University of Baghdad
College of Engineering
JE
JOURNAL OF ENGINEERING

Journal of Engineering

journal homepage: www.jcoeng.edu.iq

Volume 31 Number 8 August 2025

Using Geographic Information Systems (GIS) in Environmental Risk Analysis and Assessment: A Case Study on Baghdad City

Haqi Ismael Kadhim Alanbagi

Technical Institute of Baquba, Middle Technical University, Baghdad, Iraq

ABSTRACT

Environmental quality for a healthy life is a major focus of scientific studies on human life and health. Rapid economic growth and urbanization have exposed major cities such as Baghdad to the risk of environmental problems, including desertification, air and water pollution, and high greenhouse gas emissions. These risks can be studied and assessed using Geographic Information Systems (GIS), which provide a comprehensive understanding of environmental issues and evidence-based remedies. Focusing on water and air pollution, this study will examine and assess environmental risks in Baghdad. The study identified areas with high concentrations of PM10, NO_2, and SO_2 through analyzing GIS maps. These areas are located in densely populated and traffic-intensive areas and are severely affected by pollution around major roads and industrial areas. Wind conditions and climate change also cause seasonal fluctuations in pollution levels. Although the Tigris and Euphrates rivers have suitable pH and nitrate levels, they contain significantly higher amounts of dissolved solids and phosphates, which may result from industrial and agricultural pollution. Land cover transformation results show an increase in the percentage of built-up area from 25% in 2016 to 45% in 2024, with a decrease in green areas from 40% to 30%. The average annual temperature increased from 21.5°C to 23.2°C, while rainfall decreased from 135 mm to 115 mm. PM_{10} concentrations increased from 85 μg/m^3 in 2018 to 110 μg/m^3 in 2023, indicating a worsening of air pollution. The hotspot map shows higher concentrations near industrial areas and the Karkh–Doura corridor.

Keywords: Air pollution, Baghdad city, Environmental risk, GIS, Water pollution.

1. INTRODUCTION

Human life and health are among the most important factors that scientific research has focused on in various sciences, especially the study of the influences that directly or indirectly affect life **(Rasha, 2022)**.

---

*Corresponding author
Peer review under the responsibility of University of Baghdad.
https://doi.org/10.31026/j.eng.2025.08.04

Article received: 08/11/2024
Article revised: 22/05/2025
Article accepted: 11/06/2025
Article published: 01/08/2025

One of the most important factors that must be taken care of is the environment in which a human lives, and the suitability of that environment for a human to enjoy a healthy and sound life, especially the purity of the air in populated cities, drinking water, and the most important pollutants that affect these factors **(Ebthaj and Raad, 2022)**. The various uses of humans through their various activities in the environment in which they live are considered among the human sources of environmental pollution, whether those uses are in the industrial fields, domestic uses, or daily life **(Ahmed, 2020; Vigneshwaran, 2018)**.
Large cities such as Baghdad are unsafe due to a number of environmental risks as a result of rapid urban extension and rapid economic activity. Numerous causes, including desertification, greenhouse gas emissions, and pollution of the air and water, have a significant impact on the environment in Baghdad **(Jha, 2007)**.
A geographic information system (GIS) is a helpful tool for evaluating and analysing these environmental factors. GIS is a technique that makes it possible to examine geographical and temporal data and offers the capacity to make data-driven decisions on environmental concerns **(Marines, 2016)**.
In large cities like Baghdad, environmental risk analysis is essential to preserving the health of the populace and the environment. GIS can offer data-based solutions and a thorough approach to environmental issues **(Hameed et al., 2018)**.
This study analyses and assesses Baghdad's environmental risk using GIS. Soil falls, water pollution, and air pollution are the three main areas of work.

2. ENVIRONMENTAL POLLUTION IN IRAQ

The Iraqi environment has been exposed to a clear and tangible deterioration, and between population growth **(Danbus et al., 2017)**, due to this diverse, unstable development of different regions and modern technical agents to treat environmental toxins, lack of environment and in addition to the environment, in addition to the environment **(Muhammad, 2021)**. There was and still is a result of the wrong uses of the environment by humans, a clear imbalance in the ecosystems and a tangible change in the natural features of the Iraqi environment, including environmental damage to Iraq's infrastructure **(Fawzi and Mahdi, 2014)**. Environmental problems are many, and pollution is one of the most dangerous and important problems facing the Iraqi environment, but in many cases, it is the result of human activities, unlike most risks **(Chaichan et al., 2018)**.
Among other environmental problems, some of which are due to natural causes, Iraq has faced many environmental damages resulting from many accumulated problems resulting from military operations and the use of various types of conventional and non-conventional weapons, in addition to the damages inflicted on the Iraqi environment as a result of the outbreak of wars and the use of internationally prohibited weapons **(Douabul et al., 2013)**.
Among the results of these wars are air and water pollution and the impact of that pollution on human health through the spread of serious diseases **(Alghamdi, 2016)**. Geographical information system (GIS) software such as ArcaGIS was used to analyze environmental data on air and water pollution in Baghdad **(Weng, 2010)**, by implementing several basic spatial analysis techniques:
The purpose of Heat Maps analysis is to understand the distribution of pollution in Baghdad and identify areas with "hot spots" or higher levels of pollution **(Al-Fatalvi, 2021)**. Heat maps of PM10, NO_2, and SO_2 concentrations were produced using the ArcGIS analysis units, and the Baghdad map was produced in the air using data from the Ministry of the

