

Measurements of Air Pollutants at Al-Basra Province and Assessment of Potential Health Impact

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Abstract

This study involves evaluation of ambient air quality at Al-Basra province (south of Iraq). Sixteen different areas were chosen for monitoring of airborne contaminants during the period from December 2022 to January 2023. Air pollutants were monitored by a handheld gas analyzer for NO_x, SO_x, CO₂, HC and CO, while portable dust sampler device was used to measure total suspended particles (TSP). The results of the sampling and analysis of the air pollutants show that the total suspended particulates (TSP) values ranged from 172-322 µg/m³, CO ranged from 3.12-11.32 ppm, CO₂ ranged from 232-411 ppm, SO_x ranged from 0.79-4.05 ppm, NO_x ranged from 0.76-2.61 ppm and HC ranged from 0.01-0.97 ppm. The results of human health risk assessment using Hazard Quotient (HQ) approach show high risk due to relatively elevated concentrations of airborne pollutants.

Keywords: Air pollution, Al-Basra province, ambient air quality, total suspended particles, Hazard Quotient, health risk assessment

1. Introduction

Human-made and natural sources are major sources of air pollution. Major artificial sources include vehicles, industrial activities and power generation plants. Mostly petroleum industrial human activities using significant quantities of consumable fuel such as petroleum refineries, and power plants which discharged high emission of solid, fume toxic gases and dust as compared with other industries. Petroleum industries are considered hazardous due to their existence near the dwellings or existence inside urban area, such as Al-Basra oil refinery. The oil refinery considered as an important source for air pollutants where volumes of the released pollutants from these industries were estimated to be in millions of tons per year [1].

Over the recent years, there has been huge increase in vehicular traffic, human population, industries and road transportation which has caused in increase in the concentrations of particulate pollutants and gaseous that discharged to the human environment [1]. Atmospheric contamination can be

defined as that the occurrence of pollutant substances or contaminants in the atmosphere that interfere with welfare or human health or produce other hazardous environmental impacts. In addition, atmospheric contamination is defined as follows: the presence of energy or substances in the atmosphere in such concentrations of such exposure time as liable to cause effects to plant, human health, animal life, impact to man-made structures and materials; climate changes and weather, and interference with comfortable enjoyment of property or life, or other activities [2, 3].

The aims of the current study are to evaluate the levels of air contaminants discharged from mobile and fixed sources at Al-Basra Province (southern Iraq) and estimation of the potential health risk to local residents.

2. Materials and methods

2.1 Description of Study area

Al-Basra city is one of the industrial cities in Iraq [4]. As shown in Fig. 1, it is geographically located nearby the Arab Gulf, at a latitude of 30° N and a longitude of 47° E. The studied area is nearby to the petroleum industrial complexes.

At the studied area (Al-Basra province), situated at south of Iraq, air contamination is of major impact, which is at present the object of comprehensive scientific studies. The studied area rich in oil industries and many human and industrial activities as the major sources of pollutants releases [5] (Fig. 2).

