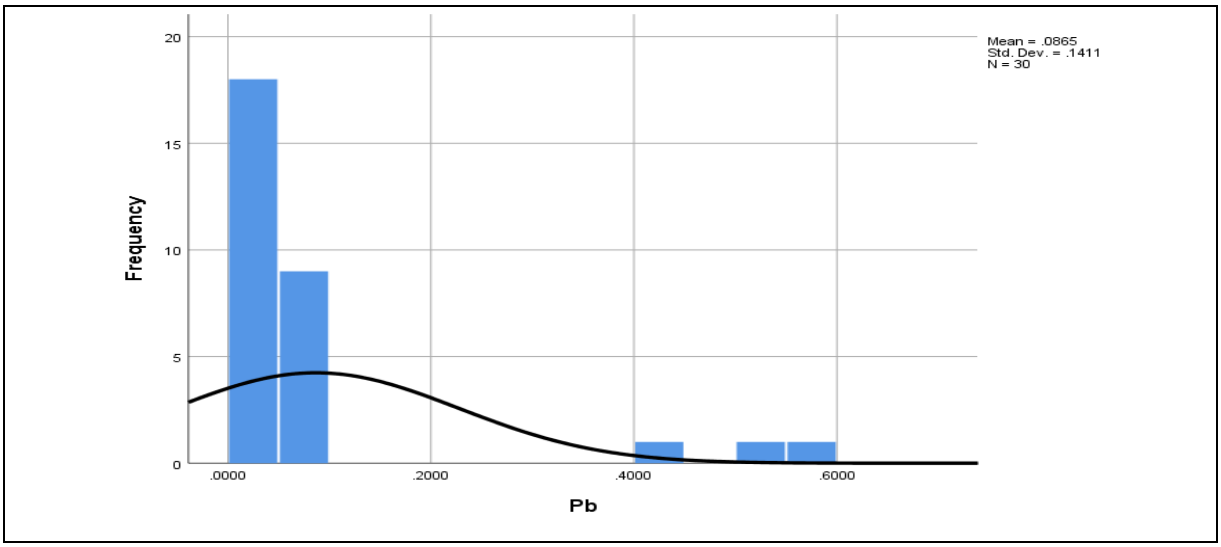

Figure 4.4: The Pb concentrations element Pb of a healthy group.

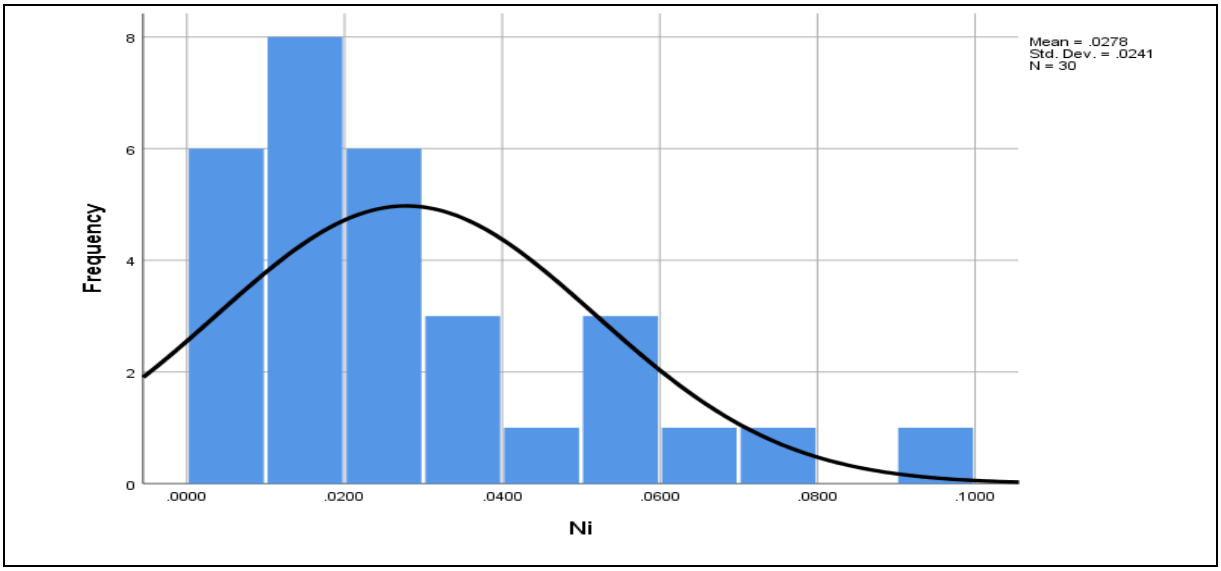

Figure 4.5: The Ni concentrations element of a healthy group.

