Evaluation of concentration (Rn222, VOCs, CO2) for dust storm samples in Najaf Governorate, Iraq

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Abstract. This study aims to assess the concentrations of (Rn222, vocs, CO2) in models of dust storms in Iraq using the AIRTHINGS method, where the results of (Rn222, vocs, CO2) were respectively. radon gas ranged where they ranged from 5.0±1.63 Bq/m^3 to 18.0±3.74 Bq/m^3 at The average 10.8±5.10 Bq/m^3 on average. the levels of volatile organic chemicals in the models that were looked at ranged from 134 ppb to 672 ppb, with a mean of 374.9 ±327.815 ppb. During dust storms, the levels of carbon dioxide ranged from 415 (ppm) to 1200 (ppm), with a mean of 764.9 ± 369.2 (ppm). This means that most of the results for carbon dioxide, radon gas, and volatile organic chemicals were within what This study says is safe. Except for some samples, it was above the permissible limit.

1 Introduction

An important part of environmental tracking is figuring out how much Radon-222 (Rn-222), Volatile Organic Compounds (VOCs), and Carbon Dioxide (CO2) are present in samples from dust storms. This is especially true in places like Najaf Governorate, Iraq. In the last ten years, dust storms have become more common and stronger, which has caused a lot of worries about the health of the people and the quality of the air. When these particles are sucked up into the air, they can carry harmful chemicals like Rn-222, VOCs, and CO2, which can seriously harm people's health.

This paper goes into great depth about how to collect, prepare, and test samples from dust storms for these specific pollutants. It does this to give a full picture of how dust storms affect the environment and the risks that come with them.

Dust storms are complicated weather events that happen because of both natural and human-made causes. Radon, carbon dioxide (CO2), and volatile organic compounds (VOCs) have been identified as important factors in the formation and severity of these emissions. Radon is a naturally occurring radioactive gas that is often forgotten when people talk about

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air quality and the health of the environment. However, the way it interacts with particles in the air can have big effects on how dust storms move.

Radon is very important for making dust storms happen, especially when it interacts with particles in the air. Because it is a naturally produced radioactive gas, radon is usually more concentrated inside, like in homes and offices, where it comes from the breakdown of uranium in rocks and dirt [1]. Recent research has looked into the link between the amount of radon and its offspring and the amount of particulate matter (PM) in the air. The results show that radon children tend to stick to these PM particles easily [2]. This connection makes it easier to study aerosols in terms of their size ranges and how well they stick to surfaces, which are very important for knowing how dust behaves in the atmosphere [3]. So, when radon and its daughters are present in large amounts, they can change the physical and chemical properties of dust particles, which could make dust storms stronger and spread out over a larger area. This connection shows how important it is to keep an eye on radon levels both inside and outside, since higher levels can make dust storms worse, which is bad for public health and air quality. Carbon dioxide, a well-known greenhouse gas, has a big effect on how dust storms move by changing the temperature and the way plants grow. Researchers looking at the Vostok ice core data set have found a link between changes in dust levels, CO2 levels, and temperature over geological time scales [4].

According to research, rising world temperatures are linked to higher CO2 levels. This can make some areas drier, which makes it easier for dust storms to happen. Also, dynamic models have shown that the prevailing winds and the climate conditions caused by CO2 levels have a big effect on the patterns of plants [5]. When there isn't much vegetation because of drought or higher temperatures, the soil is more likely to wash away, which causes more dust to be released into the air. This feedback loop shows how high CO2 levels can indirectly make dust storms more common by making soil degradation and unstable air conditions more likely [6].

Hence, lowering CO2 pollution is not only important for preventing climate change, but also for reducing the number of dust storms that happen. Another important thing that affects how dust storms move is volatile organic compounds (VOCs), mostly because of how they react with particles and change the chemistry of the air. It is known that almost all VOCs add to global warming by absorbing infrared light from the Earth's surface. The more complicated they are, the more they can warm the planet. Scientists have found that metal oxides in mineral dust can speed up the oxidation of VOCs, which makes more secondary organic aerosol (SOA). This reaction not only changes the chemicals that make up particulate matter, but it also raises the amount of particulate matter in the air, which makes dust storms stronger. Additionally, outdoor studies have been carried out to look into the chemical parts, sources, and interactions of PM and VOCs, showing the complex connections that control how they behave and impact the environment [7].

2 Study area

Najaf is one of the most prominent cities in Iraq and the center of Najaf Governorate. It is located to the southwest of the capital, Baghdad. Its population is 1,221,248 people according to 2011 statistics. Najaf Governorate is located astronomically between latitudes (29° 50 - 32° 15) north and longitudes (42° 50 - 44° 44) east.