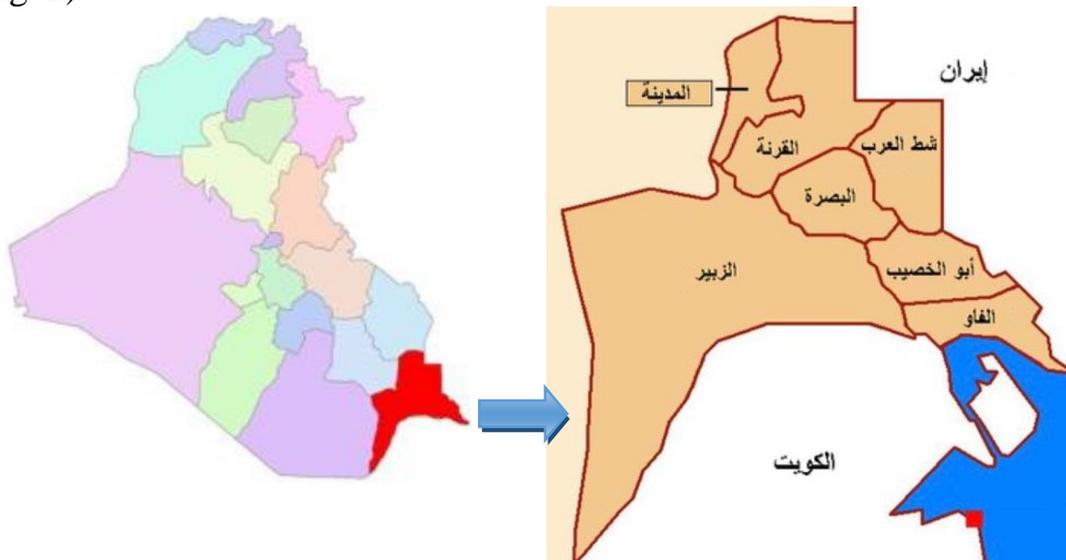




Fig. 1. Location of the studied area



Fig 2. Photography of gaseous and particulates release sources in the studied area

2.2 Sampling and Analysis

Atmospheric pollutants sampling (total suspended particulates (TSP), CO, CO₂, SO_x, NO_x and hydrocarbons (HC)) was carried out using a commercially available respirable dust sampler and portable air pollution monitors from December 2022 to January 2023 (in winter season) at 1 hour. The number of collected TSP samples was 16 during the study period. The selected sampling and in-situ measurements points were divide in order to include the western and eastern regions within the studied area and the geographical distributions of air sampling points were taken into account at the vicinity of human dwellings and were involved variety of local environments (residential, commercial in addition to industrial areas). All measurements were taken in the center of Al-Basra province, and the centers of districts and sub-districts, which have a crowded population nature. The air sampling points were strategically distributed across residential, commercial, and industrial locations.

2.3 Health Risk Assessment

The 1st step for evaluating the risk of air pollutants is the use of the following equations for the estimation of exposure concentrations (EC_{inh}) [6]:

$$EC_{inh} = \frac{C \times ET \times EF \times ED}{AT} \quad \dots (1)$$

where:

C is the mean concentrations of TSP in samples (in mg/m³),

ET is the exposure time in hours per day (24 h),

EF is the exposure frequency (365 days per year),

ED is the exposure duration (assumed to be 70 years)

AT is the mean time (70 years × 365 days × 24 h/day).

The non-carcinogenic risk estimation (toxicity, mutagenicity) caused by TSP CO, CO₂, SO_x, and NO_x via air inhalation were estimated using the Hazard Quotient (HQ), which is estimated as the ratio of exposure level for single pollutant to reference dose of that pollutant [6]:

$$HQ_{inh} = \frac{EC_{inh}}{R_f C} \quad \dots (2)$$

where R_fC is the reference concentrations for inhalation (in mg/m³).

To calculate the non - carcinogenic human health risks caused by multi - element human exposure , Hazard Index (HI) is calculated as the summation of HQs assuming accumulative effects. The HI was estimated as the summation of hazard quotients for pollutants that impact the same human target organ system. Accumulated exposures less than an HI of 1.0 estimated through using

target human organ hazard quotient will possibly not result in non - cancer human health impacts over exposure lifetime [6].

$$HI = \sum_{i=1}^i HQ_{inh} \quad \dots (3)$$

3. Results and Discussion

The variability of TSP and other investigated gaseous concentrations inside urban, rural, industrial and commercial areas during sampling period has been presented in table 1. The following comments can be drawn from data listed in table 1:

- Most of the measurements were within permissible limits listed in table 1, except for CO and TSP in some investigated areas.
- The highest average TSP concentrations were observed at Al-Zubaer, while the highest gaseous concentrations were observed at center of Al-Basra city, in addition to Al-Zubaer.
- The lowest average TSP concentrations were observed at Um Qasr, while the lowest gaseous concentrations were observed at Al-Seeba, in addition to Um Qasr.
- Generally, areas located near to petroleum industries (Al-Zubaer and Al-Madaina) and in the direction of prevailing wind (south and southeast) reported relatively highest airborne contamination levels, while areas located far away to petroleum industries (such as Um Qasr, Al-Faw and Al-Seeba) reported relatively lowest airborne contamination levels.
- In general, sampling areas located south and east of Al-Basrah province (Al-Faw, Um Qasr, Shat Al-Arab and Al-Seeba) show relatively lowest air contamination levels due to their locations far away from contamination sources and in the opposite direction to prevailing wind in the region of concern.
- The concentrations of the studied air pollutants arrange as follows ($CO_2 > TSP > CO > SO_x > NO_x > HC$).

