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Survey of Some Heavy Metals and Radioactivity in the Dust in A Selected Area in Kirkuk Governorate- Northern Iraq

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Abstract:
Air pollution means the release of pollutants into the atmosphere, which are harmful to human health and the planet as a whole. Almost all air pollutants come from production and energy use. In the present work, an assessment of some heavy metals, natural radioactivity and the quantity of dust fallen in three sites (Tessen, Rahemawa, and Laylan) in Kirkuk Governorate, northern Iraq. Three dust samples were collected from three locations (residential, commercial and industrial areas). The collected samples were analyzed for Cd, Cr, Cu, Ni, Pb, Zn, and radioactivity (Gamma rays). The studied heavy metals (Fe, Ni, Pb, and Zn) exceeded their limits in the atmosphere due to the increase in the number of automobiles, which added pollutants to the atmosphere through the fuel combustion in automobiles. The industrial processes, especially the petroleum industry considered the most dominant in Kirkuk Governorate, and anthropogenic activities also participated. Chromium Cr, Cu and gamma-ray were within the acceptable limits according to the World Nuclear Association (WNA).

Keywords: Kirkuk, heavy metals, radioactivity, gamma-ray.

مسح لبعض العناصر الثقيلة و المشعة في الغبار المتساقط لمناطق مختارة في محافظة كركوك– شمال العراق

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الخلاصة
في الدراسة الحالية، تم تقييم محتوى الغبار المتساقط من بعض العناصر الثقيلة و العناصر المشعة في ثلاث مناطق مختارة (تسعين، رحيم اوه، و ليلان) في محافظة كركوك– شمال العراق. ثلاث عينات من الغبار المتساقط تم جمعها من المناطق المختارة لغرض الدراسة (سكنية، تجارية، و صناعية). تم اجراء تحليل لمحتوى تلك العينات من بعض العناصر الثقيلة (Cd, Cr, Cu, Ni, Pb, Zn) و العناصر المشعة (اشعة بيتا و كاما). اظهرت العناصر الثقيلة (Fe, Ni, Pb, Zn) زيادة في تركيزها مقارنة مع المحددات العالمية في الهواء نتيجة احتراق الوقود في الاعداد المتزايدة من وسائط النقل الذي يزيد من نسبة بعض العناصر الثقيلة في الهواء و نواتج العمليات الصناعية و خاصة الصناعات النفطية الموجودة في محافظة

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كركوك فضلا عن الفعاليات البشرية، في حين اظهرت كان تركيز العناصر (Cr ,Cu) اقل من تلك المحددات. تركيز المواد المشعة (اشعة كاما) كانت ضمن الحدود المقبولة حسب منظمة الطاقة الذرية الدولية.

1. Introduction

Air contamination is any condition in the atmosphere where contaminants are present in different concentrations, which can cause bad consequences for humans and their environment. It mainly comes from the combustion of fuels in vehicles, petroleum industries, and power stations. In some countries, contamination may come from different sources in the industry that make dust formation and cement industries [1, 2]. The Middle East area has never been considered a significant area for mining. Therefore, it was not involved in the industrial development period based on iron and coal [3]. Recent results revealed that levels of contaminants below or even around the standards of the quality of air set by such international and national institutions; could cause health effects [2]. The Cd, Cr, Cu, Ni, Pb, and Zn in the city air traffic is considered one of the major emission sources of contaminants. Heavy metals associated with erosional soil and re-suspension of deposit dust particles and different metals toxic, heavy elements such as Cu, Cr, Pb, Ni, may play the main role in the aerosol toxicity [4, 5, 6, 7]. Many contaminants have attention in all countries because of their harmful effects on human beings; heavy metals are one of them, reaching the environment via the deposition of atmospheric particulates. Precipitation of dust includes four processes: impaction, gravitational settling, transfer by Brownian motion and turbulent transfer [8]. The heavy metals in the fallen dust, below 10 μm, can reach the lungs, and stay inside it, and it is challenging to expel with inhalation and exhalation processes which can harm the health of humans [9, 10, 11]. The accumulation of the heavy metals in the body was done through skin contact, respiration, absorption and ingestion [12, 13, 14, and 15]. Coal combustion, nuclear plants, radioactive waste, and nuclear weapons are the most important sources of radioactive dust in the atmosphere, which are precipitated according to the weight and size of the fallen dust [16]. Radionuclides consider the most important sources of radioactive dust in the atmosphere. Radon typically has almost 50% of the radiation background [17]. Radioactive dust has a dangerous and negative impact on health. Free radicals may cause significant damage to the chromosomes, DNA, tissues, and cells, which may cause a cancerous cell [18, 16]. The most probable source of radioactivity or ”NORM” Naturally Occurring Radioactive Materials in the environment is the oil well drilling processes; a mixture of gas, oil and formation water is pumped to the surface during this process. As the oil and gas in the formation are removed, much of what is pumped to the surface is formation water. Consequently, declining oil and gas fields generate more produced water. While uranium and thorium are not soluble in water, they are radioactive such as radium may dissolve in the brine. They may remain in solution or settle out to form sludge or mineral scales inside pipes and drilling equipment.

