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Measurement and Analysis of the Distribution of Pb-214 Lead Isotope in Baghdad Soil using Remote Sensing Techniques

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Abstract

The present research aims to measure concentration of lead Pb214 in soil using remote sensing and GIS, associated radiological hazards in Baghdad, Iraq. Concentration of specific radioactivity of radioactive elements was measured and analyzed naturally and artificially in 48 soil samples for separate sites from Baghdad, Iraq using crystalline spectroscopy to detect germanium. The average radioactivity concentrations of lead were found, as it was found to have varying values from one site to another, as most of them exceeded the international permissible limit, as the highest concentration was recorded at 180 Bq in the sample H28 in Waziriyah district. Battery Lab (1), and the lowest concentration value is 40Bq in (H4, H15, H45) which represents (Dora Expressway, Mansour Street, Fuel Express, and Mahmoudiya Road 2).

Remote sensing data techniques, and Global Positioning System (GPS) have been used to analyze the effect of the isotopic distribution of heavy bullets for the city of Baghdad. Using Geographic Information Systems (GIS), concentrations were measured and observed. Results of interpolation maps showed isotope of lead is concentrated in the center and west of Baghdad, and then graded with fewer values in other sites.

Keyword: Radioactive Isotopes of Lead, Remote Sensing Techniques, Samples of soil, Distributive analysis, Geographic Information System (GIS)

قياس وتحليل توزيع نظير الرصاص Pb-214 في تربة بغداد باستعمال تقنيات الاستشعار عن بعد

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الخلاصه

يهدف البحث الحالي الى قياس تركيز نظير الرصاص 214 في التربة باستعمال الاستشعار عن بعد ونظام المعلومات الجغرافية والمخاطر الإشعاعية المرتبطة به في بغداد ، العراق ، حيث تم قياس وتحليل تركيز النشاط الإشعاعي النوعي للعناصر المشعة بشكل طبيعي وصناعي في 48 عينة تربة لمواقع منفصلة عن بغداد ، العراق باستعمال التحليل الطيفي البلوري للكشف عن الجرمانيوم. تم العثور على متوسط تراكيز النشاط الإشعاعي للرصاص ، حيث وجد أن لها قيم متفاوتة من موقع إلى آخر ، حيث تجاوز معظمها الحد

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المسموح به دوليًا. تم تسجيل أعلى تركيز عند 180 بيكريل في العينة H28 في الوزيرية، معمل البطاريات (1) ، وأقل تركيز 40 Bq في (H4، H15، H45) والذي يمثل (طريق الدورة السريع ، شارع المنصور ،محطة وقود السريع ، طريق المحمودية 2. باستعمال تقنيات الاستشعار عن بعد مثل صور القمر الاصطناعي لاندسات 8 لتشغيل مستشعر الصورة الأرضية (OLI) ونظام تحديد المواقع الأرضي (GPS) لعينات من الإشارات الجغرافية لمحاكاة الواقع باستعمال صور الأقمار الاصطناعية لتحليل تأثير التوزيع النظيري لنظائر الرصاص الثقيل لمدينة بغداد تم قياس وملاحظة التركيزات ، ومن خلال خرائط الاستيفاء وجد أن نظير الرصاص يتركز في وسط وغرب بغداد ، ومن ثم متدرج بأقل القيم في مواقع أخرى.

Introduction

A comprehensive review found Remote Sensing RS's role in detecting toxic metals in soil and their effectiveness as a tool for detecting sources of toxic mineral pollution in soil. Fact that minerals are actually toxic substances, as they appear in the soil in low or moderate concentrations, and minerals and massless organic matter can become very available [1][2]. Detection of lead isotopes in an area is the main factor in reducing environmental pollution. Lead is a toxic metal that is found naturally in the earth's crust, and its great use has led to the spread of environmental pollution, human exposure, and many public health problems in many parts of the world.