Fig. 1. Najaf map.

3 Materials and methods

During the period from March to May of 2023 and also in 2024, the city of Najaf was hit by many dust storms. Ten dust samples were collected from the storms that hit the city of Najaf, at a rate of 300 grams of dust from each storm. The samples were placed in plastic bags and a code and date of the storm were placed for each sample, as shown in the following table.

Table 1. History of dust storms in the city of Najaf.

No.	Sample code	Storm History
1	ST	2023/5/18
2	ST	2023/5/19
3	ST	2023/5/21
4	ST	2023/5/24
5	ST	2023/5/26
6	ST	2024/4/15
7	ST	2024/4/20
8	ST	2024/5/13
9	ST	2024/5/17
10	ST	2024/5/31

In this study, samples were taken and put in a vacuum. A digital radon detector (AIRTHINGS Detector) was then used to measure the amounts of radon, carbon dioxide, and volatile organic chemicals in the samples. The readings for radon amounts are very accurate, and are not changed by other radiations. After 24 hours, the AIRTHINGS Detector is still very accurate at 7%. It can measure between 0 and 500 Bq/L (0 to 9999 Bq/m^3) (https://www.airthings.com/home). The same company does the testing. The product comes with a one-year guarantee and doesn't need to be serviced or calibrated during its 10-year life. (https://www.airthings.com/home) It is adjusted right away in the first minute of use. A radon monitor from Air Things has been used in a number of new tests. AIRTHINGS makes the radon tracker that is built into all of our goods. It uses alpha spectrometry technology to find out how much radon is in the air. The suggested gadget is a direct, continuous-state radon monitor with an LCD screen put in for easy short- and long-term readings of radon levels. This product, which has radon tracking technology built in, has become a best-seller and is popular with pros. A good digital radon detector (DRD) is what is being talked about. Many pros in the field of radon monitoring trust and recommend the radon sensing technology that CORENTIUM uses in their home product.

The DRD has become the market leader because it is easy to use, gives accurate readings, and works consistently. This makes it the first choice for homes that want to check and control their radon levels. As part of the monitoring process, silicon photodiodes are used. These devices can both find alpha particles and measure their energy as they break down radon gas sequentially. It doesn't seem to be affected by changes in weather, humidity, pollution, or electric fields. The monitor counts how many alpha particles are released by radon in each sample of air it looks at. The detector works all the time, and every hour it gives a data point that is added to the estimate of the average number. Because of this, radon levels are generally found by averaging the numbers seen over certain amounts of time, like 24 hours, 48 hours, a week, a month, etc. The device shows short-term averages, such as a 1-day average, a 7-day average, and a long-term average. These averages are calculated by adding up all the days those readings were taken. The measurements for this study were taken over 24 hours for each sample, and the reference unit used was Bq/m^3 [8]. This device is one of the top three choices because it is very accurate and doesn't cost too much. This gadget is a very cool way to check the quality of the air inside a building. The CORENTIUM AIR THINGS radon monitors were purposely made to only work indoors. To put it simply, the CORENTIUM AIRTHINGS monitor is very user-friendly because it is small and easy to carry around. The TVOC sensor in the Wave Plus also contains formaldehyde as part of the TVOCs (total volatile organic compounds) measurement. It also contains an NDIR (non-dispersive infrared) sensor to measure carbon dioxide.