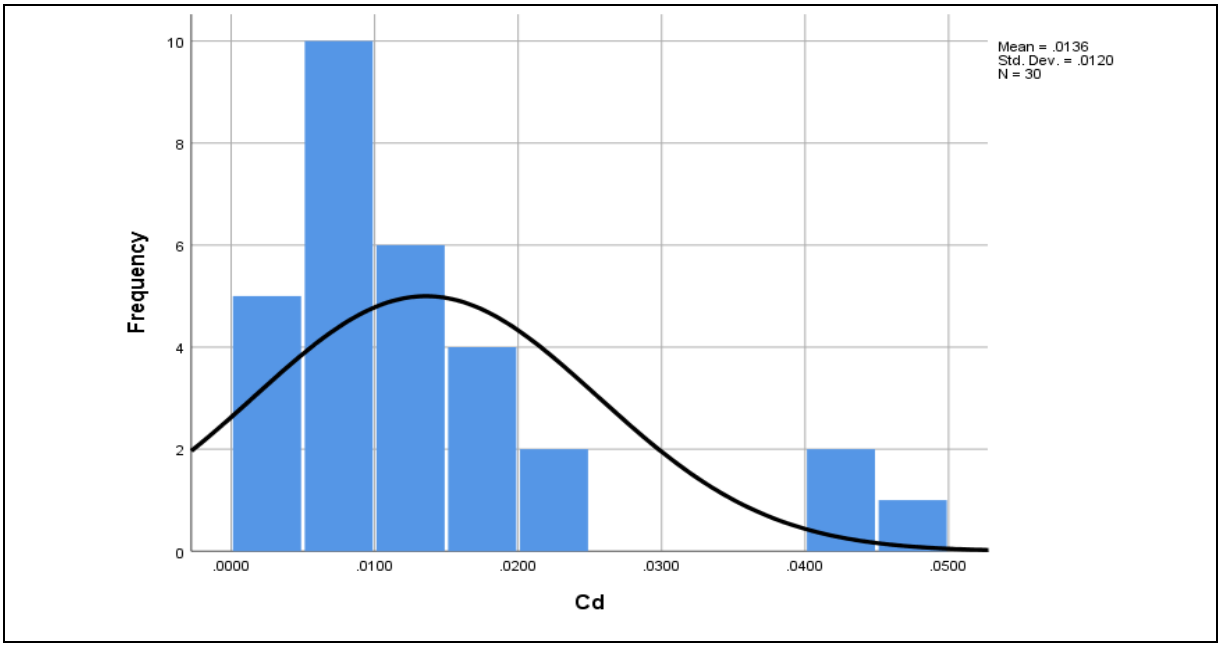

Figure 4.6: The Cd concentrations element of a healthy group.

Figures (4.4), (4.5) and (4.6) shows the histogram for statistical analysis of data to see the agreement of the real data distribution with some known distribution such as, the normal distribution, which shows the frequency of a value between the set.

Table (4-7) illustrates the concentration of Pb, Ni and Cd in human urine samples of cancer patients.

Table 4.7: Concentrations of toxic elements in urine samples for patients group.

Sample Code	Pb (mg/l)	Ni (mg/l)	Cd (mg/l)
P1	0.025	0.0059	0.0134
P2	0.0346	0.018	0.0126
P3	0.276	0.0134	0.0166

P4	0.298	0.0377	0.017
P5	0.285	0.0299	0.0189
P6	0.0188	0.0123	0.0112
P7	0.0412	0.0201	0.0092
P8	0.178	0.0745	0.0145
P9	0.051	0.0698	0.0275
P10	0.119	0.0432	0.0298
P11	0.0568	0.0212	0.0093
P12	0.0498	0.0396	0.0213
P13	0.0851	0.0288	0.0045
P14	0.333	0.0324	0.0156
P15	0.167	0.0684	0.0171
P16	0.0619	0.0539	0.0218
P17	0.0314	0.0466	0.00923
P18	0.0795	0.0397	0.0292
P19	0.0588	0.0344	0.013
P20	0.397	0.0764	0.0349
P21	0.132	0.479	0.0142
P22	0.476	0.0643	0.0204
P23	0.111	0.0511	0.015
P24	0.433	0.0529	0.0175
P25	0.317	0.0675	0.0365

P26	0.0984	0.0855	0.0571
P27	0.339	0.0549	0.0583
P28	0.216	0.0498	0.0209
P29	0.522	0.0911	0.0691
P30	0.415	0.0729	0.0655
Mean± Std. Error	**0.1902±0.028**	**0.0611±0.0149**	**0.0240±0.00313**
Minimum	**0.0188**	**0.0059**	**0.00450**
Maximum	**0.52200**	**0.4790**	**0.06910**
Global limit[11]	**0.1**	**0.025**	**0.02**

From Table (4-7) the Pb levels in urine samples of the patient's group ranged from 0.0188 to 0.5220 mg/l with an average value of 0.1902±0.028 mg/l as in figure (4-7). Figure (4-8), shows the higher and lower values of Ni is 0.0059 to 0.4790 mg/l and the mean value was 0.0611±0.0149. whereas, for Cd the maximum, minimum and rate values are 0.00450, 0.06910 and 0.0240±0.00313 mg/l, respectively illustrated in figure (4-9) .