Therefore, there is a growing concern about the health risks associated with exposure to these sources of radiation in our environment. Several studies have been conducted on radiation health risk assessment in order to gain access to a reliable database on radiation health problems [3-9]. It is important to measure radiation parameters that affect the Iraqi population because high exposure to radiation may cause very large health complications such as carcinogenesis [10]. When lead enters the body by inhalation, ingestion, or absorption through the skin, nearly all of the inhaled lead is absorbed by the body; The absorption rate is 20-70%, although children absorbed at a higher rate than adults [11]. In 2017, it was estimated that human exposure to lead caused 1.06 million deaths and losses of 24.4 million DALYs as a result of long-term health effects, with the greatest harm in low-middle-income countries [12]. Radioactivity of cement and the raw materials used in its manufacture was evaluated in Kirkuk Cement Company. Calculating specific activity of Ra-226, Th-232 and K-40 indicators to estimate the risks associated with cement and raw materials. Results were within the permissible limits according to the scientific recommendations of the United Nations Scientific Committee. It is (31-117) Bq/Kg which is less than the permissible limit (370 Bq/Kg [13], and alpha and gamma spectroscopy were used to determine the annual dose due to the consumption of some food items containing lead isotopes Pb-210 and Pb-214. It was found that the lowest concentration of the radioactive isotope of lead Pb-210 in the dry samples was in mage fish and it was 13.607 Bq/kg and in azimut with a value of 0.219 Bq/kg. The highest radioactive concentration of lead isotope Pb-214 in dry samples was found in fish melt and was 8.682 Bq/kg while it was not detected in some samples of potatoes, wheat or milk [14].

One of the most prominent environmental pollution processes with lead isotopes is (soil pollution), as the presence of pollutants in the soil in quantities that directly or indirectly allow harm to human health, sabotage ecosystems, affect the plant or animal environment, or affect the surface water environment or Subterranean. Among the most important soil pollutants: heavy metals and radioactive materials. This study is based on the assumption that soil lead contamination is unevenly distributed, and thus the level of contamination of approximately a few kilometers from one mining-related operation may vary greatly from one nearby area to another. One of the forms of soil pollution with heavy metals is lead pollution (or leaded fuels): where tetraethyl lead is added to the used gasoline to improve its properties and increase engine efficiency. Then lead oxide is released along with hot exhaust gases when

it is oxidized during combustion. Large lead particles fall directly to the ground after release, along with exhaust smoke and contaminate soil and surface water, while the smaller particles travel long distances through the atmosphere and remain in the air. Using remote sensing and geographic information systems, satellite images are observed to map the large-scale spatial distribution of toxic metals in the soil using interpolation techniques and contour lines, the novelty of this work is use of advanced data extraction tools along with multiple times satellite imagery for digital mapping For lead soil.

The aim of the study, Study of the effect of lead isotope (Pb-214) on soil in the city of Baghdad and the environmental pollution it causes on the community.

Study Area and description

It is known that Baghdad is a city that represents a center of overpopulation and human activity.

Samples were collected from separate sites in Baghdad. It is assumed that the lead isotope concentrations at industrial sites and outdoor roads are greater than the concentrations of samples taken from nearby sites in agricultural areas. The differences in concentrations are due to geological processes in general and human activity in particular, as industrial areas and external roads have a large presence of heavy metals compared to agricultural areas.

Human activities are growing very quickly, but their environmental impacts are certainly not good. Urbanization can cause significant disruption to the ecosystem by bypassing farmland, altering the environment in every building, and developing exemplary development [15].

Figure 1. represents the study area, which is the city of Baghdad. It is the administrative and economic capital of Iraq and the center of commercial and cultural gravity. It is located in the center of Iraq between longitude and latitude lines from the top left (43 50.06 ° → 33 45.68 °) and from the bottom right (44 57.23 ° → 32 48.59 °). As for the expected planar coordinates of the Universal Transverse Mercator (UTM), it was from the top left (391695.206 3736045.936) and from the bottom right (495676.664 3629683.223) meters with an area of 927.605549 square kilometers. The highest elevation in northern Baghdad is 48 meters above sea level, and in the south, 23 meters above sea level. Administratively, it is divided into 12 regions and 31 sub-districts, and plants cover the largest regions [16] and [17].

Most of the residential activities are concentrated in the city center of Baghdad, surrounded on all four sides by most of the agricultural areas and factories, and the two main rivers: Diyala River on the eastern side and Tigris River on the eastern side. Most of the seasons are humid, with three months of intense heat, which is summer and the climate is relatively dry. In general, the climate of the city varies throughout the year. It is covered with natural vegetation, orchard and farm types. Main and secondary highways pave most of Baghdad [18], as in Figure 2 and Table 1, to accommodate many different means of transportation, which posed an indirect threat to soil and farm contamination from the exhaust of vehicles that contain the most fuel. It is used by tetraethyl lead, which makes the population vulnerable to radioactive contamination with isotopes of lead in successive periods of time, as well as the occurrence of the city of Baghdad in the sedimentary plain of Iraq, which is characterized by the types of alluvial soils sloping from the northern and rocky areas with water in the periods of multiple tectonic eras as a result of erosion factors, which allows some decomposition. Isotopes of elemental lead, according to these long periods, which allow pollution of the soil and groundwater used in irrigation and drinking that exposes humans to many cancerous diseases that were not known before [19].