In addition to petroleum industries, vehicles and other transportation means constitute a major source of airborne contamination at Al-Basrah province. This means that a large proportion of the pollution comes from transportation means, in addition to oil fields and refineries.

Figures 3 and 4 present the estimated non-carcinogenic human health risks at the Al-Basra province due to exposure to dust, CO, CO₂, SO_x, and NO_x via air inhalation. The highest HQ value was reported for TSP at Al-Zubaer, while lowest HQ value was reported for SO_x at Um Qasr. Fig. 4 shows that the

accumulative health risk for investigated air pollutants is greater than the safe limit (>1).

The results of the HQ calculations in Figure 3 supported that the highest of the reported values of TSP was in Zubair, which implied that the latter region is the most potential health risk to the resident community. The results indicate that the health risk level in Zubair could exceed the safe level (1.0), which identified that areas of high pollution by TSP could lead to long-term non-cancer effects on health, including respiratory diseases. In contrast, Umm Qasr zone had a low SO_x level. Simultaneously, the HI results (Figure 4) indicated that the total risk by the pollutants being studied in most sites exceeded the safe levels, indicating a cumulative lifetime health risk as a result of long-term exposure to the pollutants.

Table 1. Results of measurements of airborne concentrations.

No.	Location	Coordinates (N, E)	TSP ($\mu\text{g}/\text{m}^3$)	Gaseous concentrations (ppm)				
				CO	CO ₂	SO _x	NO _x	HC
1	Center of Al-Basra city	30.5384715 47.3075132	212	11.32	411	3.63	2.25	0.36
2	Shat Al-Arab	30.5247680 47.846492	191	5.65	310	1.15	0.97	0.07
3	Karmat Ali	30.5861426 47.7582872	261	7.76	378	2.72	1.62	0.33
4	Al-Deer	30.7936826 47.5762351	208	6.92	342	1.93	1.37	0.11
5	Al-Qurna	31.0077296 47.4409393	252	9.45	381	2.74	2.05	0.52
6	Al-Madaina	30.9547828 47.2669662	246	8.21	405	3.04	2.11	0.72
7	Al-Huwaer	30.9743619 47.3152111	227	7.55	305	1.71	1.42	0.42
8	Talha	30.9619680 47.3334957	292	7.89	292	2.67	1.96	0.84

9	Al-Zubaer	30.3756742 47.7001009	322	7.21	324	4.05	2.61	0.97
10	Bab Al-Zubaer	30.4894917 47.8033155	287	8.96	385	2.87	2.57	0.87
11	Safwan	30.1137855 47.719565	305	5.72	333	1.6	1.41	None
12	Abi Al-Khaseeb	30.4424500 47.8792357	187	4.32	295	1.31	1.12	0.08
13	Al-Seeba	30.3233574 48.2540937	174	3.12	232	1.25	0.81	0.01
14	Al-Faw	29.9784193 48.4755455	212	4.1	238	0.97	0.76	None
15	Al-Hartha	30.6965681 47.7340127	219	6.72	407	2.77	1.78	0.72
16	Um Qasr	30.0405783 47.9271168	172	3.62	252	0.79	0.82	None
Mean \pm σ			235 \pm 4 7	6.78 \pm 2	330 \pm 60	2.2 \pm 0.9	1.6 \pm 0.6	0.46 \pm 0.3
Range			172- 322	3.12- 11.32	232- 411	0.79- 4.05	0.76- 2.61	0.01- 0.97
Permissible limits [7, 8]			45	4	5000	40	25	-