Due to the intense dryness during the last decades, dust storms in Iraq have increased [19, 20]. North African deserts, Jordan, and Syrian are other sources of dust events that influence various areas of Iraq [21]. Water scarcity, long periods of dryness, and variation in precipitation were recorded on a regional scale in Iraq [22].

The Kirkuk city is located in northern Iraq (Figure 1), with coordinates 42 9082.1 and 45 5910.9 to the east, 39 08331.3 and 39 35107.2 to the north. It lies about 236 km from Baghdad (capital of Iraq) and about 83 km from Erbil. The surface area of Kirkuk city is about 7247 km^2 and has a population rate of about 1.2 million. Kirkuk City also includes the areas between Zagros Mountains and Lower Zab and Tigris River rivers. The study area is bordered from the south by Hemrin Mountains. In Kirkuk (the study area), rapid development has resulted in chronic diseases related to the decadence of air quality. This may be due to different industries, especially the petroleum industry that thrived in Kirkuk Governorate.

This work aims to estimate some heavy metals and radioactivity content in the fallen dust in Kirkuk Governorate.

2. Materials and Methods

2.1 Collecting Samples: A sampling campaign was carried out in October 2019. Three dust samples were collected from three different stations (Tessen, Rahemawa, and Laylan) located in the Kirkuk Governorate (residential, commercial and industrial areas) (Figure 1). Special containers are used to collect the fallen dust; these comply with the USEPA (the United States Environmental Protection Agency) standards (Figure 2). Each container is assembled on a building roof (3m height) as average with metal cones cover. It has specific holes to protect samples from contamination by solid things and bird feces. The container was brought every month to the lab. Central Environmental Laboratory 2009 adapts the procedure of measurement.

