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Environmental impact evaluation of brick factories on the west of Al-Diwaneyha City, Iraq

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ABSTRACT

The objective of this study is to evaluate the environmental impact of a brick factory complex in the west part of Al-Diwaneyah City. In the study, the site characteristics of the brick factories and compares them with the locational determinants in the Iraqi environmental laws were assessed. The Arc.GIS software has been used to process the spatial data and displays. The spatial analysis shows that the current site of brick factories does not conform to the current laws and regulations of Iraq. So, it eventually will create environmental problems for the city's expansion or factory development. Furthermore, air quality in the west of the city has been measured in some monitoring sites along the direction of the wind, close to the brick factories. The gas concentration measurement has continued for 12 days and 24 hours per day in the monitoring sites.SO_2, NO_2, CO, and NMHC were measured which showed that the maximum values of SO_2, NO_2, and NMHC were higher than the Iraqi standard while the CO value was very low.

1. Introduction

The environment consists of two series of factors, the biotic (microorganisms and living organisms) and abiotic factors (atmosphere, hydrosphere, and lithosphere). Pollution is the presence of energy or substances in a form that is harmful to humans and other living organisms. So, the pollutants can be any dangerous solids, liquids, or gases substances that have higher quantities than usual that inversely affected the environment. Manisalidis et al. [1]. Contaminated sites can be defined as "areas that include human activities which have discharged or might discharge contaminants into soil, air, surface or groundwater, food-chain, causing or being able to cause impacts in human health" Drago et al. [2]. Clay brick manufacturing is one of the ancient traditional industries which widespread in most regions of Iraq and is the most polluting source to the surrounding environment where the used fuel in brick kilns operating is the residual fuel oil that remains after the distillate fuel oil and lighter hydrocarbons are distilled away in refinery operations. Iraqi environmental determinants instructions of the establishment of the project and monitoring the safety of their implementation No. (3) for the year 2011specified that the brick factories must be far (5 kilometers) from both the cities' municipal borders and residential communities which are more than (20 houses) and also must be far (1 kilometer) from roads.[3]

Brick manufacturing has a negative impact on the natural and human atmosphere as a result of the pollution which has been caused by gasses,

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smoke, and mist Al-Khateeb et al. [4]. The most pollutants that have been discharged from the brick kilns are particulate matter, (VOCs), SOX, dioxins, (PAHs), and NOX [1] and are the essential sources of air pollutants and harmful to humans Misra et al. [5]. Where the contaminated industrial sites are responsible for outdoor air pollution which contributes to the deaths of more than four million premature worldwide Perrino C et al. [6]. studied the relationship of the exposure impact to chemical and particulate matter from outdoor sources during prenatal, and postnatal which may lead to alterations in specific neural networks Herting M. M. et al. [7]. showed that the air pollution causes oxidative stress, neuroinflammation, neurodegenerative pathology and cerebral vascular damage Block, M. L. et al. [8]. worked Impact assessment of the brick kilns emissions on human health and the environment in Pakistan where the results showed that CO, CO_2 and SO_2 are the most harmful due to the environment. Nonetheless, SO_2, carcinogenic dioxin, and PM have affection on human health adversely Khan, M. W. et al. [9], in Iraq, there are many researchers studied the environmental impact evaluation of brick factories in Baghdad which approved that the sulfur compound emissions that resulted from black oil burning caused soil and air contamination Al-Nuzal S.M.D. et al. [10], in Babylon which conducted heavy metals concentrations in air and soil that result from brick factories emissions Issa. M. J. et al. [11] and in Al-Diwaneyah which studied particulate matters and heavy metals and their effect on the nearby residential communities Al-Khateeb .A. H.N et al. [4] This study focuses on the environmental impact evaluation of brick industries in Al-Diwaneyah city by studying the brick factories' site characteristics and measuring the ambient air quality in the west of the city.

The objectives of this work are:

1. Determining the spatial map of the brick factories site, neighboring cities, neighboring residential communities, and roads by using Arch GIS Program.
2. Comparison between the brick factories' site characteristics and the locational determinants in the Iraqi environmental legislations.
3. Study the ambient air quality in the west city by measuring the pollutants concentrations in the ambient air that result from brick kiln discharges.

2. Environmental legislations

2.1. Instructions No. (3) for 2011.[3]

One of the most relevant laws and constructions which deals with the site characteristics of factories is Iraqi Environmental Determinants instructions of the establishment of the project and monitoring the safety of their implementation No. 3 for the year 2011 which consists of 81 legal articles where the article No. 10 that has been stated the locations of brick factories establishment must be distant from:

1. the city's municipalities borders and the residential communities (more than 20 houses) with a distance of more than five kilometers.
2. the roads with a distance of more than one kilometer.

2.2. Regulation No. (4) for 2012.[12]

Regulation of ambient air protection from pollution No. (4) for 2012. Which consists of 22 legal articles where the article No. 8 which has been required that the chimney design and its height determining must be taking into account the chemical and physical properties of emissions, the discharge size and its temperature, the velocity and direction of winds, heights of the surrounding buildings and location topography. On the other hand, article No.18 has stated that used fuel must be natural gas or liquid petroleum gas in addition to natural gas as clean fuel due to the environment and also the sulfur content must be less than 2.5 % weight in the heavy black oil and maintained in work to use in any type of fuel that will protect the environment.

