International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 6s, 2025
https://www.theaspd.com/ijes.php

Dust Phenomena and Their Impact on Increasing Desertification in Al-Muthanna Governorate.

Sahar Sahib Kadhim and Shifa Naser jubair
University of AI-Muthanna, College of Education for Humanities
sahar.sahib@mu.edu.iq.

Abstract:
The natural characteristics of Muthanna Governorate, particularly the climatic conditions and the nature of the soil, have contributed to the occurrence of dust storms and their increasing frequency in recent years, which have had a significant impact on the expansion of various forms of desertification. The study area is characterized by a desert climate, with high temperatures throughout most of the year, minimal and irregular rainfall, which contributes to soil dryness, fragmentation, and susceptibility to wind erosion. Al-Muthanna Governorate experiences an increased frequency of dust phenomena, particularly at the end of winter and the beginning of summer months. This is attributed to rising temperatures and the cessation of rainfall, leading to soil heating and atmospheric disturbances that lift dust and particles to varying heights and distances, forming dust weather phenomena. Desertification in the study area manifests in various forms, with significant environmental and economic impacts. These include wind erosion of the soil, which varies seasonally and spatially across the governorate, as well as sand dunes occupying large areas and forming two main belts. These dunes pose serious risks by encroaching on agricultural lands, roads, and water channels, and serve as a source for sand and dust storms. Additionally, the issue of soil salinization is widespread, with the study showing that salinization is more concentrated in the sedimentary plain soils compared to the soils of the western plateau.

Keywords: *Dust Storms, Suspended Dust, Rising Dust, Desertification, Al-Muthanna Governorate*

INTRODUCTION

Dust phenomena are among the prevailing climatic phenomena in arid and semi-arid regions, which cover vast parts of the world in general and the study area in particular. These phenomena occur due to highly complex causes, starting with atmospheric factors such as high temperatures, fluctuating rainfall, low humidity, and increased evaporation, in addition to the nature of the soil in the region, and ending with various human activities. The prevalent drought conditions in these regions have contributed to creating an environment conducive to dust agitation and elevation into the air. This results from thermal heating and the formation of ascending air currents that carry soil particles from fragmented soils, leading to the formation of dust weather phenomena (rising dust, suspended dust, and dust storms). Dust weather phenomena are among the most significant contributors to desertification. They transport large amounts of dust and sand from one place to another, contributing to soil erosion and degradation. Additionally, they accelerate the encroachment of desert lands onto agricultural and pastoral lands, feed sand dunes, and expand their areas, causing significant economic losses and severe health impacts. Given the impact of dust phenomena on all aspects of human life, particularly the transport of suspended dust and drifting sand that leads to serious environmental problems in the study area, this study aims to highlight the primary causes of these phenomena, clarify their role in exacerbating desertification and its progression, and discuss the key measures that can be adopted to mitigate these phenomena. The study adopts both analytical and descriptive methodologies by analyzing climatic data and maps specific to the study area, as well as conducting field studies.

Study Area

The study area is defined by the administrative boundaries of Al-Muthanna Governorate, which is one of the central Euphrates provinces. It is located in the southwestern part of Iraq, covering an area of 51,740 km², which constitutes 11.9% of Iraq's total area of 434,128 km². Al-Muthanna is bordered: to the north by Al-Qadisiyyah Governorate, to the south by Saudi Arabia and Kuwait, to the east by Dhi Qar and Basra Governorates, and to the west by Najaf Governorate. The governorate extends geographically between latitudes 29.5° – 31.4° N and longitudes 43.50° – 46.32° E. The astronomical location of the study area has resulted in diverse environmental characteristics. The latitude influences solar radiation intensity, high temperatures, fluctuating rainfall levels, and dominant wind patterns, which directly affect soil properties, water quality, and vegetation cover. The study area consists of two distinct natural regions with different physical and economic characteristics: The Alluvial Plain Region, covering 4,812 km² (9.3% of Al-Muthanna's total area), and the Western Plateau Region, covering 46,928 km² (90.7% of the governorate's total area)(1) . (See Map 1).