Environment. These maps assist in pinpointing regions that need prompt action to cut pollution **(Dawood, 2018)**.
The use of spatial regression analysis to comprehend the correlation between geographic locations and pollution intensity enables the identification of potential sources of pollution in specific regions **(Alberti, 2003)**. To ascertain the impact of spatial variables on air quality, such as industrial sites or major highways leading from residential areas, local study was conducted. Utilising methods like "geographical regression analysis" to guarantee data accuracy, this analysis assisted in identifying locations where pollution is most likely to occur owing to their closeness to industrial areas **(Al-Jobori, 2006)**.
To assess how environmental pollutants travel from certain sources to nearby locations, network analysis was employed **(Ali, 2020)**. Through network analysis, arch housing, vehicle mobility, possible emission sources, and pollution routes, particularly from busy highways and industrial areas, were assessed. This methodology made it possible to forecast how pollution spreads from crowded regions to the residential neighbourhoods nearby **(Al-yaqoubi, 2010)**. The effects of toxins on the residents who resided close to the pollution sources were closely examined **(Marwah, 2018).** The distance between major roadways and residential neighbourhoods in industrial regions, such as pollution sources, was calculated using GIS technology. Using this methodology, the weakest field for pollution and environmental concerns was estimated **(Daniel, 2007)**. The impacted regions surrounding pollution sources, such as industrial facilities and rivers, were located using buffer analysis **(Ali, 2016)**. In order to examine the impact of air and water pollution on nearby residential areas, buffers were established around industries and major thoroughfares using ArcGIS buffer analysis tools. To monitor pollution in industrial plants, for instance, depth zones of one and three km were created **(Xu, 2007; Arshad, 2012)**.
The distribution of pollutant points was analysed using point pattern analysis, and any regions with high pollution concentrations were contrasted with population points **(Asgari, 2015)**. GIS programs, using techniques such as core density, were made maps showing the pattern for pollution distribution in different areas. This analysis allowed to understand pollution concentrations and identify the neighborhood that is in contact with large amounts of environmental toxins **(Babu, 2016)**. Predictive modelling was used to predict changes in future environmental pollution levels based on current patterns **(Khalaf, 2020)**. When using GIS equipment and future model analysis, fictitious landscapes were developed on the future of pollution, taking into account the development of industrial areas, population density and level of government intervention **(Zhao, 2006; Chang, 2019)**.

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Study Case Description

Baghdad, the capital and largest city of the Republic of Iraq, is located in the central part of the country on the banks of the Tigris River **(Fathela, 2024)**. For its geographical location, we used WGS 84/UTM zone 38N (EPSG:32638), with the approximate coordinates of the city center at Easting ≈ 444,000 m and Northing ≈ 3,688,000 m in zone 38N.
Demographically, Baghdad's population is estimated at 8,141,120 in 2025, according to the latest United Nations estimates **(Jassim, 2021)**.
Climatically, Baghdad's climate is classified as a hot desert climate (Köppen BWh), with an average annual temperature of 22.8 °C, while annual rainfall is approximately 156 mm.

Climate The following human activities are the main causes of pollution in Baghdad: vehicle emissions and private generators, factories and power plants operating on fossil fuels, and the burning of solid waste, in addition to heavy industrial sites such as oil refineries and asphalt plants (such as the Dora refinery) **(Soaded, 2015)**.

The rapid and continuous population growth, accompanied by an increase in municipal, industrial, agricultural, and other activities, in addition to climate change, has led to changes in environmental quality requirements, including air, water, and groundwater quality **(Ali, 2012)**. The city of Baghdad is limited to latitude 36°30 - 37°34 north and longitude 39°20 - 49°45 east. According to statistical studies, the proportion of urban, agricultural, and industrial areas is 72.69%, 25%, and 2.31%, respectively **(Mahal, 2022)**. These proportions show an increase in pollution expectations due to the increase in these proportions outside urban planning **(Al-Jubouri and Al-Basrawi, 2013)**. The study area is located in the Universal Transverse Mercator – UTM structure 1984-Zone 38° N of the Universal Transverse Mercator – UTM structure, as shown in **Fig. 1**.

