Plant Archives Volume 20 No. 2, 2020 pp. 7285-7293 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

ASSESSMENT OF ASBESTOS SOIL POLLUTION IN MOSUL CITY, IRAQ

Aws N Al-Tayawi[1*] and Kossay K Al-Ahmady[2]

[1*]College of Environmental Sciences and Technology, University of Mosul. Iraq.
[2] Department of Environmental Engineering, University of Mosul. Iraq.

Abstract

Asbestos is a generic name given to the group of six naturally occurring fibrous minerals which has world widespread use in a variety of commercial products. Asbestos is a professional and environmental risk, studies refer that asbestos cause death to 107000 person per year around the world, and it's probably cause millions of deaths. In this study, the soil of the selected zones in Mosul City has been analyzed to identify the asbestos fibres. Nine samples with three replicas has been selected from study area. Using PLM analysis; the results showed that the adjacent part, to the airport, of the study area had been more contaminated with asbestos fibres than the other parts, with the concentrations between (0.010417-1.9519%) using Point Count, and (0.015208 - 2.565833-%) using Visual Area Estimate. The results of the statistical analysis using one-way ANOVA, for the nine samples with their three replicates for both methods VAE & PC, showed that there are statistically significant differences between the nine samples.

Key words : Asbestos, Soil pollution, Polarized Light Microscope, Point Count, Visual Area Estimate.

Introduction

Asbestos is a generic name given to the group of six naturally occurring fibrous minerals which has world widespread use in a variety of commercial products (Strohmeier *et al.,* 2010). Asbestos is a professional and environmental risk, studies refer that asbestos fibres cause death to 107000 person per year around the world, and it's probably cause millions of deaths (Takahashi *et al.,* 2016, LaDou *et al.,* 2001).

Asbestos minerals had a special kind of fibrous morphology, which called asbestiform. This morphology consists of fibers or bundles of fibers which easily split lengthwise into thinner fibers, this feature has made the asbestos fibers used in a variety of commercial products (Strohmeier *et al.,* 2010, Spasiano and Pirozzi, 2017).

The industrial importance of asbestos is flexible, strong, heat-resistance, as well as their ability to resist chemical and thermal decomposition (Virta, 2005). This characteristic and non-neglected production has led to the widespread of asbestos (Garcia, 2013, Strohmeier *et al.,* 2010).

***Author for correspondence :** E-mail: awsaltayawi@uomosul.edu.iq

Asbestos can be manufactured as: pipes, sheets, car brake, as well as pigmentation and many other products. This development led to a rapid increase in the use of asbestos all over the world (Garcia, 2013).

In the twentieth century, the term 'asbestos' took on a different denotation, when the inhalation airborne asbestos fibers could cause pulmonary diseases, including mesothelioma, lung cancer and asbestosis (Strohmeier *et al.,* 2010, Kameda *et al.,* 2014).

Today the world facing which has known "Asbestos Related Disease", when the asbestos fibers is emitted from manufacturing processes, it can contaminate the air, water, soil and food, and interference to the human body through the respiratory or digestive (Gaffney *et al.,* 2017, Xu *et al.,* 2018).

Materials and Methods

Study area

The report of UNEP about "Environmental issues in areas retaken from ISIL, Mosul, Iraq" refer that there are three sites contaminated with asbestos, Mosul airport, Ghizlani military camp and Western Mosul's central garages (UNEP, 2017). The Tayaran quarter, being a residential quarter adjacent to the Mosul airport with total area about 0.94 km^2, had been selected as a study area. This study aims to assess the asbestos soil pollution in Al-Tayaran Quarter Fig. 1, through analysis the soil of the study area using Polarized Light Microscope.

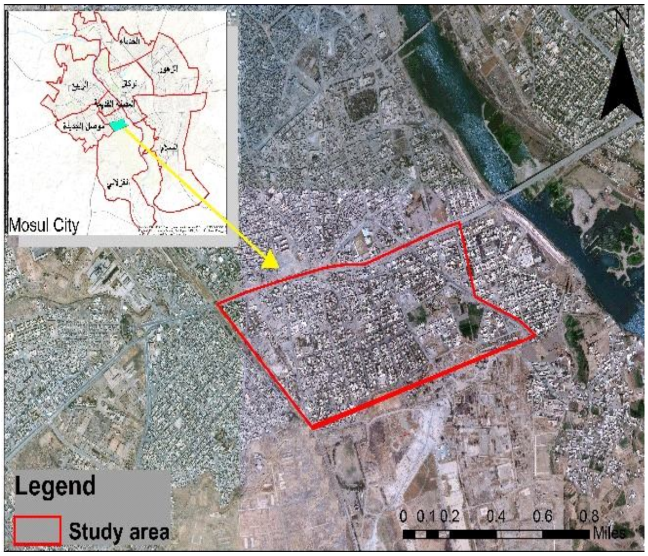

Fig. 1: Location of Study Area.

Sample collection

The separate sampling method (Grab) is commonly used as a typical method for collecting samples of soils contaminated with asbestos. (Wroble *et al.,* 2017). This method is suitable for contaminated soil in which the source of asbestos fibers is externally (such as disposal of building materials containing asbestos or mine waste) as well as naturally occurring asbestos in soil (ASTM, 2013). As in Fig. 2

Fig. 2: Collection of surface samples.