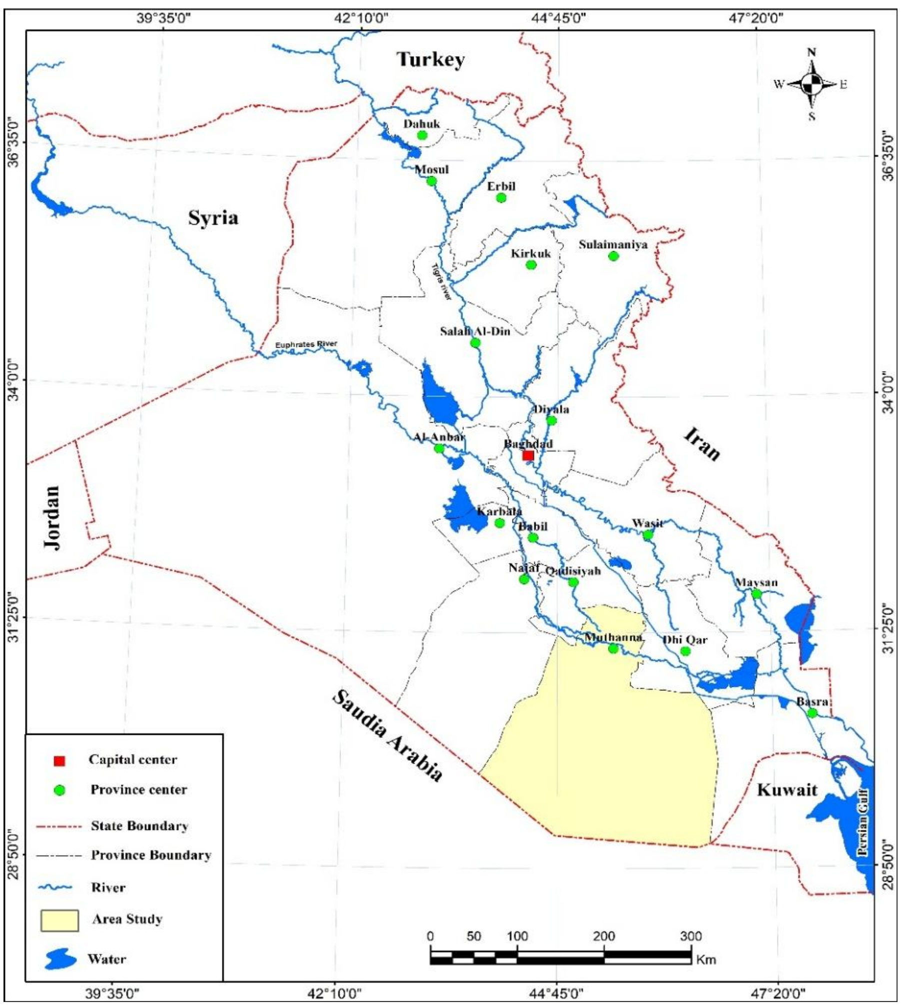

Figure (1): The Location of Al-Muthanna Governorate in Iraq

First/ Climatic Characteristics of the Study Area and Their Impact on the Increase of Desertification

SOLAR RADIATION

The impact of solar radiation is evident through the measurement of the amount of radiation reaching the Earth's surface, as well as the theoretical and actual sunshine duration and their annual averages. Solar radiation is the primary climatic factor responsible for heating the Earth's surface and raising temperatures. As shown in Table (1), the actual sunshine duration reaches its highest levels during the summer months (June, July, and August), recording 11.5, 11.8, and 11.9 hours/day, respectively. It then gradually decreases, reaching its lowest levels during the winter months (December, January, and February), with 6.3, 7, and 7.6 hours/day, respectively. Regarding the theoretical sunshine duration, the highest value was recorded in June at 14.1 hours/day, while the lowest was in January at 10.1 hours/day. The annual average of theoretical sunshine duration was 11.99 hours/day, whereas the actual sunshine duration averaged 8.96 hours/day annually. Given these findings, the study area receives a large amount of solar radiation, particularly during the summer months due to long daylight hours. This leads to increased land heating, higher evaporation rates, soil dryness, and disintegration, creating a favorable environment for dust storms and the expansion of desertification in the region.

Table (1): Monthly and Annual Averages of Theoretical and Actual Sunshine Duration (hours/day) for the Study Area (2000–2024) .