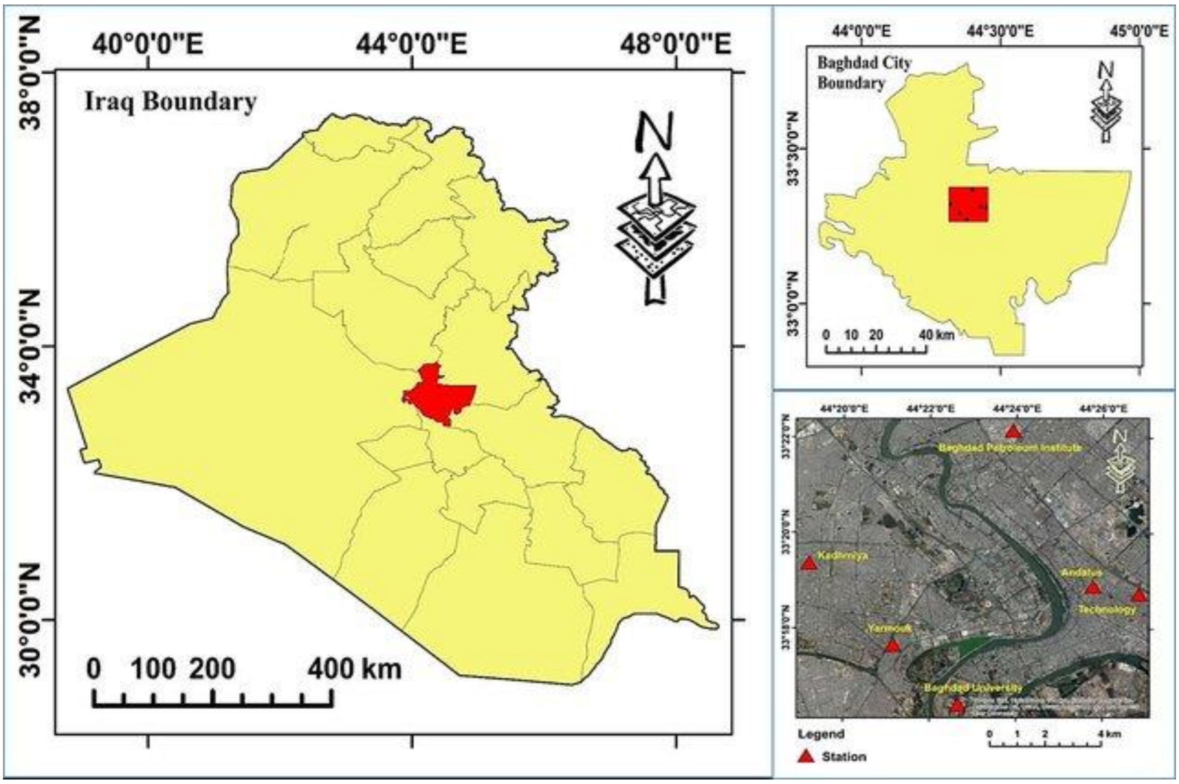

Figure 1. Study Area location.

3.1.2 Data Collection

Spatial and environmental data were collected from a range of reliable sources, including:

- Topographic maps of Baghdad city: obtained from the Iraqi Ministry of Planning to identify the city's geographic locations.
- Satellite imagery: including Landsat and Sentinel data to examine land transitions and urban growth.
- Climate data: from the Iraqi Meteorological Authority, i.e., temperature, rain, wind speed, humidity.
- Environmental data: such as air pollutant concentrations (PM10, NO_2, SO_2) and water pollutant information from the Iraqi Ministry of Environment.

3.2 Methods

In this research, we adopted a systematic approach based on Geographic Information Systems (GIS) to process and analyze remote sensing, climate, and pollution data. This includes the following detailed steps:

3.2.1 Initial Data Preparation

A. Satellite Imagery: Landsat 8 OLI/TIRS and Sentinel-2 MSI images were acquired in their Level-2 SR/BOA format, processed radiometrically and with atmospheric correction, and then cropped to the Baghdad Governorate boundaries using the Clip tool in ArcGIS.

B. Climate Data: Daily data for temperature, rainfall, wind speed, and humidity were collected from the Iraqi Meteorological Authority and subjected to a quality assurance (QA/QC) process before being aggregated into monthly and seasonal averages.

C. Pollution data: Includes hour-by-hour readings of PM_{10}, NO_2, and SO_2 concentrations from three main stations (Karkh, Rusafa, Adhamiya), adjusted to extract daily and monthly averages.

3.2.2 Extracting and Classifying Spatial Information

A. Land Cover Classification: Using the Maximum Likelihood supervised classification algorithm in the Spatial Analyst extension, we classified images into categories: built-up area, green space, water, and bare soil.

B. Temporal Change Analysis: Using the Change Detection (Post-Classification Comparison) tool, we compared cover layers for the years (2016, 2018, 2020, 2022, and 2024) to determine the rate of conversion to built-up area.

3.2.3 Spatial Pollution Mapping

A. Spatial Interpolation: Inverse Distance Weighting (IDW) was used to produce continuous surfaces of pollutant concentrations from station points.

B. Heat Maps: Using the Kernel Density tool, areas with high levels of PM_{10}, NO_2, and SO_2 were identified, highlighting "hot spots" such as Adhamiyah and Karkh.

4. RESULTS AND DISCUSSION

4.1 Air Pollution

Table 1 displays the results of Baghdad's air pollution based on the concentrations of the three main pollutants, PM10, NO_2, and SO_2. The Ministry of the Environment tracked Iraqi data, and the geographical information system (GIS) was utilised for analysis. **Fig. 2** illustrates how environmental contamination spreads and impacts ecosystems and public health.

Table 1. Baghdad air pollution

Area	PM10	NO_2	SO_2
Al-Karkh	120	45	25
Rusafa	135	50	30
New Baghdad	110	40	20
Al-Adhamiyah	145	55	35
Alshaab	130	48	28

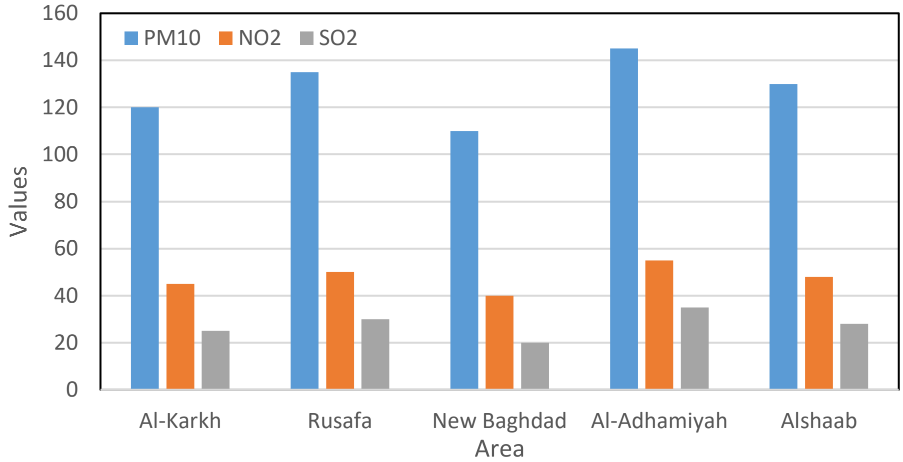

Figure 2. Air pollution in Baghdad

The World Health Organisation (WHO) recommends that the daily average should not exceed 50 µg/m³, and the findings of the PM10 level analysis in numerous parts of Baghdad indicated high levels that exceed safe limits. Al-Akara and Al-Adhia were two neighbourhoods that exhibited concentrations of 120–145 µg/m³. Vehicles and emissions from heavy industrial activity are two of the causes that contribute to the high PM10 level. Other factors that contribute to the buildup of fine particles in the air include dense populations and frequent construction projects. One beneficial particle that may enter the airways and lead to health issues including asthma and heart disease is PM10.