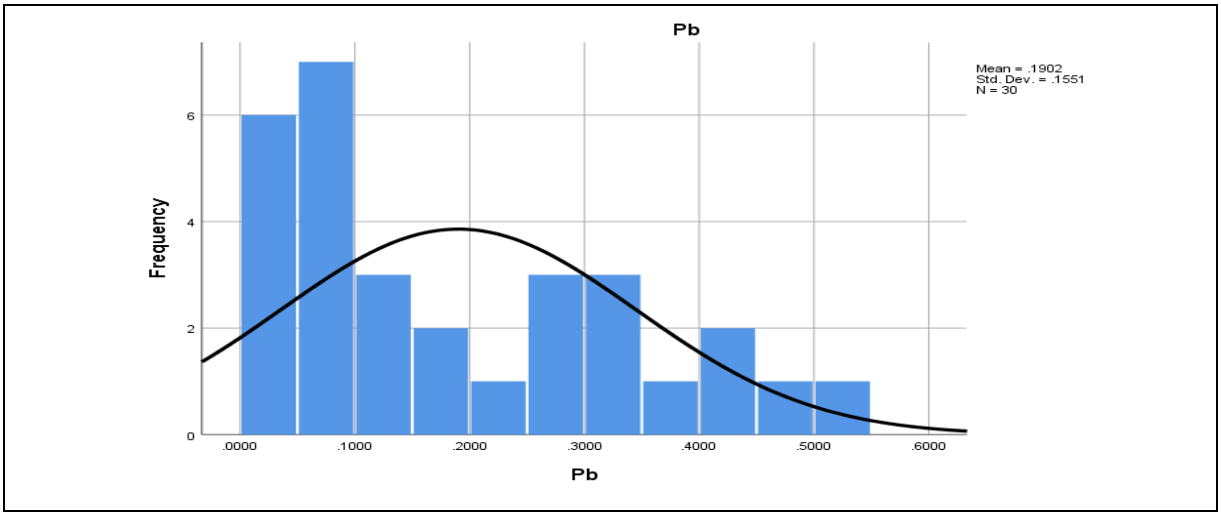

Figure 4.7: The Pb concentrations element of the patients group.

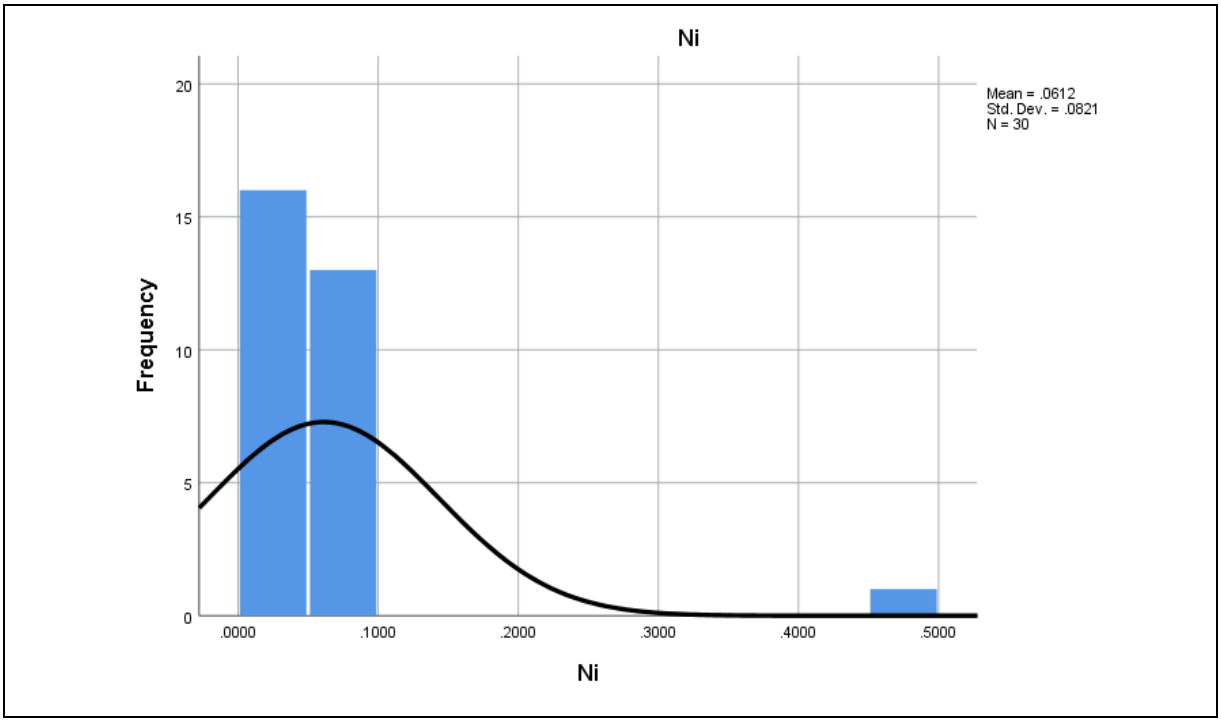

Figure 4.8: The Ni concentrations element of the patients group.