2.3. Instructions No. (3) for 2012.[13]

National Determinants Instructions of Emissions of Activities and Operations No. 3 for 2012 which consist of 18 legal articles for regulation, determination, and control of the emissions of air pollutants and deals with mobile and fixed sources. Where it stated that the gas concentrations of fixed sources which have been used hydro carbonic fuel must be as shown in **Table 1** below.

Table 1. Standards of fixed-sourced emissions

Air Pollutants	Symbols	Source		Limits (mg/m3)
Smokes and Visible Pollutants		All sources		250
Nitrogen oxides (measured as NO2)	NOX	Kilns	Gas Fuel	350
			Liquid Fuel	500
Sulfur Dioxide	SO_2	All Sources		500
Total Suspended Particles	TSP	All Sources		250
Carbon Monoxide	CO	All Sources	Old	500
			New	250

3. Productivity process

There are two production processes of clay brick manufacturing, the manual which is not used nowadays, and the mechanical process. The difference between these methods is in the preparation processes of the bricks which includes the mixing, grinding, and forming processes. The first process of bricks manufacturing is excavating soil to prepare the raw material and then transferring it into mixing, grinding, pressuring, and forming machines then the wet clay bricks will be produced which required spreading them in an open area for drying by sun temperature therefore the mentioned processes are stopped or deaccelerated in the winter. After the complete drying stage, the firing process is the final stage in which the dried bricks are transferred into the firing kiln where its size is (100 lengths * 20 widths * 3 depth) average. Each factory produces an average (of 64000 bricks per day) and the heavy black oil quantities which have been consumed about (120 –135 liters per 1000 bricks) [Environmental Authority, 14]. Table 2 explains the manufacturing process details with potential environmental damages from each stage.

Table 2. The productivity process stages of brick manufacturing with associated environmental damages (Researcher)

Manufacturing Stages of Bricks	Environmental Damages

Excavation of Earth	Soil Depletion and Ground Water Exposure to Evaporation
Mixing & Grinding of Soil	Electricity Consumption
Pressing into Desired Form	
Drying by Sun	-------
Firing in Kiln	Discharge Air pollutants
Bricks	Solid Wastes

4. Site Characteristic

Al-Diwaneyah city is the center of AL-Qadisiyah province where it is located about (180 km south of Baghdad), the location of brick factories is 5 kilometers west of the official borders of Al-Diwaneyah municipality and is surrounded by two other towns, AL-Shafiyaa and Saniyah, from south and north respectively. After 2003 and due to the change in the political system in Iraq, which leads to the economic improvement of Iraqi individuals, the need for construction has increased year by year, and as a result, the number of brick factories enlarged to cover this need, where the number of factories became more than (15 factories) in this site and the total areas reached into (5.5 km2,) also the habituated areas have been unofficially expanded in the direction of factories location and the actual distance between the cities and brick sites become 3 kilometers.

Furthermore, if the expansion status continues there many environmental crises faced in the future, difficulty the living in the new residential regions because of the ambient air quality which will be affected by air pollutants produced by nearby brick factories, also the difficulty of factories development because of the proximity of residential communities. More urbanization expansions were unplanned and uncontrolled because of the authority's weakness. Image 1 the spatial spreading of villages and towns due to brick factory sites and the wind direction.

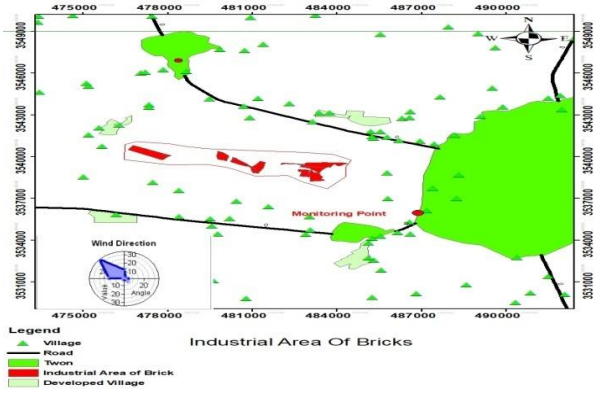

Figure 1. Site plan of the brick industrial region with surrounding towns and villages

5. Results and discussions

The Mobile plant for Air Quality Monitoring is manufactured by HORIBA Company which contains modern analyzers for sampling and measuring air quality instantaneously. It measures 12 types of gases in addition to the condition parameters such as wind direction, temperature, air pressure, wind speed, and humidity. this study has been focused on four gases (SO2, NO2, CO, and non-methane hydrocarbons NMHC) and for 12 days each day continues for 24 hours. The below Table shows the maximum and minimum values of gases.