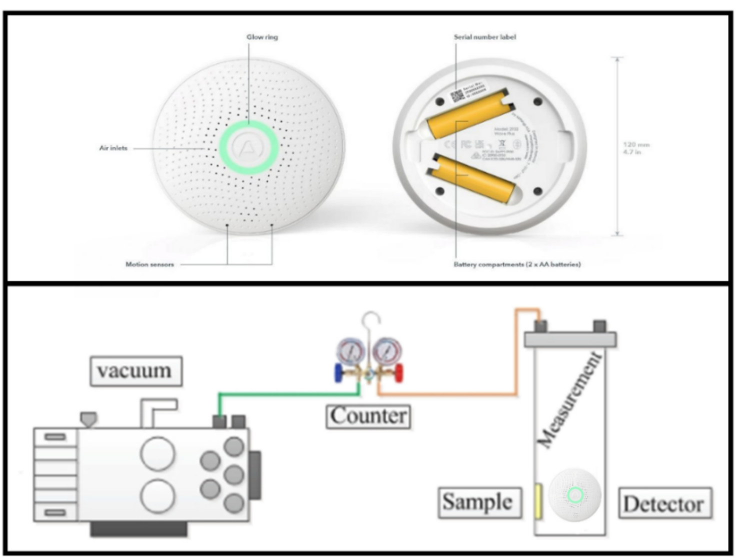

Fig. 2. Device AIRTHINGS Wave Plus Monitor with Radon Detection**.**

4 Results and discussion

Table 2 shows the concentrations of radon gas in models of dust storms in Iraq, where they ranged from 5.0±1.63 Bq/m^3 to 18.0±3.74 Bq/m^3 at the average 10.8±5.10 Bq/m^3 .As it is among the permissible limits globally .The variation in radon levels during dust storms can be attributed to a multitude of factors. One significant factor is the composition of the dust particles themselves, as certain types of dust may contain higher concentrations of radon. This can result from the minerals or geological formations present in the dust particles releasing radon gas. Furthermore, influencing the dispersion and concentration of radon-bearing dust particles are meteorological factors like wind speed and direction. Strong winds can carry the particles over great distances, therefore distributing the radon gas across a bigger region. Furthermore, the direction of the wind helps one to ascertain the course of the dust storm and which areas are more likely to be subjected to high radon levels [9].

Table 2. The results of (Radon*222*) tests on samples from the Najaf dust storms.

No.	Sample code	Radon-222 Concentrations (Bq/m^3)				
		Sample 1	Sample 2	Sample 3	Average	±S.D
1	ST	7	11	6	8.0	2.16
2	ST	23	14	17	18.0	3.74
3	ST	3	5	7	5.0	1.63
4	ST	18	13	8	13.0	4.08
5	ST	9	7	5	7.0	1.63
6	ST	6	4	10	6.7	2.49
7	ST	24	22	16	20.7	3.40
8	ST	11	8	16	11.7	3.30
9	ST	5	3	8	5.3	2.05
10	ST	12	10	15	12.3	2.05
Average±S.D		10.8±5.10				

The geographical location of the source of the dust storm also influences the variance of radon levels. Variations in radon naturally occurring in the soil might exist throughout different areas. High radon concentrations in areas with underlying bedrock or soil increase their likelihood of producing dust particles with greater radon concentration. For instance, areas with granite or uranium reserves have a chance of high radon levels during dust storms. Conversely, low radon levels in the soil can cause the dust particle concentrations to be reduced during dust storm episodes.

Moreover, human actions could help to explain the fluctuations in radon levels during dust storms. Particularly in the extraction of uranium or other radioactive materials, mining activities can produce notable volumes of radon gas into the surroundings. Together with the dust particles, these emissions can form part of the dust storm comparatively [10]. Building projects that disrupt radon-rich soil might add further radon sources into the dust storm. When evaluating radon levels during dust storms, one should take into account these manmade sources as they can greatly affect the general radon concentration.

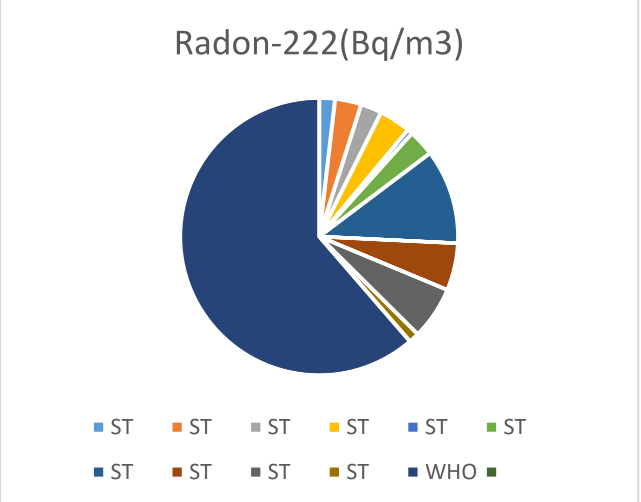

Fig. 3. Radon concentration in dust storm models with world average by (WHO).

Table 3. The results of (VOCS) tests on samples from the Najaf dust storms.

No.	Sample code	Vocs (ppb)
1	ST	269
2	ST	357
3	ST	489
4	ST	672
5	ST	519
6	ST	139
7	ST	752
8	ST	134
9	ST	168
10	ST	255
The average		374.9 ±327.815

Table 3 shows the results of volatile organic compounds in the studied models, which ranged from 134 ppb to 672 ppb at an average of 374.9 ±327.815 ppb. Some samples were higher than the permissible limit set by the World Health Organization One possible explanation for the distinctiveness of VOCs in dust storm occurrences lies in their molecular structure. These chemicals often have many functional groups, like alcohols, aldehydes, and esters, that make them very reactive and volatile. For example, VOCs have low boiling points and high gas pressures, which make them more sensitive to changes in the atmosphere. Unlike places where VOCs are normally found, like dirty cities or factories, dust storms pose special problems and have different effects on these chemicals. Dust storms have strong winds and rough conditions, which raise the number of particles in the air. These particles can directly interact with VOCs. The wind can change the physical world in ways like aerosolization and spread, which can have an impact on how VOCs behave and where they end up in the atmosphere.