This method aims to collect "free fibers" that have been separated from building material debris or separate fibers from the NOA by collecting soil samples in which free fibers may be present (ASTM, 2013).

Personal Protection Equipment

Since the soil will be collected in a mainly dry condition, and pieces of asbestos-containing debris may be dealt with, the respiratory system should be well protected (ASTM, 2013). gloves, face masks N95 and goggles have been used.

Select the area of sample

A soil sampling area has been identified for a potential asbestos contamination site through the wreckage of nearby buildings. An area is chosen so that there are no large quantities of rubble, the goal is to collect contaminated soil and not debris or visible waste in addition to that the area should be free from contamination with oils, grease or other dangerous or interfering materials (ASTM, 2013). (Wroble *et al.,* 2019)

Sample Preparation

All samples were individually dried in a furnace at 110 ° C until the weight stabilized, after that the sample was converted into a homogeneous shape through milling. The choice of a suitable milling device depends on the personal preference and the nature of the material to be analyzed (Perkins *et al.,* 1993).

As soon as the soil appears homogeneous, The Milling is then stopped. Then the milling device is thoroughly cleaned before preparing a new sample. The grinding devices should be disassembled and thoroughly cleaned after each use to reduce pollution (Perkins *et al.,* 1993).

To eliminate interference (such as organic or soluble substances) that may cause errors in analysis, the sample is burned using furnace at 450° C for a period of 6 hours as a minimum (ASTM, 2013). The sample placed in the crucible should be well covered before burning, to prevent contamination during the burning process. The crucible is then removed from the oven and placed in desiccator (Xu *et al.,* 2018). The sample is weighed before and after the burn, and the difference in weight. This information is recorded in a notebook (ASTM, 2013).

Sieves are then prepared Fig. 3 by arranged sequentially from top to bottom, placing the sieve 2.3 mm (coarse grains) up and 300µm (medium grains) below and ending with the sieve 75µm (fine grains). After that, the sample is emptied into the upper sieve with aluminum foil fixed above the 2.3 mm sieve and 75µm below the sieve to prevent particle leakage during screening (ASTM, 2013). The sieving stopped after 5 minutes, and determined the weight for each fraction, coarse, medium and fine grains, then each fraction is placed in a container

Fig. 3: Sieves arranged sequentially from top to bottom (2.3 mm, 300 µm, 75 µm)

and the sample information is recorded on it. Sieves are well brushed with soap and water and dried after finishing sample preparation and before starting preparing another sample (ASTM, 2013).

Analysis

Measuring the concentration of asbestos in polluted soil is difficult, and the data are often very mixed (Wroble *et al.,* 2019). The most common methods used for asbestos analysis are scanning electron microscopy using energy dispersed X-ray spectroscopy (SEM-EDS), transmission electron microscopy (TEM-EDS), X-ray deflection (XRD), and polarized optical microscopy (PLM) (Strohmeier *et al.,* 2010, Martínez-Pérez *et al.,* 2019). Other methods such as Raman and Micro-Raman Spectroscopy are also used in asbestos analysis (Rinaudo *et al.,* 2004).

Analysis using polarized light microscopy is the primary method and the first procedure used to determine asbestos fibers (Perkins *et al.,* 1993). The polarized light microscope is the oldest method used to determine asbestos minerals, and It has been used since the 1920s and is based on identifying fibers through their optical properties (OSHA, 1995).

Slides Preparation

For identifying the type of asbestos fiber, 12 slides were prepared by placing 2-3 drops of refractive index liquids (RI), for each type of asbestos, on 12 slides with two duplicates for both of soil samples & asbestos sheets which collected from the site Fig. 4. This process was repeated for all of the soil samples was collected from the study area for the purpose of determining the type of asbestos fibers (Crane, 1992).

Fibers identification using polarized light microscopy (PLM)

The analysis was carried out using a microscope of

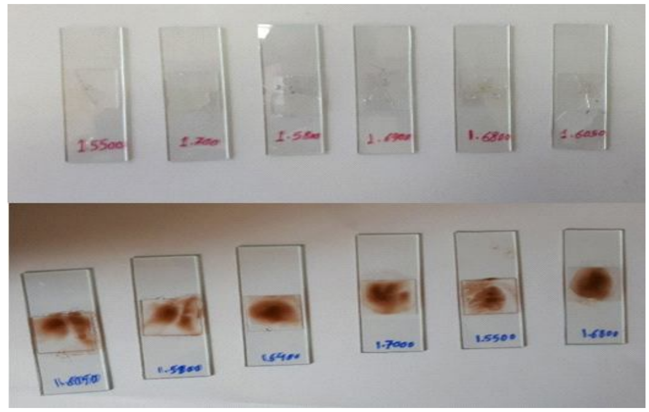

Fig. 4: Glass slide of asbestos sheet and soil.

type (JAMES SWIFT & SON LTD.) Model (M.P.120) with an eyepiece with a magnification of 10x and objective lens with a magnification of (5X, 10X, 20X, 40X). Cargille Asbestos High Dispersion Liquid Set - Six 1/4 oz. Bottles from SPI, where the optical properties of the fibers in the glass slide are compared with the optical properties of standard asbestos fibers (NÄSI, 2018). and then the type of asbestos fibers is determined Fig. 5&6&7.