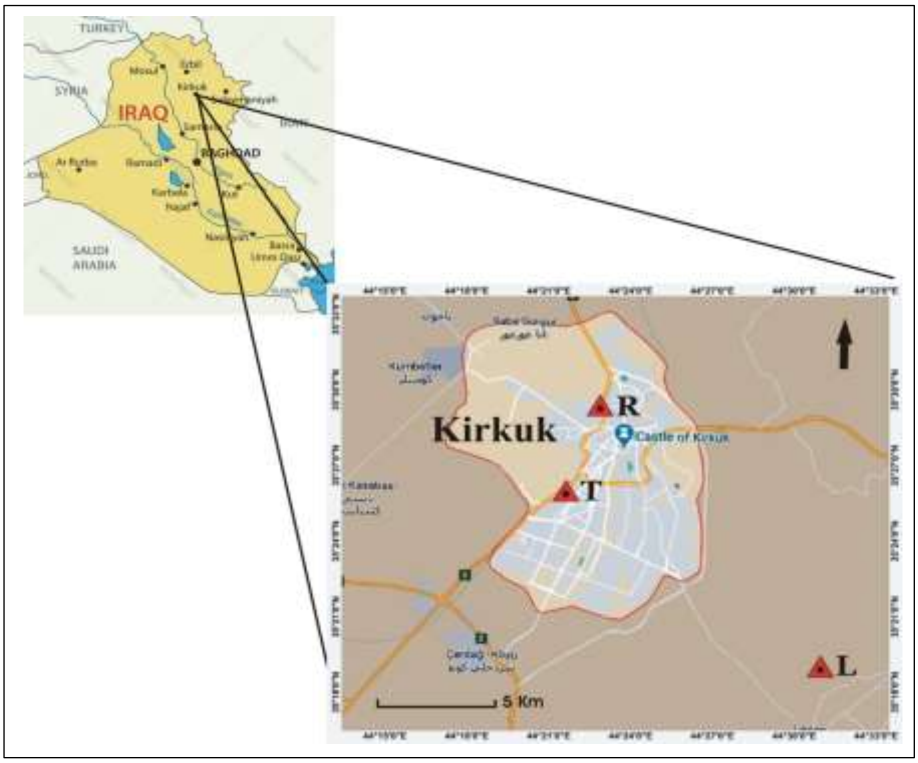

Figure 1- Kirkuk map with the Sampling points.

2.2 The procedure of collecting dust samples:

1- The dust collected in a container that was washed several times with distilled water
2- Put the solution in a beaker of 500 ml.
3- Drying the solution to 50 ml.
4- The solution should transfer to a clean, new, dry beaker and be weighted (W_1).
5- The dried beaker should be cool, and then weighted again (W_2).

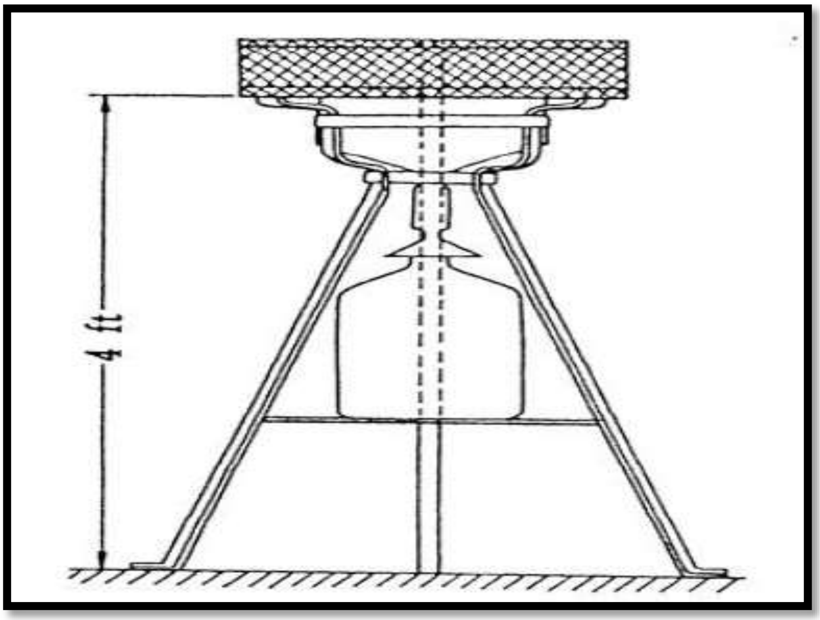

Figure 2- The container that used for collecting dust samples

Heavy elements (Cd, Cr, Cu, Fe, Ni, Pb, and Zn) were measured using Atomic Absorption Spectroscopy (AAS) technique after samples preparation by digestion; all the laboratory analyses were done in Kirkuk Environmental Directorate. Whereas the measurement of radioactivity (Gamma rays) was done using the Giger instrument.