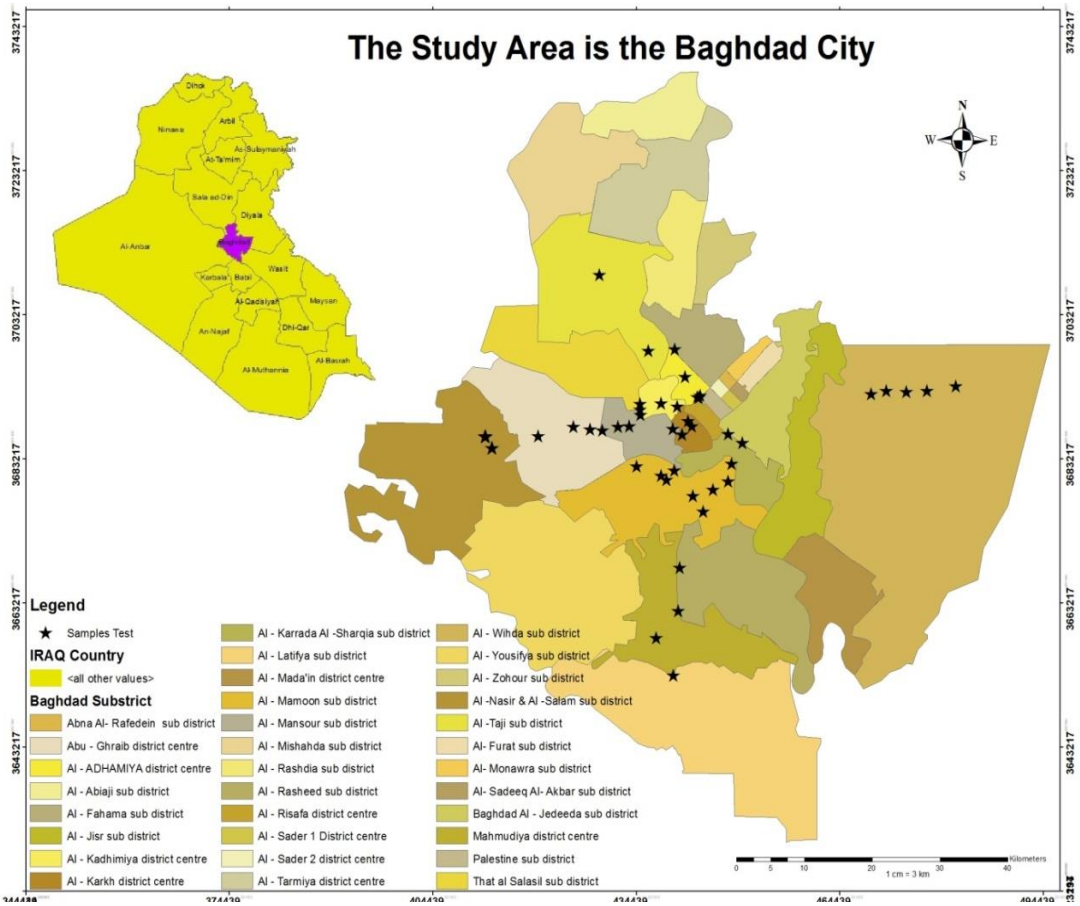
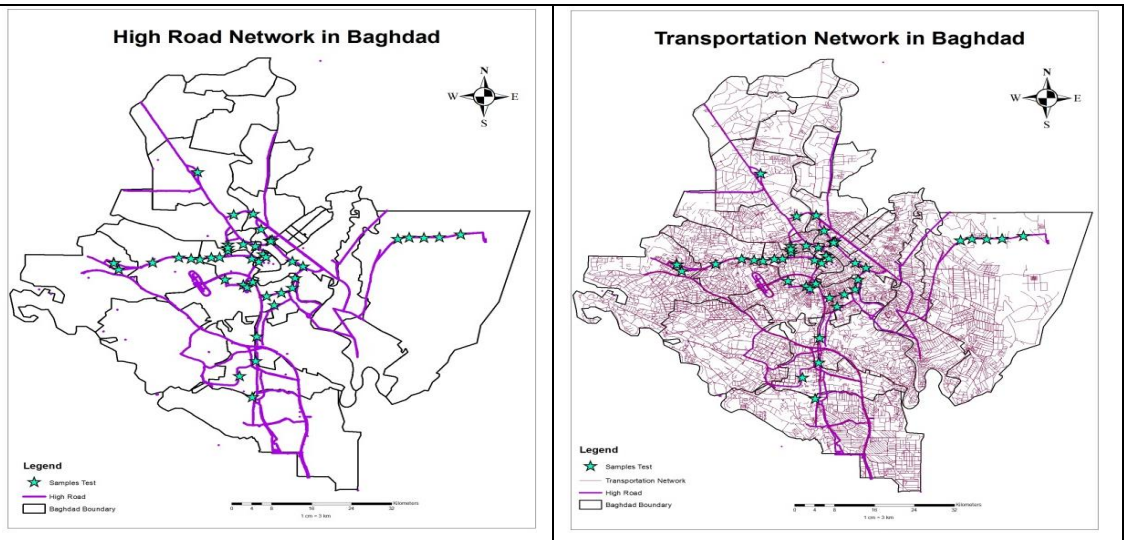