Measure the concentration of asbestos fibers

The concentration of asbestos fibers in soil samples, is measured by the Visual Area Estimate as well as the Point Count (Wroble *et al.,* 2019).

For VAE, At least three slides should be analyzed to determine the asbestos content by estimating the visible area. Eight slides with 0.01 g of soil were prepared for each part of the sample (coarse, medium, and fine grains). Each slide is analyzed in its entirety, indicating percentages of asbestos fibers and non-asbestos materials (soil grains) in the slide. The ratio of asbestos to soil ratio is recorded by comparing the ratio of asbestos fibers under the microscope with the standard and spectrum (Fig. 9). The horizon analysis of asbestos fiber in the glass slide is performed in 12 times in (Fig. 8). As for the PC, at least 400 non-blank points were counted for each sample. Calculating the 400 points helps reduce the bias that may result from a lack of homogeneity when preparing the glass slide.

Results and Discussion

The risk of asbestos is caused by inhaling its fibers, so the release of fibers from soil to air depends on a number of site factors, which can be divided into: site and extent of pollution, indoor and outdoor activities at the site, and weather effects (Swartjes and Tromp, 2008).

The Site and extent of pollution

(Table 1) shows the results of Visual Area Estimate as well as Point Count using Polarized Light Microscope

Fig. 5: The edges of chrysotile fibers can hardly be seen in plane polarized light. Taken with 100X magnification power.

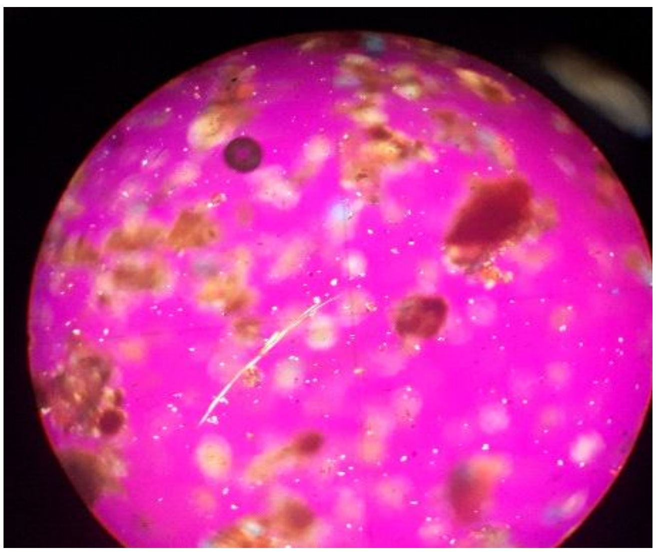

Fig. 6: The same fibre in light of cross-polarization. The fibers exhibit an equal colour in the cross polarized light that is seen only in the mineral fibers. Taken with 100X magnification power.

Table 1: The mean results of soil sample using VAE and PC.

No.	Sample	Total Asbestosvae VAE %	Total Asbestos % PC	Long	Lat
1	TQ1	2.565833	1.951984	43°08'55.7	36°19'28.47
2	TQ2	0.91875	0.651587	43°08'51.33	36°19'37.39
3	TQ3	0.129692	0.046627	43°08'46.68	36°19'47.6
4	TQ4	0.015208	0.010417	43°08'28.12	36°19'40.04
5	TQ5	0.716833	0.493254	43°08'33.65	36°19'31.42
6	TQ6	0.689917	0.549306	43°08'40.2	36°19'22.68
7	TQ7	0.054083	0.915079	43°08'18.23	36°19'11.96
8	TQ8	0.228625	0.05506	43°08'11.54	36°19'24.91
9	TQ9	1.287958	0.032738	43°08'07.89	36°19'35.15

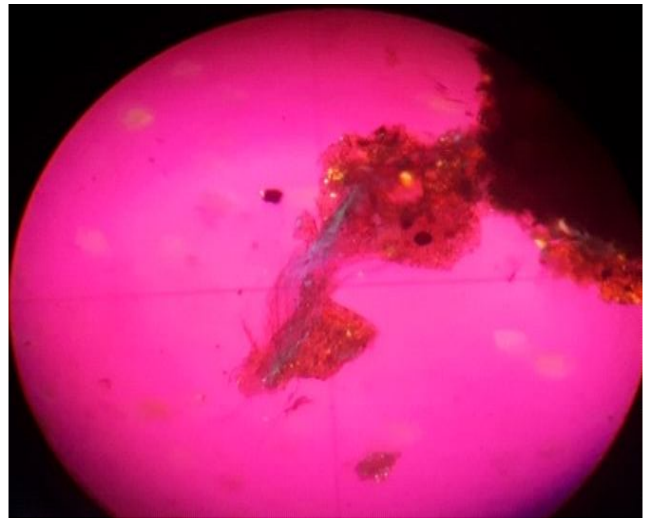

Fig. 7: A portion of asbestos sheets show chrysotile as Appearing under Polarized light Microscope.