Month	Actual solar brightness	Theoretical solar brightness
January	7	**10.1**
February	7.6	**11.2**
March	7.8	**12**
April	8.6	**12.56**
May	9.5	**13.45**
June	11.5	**14.1**
July	11.8	**13.58**
August	11.9	**13.19**
September	9.9	**12.03**
October	8.6	**11.26**
November	7.6	**10.3**
December	6.3	**10.2**
Total	8.96	**11.99**

TEMPERATURE

Data from Table (2) indicate a variation in temperature averages throughout the year. During the winter months (December, January, and February), the average temperatures were approximately 13.6°C, 11.5°C, and 14.1°C, respectively. The maximum temperatures for these months reached 19.3°C, 17.2°C, and 20.4°C, respectively. As the months progress, temperatures begin to rise, reaching their highest levels during the summer months (June, July, and August), with average temperatures of 34.9°C, 36.3°C, and 36.1°C, respectively. The maximum temperatures for these months were recorded at 43°C, 44.6°C, and 44.5°C, while the minimum temperatures were 26.8°C, 27.9°C, and 27.6°C, respectively. The high temperature levels have contributed to increased wind speed and dryness, leading to higher evaporation rates and

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 6s, 2025
https://www.theaspd.com/ijes.php

reduced soil moisture. As a result, the soil becomes dry and loose, making it more susceptible to wind erosion and the formation of dust storms. These factors collectively contribute to the expansion of desertification across the study area.

Table (2): Monthly and Annual Averages of Minimum, Maximum, and Mean Temperatures (°C) for the Period (2000–2024)

MONTH	MAXIMUM TEMPERATURES	LOWEST TEMPERATURES	MONTHLY RATE
January	17.2	5.8	11.5
February	20.4	7.7	14.05
March	25.8	11.9	18.85
April	31.8	17.6	24.7
May	38.2	23.4	30.8
June	43	26.8	34.9
July	44.6	27.9	36.3
August	44.5	27.6	36.1
September	41.3	23.5	32.4
October	35	19.5	27.25
November	25.3	12.2	18.7
December	19.3	7.9	13.6
Total	32.2	17.65	

WIND

The prevailing winds in Iraq, including the study area, are northwesterly winds, which are characterized by their strong intensity, causing dust and sandstorms during the day, especially in the summer months (June, July, and August). These winds slow down at night and are locally known as "Reeh Al-Shamal" (Northern Wind) or "Al-Gharbi" (Western Wind). Iraq serves as a passage for these winds, which blow from high-pressure areas over the Anatolian Plateau and the Sahara Desert toward low-pressure areas in Central Asia, the Indian subcontinent, and the Arabian Gulf (2). Wind speed varies across different seasons in the study area. As shown in Table (3), wind speed increases during the summer months (April, May, June, July, and August), reaching 3.8, 3.7, 4.4, 4.1, and 3.5 m/s, respectively. This increase is due to the rise in temperatures, which accelerates convection currents. Conversely, wind speed decreases during the winter months (December, January, and February), recording 2.6, 2.7, and 3.2 m/s, respectively. It is evident that the summer months recorded monthly wind speeds exceeding the annual average of 3.4 m/s. The high wind speeds contribute to lifting loose soil particles, increasing dust storms, and intensifying desertification processes in the study area.

Table (3): Annual and Monthly Averages of Wind Speed (m/s) in the Study Area for the Period (2000–2024)

Month	January	February	March	April	May	June	July	August	September	October	November	December	Total
Wind speed	2.7	3.2	3.5	3.8	3.7	4.4	4.1	3.5	3.2	2.9	2.5	2.6	**3.4**

RAINFALL

Data from Table (4) indicate that rainfall characteristics vary from month to month in the study area. Precipitation is limited to the colder months, with no rainfall during the hot months. November recorded the highest rainfall, at 23.4 mm, followed by December, which recorded 15.6 mm. In contrast, the months of June, July, August, and September recorded no rainfall, with a monthly average of 0.0 mm. This is due to the lack of low-pressure systems reaching the study area during these months. Thus, the study area receives low amounts of rainfall, with an annual total of 98.5 mm, which negatively affects soil moisture and vegetation cover. This reflects the prevailing climatic conditions in the region and results in loose, dry soil particles, making it more prone to wind erosion and desertification. (See Figure).