The study's findings show that there are significant regions with elevated PM10 levels that may have a negative impact on public health, particularly for young people and the elderly. While the WHO advises that the yearly average should not surpass 40 ppm, NO2 levels in some places, such Roussefa and Edmiya, were recorded at 50–55 ppm. The primary sources of NO_2 pollution are power plants, industry, and diesel vehicles.

In Baghdad, vehicle exhaust is the largest source of this type of pollution due to high traffic density, especially in central areas. High levels of NO_2 lead to adverse health effects, such as respiratory irritation and increased rates of heart and lung diseases. NO_2 also affects plants and buildings and contributes to the formation of acid rain, which further degrades the urban environment.

The results showed that SO_2 levels in areas such as Al-Shaab and New Baghdad reached 25-35 parts per million, which is considered high compared to the safe limits recommended by the World Health Organization, which should not exceed 20 parts per million for an hourly average, as **Fig. 3**.

SO_2 is mainly emitted from the combustion of fossil fuels used in factories and power plants, as well as from some industrial processes. In Baghdad, the bulk of SO_2 pollution is due to industrial activity and power plants that use high-sulfur fuels. SO_2 has a negative impact on health, as it irritates the respiratory system, can lead to asthma attacks, and increases the risk of heart disease. SO_2 also affects the environment by forming acid rain, which harms agriculture, soil, and buildings and increases the fragility of the urban ecosystem, as **Fig. 4.**
Fig. 5 shows the overall pollution in Baghdad's areas, which are classified into low-pollution areas in yellow, gradually moving to red, which represents highly polluted areas.