3. Results and Discussion

3.1 Heavy metals: The concentration of Pb ranged between 23 and 27 mg/kg with a mean of 24 mg/kg. Lead (Pb) exceeded the geochemical background 20 mg/kg (Table- 1). Fuel combustion in automobiles, which adds to automobiles' fuel as tetraethyl lead [21], may be responsible for increasing Pb in all sites. The maximum concentration of Pb in the sample of Laylan was 27 mg/kg, while the minimum concentration in Tessen and Rahemawa was 23 mg/kg (Figure 3). Zn concentration ranged between 167 and 173 mg/kg with a mean of 169 mg/kg and exceeded the concentration in the atmosphere 39 mg/kg in all samples according to [23] (Table- 1). The maximum level in the sample of Tessen was 173 mg/kg, whereas the minimum concentration in Rahemawa was 167 mg/kg (Figure 3). Zn enters the atmosphere in the vapour, and particulate forms from industrial processes, incineration of waste, cement plant, and fuel-fired power plants, influence the load of Zn in the atmosphere [24]. The mean concentration of Ni was 45 mg/kg and ranged between 44 and 46 mg/kg. It exceeds the level in the atmosphere (10 mg/kg) in all samples (Table 1). The maximum level in Rahemawa was 46 mg/kg, and the minimum level in Laylan was 44 mg/kg (Figure 3). The main natural Ni sources are windblown dust 56%, while anthropogenic sources mainly burn residual and fuel oil 62%. Fe concentration ranged from 8300 to 9990 mg/kg with an average of 9400 mg/kg (Table 1), the maximum concentration in Laylan was 9990 mg/kg, while the minimum concentration in Rahemawa was 8300 mg/kg (Figure 4). The origin of Fe in the atmosphere is from terrestrial and industrial sources [24]. Cu concentration ranges between 6 and 7 mg/kg with an average of 6 mg/kg (Table 1). The concentration of Cu in all samples was less than the average in the atmosphere, according to [23]. The maximum concentration of Cu in Rahemawa was 7 mg/kg, whereas the minimum concentration in Laylan and Tessen was 6 mg/kg (Figure 3). Finally, the concentration of Cr was 10 mg/kg in all samples; the mean of Cr in the present study is less than the average in the atmosphere (Table 1), (Figure 3). Many pollutants sources may be added and cause an increase in heavy metal concentration within the Kirkuk Governorate, such as petroleum industries, fuel combustion in different types of vehicles, and Baghdad transport station and high traffic intensity [25].

Table 1- The concentrations of Heavy metals (mg/kg) in the Tessen, Rahemawa, and Laylan.

Parameters	Tessen	Rahemawa	Laylan	Mean	Range	Geochemical Background After [26]
Cr	10	10	10	10	10	50
Cu	6	7	6	6	6- 7	17
Fe	9900	8300	9990	9400	8300- 9990	---
Ni	45	46	44	45	44- 46	10
Pb	23	23	27	24	23- 27	20
Zn	173	167	168	169	167- 173	39

Pollution index (Pi):

The following formula defines Pi:

Pi$= C_n / C_{ref}$

Where C_n is the concentration of metal in a sample, C_{ref} is the value of background of the metal in the studied sample, pollution categories after [27, 28]: (Pi < 1) unpolluted, (Pi = 1–2) low pollution, (Pi = 2–3) moderate pollution, and (Pi > 3) high pollution.

The results of Pi Table 1 reveal that the studied area was unpolluted with (Cr and Cu), with moderate pollution with (Pb), and high polluted with (Fe, Ni, and Zn).

The equation that was used to calculate the amount of fallen dust:

Amount of fallen dust (g/m^2) $= \frac{\Delta W \times 1000}{0.7855 \times 255}$ $\Delta W = W_2 - W_1$

Table 1- Level of dust pollution by selected heavy metals based on Pi.

Pollution indices	**Cr**	**Cu**	**Fe**	**Ni**	**Pb**	**Zn**
Pi	0.2	0.35	26	4.5	1.2	4.3