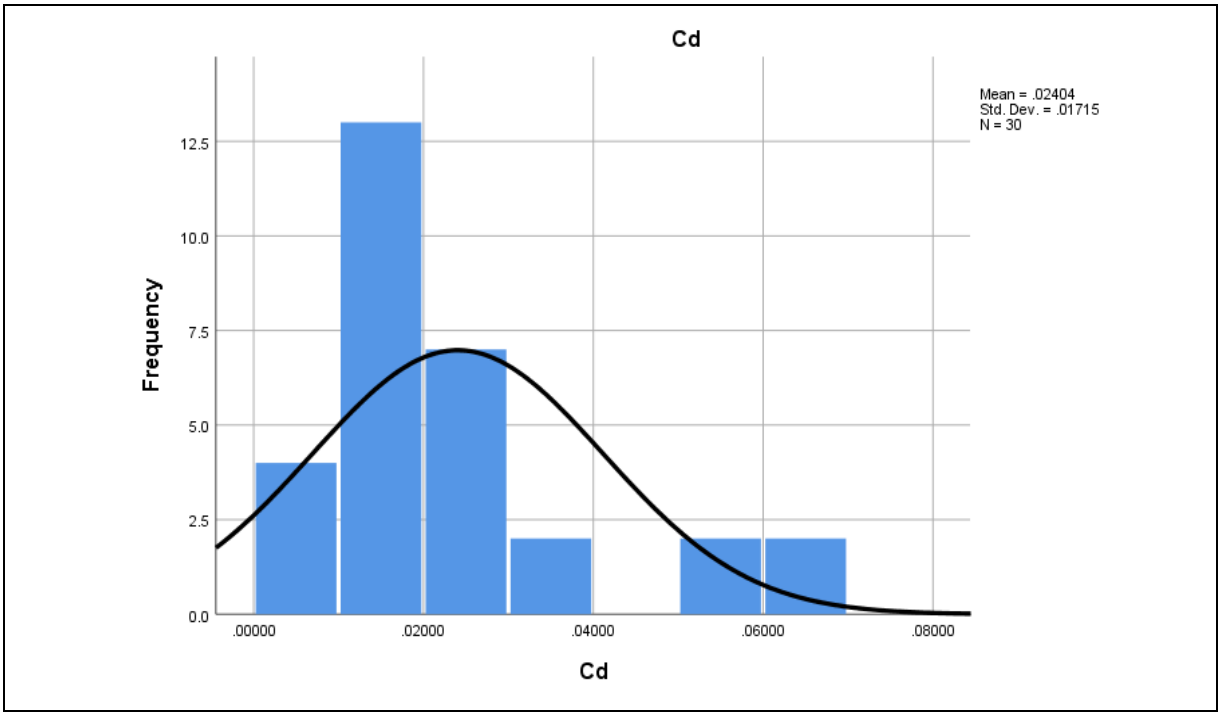

Figure 4.9: The Cd concentrations element of the patients group.

4.5.1 Comparison with other results

The levels of (Pb), Ni and Cd in the urine samples for cancer patients are compared with other studies from different regions in Iraq and other countries, as shown in Table (4-8).

Table 4.8: Comparison between concentrations of Pb, Ni and Cd with different studies to the current study.

Country	Pb mg/l	Ni mg/l	Cd mg/l	Refe.
Iraq-southern	0.435	0.217	0.115	[35]
Iraq- Diwaniyah	0.340	0.203	0.072	[40]
Egypt	17.1	NA	1.94	[84]
China	0.080	0.013	0.0039	[85]
UK	0.012	0.0008	0.0003	[86]
Twain	0.052	0.036	0.0095	[11]
Iraq-Babylon	0.1902	0.0611	0.0240	Present Work

The obtained average values of Pb, Ni, and Cd are higher than the acceptable limits 0.15 mg/l, 0.025 mg/l, and 0.02 mg/l, respectively [11]. These data explain that the individuals in the study area were exposed to high levels of toxic metals as a result of human activities. This Table (4-8) reveals that the highest toxic elements concentration values are observed in Iraq-southern [35] , Iraq- Diwaniyah [40] and Egypt [84]. The figures in the current study are higher than the results of Twain, UK, and China individuals.

4.6 Statistical Analysis of Data

In the treatment of the data, significance difference tests such as ANOVA. The ANOVA test was applied due to its greater dependability. In

this test, the overall patient group results were compared with the overall concentration of the healthy group as shown in Table (4-9).

Table 4.9: Tests of between-healthy group and patients group effects of (Pb, Ni and Cd).

Dependent Variable	Metal	Sum of Square	df	Mean Square	f	P-value
Age	**Pb**	**0.088**	**4**	**0.022**	**2.738**	**0.045**
	Ni	0.013	4	0.003	0.696	0.600
	Cd	0.001	4	0.000	1.429	0.246
Gender	**Pb**	**0.087**	**1**	**0.087**	**10.840**	**0.002**
	Ni	0.000	1	0.000	0.089	0.768
	Cd	$1.106* 10^{-5}$	1	$1.106* 10^{-5}$	0.081	0.777
Smoking - Non Smoking	Pb	0.020	1	0.020	2.519	0.122
	Ni	$7.633* 10^{-5}$	1	$7.633* 10^{-5}$	0.016	0.899
	Cd	**0.002**	**1**	**0.002**	**13.326**	**0.001**

Table (4-9) shows the comparison between healthy and patient's groups for both variables (age, gender and smoking or non-smoking). The multi variance analysis confirmed that the differences between the concentrations of toxic elements in urine samples from cancer patients and the healthy group. The contents of Pb, based on age, were higher than Ni and Cd when (statistically significance of <0.05).As for gender, there is a statistical significant < 0.02 of Pb in cancer patients.

Smoking has an important association with cancerous diseases, and it has a statistical significant <0.05 of Cd. The reason behind these results is related to the use of Pb in man-made activities, which led to an increase in human exposure to Pb.

In order to make a comparison between healthy and patients sample for the variables that had the above effect; it is performed the L.S.D- test (Least Significant Difference). When comparing the study groups, patients and healthy participants, as shown in Table (4-10).