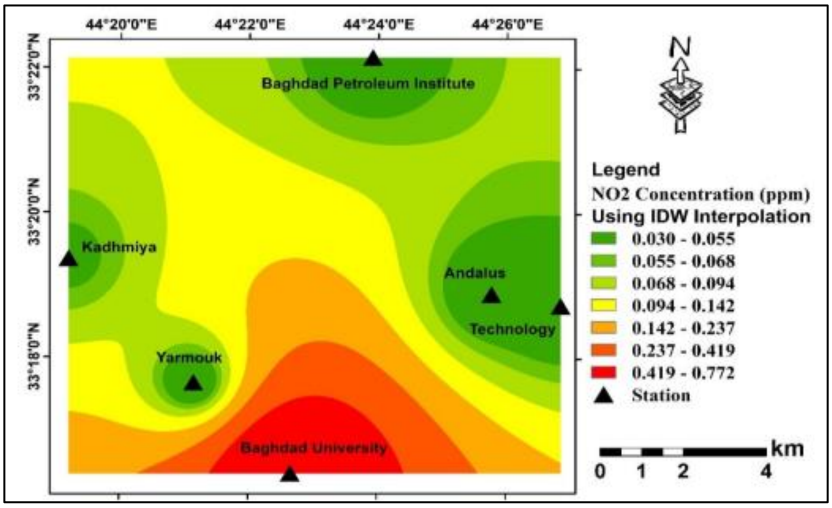

Figure 3. NO_2 pollution in Baghdad

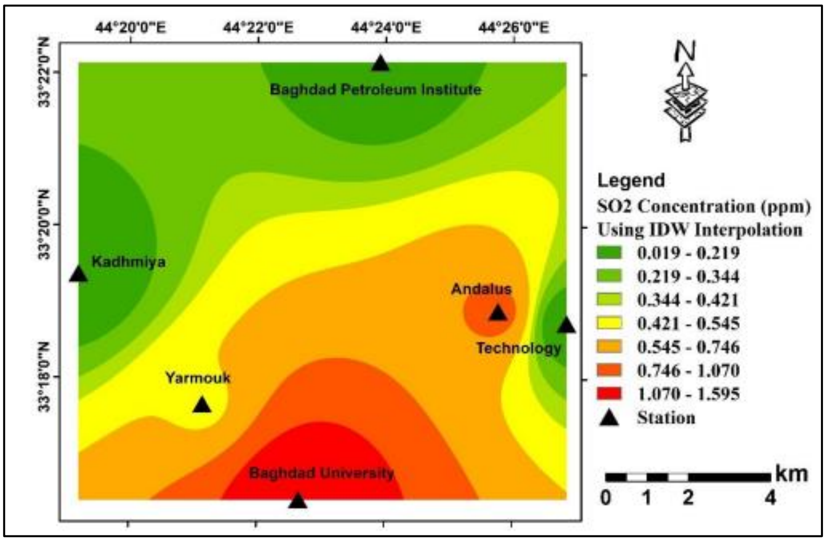

Figure 4. SO_2 pollution in Baghdad

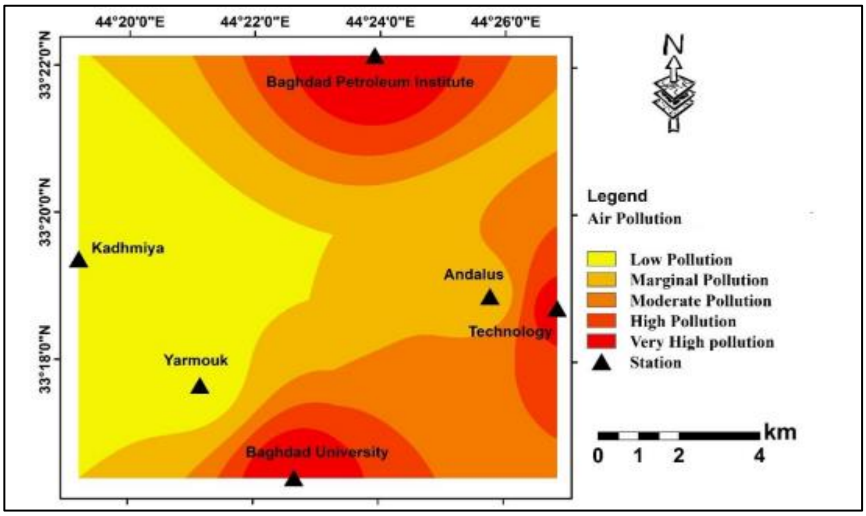

Figure 5. Total pollution in Baghdad

4.2 Water Pollution

Table 2 contains four main indicators for measuring water quality: pH, total dissolved solids (TDS), nitrates (NO_3), and phosphates (PO_4). These indicators provide a comprehensive picture of the water pollution status in Baghdad.

Table 2. Water pollution in Baghdad

Location	pH	Dissolved Solids (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
Tigris River	7.5	600	20	1.5
Euphrates River	7.8	580	25	2
Groundwater	7.3	550	15	1

The pH values ranged between 7.3 and 7.8, which is within the normal acceptable range for drinking water, which should be between 6.5 and 8.5 .These values indicate that water in these places is not very acidic or alkaline, which is a positive indicator of the balance between chemicals. The pH is an important indicator of water protection, as balanced values between acidity and alkalinity help maintain aquatic life and do not adversely affect human health when using water.
The total dissolved fixed level recorded values between 550 and 600 mg/L. The World Health Organization recommends that the level of TDS in drinking water should not exceed 500 mg/L. The high TDs here are a sign of the presence of high-to-normal disintegrated minerals and salts, which may be the result of industrial pollution or wastewater.
High levels of TDS can lead to long-term health problems, such as kidney disease, especially in sensitive groups. It can also affect the taste of water and make it undesirable for human consumption.
Nitrate levels in water were recorded between 15 and 25 mg/L, which is within the acceptable safety limits, as the World Health Organization suggests that the nitrate level should not exceed 50 mg/L.

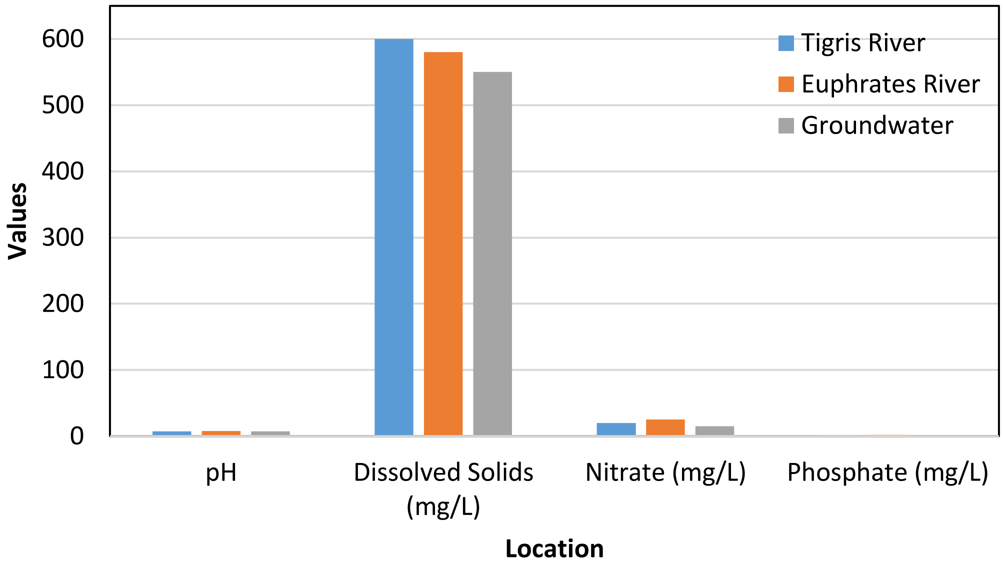

Figure 6. Water pollution in Baghdad

Nitrate levels are moderate, but in some places their high levels may indicate pollution caused by excessive use of fertilizer in agriculture or leaking in water sources. Nitrate is a dangerous environmental toxin, especially for children, as it can give rise to serious health disorders, such as "Blue Baby syndrome" in infants. Therefore, some areas require measures to reduce high levels of periodic monitoring and water pollution. Phosphate levels ranged between 1.0 and 2.0 mg/L, which are relatively high levels compared to normal rates. High phosphate indicates pollution resulting from human activities such as excessive use of chemical and agricultural fertilizers, as well as from untreated wastewater. The accumulation of phosphate in water leads to increased water fertility (nutrient sedimentation), which may cause excessive growth of algae. The accumulation of phosphate leads to the phenomenon of eutrophication or algal blooms, which reduces oxygen in the water and leads to the death of aquatic organisms. It can lead to water pollution with certain toxins that negatively affect public health. **Table 3** shows the change in land cover in Baghdad for the period (2016-2024). The land cover transformation shows an increase in the percentage of built-up areas from 25% in 2016 to 45% in 2024, with a decrease in green areas from 40% to 30%.

Table 3. Land Cover Change in Baghdad (2016–2024).