Figure 1-The study area, the city of Baghdad is the capital of Iraq and is located in the middle and consists of 31 District, and is Marked by the soil samples that covers the most Baghdad city.



(a) (b)

Figure 2- (a) the High road network extending in the study area, and the (b) the transportation network that covers the study area. Samples were taken near this network, fuel stations and industrial areas to verify the effect of vehicle exhaust on the study area.

Methodology and materials

1- Samples collection and preparation:

48 soil samples were collected from different locations in Baghdad governorate (petrol stations, external roads, liquid battery factories, and vehicle maintenance sites) with a depth of 20 cm during the period from 26-Nov-2020 to 5-Jan-2021.

The sample weighed about 1kg and was kept in a plastic bag with the sample information label (sample weight, code sample, and website sample). Then, all 48 soil samples were dried first by sunlight for 4 hours and then dried again in an oven at 200 ° C for 1 hour to remove any moisture. The samples were sifted with a coarse sieve, then the dried samples were ground by an electric grinder, and homogenized and sifted through another fine sieve. Each sample was placed in a 1 kg Marinol flask and stored for 4 weeks for normal balance. The geographical coordinates of each sampling site are recorded using GPS (Global Positioning System). We used corrected aerial imagery for the Landsat Data Continuity mission (Landsat 8).

All images were projected (30m spatial resolution) using WGS 1984 / UTM map of projection area 38 North. Due to the cloud cover issue, a set of images representing the sampling locations was chosen as we assumed, in order to improve the predictive power of the toxic lead metal in the soil the cap may provide important information for the spatial modeling of toxic soil minerals. ArcGIS was used to extract forecast values in sampling sites.

2-Experimental technique:

Radioactivity measurement of soil samples was carried out using gamma ray spectrometer with High purity germanium detector (HPGe). Gamma-ray spectroscopy is an important technology extensively used in detection of isotopes and cores that emit gamma rays in terms of analysis ability, accuracy of results, and possibility of work in low-level energies. Also minimizes the time duration of the measurement compared to the plastic reagents. In our study, we used a BSI-supplied multichannel spectral analyzer that contains 4096 channels, As shown in Figure 3, as the dimensions of the crystal used are 2 x 2 cm . Liquid nitrogen is used to cool down temperature to -200 (below zero). It is placed inside a protective barrier (bullet shield) that is it consists of three layers: lead, aluminum and copper, respectively. The voltages required for operation is 2500V. It has a separation energy of 2 Kev at an energy of 1332.5. The Kev of cobalt isotope Co 60 has a detector efficiency of 40%.