Table (4): Total Monthly Averages of Rainfall (mm) in the Study Area for the Period (2000–2024)

Month	January	February	March	April	May	June	July	August	September	October	November	December	Total
Rate	13.6	11.6	14.3	10.4	5	0	0	0	0	4.6	23.4	15.6	**98.5**

RELATIVE HUMIDITY

Data from Table (5) show that the monthly averages of relative humidity vary across the seasons in the study area. The winter months (December, January, and February) recorded the highest relative humidity, with values of 61.9%, 64.6%, and 57.2%, respectively. In contrast, the summer months (June, July, and August) recorded the lowest values of relative humidity, at 23.7%, 22.4%, and 23.5%, respectively. This decrease in humidity coincides with the high temperatures and the lack of rainfall during these months. The decrease in relative humidity contributes to increased dust storms, as dry air has a greater ability to carry and transport dust particles. Additionally, relative humidity has an inverse relationship with the amount of evaporation from the soil. As air moisture decreases, the evaporation rate increases, leading to drier soil that is more vulnerable to wind erosion, further exacerbating desertification in the study area.

Table (5): Monthly and Annual Averages of Relative Humidity (%) for the Study Area for the Period (2000–2024)

Month	January	February	March	April	May	June	July	August	September	October	November	December	Total
Relative humidity	64.6	57.2	46.7	39.2	29.3	23.7	22.4	23.5	27.3	36.8	53.2	61.9	**40.5**

DUST PHENOMENA

Dust Phenomena are considered a dry climatic event that occurs when soil particles are lifted into the air by the pressure of winds exerted on the earth's surface, exceeding the soil's resistance. These particles are carried by the wind and remain suspended in the air until gravity forces them back to the ground (3). In the study area, these phenomena occur throughout the year but are more active during the spring and summer months, due to the formation of thermal pressure pockets that create unstable atmospheric conditions. Most of the sources of dust storms come from local soils that have been eroded by the wind, while some sources originate from outside the regional boundaries. Dust phenomena are divided into rising dust, suspended dust, and dust storms. The phenomenon of rising dust occurs under unstable atmospheric conditions, caused by sudden changes in pressure gradients or the daytime heating of the earth's surface, which generates updrafts that lift soil particles into the air. These particles can reach heights of up to 15 meters, reducing visibility to 1-4 km. This phenomenon occurs when wind speeds are moderate, ranging between 4.2 – 6.9 m/s (4). As shown in Table (6), the frequency of rising dust varies by season due to changes in temperature, rainfall, relative humidity, and wind speed. The lowest frequency of rising dust occurs in November, December, and January, with rates of 1.7, 2.1, and 3 days, respectively. The highest frequency occurs in May, June, and July, with 8.3, 9.5, and 8.3 days, respectively, while the annual average is 5.7 days. Regarding suspended dust, these are fine particles with a diameter of up to one micron that remain suspended in the air for several hours or days before settling to the ground due to gravity or rainfall. Suspended dust does not require high wind speeds, as the small size and light weight of the dust particles allow them to be carried by winds with low speeds or even calm conditions. The visibility in suspended dust typically ranges from 1-5 km, but in some cases, it can drop below 1 km (5). The highest frequency of suspended dust occurs in May and June, with rates of 16.7 and 15.3 days, respectively. The lowest frequency occurs in December and January, with rates of 3.2 and 4.1 days, respectively, and the annual average is 9.6 days.

Table (6): Monthly Averages of Dust Phenomenon Frequency (Days) in the Study Area for the Period (2000–2024)

MONTH	SUSPENDED DUST	RISING DUST	DUST STORMS
January	4.1	3	**0.2**
February	9.4	5.6	**0.8**

March	11.7	8.2	**1.3**
April	13.8	7.8	**1.4**
May	16.7	8.3	**1.6**
June	15.3	9.5	**1.2**
July	11.5	8.3	**0.5**
August	6.8	5.2	**0**
September	7.4	4.6	**0.1**
October	10.6	4.3	**0.3**
November	4.4	1.7	**0.1**
December	3.2	2.1	**0**
Rate	9.6	5.7	**0.7**

As for dust storms, it is observed that the months of April and May recorded the highest frequency of dust storms, with averages of 1.4 and 1.6 days, respectively. These storms are associated with thermal depressions carrying dust particles across the dry lands. In contrast, August recorded the lowest frequency of dust storms, with an average of 0 days. The annual average for dust storms was 0.7 days.