Year	Built-up (%)	Vegetation (%)	Water (%)	Bare Soil (%)
2016	25	40	5	30
2018	30	38	6	26
2020	35	35	7	23
2022	40	32	8	20
2024	45	30	9	16

Table 4 shows the changing climate trends in Baghdad for the period (2016-2024). The annual average temperature increased from 21.5 °C to 23.2 °C, while rainfall decreased from 135 mm to 115 mm.

Table 4. Land Cover Change in Baghdad (2016–2024)

Year	Avg Temp (°C)	Precipitation (mm)
2016	21.5	135
2018	22	130
2020	22.5	128
2022	23	120
2024	23.2	115

Table 5 shows the annual air pollution levels in Baghdad for the period (2018-2023), where PM_{10} concentrations are observed to have increased from 85 μg/m^3 in 2018 to 110 μg/m^3 in 2023, indicating the worsening of air pollution.

Fig. 7 shows higher concentrations near industrial areas and the Karkh–Doura corridor, where the dot represents the color indicating the level of pollution.

Table 5. Annual Air Pollution Levels (2018–2023)

Year	PM10 (μg/m^3)	NO_2 (ppb)	SO_2 (ppb)
2018	85	45	15
2019	90	48	16
2020	95	50	18
2021	100	55	20
2022	105	60	22
2023	110	65	25

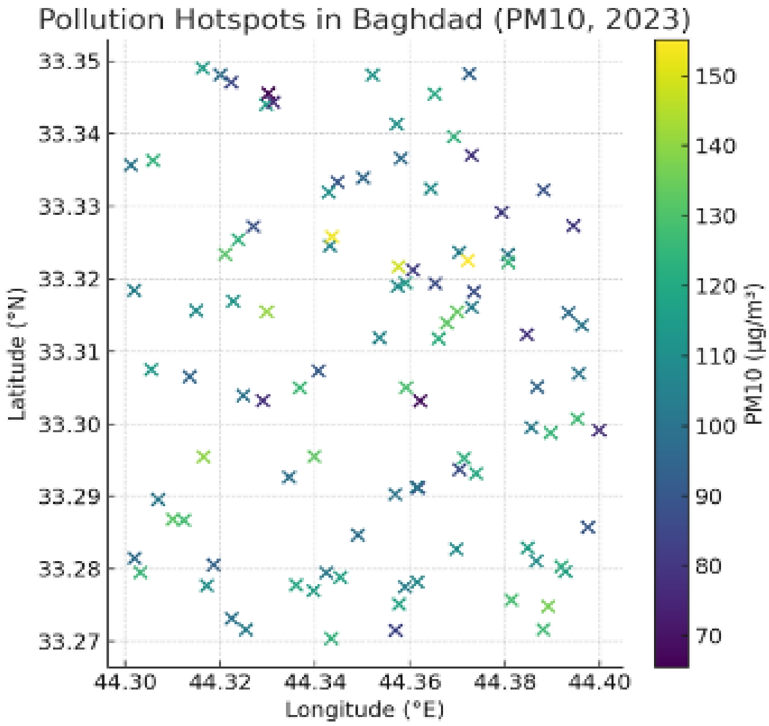

Figure 7. Pollution Hotspots in Baghdad

5. CONCLUSIONS

Based on the analysis of the maps created by the study using GIS, some areas were identified as hotspots, such as Adhamiya, Karkh, and Rusafa, where high levels of PM10, NO_2, and SO_2 accumulate. The maps show that these hotspots are located in areas with high population density and heavy traffic. The data indicate that pollution is significantly higher in areas close to main roads and industrial areas, indicating the impact of concentrated pollution sources at the level of neighboring areas. Some seasonal variations in pollution levels are also evident due to climate change and wind conditions. The results indicate that the waters of the Tigris and Euphrates Rivers and some groundwater sources contain relatively acceptable levels of pH and nitrates, but they have significantly increased dissolved solids and phosphate, which may be related to industrial and agricultural pollution. This indicates the need to implement pollution of strict environmental policy that includes the treatment of industrial wastewater and improves irrigation practices for agriculture, protects water sources and preserves the water environment. In air pollution, policies should be kept to reduce vehicle emissions, such as improving the green area of public transport and improving fuel efficiency. Limitations for industrial functions are recommended to reduce the use of fuel with high sulfur and stimulate the use of cleaner energy sources. Increasing green areas can help reduce air pollution by absorbing pollutants and producing oxygen. In water pollution, we recommend monitoring agricultural and industrial sources to reduce emissions of nitrates and phosphate in rivers and water bodies. Prohibition and awareness should be implemented in agricultural and industrial areas about the effects of these pollutants. To ensure that water treatment plants improve that the level of dissolved materials and metals in the water is reduced. Increase buffer zones in agricultural areas near water sources. Buffer areas can reduce the runoff of the surface and thus limit the transfer of pollutants.

NOMENCLATURE

Start with Latin characters, then Greek ones, in lowercase with units, and should be sorted alphabetically, as an example:

Symbol	Description	Symbol	Description
PM10	Particulate Matter less than 10 micrometers in diameter, μg/m³	TDS	The total dissolved, mg/L.
NO_2	Nitrogen Dioxide, ppm	GIS	Geographic Information Systems
SO_2	Sulfur Dioxide, ppm	Avg T	The average annual temperature, °C

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Ahmed, R.S., 2020. A review of soil radionuclide distribution in Iraq analyzed using gamma-ray spectroscopy. *Environmental Forensics Journal*, 22(1–2), pp. 91–98. https://doi.org/10.1080/15275922.2020.1805827

Ahmed, R.S., 2022. The concentration of radioactive materials in Iraqi soils, water, and plants: A review, *Journal of Radiation Research and Applied Sciences*, 15(1), pp. 245-256. https://doi.org/10.1016/j.jrras.2022.03.012.