Table 4.10: Comparison between the concentration of toxic elements in urine samples of study groups.

Elements	Dependent Variable		Mean Difference	Std. Error	p-value
Pb	Healthy	**Patient's**	**-0.087$^{-*,b,c}$**	**0.029**	**0.005**
Ni	Healthy	Patient's	-0.020$^{-b,c}$	0.022	0.374
Cd	Healthy	**Patient's**	**-0.007-^{b,c}**	**0.004**	**0.05**

There are indications in Table (4-10) shown is that the concentrations of toxic elements in urine samples of patients were higher than in urine samples of healthy people, especially Pb and Cd. This research indicates a relationship between toxic element concentration contamination in the study area and cancerous diseases. Table (4-11) shows statistically significant differences between (Pb, Ni and Cd depending on age).

Table 4.11: Comparison between concentrations of toxic elements and age.

Elements	Dependent Variable	Mean Difference	Std. Error	p-value
Pb	Age 10-20	-0.098$^{-a,b}$	0.072	0.179
	21-30	-0.077$^{-a,b}$	.0730	0.301
	31-40	-0.069$^{-a,b}$	0.070	.3330

	41-50	$0.029^{a,b}$	0.045	0.520
	51- et	**$-0.155-^{a,b,*}$**	**0.066**	**0.026**
Ni	Age 10-20	$-0.013^{-a,b}$	0.055	0.821
	21-30	$-0.040^{-a,b}$	0.056	0.486
	31-40	$-0.035^{-a,b}$	0.054	0.517
	41-50	$-0.059^{-a,b}$	0.051	0.255
	51- et	$0.059^{a,b}$	0.051	0.255
Cd	Age 10-20	$-0.006^{-a,b}$	0.009	0.507
	21-30	$-0.008-^{a,b}$	0.010	0.436
	31-40	$-0.012^{-a,b}$	0.009	0.205
	41-50	$-0.004^{-a,b}$	0.006	0.498
	51- et	**$-0.012^{-a,b,*}$**	**0.005**	**0.039**

Based on estimated marginal means

*The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The influence of age on the accumulation of toxic elements in the human body was studied .The ages of patients and healthy participants are divided into five age groups as: 10-20 y, 21-30 y, 31-40 y, 41-50 y and up to 50 y. The findings show that element of concentrations are higher in those between the ages of 30-50 but not in those up to 50. People aged up to 50 are found to be the most affected, as evidenced by significant levels of hazardous components in urine samples.

Pb and Cd levels are high in people between the ages of up to 50, which could be related to their relative increased exposure to the environment (compared to other age groups) according the figure (4.10).

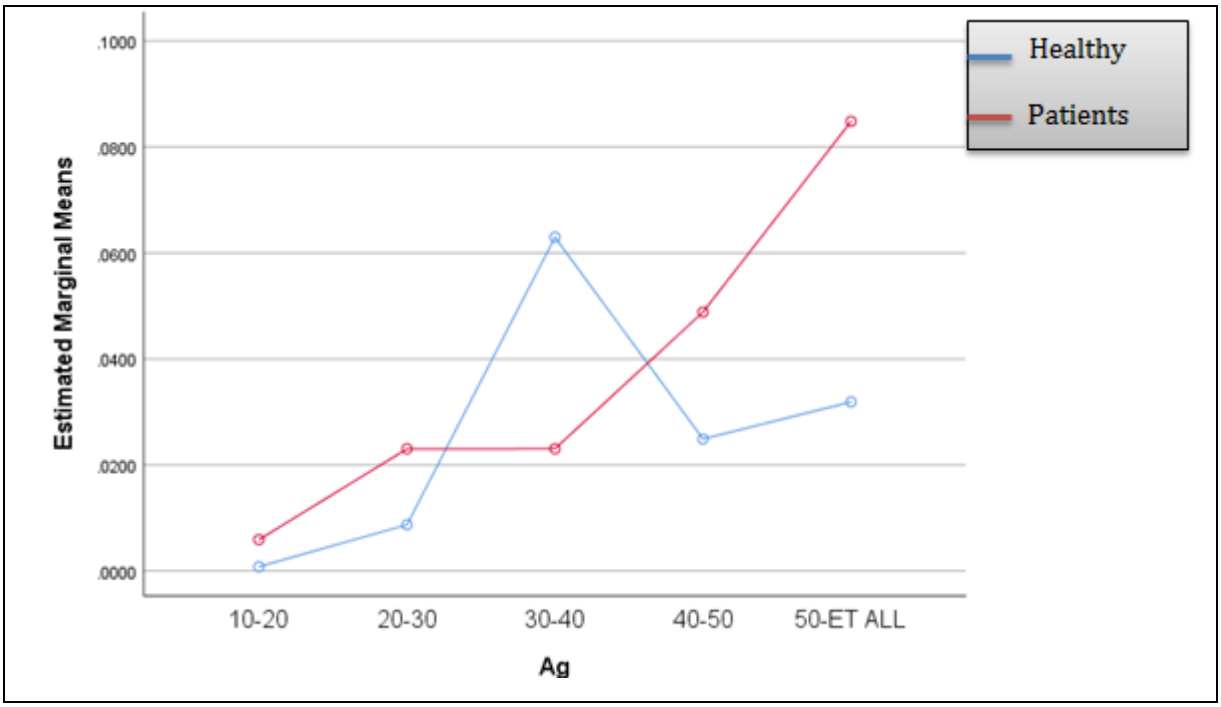

Figure 4.10: Effect the age on concentrations of toxic elements.