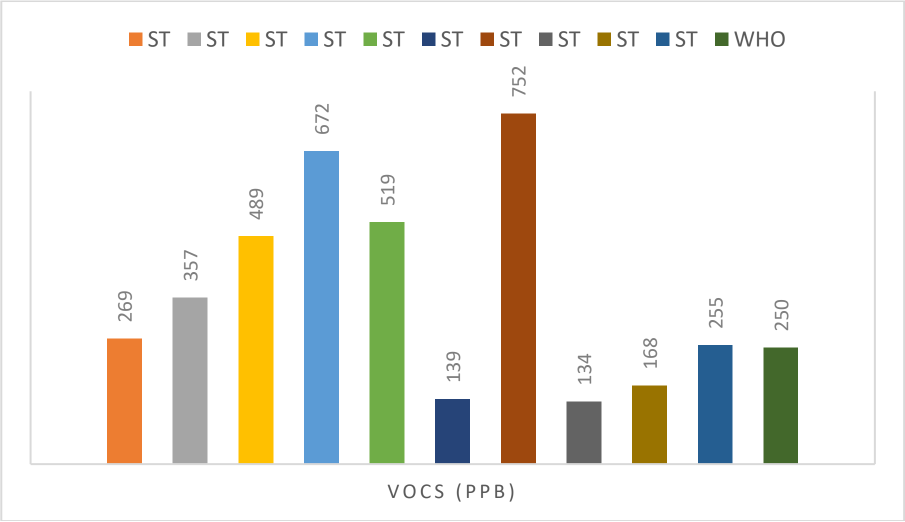

Fig. 4. Vocs (ppb) concentration in dust storm models with world average by (WHO).

Table 4. The results of (Co2) tests on samples from the Najaf dust storms.

No.	Sample code	Co2 (ppm)
1	ST	753
2	ST	930
3	ST	415
4	ST	852
5	ST	753
6	ST	654
7	ST	364
8	ST	1200
9	ST	741
10	ST	987
The average		764.9 ±369.2

Table 4 shows the results of carbon dioxide in dust storms, where the values ranged from 415(ppm) to 1200 (ppm) and at an average of 764.9 ±369.2(ppm) where the results were within the acceptable limit set by the World Health Organization, with the exception of some higher models. Causes of high carbon dioxide in dust storms include natural phenomena such as volcanic eruptions, wildfires, and desertification. These events release vast amounts of carbon dioxide into the atmosphere, trapped within the suspended dust particles during dust storms. Besides natural processes, human actions like cutting down trees, making factories pollute, and burning fossil fuels also release a lot of carbon dioxide [11]. When these things come together, they raise the amount of carbon dioxide in dust storms, which makes the environmental problems worse and adds to climate change [12]. To make effective prevention plans and lower the total carbon footprint, it is important to know why dust storms produce high levels of carbon dioxide.

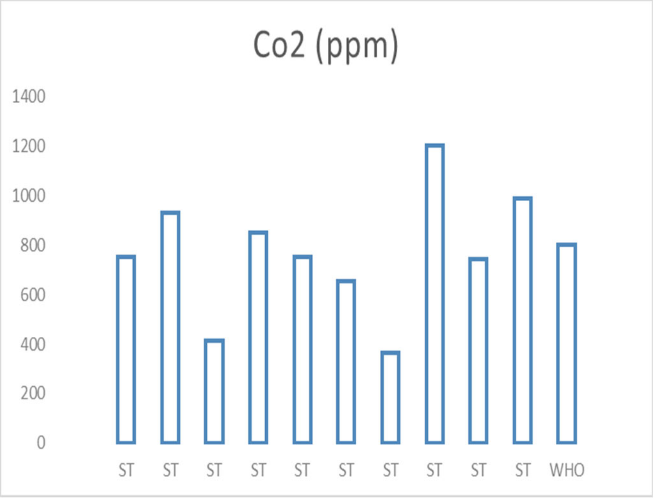

Fig. 5. Results of (Co2) concentration is the in-dust storm models with world average by (WHO).

5 Conclusion

Radon and volatile organic chemicals levels were checked in samples from dust storms in Najaf Governorate, Iraq, for this study. This means that most of the readings for radon gas, carbon dioxide, and volatile organic substances were within the limits set by science except for a few samples.

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