Alberti, M., Marzluff, J.M., Shulenberger, E., Bradley, G., Ryan, C., and Zumbrunnen, C., 2003. Integrating humans into ecology: Opportunities and challenges for studying urban ecosystems. *Bioscience,* 53(12), pp. 1169–1179. https://doi.org/10.1641/0006-3568(2003)053[1169:IHIEOA]2.0.CO;2.

Al-fatlawi, M.A., and Jasim., S.N., 2019. Study of spatial distribution of vegetation index of Alzawra amusement park in Baghdad area using geotechniques. *Iraqi Journal of Agricultural Sciences (IJAS)*, 50, pp. 173–181. https://doi.org/10.36103/ijas.v50iSpecial.188.

Alghamdi M.A. 2016. Characteristics and risk assessment of heavy metals in airborne PM10 from a residential area of northern Jeddah City, Saudi Arabia. *Polish Journal of Environmental Studies*. 25, pp. 939-949. https://doi.org/10.15244/pjoes/61531.

Ali, A.K.M., and Al Ramahi, F.K.M., 2020. The study air temperature annual rates effect for urban of Baghdad city by using remote sensing data techniques. *Engineering and Technology Journal*. 38, pp. 66–73. https://doi.org/10.30684/etj.v38i2B.532.

Ali, F.A., Salman, A.D., 2024. Spatial assessment and comparison of land use in Karrada city, Iraq, using geographic information systems. *Journal of Engineering*, 30(10), pp. 134-149. https://doi.org/10.31026/j.eng.2024.10.08.

Ali, Z.R., and Muhaimeed, A.S., 2016. The study of temporal changes on land cover/land use prevailing in Baghdad governorate using RS and GIS. *Iraqi Journal Agric. Sci*. 47: pp. 846–855. https://doi.org/10.36103/ijas.v47i3.576.

Al-joboory, B., Al-Bakry, M., and Al Hamadany, O., 2006. The selection of optimum road path using geographic information systems (GIS*). Journal of Engineering*. 12(02), pp. 295–303. https://doi.org/10.31026/j.eng.2006.02.09.

Al-Kasser, M.K., 2021, June. Air pollution in Iraq sources and effects. In *IOP Conference Series: Earth and Environmental Science,* 790(1), P. 012014. IOP Publishing. http://doi.org/10.1088/1755-1315/790/1/012014.

Alsaqqar, S., Hashim, A., and Mahdi Ali, A., 2015. Water quality index assessment using GIS case study: Tigris River in Baghdad City*. International Journal of Current Engineering and Technology 5(4)*, pp. 2515-2520.

Alwaeli, J.M., Ali, S.K., and Mohammed, A.H., 2021. Using geographic information systems (GIS) program and water quality index (WQI) to assess and manage groundwater quality in the city of Baghdad, *Journal of Engineering*, 27(3), pp. 93–112. http://doi.org/10.31026/j.eng.2021.03.07.

Al-Yaqoubi, S., 2010. Classification of land use and land cover in AL-Rashidiya district using remote sensing and geographic information systems. *Journal of the Faculty of Arts*, (94). https://doi.org/10.31026/j.eng.2024.10.08.

Arshad, A., and Shahab, F., 2012. Land transformation analysis using remote sensing and GIS techniques (A case study). *Journal of Geographic Information System*, 4(3). pp. 229-236. https://doi.org/10.4236/jgis.2012.43027.

Arzoqi, E.A., Ali, R.S., 2022. Environmental pollution problems in Iraq a study in natural, human and industrial resources. *Journal of Juridical and Political Science*, 11(1), pp. 397-422. https://doi.org/10.55716/jjps.2022.11.1.15.

Asgarian, A., Amiri, B.J., and Sakieh, Y., 2015. Assessing the effect of green cover spatial patterns on urban land surface temperature using landscape metrics approach. *Urban Ecosyst*. 18, pp. 209–222. https://doi.org/10.1007/s11252-014-0387-7.

Babu, B.S., 2016. Comparative study on the spatial interpolation techniques in GIS. *International Journal of Scientific & Engineering Research*,7(2), pp. 550-554.

Chaichan, M.T., Kazem, H.A., and Abed, T.A., 2018. Traffic and outdoor air pollution levels near highways in Baghdad, Iraq. *Environ Dev Sustain* 20, pp. 589–603. https://doi.org/10.1007/s10668-016-9900-x

Chang, K., 2019. *Introduction to geographic information systems, 9th ed.* New York: McGraw-Hill. https://doi.org/10.1002/9781118786352.wbieg0152.

Danboos, A., Jaafar, O., and El-Shafie, A., 2017. Water scarcity analysis, assessment, and alleviation: New approach for arid environment. *International Journal of Applied Engineering Research*, 12(18), pp. 7536-7545.

Daniel G.C., 2007. Remote sensing for GIS managers. *Cartographic Perspectives (CP)*. (56), pp. 54-56. https://doi.org/10.14714/CP56.308.

Dawood, A., Kalaf, Y., Abdulateef, N., and Falih, M., 2018. Investigation of the surface area of lakes and marshes from satellite images by using remote sensing and geographic information system integration in Iraq. *MATEC Web of Conferences*, 162, 03016. https://doi.org/10.1051/matecconf/201816203016.

Douabul A., Al Maarofi S., Al-Saad H., and Al-Hassen S., 2013. Gaseous pollutants in Basra City, *Iraq Air, Soil and Water Research,* 6(1), pp. 15-21. https://doi.org/10.1177/ASWR.S10835.