We not from the figure (4.10), that there is an increase in the ages from (31-50) in the healthy group due to the possibility of increased occupational exposure and other health habits for these ages.

There is a relationship between smoking and increases in the concentration of toxic elements in the human body, according to Table (4-12).

Table 4.12: Toxic elements in the urine sample of study groups as a function of a smoking habit

Elements	Dependent Variable		Mean Difference	Std. Error	p-value
Pb	Non Smoking	**Smoking**	**-0.099-*,b,c**	**0.031**	**0.003**
Ni	Non Smoking	Smoking	-0.024-b,c	0.024	0.322
Cd	Non Smoking	**Smoking**	**-0.018-*,b,c**	**0.004**	**0.000**

Based on estimated marginal means

*The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The accumulation of toxic elements in the human body was found to have a significant association with the participants' smoking habits. Found Pb, and Cd concentrations in smokers' urine samples are much greater than in non-smokers according to Table (4-12). These findings indicate that smokers are exposed to significantly higher quantities of toxic elements than non-smokers as shown in figure (4-11). This is due to the fact that different levels of metals are present in tobacco.

A cigarette contains about 0.6-17 µg Pb, 4.2 -7.5 µg Ni and 1-2 µg Cd. The penetration of toxic metals from soil to tobacco plants; the use of chemical fertilizers and insecticides in tobacco fields; and these particles in the air are accumulated on the leaves of tobacco plants and can also become a

source of these toxic elements are some of the causes for high concentrations of toxic elements in tobacco plants[35].

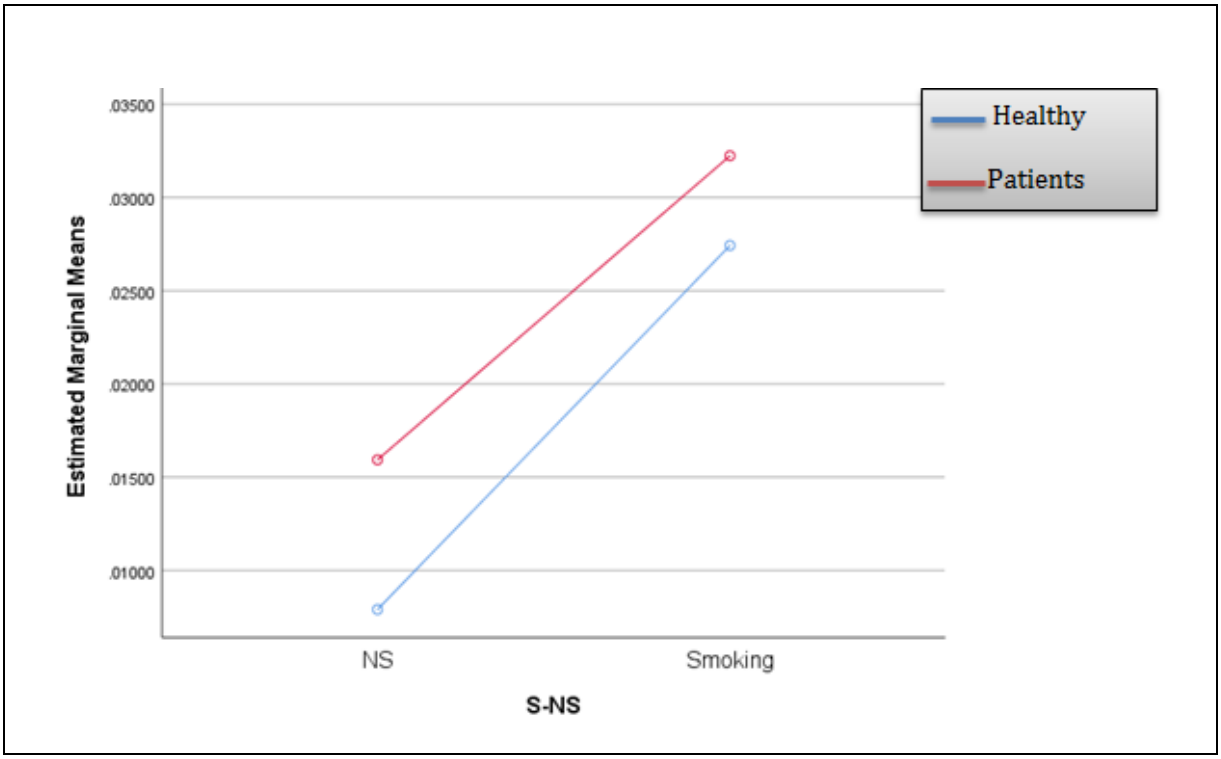

Figure 4.11: Comparison between smoking and non-smoking.

The analytic results of toxic elements concentration (Pb, Ni, and Cd) in urine samples of study groups depending on the gender of the participants are illustrated in figure (4-12) and Table (4-13).

We found statistical indications (<0.05) of Pb concentration in urine samples in males are higher compared with females, which may be caused by occupational exposure.

Table 4.13: Comparison in urine samples depending on the gender of participants.