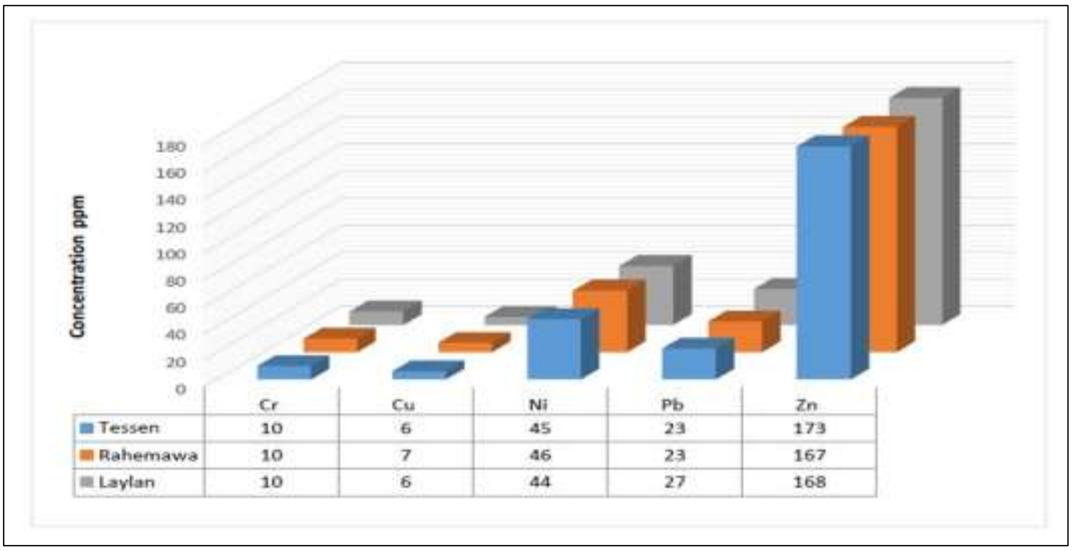

Figure 3- Concentration of Heavy metals (Cr, Cu, Ni, Pb, and Zn) in selected sites of Kirkuk City.

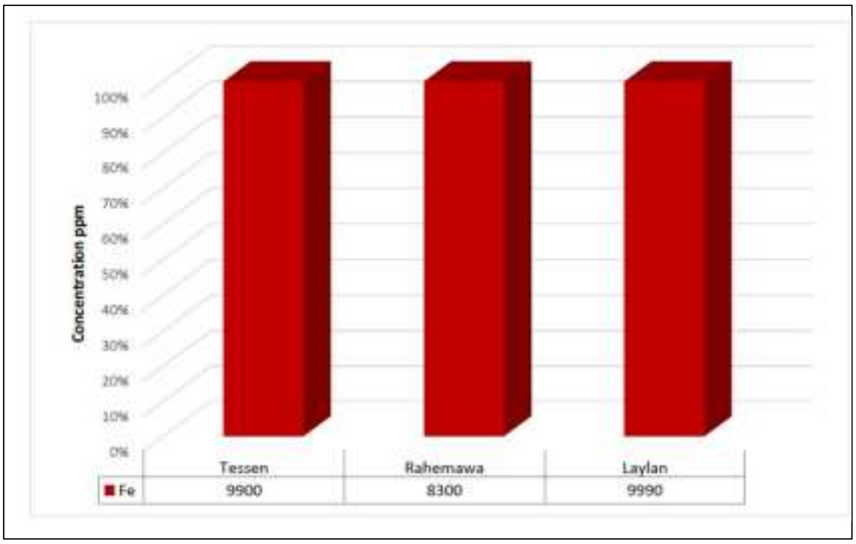

Figure 4- Concentration of Fe in selected sites of Kirkuk City

3.2 Radioactivity: The most probable source of radioactivity or NORM Naturally Occurring Radioactive Materials in the environment is the oil well drilling processes in the study area (Kirkuk Governorate). Ra transport in the atmosphere is mainly by the movement of particulate matter [29]. Radioactivity (Gamma rays) in the studied samples was within the normal background, according to the World Nuclear Association (WNA) (Table 3).

Table 3- Radioactivity levels at the dust samples (Gamma rays) (mSv/y).

Parameters	Tessen	Rahemawa	Laylan	Mean	Range	Normal background (WNA)
Radioactivity	0.737	0.684	0.474	0.635	0.474- 0.737	1.5- 3.5

4. Conclusions

The concentrations of the proposed heavy metals (Cr, Cu, Fe, Ni, Pb, and Zn) were analyzed to be measured in the atmospheric dust in Kirkuk Governorate. They were divided into two groups; the first (Cr and Cu) is within limits in the atmosphere. The second one (Fe, Ni, Pb, and Zn) exceeded the limits attributing to automobiles, which add some heavy metals to the atmosphere by fuel combustion, industrial processes, especially the petroleum industry, which is considered the most dominant in Kirkuk Governorate, and anthropogenic activities. Radioactivity (gamma rays) levels were also measured within limits.

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