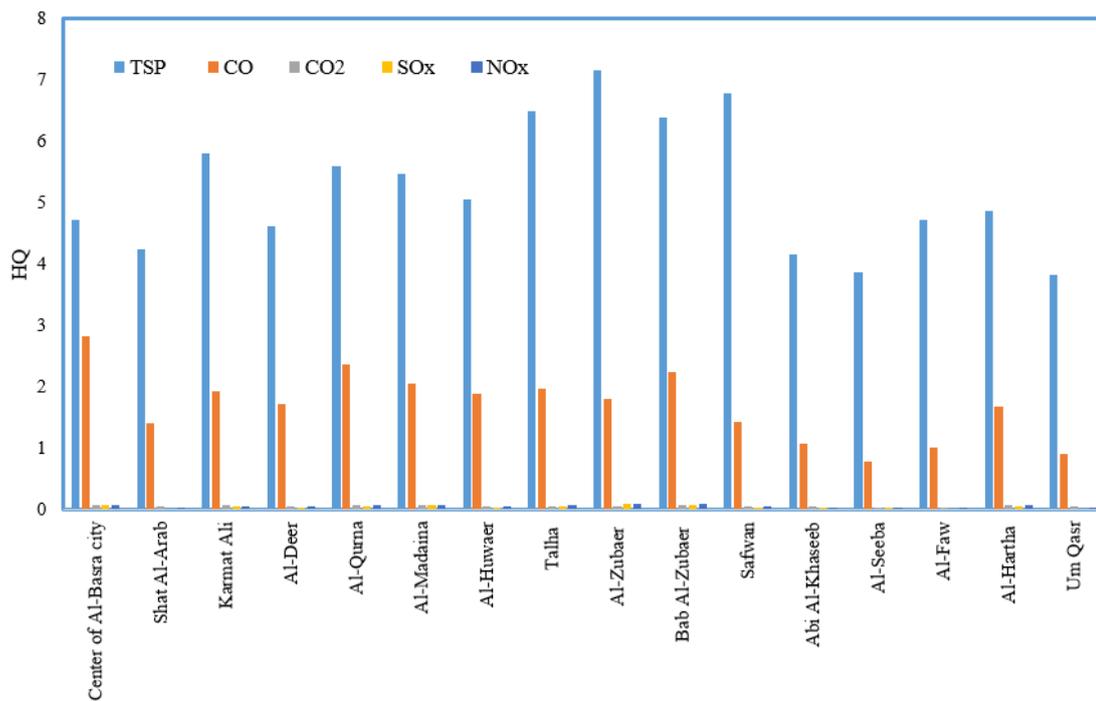


Fig 3. Results of HQ calculations in the studied areas

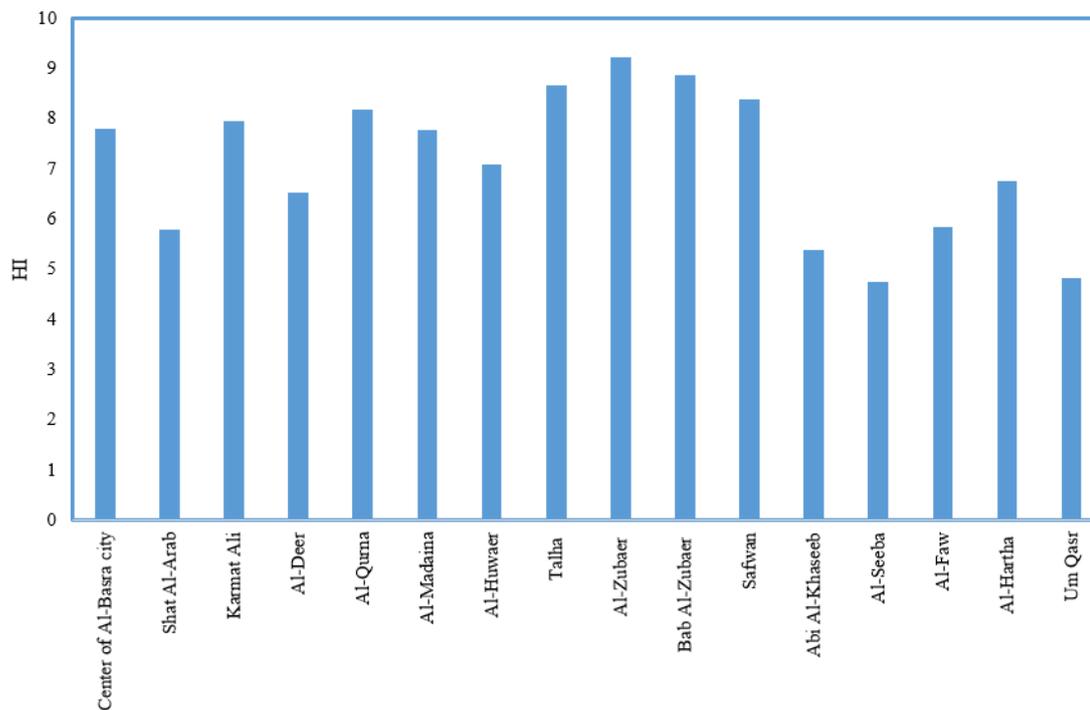


Fig 4. Results of HI calculations in the studied areas

4. Conclusions

The present study has provided an assessment of airborne contaminants concentrations at Al-Basra province. The concentrations showed a well-defined variation between investigated areas. With respect to analysis of the geographical distribution of atmospheric contaminants, the current study conclude that the concentrations of air contaminants at Al-Basra governorate (the studied area) were significantly varied and that this significant variation was found to be correlated with geographical distributions of discharge sources existing within studied area. It was obvious from the results of non-carcinogenic risks estimation (toxicity, mutagenicity) caused by TSP, CO, CO₂, SO_x, and NO_x via air inhalation that the Hazard Quotient (HQ) values were high, indicating that continuous monitoring of airborne contamination levels at Al-Basra province is strongly recommended.

The results of the measurement showed that levels of various compounds in Basra Governorate's air varied significantly between residential, commercial, and industrial areas. Areas adjacent to oil installations (e.g., Zubair) contained the greatest amounts of suspended particulate material (TSP) and harmful gases (CO, CO₂, SO_x and NO_x), and areas farther away from the facilities (e.g., Umm Qasr) contained the lowest rates of air pollution. Major sources of contamination in the region are oil plants, which are one of the major sources, followed by transport and cars, adding significantly to the air pollution levels. South and southeast to directions are dominant winds blowing to directions close to oil plants, so air contamination is more dominating around these areas.

Hazard Quotient (HQ) calculation reported that the risk to human health from TSPs and gas exposure was very high at areas such as Zubair, reporting values greater than safe thresholds (1.0), with indication of long-term health risk posed to inhabitants. The Cumulative Hazard Index (HI) calculation also demonstrated the risk of harm to health caused by exposure to contaminant chemicals is beyond the safe level for most of these areas and has to be brought under control due to air pollution in the area.