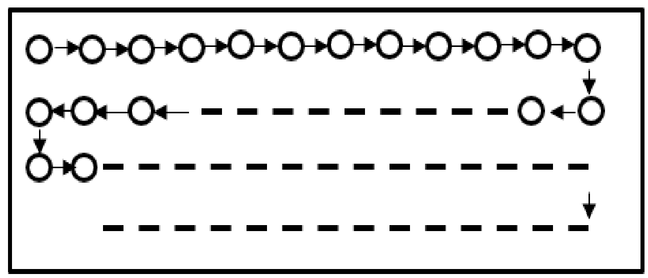

Fig. 8: Diagrammatic drawing of moving field of view.

for the soil samples. It shows that the concentrations of asbestos ranged between 0.015208-2.565833% for VAE and 0.010417% -1.951984% for PC. These concentrations, with the exception of samples (TQ4, TQ7) for VAE, and (TQ3, TQ4, TQ8, TQ9) for PC, exceeded the criteria for soil pollution within the permissible asbestos concentrations contained in (Swartjes and Tromp, 2008).

Cumulative frequency curve

(Fig. 10) represents the cumulative frequency curve of the fiber concentration using VAE and PC. Its shows that 44% of the samples for the VAE method and 55 % for the PC method were less than the indicate value of 0.1%. which are classified as not posing a risk to health (Swartjes and Tromp, 2008). Whereas, 77% of the samples for the VAE method and 88% for the PC method were at the concentration limits of 0.5-1.0%. It is also noted that 88% of the samples were recorded at a concentration of 1.0-1.5%. Note that the concentrations ranging between 1.5-2% made up 88% for VAE and 100% as the highest recorded concentration for PC, Whereas, the highest values of concentrations recorded by VAE

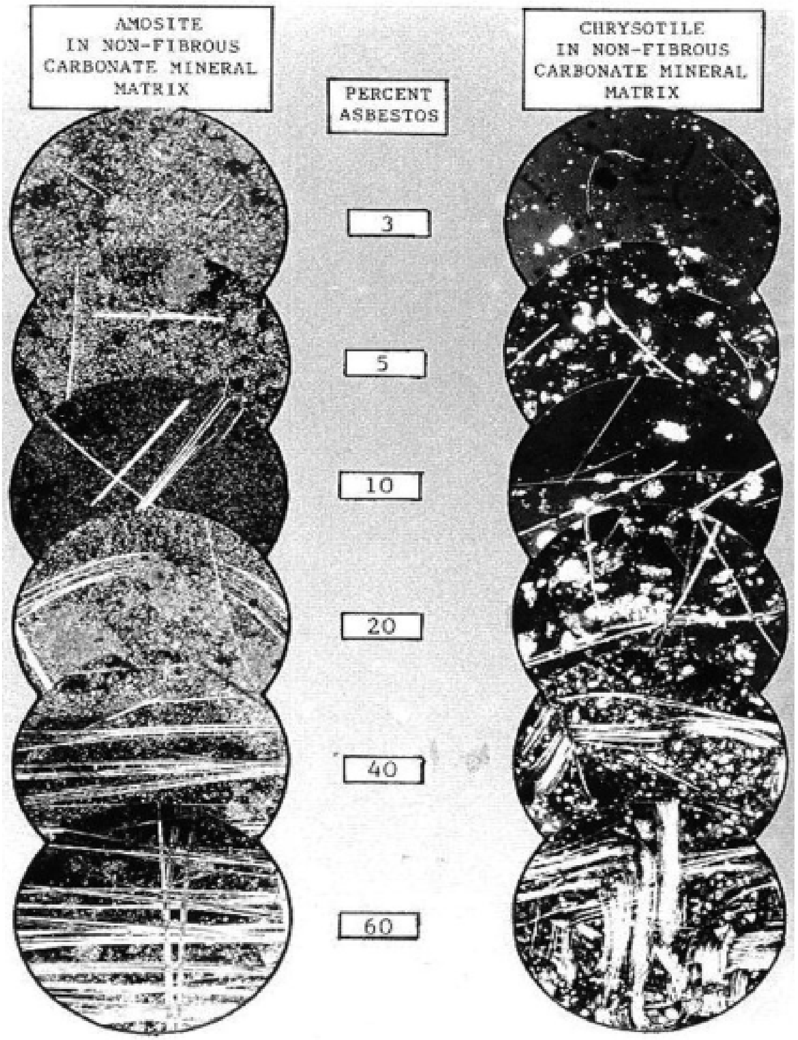

Fig. 9: Spectrogram of chrysotile and amosite fiber content (Xu *et al.*, 2018).

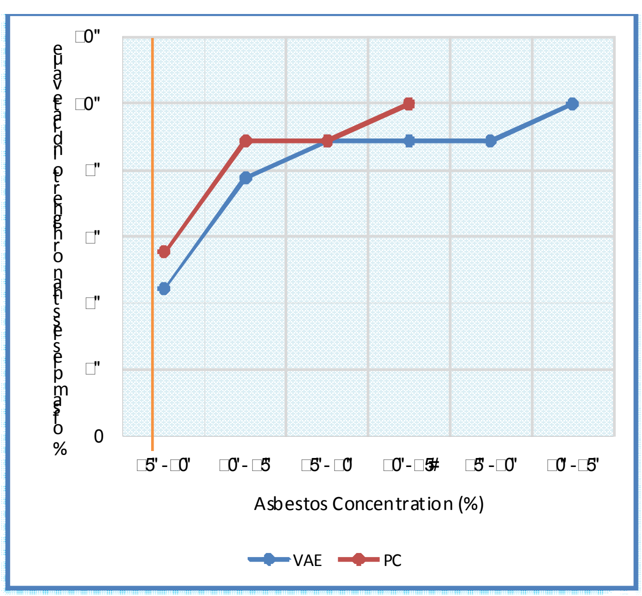

Fig. 10: Cumulative frequency curves for VAE and PC.

method, which constituted 100% at 2.5-3%. These concentrations were caused by prevailing winds and debris lifting trucks that spread the fibers.