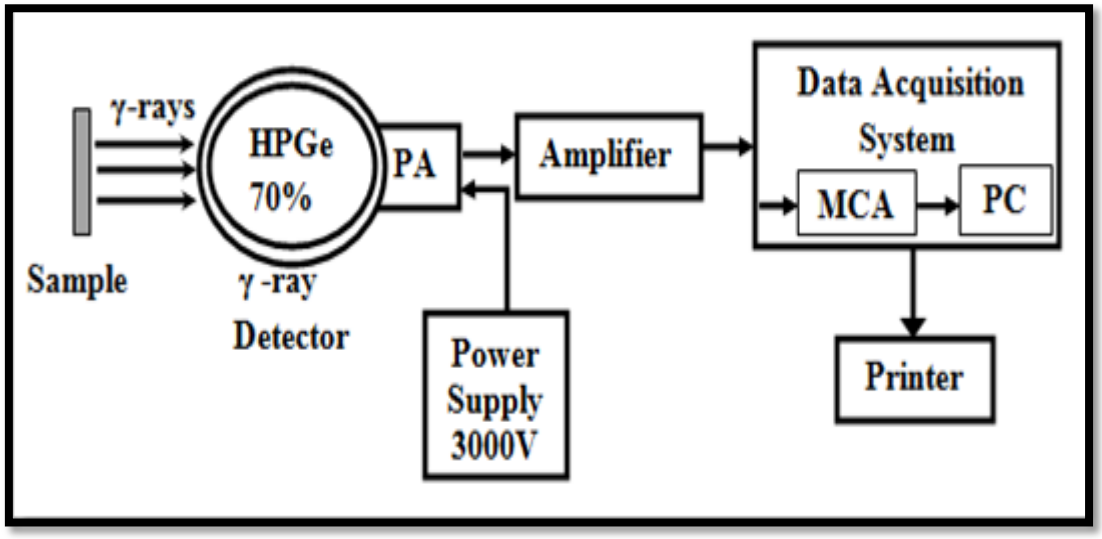


Figure 3- Schematic view of a laboratory germanium crystal reagent system .

The spectrometer was calibrated using two standard radioactive sources: Americium Am-241 at energy (59) Kev, and cobalt Co-57, Co-60 having two camelines at energy (1173, 1332)

Kev and Cesium Cs-37 at energy (661) Kev to obtain the amount of energy per channel (Kev/channel). The soil samples used were examined by placing one kilogram (1000 g) of each sample in a box similar to a Marnelli box to 3600s and collecting spectrum for two (Marinelli Beaker) to calculate the radioactivity of samples.

Results and discussion:-

Table-1 shows the concentrations of lead 214 with energy 241 Kev in the selected locations for Baghdad soil. Where the concentrations of this isotope were observed varying from one place to another. It was found that the highest concentration is 180 Bq in the H28 sample in Al-Wazeriah Battery Laboratory (1), and it was found that the lowest concentration is 40Bq in (H4, H15, H45), which represents (Dura Highway, Mansur Street Fuel, Mahmodia Highway 2).

Table 1- Locations and isotope concentrations of Pb-214 for Eɣ = 241 kV in Baghdad.

Pb-214 for Eɣ=241 KeV									
No	**Local-Name**	**Longitude**	**Latitude**	**X-Axis UTM**	**Y-Axis UTM**	**Address**	**Eɣ (KeV)**	**I(Eɣ) (%)**	**Activity (Bq)**
1	**H1**	44.295836	33.276875	434425.5	3682203.12	**Gyhaad District**	241	7	100
2	**H2**	44.335033	33.265459	438067.68	3680913.52	**Bayaa District**	241	7	90
3	**H3**	44.343053	33.259970	438810.82	3680300.24	**Sayedia District**	241	7	50
4	**H4**	44.385524	33.240279	442753.87	3678093.08	**Dura Highway**	241	7	40
5	**H5**	44.401468	33.220591	444226.78	3675901.72	**Dura Street 60**	241	7	100
6	**H6**	44.266242	33.325895	431707.74	3687656.9	**Ghzaliya District**	241	7	60
7	**H7**	44.283617	33.326450	433325.32	3687707.19	**Ghzaliya Highway**	241	7	50
8	**H8**	44.301805	33.340842	435028.82	3689291.34	**Shuala Highway1**	241	7	80
9	**H9**	44.300916	33.354852	434956.51	3690845.17	**Kadhimya Highway**	241	7	100
10	**H10**	44.334464	33.355636	438078.47	3690911.66	**Kadhimya Industrial**	241	7	120
11	**H11**	44.359893	33.351883	440441.87	3690480.74	**Autefiya Street**	241	7	50
12	**H12**	44.377121	33.333672	442032.79	3688452	**Shaikh Aumer Industrial**	241	7	60
13	**H13**	44.383547	33.327470	442626.76	3687760.83	**Allawi Street**	241	7	100
14	**H14**	44.367671	33.316857	441142.02	3686593.03	**Mansur Street**	241	7	120
15	**H15**	44.352766	33.323978	439759.52	3687391.04	**Mansur Street Fuel**	241	7	40
16	**H16**	44.355469	33.271846	439975.41	3681609.7	**Bayaa Highway**	241	7	50
17	**H17**	44.440612	33.258804	447897.07	3680118.07	**Dura Highway1**	241	7	100
18	**H18**	44.416905	33.247725	445682.05	3678901.85	**Dura Highway2**	241	7	80
19	**H19**	44.446122	33.280739	448423.19	3682547.2	**Dura Highway3**	241	7	70
20	**H20**	44.462999	33.306983	450009.75	3685448.59	**M. Qasim Highway1**	241	7	70