According to the study, long-term air pollution in Basra is likely to have non-cancer health impacts on the population, especially in highly contaminated areas such as Zubair. These include respiratory diseases and other diseases because of prolonged exposure to pollutants.

5. Recommendations

- It is essential to take measures to reduce pollutant emissions because of oil plants and transport in Basra.
- There should be enhanced environmental monitoring activities in the area, focusing on regular health risk assessments and greater public awareness about environmental pollution risks.
- These findings indicate the need for immediate improvement of air quality in Basra City by adopting effective environmental policies that contribute to protecting the health of the population and the environment.

Acknowledgements

The authors would like to express thanks to the Mustansiriyah University (www.uomustansiriyah.edu.iq) Baghdad – Iraq for its support in the current study.

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مستخلص البحث:

تتضمن هذه الدراسة تقييم جودة الهواء المحيط في محافظة البصرة (جنوب العراق). تم اختيار ستة عشر منطقة مختلفة لرصد الملوثات المحمولة جواً خلال الفترة من ديسمبر 2022 إلى يناير 2023. رُصدت ملوثات الهواء بواسطة جهاز تحليل غازات محمول باليد لأكاسيد النيتروجين وأكاسيد الكبريت وثاني أكسيد الكربون والهيدروكربون وأول أكسيد الكربون، بينما استُخدم جهاز أخذ عينات الغبار المحمول لقياس إجمالي الجسيمات العالقة وأظهرت نتائج أخذ العينات وتحليل ملوثات الهواء أن قيم إجمالي تراوحت بين 172 و322 ميكروغرام/م³، وتراوحت قيم أول أكسيد الكربون بين 3.12 و11.32 جزء في المليون، وتراوحت قيم ثاني أكسيد الكربون بين 232 و411 جزء في المليون، وتراوحت قيم أكاسيد الكبريت بين 0.79 و4.05 جزء في المليون، وتراوحت قيم أكاسيد النيتروجين بين 0.76 و2.61 جزء في المليون، وتراوحت قيم الهيدروكربون بين 0.01 و0.97 جزء في نتيجة لتركيزات مرتفعة نسبياً من الملوثات المحمولة جواً. أظهرت نتائج تقييم مخاطر الصحة البشرية باستخدام معامل الخطر ارتفاعاً في المخاطر.

الكلمات المفتاحية: تلوث الهواء، محافظة البصرة، جودة الهواء المحيط، إجمالي الجسيمات العالقة، معدل الخطر، تقييم المخاطر الصحية