Table 3. The values of gases emissions in the study region [Environment Authority, 14]

Days	SO_2 (mg/l)		NO_2(mg/l)		CO (mg/l)		NMHC (mg/l)	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	0.011	0.002	0.018	0.006	2	0.9	0.4	0
2	0.012	0.001	0.026	0.004	2	1.9	0.7	0
3	0.004	0.001	0.017	0.002	2	1.9	0.3	0.1
4	0.007	0.001	0.017	0.004	2	2	0.3	0
5	0.009	0.001	0.024	0.002	3	2	0.9	0.1
6	0.014	0.002	0.037	0.003	2	1.8	0.9	0.1
7	0.02	0.003	0.049	0.006	2	1.9	1.1	0.1
8	0.043	0.006	0.054	0.009	2	1.9	0.7	0.1
9	0.018	0.005	0.019	0.005	2	1.9	0.5	0.2
10	0.025	0.002	0.024	0.006	2	1.9	0.2	0.1
11	0.006	0.002	0.016	0.004	2	1.9	1.1	0.1
12	0.012	0.005	0.031	0.002	2	1.9	0.3	0.1
AVG.	0.015	0.003	0.028	0.004	2.083	1.825	0.617	0.083

Fig. 2 shows the Iraq standard of ambient air, the maximum and minimum values of NO_2 and which were measured by APNA 370-CE and ASPA 370-CE Analyzers respectively where the maximum value of NO2 on most days is high than the standard while the value of SO2 is low. Fig. 3 shows the maximum and minimum values of CO which were measured by the APMA 370-CE analyzer where the results seemed very stable and similar and at the same time lower than the Iraqi standard where this is a positive indicator due to air quality.

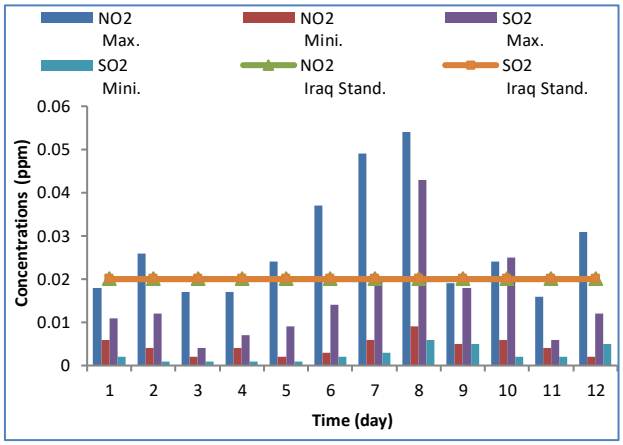

Figure 2. Concentrations of NO2 and SO2 in study region

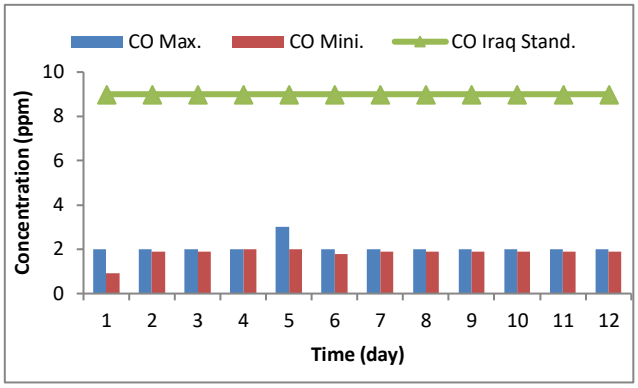

Figure 3. Concentrations of CO in the study region

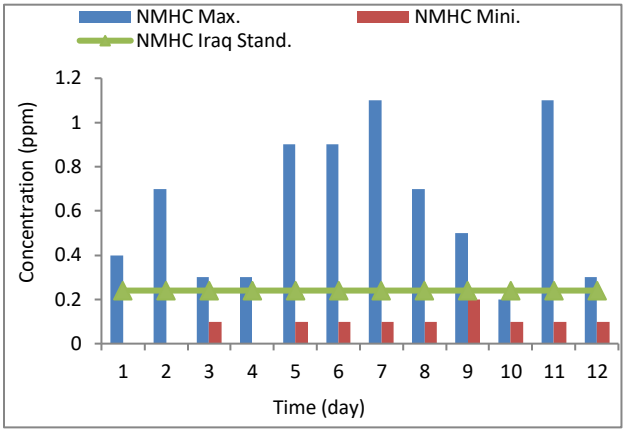

Figure 4. Concentrations of NMHC in the study region

The measure of non-methane hydrocarbons in air quality by APHA 370-CEanalyzer is a very significant indicator due to the pollutant sources and have been used petroleum derivatives such as heavy black oil as fuel for kiln operation. **Fig. 4** displays the results of NMHC which have been showing the gap between the maximum and minimum values and also the maximum values very high than the Iraqi standard.

Generally, there is air pollution in the city's west that is produced by the brick factories which are located in the west and with prevailing wind direction therefore it is more harmful due to the environment and human health.

6. Conclusions

- The location of brick factories in the present is not suitable because it is surrounded by three directions and in the future will create environmental troubles due to the town's expansion.
- This site of brick factories has caused pollution of ambient air quality in west Al-Diwaneyah city.
- Appropriate and modern air pollution control devices must be installed for the mitigation of emissions.
- It is recommended to Follow special strategies and continue environmental monitoring for this site.

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

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