Second: Desertification Features in Al-Muthanna Governorate

WIND EROSION OF SOIL

Wind erosion is the process of transporting loose and dry soil particles from the surface layer of soil that lacks vegetation cover, by the kinetic energy of the wind. This leads to soil degradation and a decrease in its productivity. Winds erode and transport soil through three main mechanisms depending on wind speed and the size of the transported particles: suspension, saltation, and creep. Wind erosion of soil depends on two main factors: The climatic factor, which involves wind speed and the actual amount of rainfall, both of which affect the moisture content of the soil surface. This factor is referred to as the climatic susceptibility to wind erosion. The soil factor, which is expressed by the percentage of the soil surface that contains aggregates and particles resistant to erosion (larger than 1 mm in diameter). This is called soil susceptibility to erosion. In the study area, the surface soil is highly and continuously subjected to wind erosion due to several factors, primarily the dryness characteristic of the region's climate. High temperatures, low rainfall, high wind speeds, and increased evaporation have negatively impacted the vegetation cover, which is limited to scattered desert plants, especially in the Western Plateau region. This has reduced soil moisture, weakened the soil's cohesion, and made it easy for wind to transport it. Wind erosion intensity varies spatially and seasonally within the study area. Wind erosion is absent during the theoretical winter months due to rainfall, which increases soil moisture and cohesion, thus reducing the wind's ability to erode it. In contrast, wind erosion intensity increases during the theoretical spring months, reaching its peak in the summer, coinciding with the absence of rainfall, higher temperatures, and increased soil dryness, making it easier for wind to transport soil. Regarding spatial variation, the intensity of wind erosion differs between the alluvial plain and Western Plateau regions of the study area. The amount of soil particles transported by the wind from the surface of the Western Plateau is higher than from the alluvial plain. This is because the Western Plateau soil is more susceptible to erosion due to the higher proportion of loose soil particles smaller than 1 mm in diameter compared to the alluvial plain soil.

SOIL SALINIZATION

Soil salinization refers to the process of salt accumulation on the soil surface, which leads to the transformation of land into desert-like areas with poor characteristics. This phenomenon is a major factor affecting agriculture and is common in dry and semi-dry irrigation areas, including Iraq. Salt accumulation is particularly concentrated in its central and southern regions. Several natural factors have contributed to the onset and expansion of soil salinization in the study area, including intense solar radiation and high temperatures, especially during the summer months, which exceed 40°C. The prevailing northwestern winds, which are characterized by their speed and dryness, also play a role, along with human factors such as poor land management, excessive irrigation, and the lack of knowledge among farmers regarding the water requirements of each plant. Additionally, the expansion of summer farming, which requires large amounts of water to compensate for evaporation and transpiration, has led to the significant accumulation and spread of salts on the soil surface after the excess water evaporates. Soil salinization has worsened in recent years, particularly in the Iraqi alluvial plain, due to the expansion of irrigation farming in response to increasing population demands. The absence or inadequacy of drainage systems in many of these areas, which are necessary for irrigation farming, has exacerbated the issue. This problem is critical, as approximately 34 million dunams (out of a total of 46 million dunams of arable land) in Iraq suffer from salinity, representing 74% of the country's cultivable land (11). Soil salinity varies across the study area. The soil in the alluvial plain is classified as saline but non-alkaline, containing varying levels of dissolved salts. The electrical conductivity (EC) of the soil in the river terraces is (7.6 Deci siemens per meter (ds/m), making it moderately saline. In contrast, the EC of the soil in the river basin areas is higher, at 11.8 ds/m, classifying it as highly saline. This high salinity is due to the lower surface level of the soil compared to the river terraces, as well as the finer texture of the soil, which makes drainage difficult, compounded by the lack or inadequacy of drainage systems. As for the Western Plateau, its soil has an EC value of 3.1 ds/m, classifying it as low salinity according to American salinity laboratory classification. This low salinity is attributed to the well-drained nature of the soil, which has a coarse texture and weak water retention capacity, resulting in limited upward movement of groundwater in this region.