21	**H21**	44.440250	33.318042	447898.56	3686685.81	**M. Qasim Highway2**	241	7	130
22	**H22**	44.391117	33.363444	443354.61	3691745.09	**M. Qasim Highway3**	241	7	90
23	**H23**	44.372190	33.389306	441611.1	3694622.8	**M. Qasim Highway4**	241	7	140
24	**H24**	44.355349	33.423725	440068.4	3698448.5	**Muthana Street**	241	7	160
25	**H25**	44.313214	33.421534	436149.5	3698230.6	**Tajiat Street**	241	7	170
26	**H26**	44.300857	33.347338	434945.4	3690012.1	**Shuala Highway2**	241	7	120
27	**H27**	44.396345	33.365694	443842.4	3691991.7	**Battery Laboratory1**	241	7	140
28	**H28**	44.393630	33.362944	443588.1	3691688.3	**Battery Laboratory2**	241	7	180
29	**H29**	44.06668	33.29775	413105.6	3684684.9	**Ghanthary Industrial1**	241	7	140
30	**H30**	44.06731	33.29766	413164.2	3684674.4	**Ghanthary Industrial2**	241	7	140
31	**H31**	44.06693	33.29776	413128.9	3684685.8	**Ghanthary Industrial3**	241	7	100
32	**H32**	44.241554	33.321363	429406.3	3687170.9	**Abo-Ghraib Highway1**	241	7	160
33	**H33**	44.222093	33.322737	427596	3687336.6	**Abo-Ghraib Highway2**	241	7	140
34	**H34**	44.195704	33.325374	425142	3687647.5	**Abo-Ghraib Highway3**	241	7	100
35	**H35**	44.139660	33.313521	419914.9	3686375	**Abo-Ghraib Highway Fuel**	241	7	60
36	**H36**	44.055410	33.312221	412070.8	3686298.7	**Lead Foundry Outer**	241	7	80
37	**H37**	44.056172	33.312634	412142.2	3686343.9	**Lead Foundry Inner**	241	7	100
38	**H38**	44.056829	33.312166	412202.9	3686291.5	**Lead Foundry Location**	241	7	61
39	**H39**	44.801388	33.379000	481526.3	3693321.8	**Nahrawan Street1**	241	7	150
40	**H40**	44.755555	33.372583	477261.5	3692619.5	**Nahrawan Street2**	241	7	100
41	**H41**	44.723000	33.371527	474232.8	3692510	**Nahrawan Street Fuel1**	241	7	50
42	**H42**	44.666805	33.368805	469004.4	3692223.5	**Nahrawan Street Fuel2**	241	7	90
43	**H43**	44.690805	33.372388	471238.2	3692613.9	**Al-Qahera Fuel**	241	7	70
44	**H44**	44.364768	33.150296	440759.6	3668128.6	**Mahmodia Highway1**	241	7	48
45	**H45**	44.363091	33.096046	440566.7	3662115.1	**Mahmodia Highway2**	241	7	40
46	**H46**	44.328771	33.062259	437340.1	3658389.3	**Mahmodia Highway3**	241	7	60
47	**H47**	44.356212	33.015405	439869.9	3653178.8	**Mahmodia Highway3**	241	7	70
48	**H48**	44.23489	33.51588	428944.6	3708741.8	**Taji Highway**	241	7	80