Elements	Dependent Variable		Mean Difference	Std. Error	p-value
Pb	**Male**	Female	**0.095**^{*,b,c}	**0.029**	**0.002**
Ni	Male	Female	0.002^{b,c}	0.022	0.926
Cd	Male	Female	0.005^{b,c}	0.004	0.193

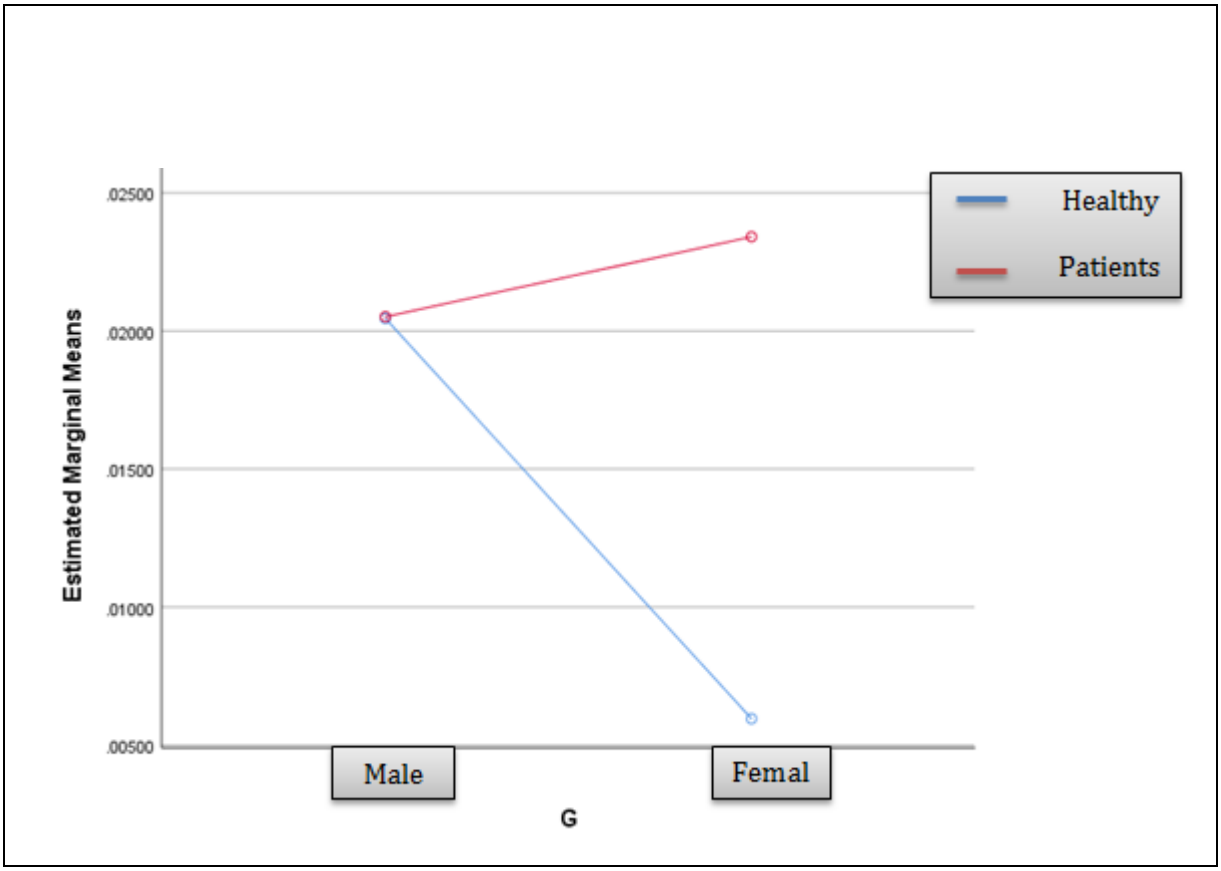

Figure 4.12: Effecting the gender on toxic element concentration.

Figure (4.12) shows the difference between the two groups according to the effect of gender. There is clear difference for males. the concentration of lead in males was due to the possibility of exposure to a lot outside the home.

Chapter Five

Conclusion, Future Work and Recommendation

5.1 Introduction

This chapter shows the conclusions which are extracted from the present study, recommendations and future studies.

5.2 Conclusions

The results of the specific activity for ^{40}K larger than the specific activity of ^{232}Th and ^{238}U) showed that the proportion of potassium in the study region was high due to minerals in the soil and the fact that most of the areas are agricultural. Also, in the Al-hilla river, there is one a concentration of ^{40}K anomalous was above the permissible limit. The studied area in the most Babylon governorate was safe for the population. Whereas, the calculated radium equivalent (Ra_{eq}) value was less than the permissible limit. Also, all the results of hazard indices absorbed dose rate (AD), external (Hex) and internal (Hin) hazard indices, gamma index ($I\gamma$), annual effective dose (AEDE) indoor, outdoor, and total dose were within the allowed limits.

The concentrations of average values of some metals in soil samples of Pb, Cd and Ni were higher than the permissible limits in the world. Thus, we conclude that these some areas concentrations of soil pollution. The high averages were in industrial areas, power stations and fuel stations due to the use of heavy metals in fuel, as well as in some industries.