THE PHENOMENON OF SAND DUNE SPREAD

Sand dunes are among the most dangerous features of desertification in arid and semi-arid regions, including the study area, due to their activity and spread across neighboring lands, which increases the spread of other desertification features. Sand dunes are defined as mounds or accumulations of sand with an aeolian origin, which can either be active (moving) when the dune surfaces are exposed or devoid of vegetation, or inactive (stable) when plants' roots stabilize the sand, preventing its movement (9). Winds carry dry, loose soil particles and transport them to create dust storms and feed sand dunes, which pose a great danger to agricultural lands, roads, and irrigation and drainage projects. Sand dunes spread in various forms, including longitudinal, transverse, crescent-shaped dunes, and Nabak dunes, as shown in image (1). They occupy an area of (22,406.56 km^2), which forms (43.4%) of the total area of Al-Muthanna Governorate, as shown in table (7). The map (2) indicates that sand dunes are distributed in two main zones. The first zone extends on the left side of the Euphrates River, part of the central belt of sand dunes in Iraq, with its source from the recent deposits of the Tigris and Euphrates rivers and the soils of abandoned lands in the floodplain that have undergone disintegration due to prevailing drought conditions. These dunes are characterized as pseudodunes due to their soft sand, with a high percentage of silt, clay, and river shell remains. The second zone of sand dunes in the study area extends on the right side of the Euphrates River, within the western plateau region, which is part of the western belt of sand dunes, the largest sand dune belt in Iraq. These dunes are classified as true dunes, where the sand content exceeds 90% of their total composition (10).

Figure (2) Sand Dunes in Al-Muthanna Governorate

Type of ground cover	Area (km^2)	(%) Percentage
Sand dunes	22406.56	%43.4
Vegetation and wet areas	2449.003	%4.7
Barren lands	26885.035	%51.9
the total	51740.6	%100

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 6s, 2025
https://www.theaspd.com/ijes.php

Table (7) Area of Sand Dunes in Al-Muthanna Governorate

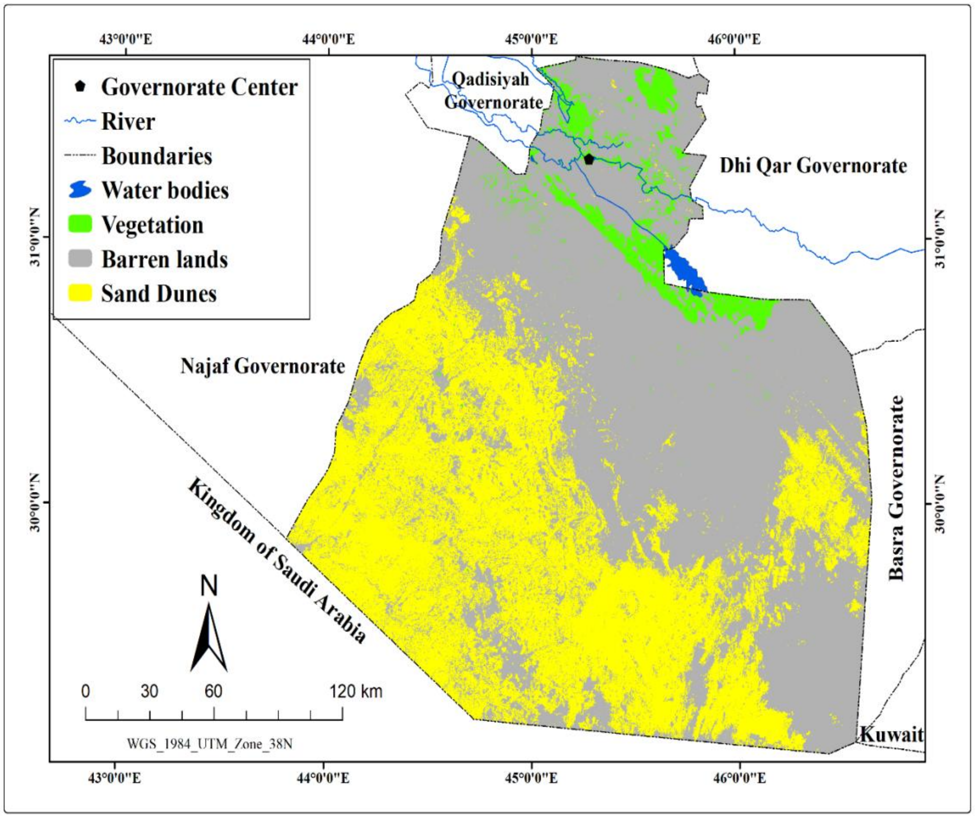

Figure (3) Distribution of Sand Dunes in the Study Area, based on Landsat-9 Satellite Imagery from 2024 and ArcMap10.4.1 Program.