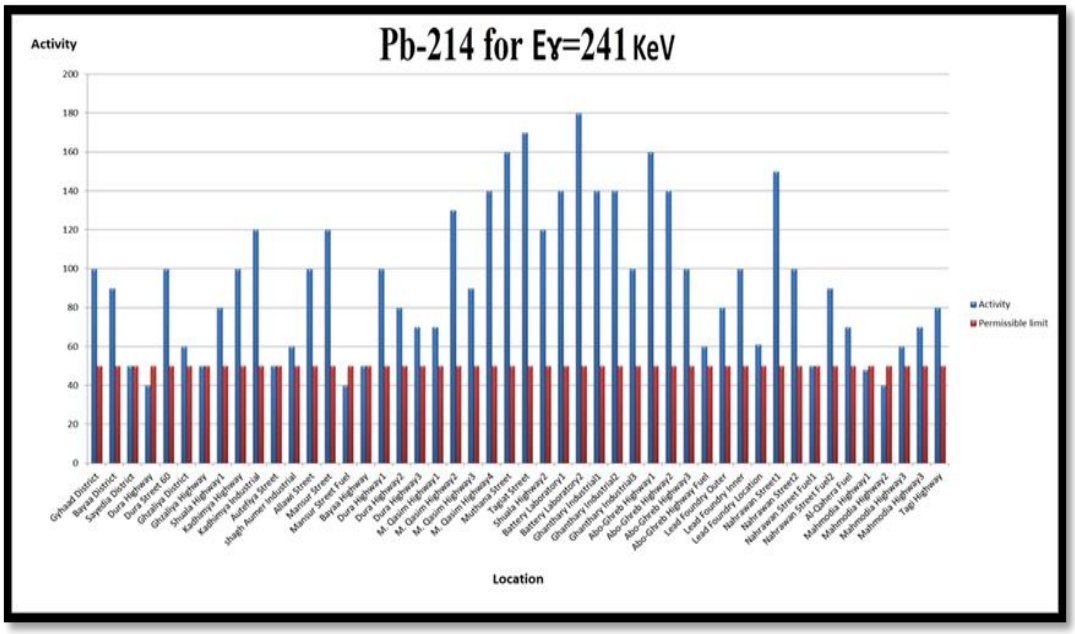


Figure 4-Concentration of lead isotope Pb-214 for Eγ = 241 KeV in Baghdad city, compared to the world record value [20].

When comparing the resulting concentrations of the isotope Pb-214 with the global standard value (permissible limits), we find that most of them exceeded the permissible limit, which means that soils in these sites are contaminated with the isotope Pb-214. That includes (Dura Highway, Mansur Street Fuel, Mahmodia Highway1, Mahmodia Highway 2). However, the concentrations were classified on the basis of sites in order to be compared with each other and to note the marked change in the concentration from one site to another and also compared to the global standard value.

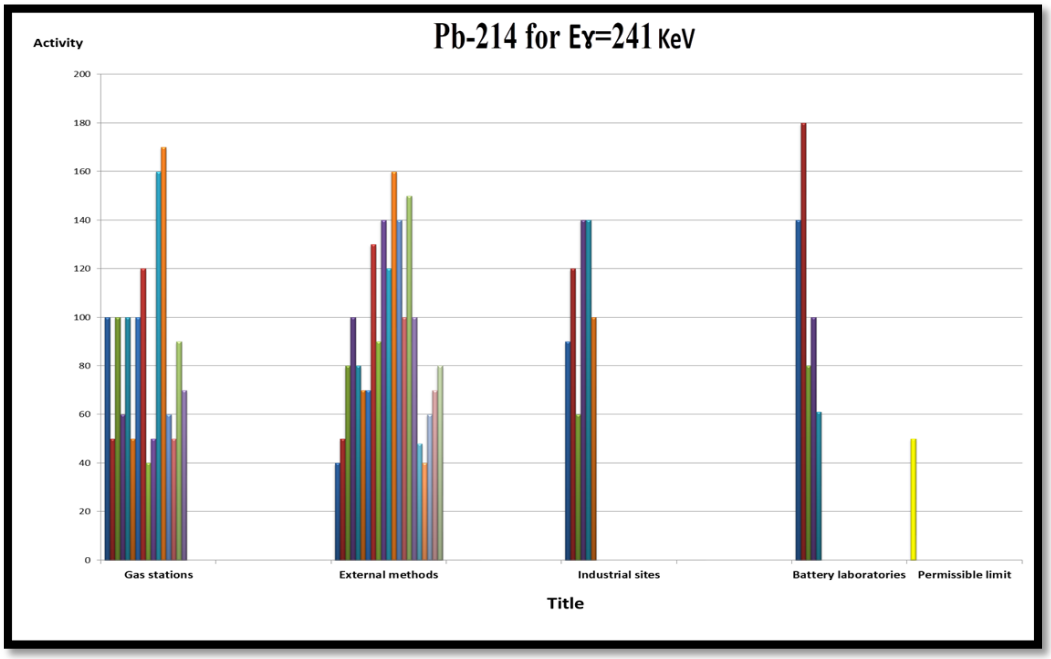


Figure 5-Classification of isotope concentration sites: Pb-214 for Eγ = 241 KeV in Baghdad city.

The interpolation maps are shown in (Figure 6) for the concentration of the isotope Pb-214, with high concentrations in central and eastern Baghdad, represented by (Al-Nahrawan, Al-Waziriya Battery Factory, and the Lead Foundry in Abu Ghraib), and the lowest in central and southern Baghdad are (Al-Dora and Al-Mahmoudiya) [21-27].