Distance to the emission source effect

Fig. 11 represents the relationship between the concentration of the fibers to the distance to the emission source. It shows that in both methods (VAE and PC) the concentration of the fibers gradually decreases by moving away from the debris site (emission source) by following 3 paths for each of the three samples based on the nearest debris site.

Indoor and outdoor activities

Rubble removal activities also affect the spread of pollutants at study area (Al-Jarjees *et al.,* 2020, Al-Jarjees, 2020). The concentration of asbestos fiber, located on the path of transporting tracks, is higher than the others, Where the activities of transporting rubble Fig. 12 affect the spread of asbestos fibers (Parkitny *et al.,* 2017, Frisiani and Pastorino, 2019).

Weather effects

The total concentration of fibers is related to atmospheric stability and prevailing wind direction in relation to the emission source. (Singh and Thouez, 1985). (Table 2) represents the monthly average wind direction for Mosul station from 1980 to 2010, shows that the direction of prevailing winds in the city of Mosul, through the data obtained from the Mosul station over a period of 30 years, was northwest.

Fig. 13 & 14 shows that the concentration of the fibers decreases with the direction of the prevailing winds and distance to emission source. the wind increases the diffusion of the fibers away from the emission source. And it's shows the highest pollution in the eastern part of Al-Tayaran quarte.

Statistical analysis

The results of the statistical analysis using one-way ANOVA, showed that there are statistically significant differences between the nine samples, Figs. 14,15 showed that the sample 4 showed the lowest pollution rate.

Conclusion

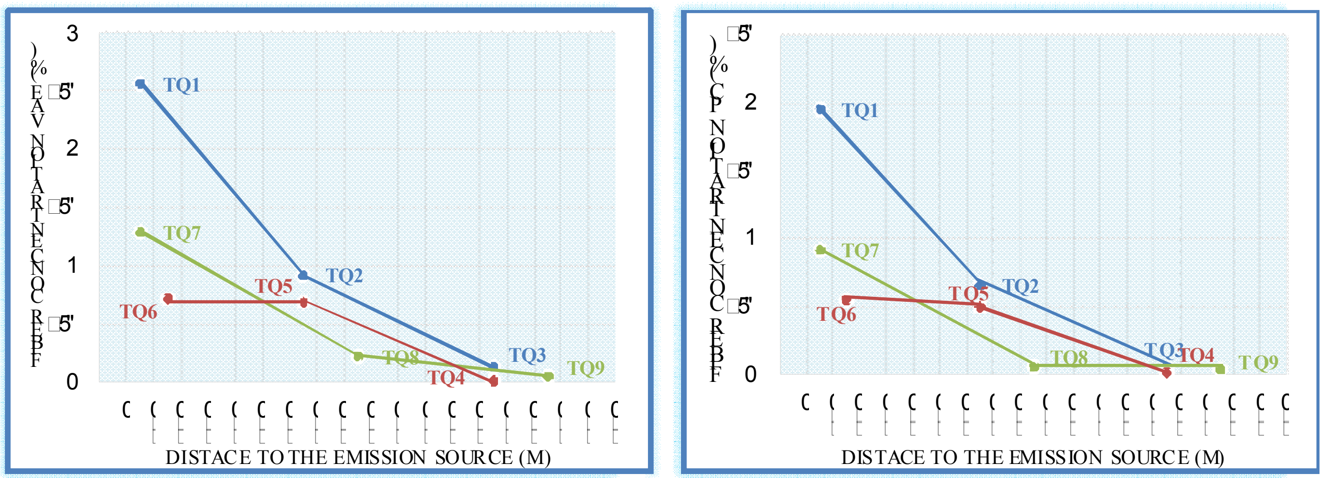

Fig. 11: The relationship between the distance (m) to the emission source for VAE and PC.