Fawzi, M.N., and Mahdi, A.B., 2014. Iraq's inland water quality and their impact on the NorthWestern Arabian Gulf. *Marsh Bulletin*, 9 (1), pp. 1–22.

Guillaune, M., 2016. Napalm in US bumping doctrine and practice 1942,1975, *The Asia-Pacific Journal*, 12(23). p1.

Hameed, M., Ahmadalipour, A., and Moradkhani, H., 2018. Apprehensive drought characteristics over Iraq: Results of a multidecadal spatiotemporal assessment. *Geosciences*, 8(2), P. 58. https://doi.org/10.3390/geosciences8020058.

Jha, M.K., Chowdhury, A., Chowdary, V.M., and Peiffer, S., 2007. Groundwater management and development by integrated remote sensing and geographic information systems: prospects and constraints. *Water Resources Management*, 21(2), pp. 427-467. https://doi.org/10.1007/s11269-006-9024-4.

Kadhim, M.M. 2018. Monitoring land cover change using remote sensing and GIS techniques: A case study of Al-Dalmaj Marsh, Iraq. *Journal of Engineering*. 9(24), pp. 96-108. https://doi.org/10.31026/j.eng.2018.09.07.

Khalaf, A.B., and A.I.J., Al-Jibouri., 2020. Detection of land cover changes of the Baquba city for the period 2014-2019 using spectral indices. *Iraqi Journal of Agricultural Sciences (IJAS).* 51: pp. 805–815. https://doi.org/10.36103/ijas.v51i3.1036.

Mahal, S., Al-Lami, A.M., and Mashee, F.K., 2022. Assessment of the impact of urbanization growth on the climate of Baghdad Province using remote sensing techniques. *Iraqi Journal of Agricultural Sciences*, 53(5), pp. 1021-1034. https://doi.org/10.36103/ijas.v53i5.1616.

Vigneshwaran, S., and Vasantha Kumar, S., 2018. Extraction of built-up area using high-resolution Sentinel-2A and Google satellite imagery. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, International Conference on Geomatics and Geospatial Technology*. 42, pp. 165–169. https://doi.org/10.5194/isprs-archives-XLII-4-W9-165-2018.

Weng, Q., 2010. *Remote sensing and GIS integration: Theories, methods, and applications*. New York: McGraw-Hill.

Xu, H., 2007. Extraction of urban built-up land features from Landsat imagery using a thematic-oriented index combination technique. *Photogramm. Engineering Remote Sens*. 73: pp. 1381–1391. https://doi.org/10.14358/PERS.73.12.1381

Zhao, S., Da, L., Tang, Z., Fang, H., Song, K., and Fang, J., 2006. Ecological consequences of rapid urban expansion: Shanghai, China. *Frontiers in Ecology and the Environment* 4(7). pp. 341–346. http://www.jstor.org/stable/3868879.

استخدام نظم المعلومات الجغرافية في تحليل وتقييم المخاطر البيئية: دراسة حالة مدينة بغداد

حقي إسماعيل كاظم

المعهد التقني، الجامعة التقنية الوسطى، بعقوبة، العراق

الخلاصة

تُعدّ جودة البيئة لحياة صحية محور الاهتمام الرئيسي في الدراسات العلمية حول حياة الإنسان وصحته. وقد عرّض النمو الاقتصادي السريع والتوسع الحضري مدنًا رئيسية مثل بغداد لخطر المشاكل البيئية، بما في ذلك التصحر وتلوث الهواء والماء وارتفاع انبعاثات غازات الاحتباس الحراري. ويمكن دراسة هذه المخاطر وتقييمها باستخدام نظم المعلومات الجغرافية (GIS)، التي توفر فهمًا شاملاً للقضايا البيئية والعلاجات القائمة على الأدلة. مع التركيز على تلوث المياه وتلوث الهواء، ستدرس هذه الدراسة المخاطر البيئية في بغداد وتقيّمها. وقد حددت الدراسة المناطق التي تتركز فيها مستويات عالية من PM10 وNO_2 وSO_2، من خلال تحليل خرائط نظم المعلومات الجغرافية. وتقع هذه المناطق في مناطق مكتظة بالسكان وذات حركة مرور كثيفة، وتتأثر بشدة بالتلوث في محيط الطرق الرئيسية والمناطق الصناعية. كما تتسبب ظروف الرياح وتغير المناخ في تقلبات موسمية في مستويات التلوث. على الرغم من امتلاك نهري دجلة والفرات مستويات مناسبة من الرقم الهيدروجيني والنترات، إلا أنهما يحتويان على كميات أعلى بكثير من المواد الصلبة الذائبة والفوسفات، والتي قد تكون ناتجة عن التلوث الصناعي والزراعي. نتائج تحول الغطاء الأرضي تُظهر ارتفاع نسبة المساحات المبنية من 25% في 2016 إلى 45% في 2024، مع تناقص في المساحات الخضراء من 40% إلى 30%. المتوسط السنوي لدرجة الحرارة ارتفع من 21.5 °C إلى 23.2 °C، بينما انخفض هطول الأمطار من 135 مم إلى 115 مم. تركيزات PM10 زادت من 85 $\mu g/m^3$ في 2018 إلى 110 $\mu g/m^3$ في 2023، ما يوضح تفاقم التلوث الجوي. خريطة النقاط الساخنة تُظهر تركيزات أعلى بالقرب من المناطق الصناعية والطريق السريع (Karkh–Doura corridor).

الكلمات المفتاحية: نظم المعلومات الجغرافية، مدينة بغداد، المخاطر البيئية، تلوث الهواء، تلوث المياه.