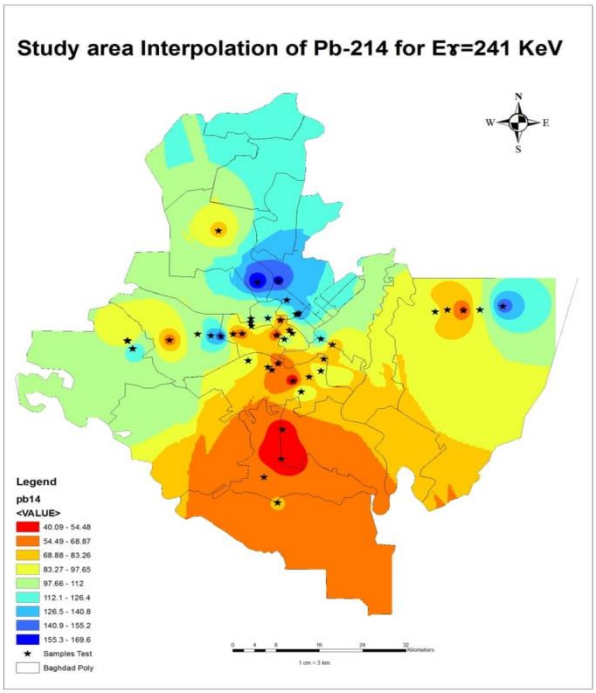


Figure 6-Interpolation of lead concentration isotope Pb-214 for Eɤ = 241 KeV in Baghdad city soil.

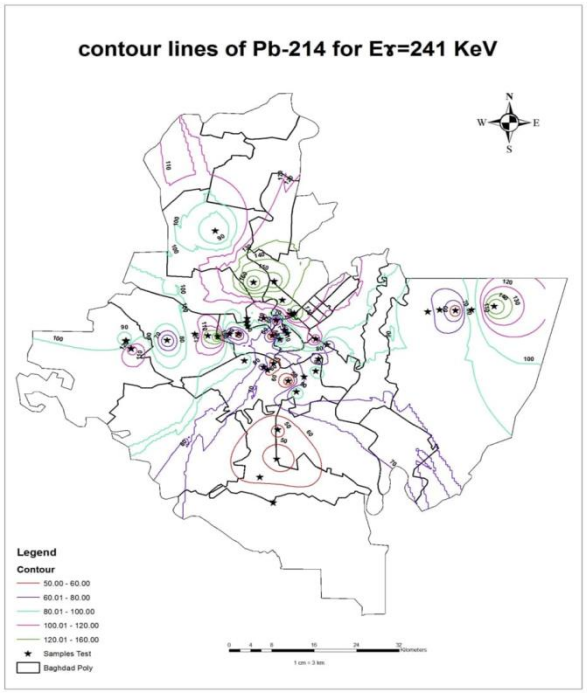


Figure 7-Show the contour lines of lead isotope Pb-214 for Eɤ = 241 KeV in Baghdad city soil.

Conclusions:

The interpolation and contour map used in this research study, which is based on the IDW model, shows that a concentration of the radioactivity of the lead isotope Pb-214 is present in industrial environments that include battery plants, lead foundries, and gas. stations and external roads, because all that was mentioned directly or indirectly, as it was found that this lead isotope exceeded the permissible limit in most of the samples taken, and reached the highest value of 180 Bq in (Battery Lab 2), then it was graded to 170 Bq in (Al Tajiat Street), and then graded to 160 Bq (Al Muthanna Street) where these values were recorded close to each other in the vicinity and this is evidence that these sites are contaminated. The values decreased gradually in specific locations until they reach 50 Bq , which is exactly equivalent to the standard value allowed in (Al Nahrawan Street 1 Fuel, Al Bayaa Road, Utaifiya Street, Al Ghazaliya Highway, Sidiya area) and then the lowest value is recorded. 40 Bq (Al-Dora Road, Mahmoudiya 2 Road, Al-Mansour Petrol Street). This means that these sites are not radioactively polluted because they recorded a value lower than the standard value. The danger of pollution to humans is through farms near the outside and polluted roads, and it is transmitted through soil and cultivation, then to humans when eating agricultural products, and it has been proven that plants with large leaves are quick to absorb radioactive isotopes and polluting. The central authority and authorities in the Ministry of Health and Environment must take preventive radiological measures and protection from the impact of these radiations that cause this human activity for a major environmental reason by providing the suitable fuel that does not contain tetraethyl lead for cars and other vehicles so that lead particles do not fall on the sidewalks and cause environmental radioactive pollution.

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