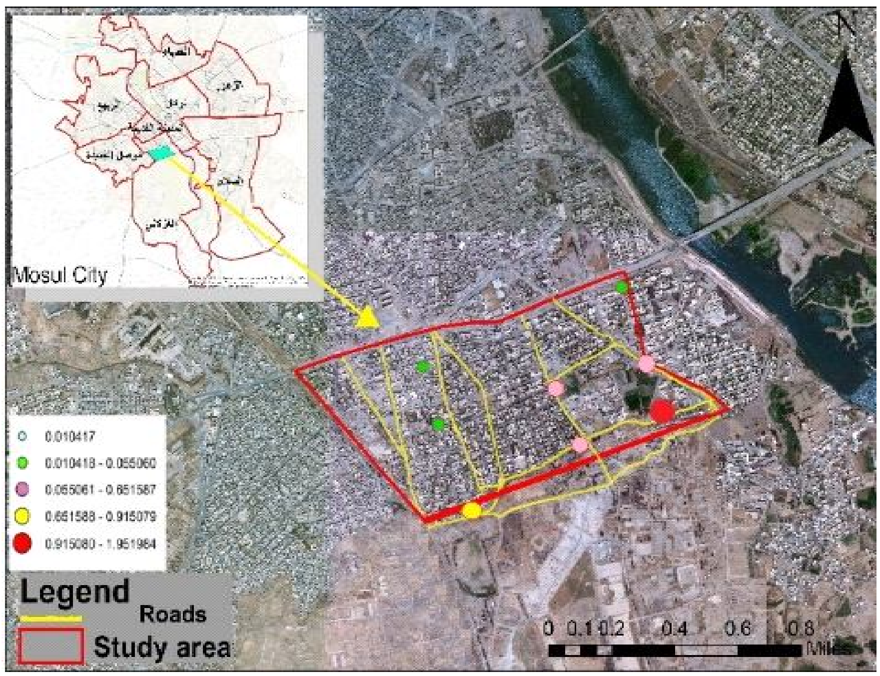

Fig. 12: The available road to transport the rubble.

Table 2: Monthly average wind direction for the Mosul station from 1980 to 2010.

Months	North	Northwest	Western	Southwest	South	Southeast	East	Northeast	Calm
January	2.1	4.1	5.4	1.1	1.3	9.5	12.9	1.4	13.3
February	1.4	5.1	8.1	1.4	2.1	9.2	11.9	1.6	6.8
March	2.9	5.7	11.3	6.9	6.5	7.9	7.2	2.1	17.2
April	3.2	15.2	19.3	2.1	2.2	3.5	10.5	8.2	6.8
May	8.5	13.3	16.2	1.2	2.8	1.2	6.6	6.1	3.4
June	10.5	14.1	19.5	7.3	1.5	2.3	5.5	1.8	0
July	9.3	20.1	10.1	1.2	1.8	3.4	4.6	1.9	0
August	1.8	20	10.1	1.6	1.9	1.5	6.6	5.1	0
September	2.4	15.2	22.2	7.7	1.1	1.8	6.2	2.3	0
October	2.9	13.5	15.2	1.8	1.6	3.4	5.6	2.1	10.3
November	3.1	18.6	14.2	1.5	2.3	8	12.1	4.2	3.4
December	2.1	2.4	5.2	1.7	6.6	11.3	12.5	5.3	0
Annual rate	4.1	12.275	13	2.9	2.6	5.25	8.5	3.5	1.4

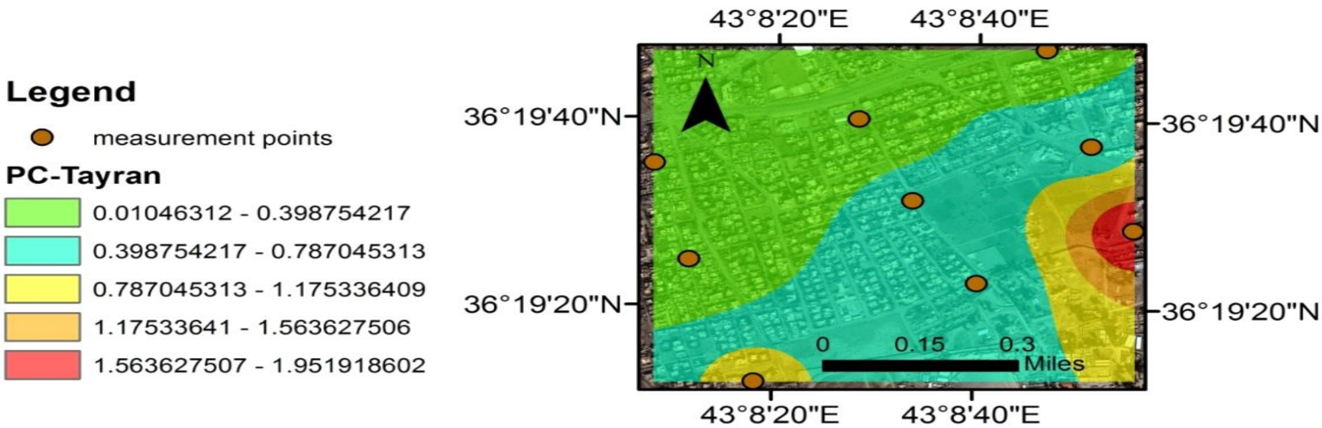

Fig. 13: Map of the distribution of fiber concentrations (PC) and wind direction in Al-Tayaran quarter using IDW by ArcMap GIS.