The average values of toxic elements concentration of urine samples for Pb >Cd >Ni. For cancer patients, the obtained average values of (Pb, Cd, and Ni) were found higher than the acceptable limits of 0.1, 0.02, and 0.025mg/l, respectively, while in the healthy group the average values were within the acceptable limits. The level of toxic elements in cancer patient's urine samples is much higher than in the healthy group. These findings indicate a relation

between the contamination of the Babylon environment with toxic elements and cancerous diseases.

It is concluded from the comparison between urine samples of patients and healthy, there is statistical significance indicating that the concentration of the toxic elements was higher in those ages up to 50 years, which may be the reason for the relatively high exposure to the environment.

Whereas the concentrations of Pb, Cd and Ni in urine samples of smokers are statistical significance higher than those of non-smokers. This could explain these findings by the presence of variable levels of metals in the tobacco plant. The average value of toxic elements in the urine samples of males was found higher compared with females. This result is attributable to occupational exposure.

5.3 Future Work

1- Studying the radioactivity for the whole of Babylon Governorate using high purity germanium (HPGe).

2- Studying concentration of heavy metals (lead, cadmium and nickel) for drinking water samples in Babylon Governorate using atomic absorption spectroscopy.

3- Studying the concentrations of toxic elements (Pb, Cd, Ni and Cu) in blood and serum samples of the cancer patients group and healthy group.

5.4 Recommendations

1. Compliance with the instructions for transporting solid and liquid electrical power generation waste.

2. Making use of solid and liquid waste resulting from the process of generating electric power by use of scientific and practical methods in waste recycling.

3. Allocating areas for sanitary landfill far from residential areas and raising construction waste to reduc the percentage of heavy elements resulting from raw materials.

4. It is recommended not to smoke because the tobacco plant contains levels of toxic elements such as (Pb, Cd and Ni), these elements cause cancerous diseases in the human body.

5. It is recommended not to be exposed to industrial areas and fuel combustion, as well as keeping the brick factories away from residential and agricultural cities.

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جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بابل / كلية العلوم
قسم الفيزياء

تقدير العوامل الأشعاعية والعناصرالسمية في نماذج مختارة من التربة والأدرار في محافظة بابل

أطروحة مقدمة إلى
مجلس كلية العلوم - جامعة بابل
وهي جزء من متطلبات نيل درجة دكتوراه الفلسفة في علوم الفيزياء.

من قبل
اسراء سالم عبيس كاطع

بكالوريوس علوم في الفيزياء/2013
ماجستير علوم في الفيزياء/ 2016

بإشراف:
أ. د. خالد حسين هاتف العطية

2022 م

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الخلاصة

في هذه الدراسة تم قياس النويدات المشعة التي تحدث بشكل طبيعي (^{238}U, ^{232}Th, ^{40}K) الموجودة بعينات التربة في محافظة بابل و بأستخدام كاشف يوديد الصوديوم المنشط بالثاليوم NaI(Tl) لتقييم مؤشرات المخاطر الصحية للاشعاع .كذلك تم فحص المعادن الثقيلة الرصاص(Pb) ،النيكل (Ni) والكادميوم(Cd) لتحديد التلوث في عينات التربة باستخدام تقنية مقياس الامتصاص الذري(AAS). يعتبر فحص عينات الادرار الطريقة المفضلة لمراقبة التعرض الداخلي للملوثات السامة للرصاص والنيكل والكادميوم في أجسام البشر. تضمنت هذه الدراسة مجموعتين من المتطوعين والمتطوعات. المجموعة الأولى هي مرضى السرطان والمجموعة الثانية مجموعة اصحاء. جمعت عينات الادرار من مرضى السرطان وتم اختيارهم من المستشفى في محافظة بابل . وبالمثل ، تم جمع عينات الادرار من مجموعة الأصحاء من مناطق مختلفة في محافظة بابل

وكانت معدلات الفعالية الاشعاعية (209.886±3.237, 8.322±0.416,1.344±0.175) لليورانيوم^{238} والثوريوم^{232} والبوتاسيوم^{40} . اما مكافئ الراديوم و معاملات الخطورة الداخلية والخارجية والجرعة السنوية الفعالة كانت اقل من الحد المسموح به .

اما بالنسبة لنتائج بعض المعادن بلغ متوسط قيم الرصاص والنيكل والكادميوم (18.919 ،81.043 و 0.202) ملغم / كغم على التوالي. معدلات تراكيز هذه العناصر كانت أعلى من الحد المسموح به في بعض المناطق.

كان متوسط قيم تركيز العناصر السامة (Pb، Ni و Cd) في عينات الادرار من مرضى السرطان (0.1902 ± 0.028 ،0.0611 ± 0.0149 و 0.0240 ± 0.00313) ملغم/ لتر على التوالي . في الأفراد الأصحاء، كانت القيم المتوسطة المقابلة لتركيز العناصر السامة (Pb ، Ni و Cd) في عينات الادرار(0.0865 ± 0.257 ، 0.027 ± 0.0043 و 0.0135 ± 0.0021)ملغم / لتر على التوالي. وفقًا لذلك ، كانت القيم المتوسطة لتركيز العناصر السامة في عينات ادرار متطوعين أصحاء أقل بكثير منها في مجموعة مرضى السرطان.

نستنتج من ذلك ان النشاط الأشعاعي كان ضمن الحد المسموح به عالميا وكانت أمنة للسكان اما بالنسبة للمعادن كان هناك تلوث بالتربة في بعض المناطق .