CONCLUSIONS

1 – The prevailing desert climate conditions in Al-Muthanna Governorate, characterized by high temperatures for most of the year, limited and fluctuating rainfall, have contributed to soil drying, disintegration, ease of wind transport, and increased dust storm activity.

2 – The study revealed that Al-Muthanna Governorate faces the problem of desertification, manifested in various forms such as dust storms, wind erosion, soil salinization, and the spread of sand dunes.

3 – The intensity of wind erosion varies seasonally in the study area, increasing during the spring, reaching its peak in the summer, and then decreasing during the winter months in line with rainfall and increased soil moisture.

4 – The soil in the study area suffers from salinization, which poses a significant threat to agricultural lands, especially the soil of the floodplain. It was found that soil salinity in the floodplain region ranges from moderate to high, while in the western plateau region, it is classified as low salinity according to the American Soil Salinity Laboratory classification.

5 – Sand dunes of various types are spread across two main zones, one on the left side of the Euphrates River and the other on the right side. Their total area is (22,406.56 km²), forming 43% of the total area of Al-Muthanna Governorate.

SUGGESTIONS

1 – Focus on creating windbreaks and green belts around agricultural and pastoral lands in Al-Muthanna Governorate due to their many benefits. They help reduce wind speed, moderate the temperature, increase air humidity, stabilize the soil, enhance its cohesion, and thus reduce the impact of wind erosion.

2 – Guide farmers to adopt modern irrigation methods, avoid excessive plowing of land, leaving it exposed to winds for extended periods, and follow appropriate crop rotations. Additionally, encourage the development and protection of natural pastures, regulate grazing activities, and consider controlling livestock numbers according to the grazing capacity.

3 – Raise awareness among individuals about environmental issues, focusing on desertification, its causes, impacts on human life, and ways to prevent it. Support and encourage research and studies related to combating desertification and protecting the environment.

4 – Limit the spread and encroachment of sand dunes by establishing mechanical fences and covering the surfaces of the dunes with permanent and temporary methods to stabilize them and reduce their danger.

5 – Continue land reclamation efforts for areas suffering from salinity issues by soil leaching, replanting, and expanding irrigation and drainage networks.

6 – It is essential to enact laws to protect green spaces, monitor encroachment on orchards, and address the issue of rapid urban growth

REFERENCES

1- Alaa Shakir Omran Mousa, Al-Muthanna Governorate (A Study in Regional Geography), Master's Thesis, College of Education, University of Basrah, 2011.
2- Abbas Fadel Al-Saadi, *Geography of Iraq*, Al-Dar Al-Jami'ya, Baghdad, 2009 .
3- Mohammed Mahmoud Zankah, "Dust Phenomena and Their Impact on Human Health in Najaf Governorate," Master's Thesis (Unpublished), College of Arts, University of Kufa, 2012 .
4- Suleiman Abdullah Ismail, "Dust and Sandstorms in Iraq (Classification and Analysis)," *Iraqi Geographical Society Journal*, Issue (39), 1999 .
5- Taleb Hussein Zayer Al-Ramahi, "Study of Dust Phenomena in Iraq Using Remote Sensing Technology," Ph.D. Thesis (Unpublished), College of Arts, University of Kufa, 2021 .
6- Mohammed Safi Al-Din, *Geomorphology of the Earth's Crust*, Dar Al-Nahda Al-Arabia, Beirut-Lebanon, 1st Edition .
7- Abdullah Salem Al-Maliki, "Using Quantitative Methods to Estimate Wind Erosion of Soil in Wasit Governorate," *Geographical Studies Journal*, Issue (1), University of Basra Press, 2004 .
8- Muhannad Hassan Rahiif Al-Kaabi, "Desertification Problem in Al-Muthanna Governorate and Some of Its Environmental Impacts," Master's Thesis (Unpublished), College of Education, University of Basra, 2008 .
9- Arthur N. Strahler, *Physical Geography*, Second Edition, John Wiley & Sons, Inc., New York, London, 1961 .
10- Walaa Kamel Sabri Hussein Al-Asadi, "Sand Dunes in Al-Muthanna Governorate (An Applied Geomorphological Study)," Master's Thesis (Unpublished), College of Arts, University of Baghdad, 2011 .