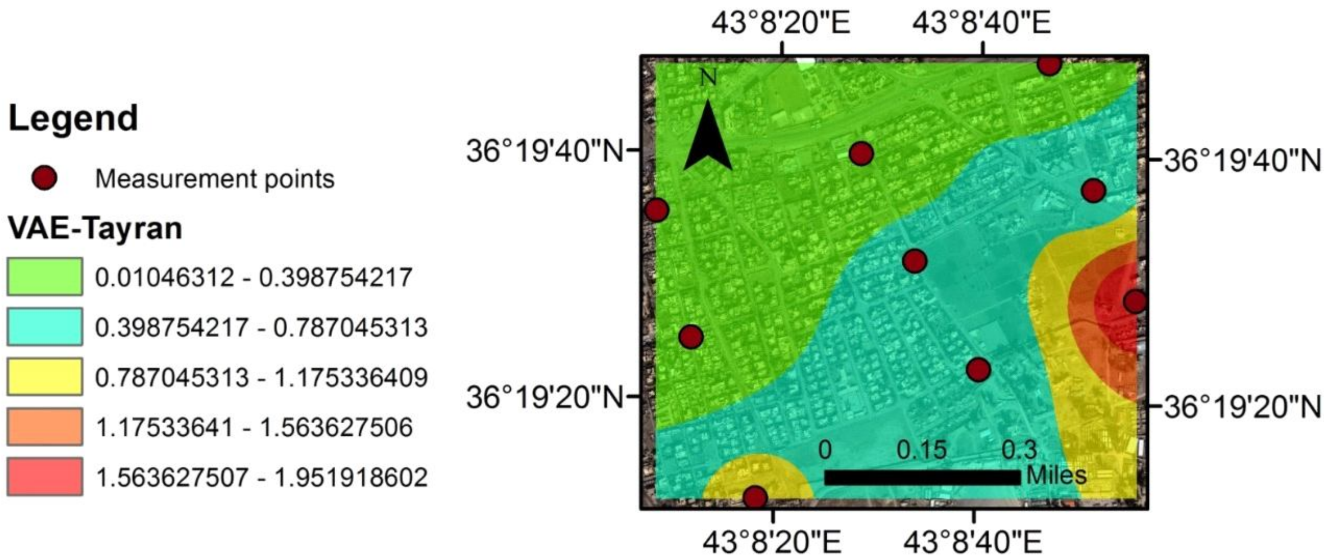

Fig. 13: Map of the distribution of fiber concentrations (VAE) and wind direction in Al-Tayaran quarter using IDW by ArcMap GIS.

Table 3: The statistical analysis results for PC.

Groups	N	Mean ± S.D.	F	Sig.
1	3	1.9520±0.37627	45.479	0.000
2	3	0.6516±0.19871		
3	3	0.0466±0.01521		
4	3	0.0104±0.00150		
5	3	0.493±0.08699		
6	3	0.5493±0.12768		
7	3	0.9151±0.17124		
8	3	0.0551±0.00948		
9	3	0.0327±0.11120		
F tab. : 0.05 , 8 , 18 : 2.51				

Table 4: The statistical analysis results for VAE.

Groups	N	Mean ± S.D.	F	Sig.
1	3	2.5658±0.34277	95.870	0.000
2	3	0.9188±0.17527		
3	3	0.1297±0.01482		
4	3	0.0152±0.00295		
5	3	0.7168±0.12846		
6	3	0.6899±0.08627		
7	3	1.2880±0.11212		
8	3	0.2286±0.03896		
9	3	0.0541±0.00725		
F tab. : 0.05 , 8 , 18 : 2.51				

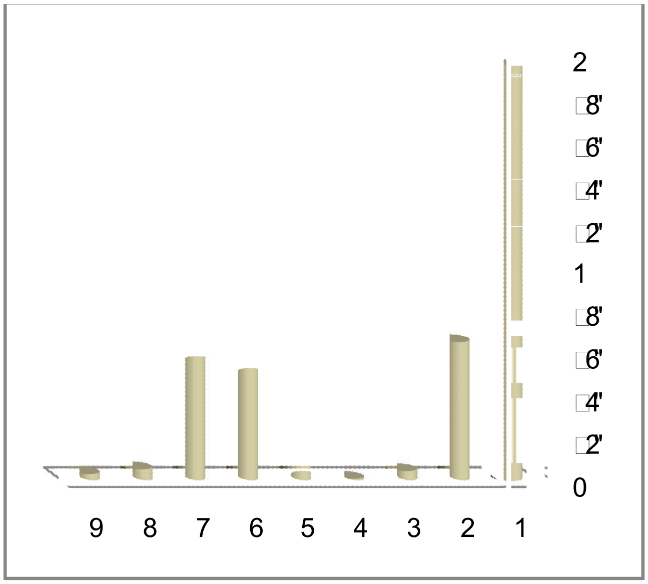

Fig. 14: The statistical analysis results for PC.

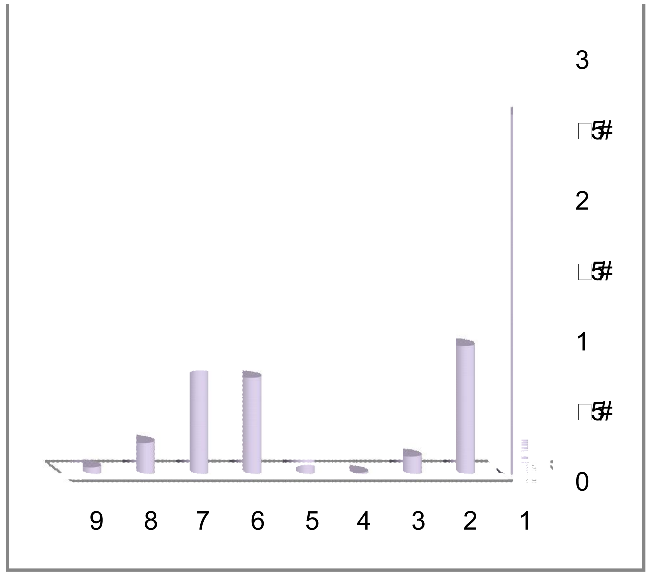

Fig. 15: The statistical analysis results for VAE.

The highest pollution was recorded in the southeastern part of the study area with concentration of 2.565833% VAE & 1.951984% PC. The concentrations of asbestos fiber affected by wind direction and decrease with distance to the emission source, and it is also affected by rubble removal activities which spread the fiber in the study area.

References

ASTM D7521-13, (2013). Standard Test Method for Determination of Asbestos in Soil: ASTM International, West Conshohocken, PA. doi:10.1520/D7521-13. www.astm.org

Al-Jarjees, S.D., K.K.J.W.M. Al-Ahmady and Research (2020). Planning the optimal debris removal of destroyed buildings in the Midan region in the Old City of Mosul, **38:** 472-480. Al-Jarjees, S. D., K.K.J.W.M. Al-Ahmady and Research (2020). Planning the optimal debris removal of destroyed buildings in the Midan region in the Old City of Mosul, **38:** 472-480.

Al-Jarjees, S.D.J.T.I.G.J. (2020). The usage of GIS for the devastated urban centers managent and preservation of monuments/study case: Nabi-Jarjis district in Musul city in Iraq, 57-69.

Crane, D.T. (1992). Polarized Light Microscopy of Asbestos.

Gaffney, S.H., M. Grespin, L. Garnick, D.A. Drechsel, R. Hazan, D.J. Paustenbach and B.D.J J.O.A.T. Simmons (2017). Anthophyllite asbestos: state of the science review, **37:** 38-49.

Garcia, E.D. (2013). Asbestos Exposure in the Research Laboratory.

Kameda, T., K. Takahashi, R. Kim, Y. Jiang, M. Movahed, E.K. Park and J.J.B.O.T.W.H.O. Rantanen (2014). Asbestos: use, bans and disease burden in Europe, **92:** 790-797.

Ladou, J., P. Landrigan, J.C. Baila, V. Foa and A.J.C. Frank (2001). A call for an international ban on asbestos, **164:** 489-490.

Martinez-Perez, A., G. Luis-Raya, G. Villagomez-Garcia, E. Vera-Cardenas, R. Cabrera, M. Villanueva-Ibanez, M. Moreno-Rios, E.J.M. Avila-Davila and Microanalysis (2019). SEM, EDS and XRD Study of Heavy-Duty Asbestos Brake Pads, **25:** 794-795.

Perkins, R., B.J.O.O.R. Harvey, U.E.P.A. Development and D.C. Washington (1993). Method for the determination of asbestos in bulk building materials.

Rinaudo, C., E. Belluso and D.J.M.M. Gastaldi (2004). Assessment of the use of Raman spectroscopy for the determination of amphibole asbestos, **68:** 455-465.

Singh, B. & J.P. Thouez (1985). Ambient air concentrations of asbestos fibers near the town of Asbestos, Québec. *Environmental Research,* **36:** 144-159.

Spasiano, D. and F.J.J.O.E.M. Pirozzi (2017). Treatments of asbestos containing wastes, **204:** 82-91.

Strohmeier, B.R., J.C. Huntington, K.L. Bunker, M.S. Sanchez, K. Allison and R.J.J.I.G.R. Lee (2010). What is asbestos and why is it important? Challenges of defining and characterizing asbestos, **52:** 801-872.

Swartjes, F.A. and P.C. Tromp (2008). A Tiered Approach for the Assessment of the Human Health Risks of Asbestos in Soils. *Soil and Sediment Contamination: An International Journal,* **17:** 137-149.

Takahashi, K., P.J. Landrigan and C.J.A.O.G.H. Ramazzini (2016). The global health dimensions of asbestos and asbestos-related diseases, **82:** 209-213.

Unep, U.N.E.P. (2017). "Environmental Issues in Areas Retaken from ISIL: Mosul, Iraq", Technical report. Available at http://www.uniraq.org/index.php?option=com k2&view=item&task=download&id=2449a2a71fec80f71cbbe0f3cd5740ccb4ad&lang=en.

Virta, R.L. (2005). *Mineral Commodity Profiles, Asbestos*, US Geological Survey Circular 1255-KK. Reston, VA.

Wroble, J., T. Frederick, A. Frame and D.J.P.O. Vallero (2017). Comparison of soil sampling and analytical methods for asbestos at the Sumas Mountain Asbestos Site-Working towards a toolbox for better assessment, **12**.

Wroble, J., T.J.E. Frederick and E. Geoscience (2019). Refinement of Sampling and Analysis Techniques for Asbestos in Soil.

XU, X., Y. Li, L.A. Belfiore and J. Tang (2018). Polarized light microscope method for the determination of asbestos fiber of textile. *Integrated Ferroelectrics,* **188:** 136-147.