# ENVIRONMENTAL IMPACT OF VOLATILE ORGANIC COMPOUNDS EMITTED FROM ASPHALT PAVEMENT [1]

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## ABSTRACT

Hot mix asphalt (HMA) is a major construction material used for building roads, airport runways, and parking lots (ASCE 2014). During HMA construction, a massive amount of volatile organic compounds (VOC'Ss) is emitted from the hot asphalt mixtures, creating a potential health risk to on-site workers. Few studies have quantitatively investigated (Chong *et al.*, 2013). The constituents and the potential health effects of the VOC's generated from HMA pavement construction were studied. This paper presents the results of a study in which air samples were collected at multiple locations and time points of several projects during HMA pavement construction and were their chemical compositions and concentrations subsequently characterized by using gas chromatography/mass selective detector (GC/MSD). Although the individual concentrations of the identified chemicals were found to be below various exposure limits, their collective effect on human health remains unknown and may not be ignored (Chong *et al.*, 2013).

**Keywords**: Asphalt; Volatile Organic Compounds (VOC's)

## INTRODUCTION

The purpose of this research was to determine the origins of the majority of ambient VOC'Ss detected in Giza government in March, August, October and December of 2017 in Maryoutia Street, El Zomor street, El-Orouba street and Feisal street respectively. A preliminary study was conducted to determine whether they were being emitted from an industrial point source, or

by personal vehicles source. The initial results showed that the greatest amount of VOC's didn't come from these alleged sources. The research samples were taken from the sites before and immediately after pavement.

Furthermore, this research shows that newly applied asphalt may continue to release VOCs after the initial pour, making asphalt one of the most important factors to be considered when testing the Ozone precursor (Kice and Sean Jason, 2005).

The majority of ozone production in the troposphere however, occurs when sunlight reacts with NOx and VOC's in a photochemical reaction (NOAA, 2001). Other byproducts are also produced depending upon the chemical species of both NOx and VOC's involved in the reaction. There are roughly about 120 species of NOx and VOC's that can be involved in this reaction (Finlayson and Pitts, 1999).

## AIM OF STUDY

- The knowledge about asphalt pavement the emissions.
- The environment impact of asphalt pavement.
- The effect of the exposure VOC's on health.

## MATERIALS AND METHODS

This study represents the construction, characterization concentration and chemical composition of several air sample collected from multiple location and time point of several projects during (HMA) pavement Giza zone. Gas analyzer used to measure the different pollutants and volatile organic compounds.

## STATISTICAL ANALYSIS

All analysis was done using the statistical package for the social science (SPSS software version 22) on a personal computer.

**Level of significance:**

p value = level of significance.

$p > 0.05$ non significant.

$p \leq 0.05$ significant.

$p \leq 0.001$ highly significant.

## RESULTS

**Table (1):** Concentration of Air Pollutants in Maryoutia St. and El Zomor St. before and immediately after asphalt per ppm

| Time (min.) | Before asphalt | | After asphalt | |
|---|---|---|---|---|
| | Maryoutia | El Zomor | Maryoutia | El Zomor |
| 1 | 130 | 159 | 1753 | 1985 |
| 2 | 128 | 158 | 1770 | 1990 |
| 3 | 136 | 156 | 1790 | 1993 |
| 4 | 120 | 169 | 1810 | 1999 |
| 5 | 126 | 165 | 1810 | 2011 |
| 6 | 115 | 172 | 1820 | 2195 |
| 7 | 124 | 179 | 1821 | 2196 |
| 8 | 146 | 175 | 1823 | 2200 |
| 9 | 129 | 178 | 1823 | 2201 |
| 10 | 134 | 188 | 1830 | 2212 |
| 11 | 138 | 182 | 1833 | 2215 |
| 12 | 146 | 184 | 1834 | 2215 |
| 13 | 147 | 185 | 1834 | 2230 |
| 14 | 138 | 189 | 1834 | 2239 |
| 15 | 145 | 190 | 1835 | 2243 |
| 16 | 137 | 193 | 1838 | 2243 |
| 17 | 129 | 199 | 1840 | 2249 |

**Table (1):** Cont.

| Time (min.) | Before asphalt | | After asphalt | |
|---|---|---|---|---|
| | Maryoutia | El Zomor | Maryoutia | El Zomor |
| 18 | 135 | 210 | 1841 | 2251 |
| 19 | 139 | 205 | 1841 | 2254 |
| 20 | 145 | 209 | 1843 | 2259 |
| 21 | 131 | 212 | 1843 | 2260 |
| 22 | 167 | 215 | 1843 | 2264 |
| 23 | 162 | 213 | 1844 | 2279 |
| 24 | 160 | 206 | 1849 | 2284 |
| 25 | 154 | 217 | 1851 | 2290 |
| 26 | 169 | 219 | 1854 | 2295 |
| 27 | 154 | 224 | 1856 | 2297 |
| 28 | 169 | 225 | 1860 | 2310 |
| 29 | 159 | 215 | 1864 | 2315 |
| 30 | 145 | 220 | 1895 | 2310 |

**Table (2):** study of VOC"s in Maryoutia and El Zomor before and immediately after asphalt per ppm

| Difference in Concentration of VOC'S in Maryoutia before and immediately after asphalt | | | | | |
|---|---|---|---|---|---|
| | Min. | Max. | Mean | Std. Deviation | p-value |
| Concentration of VOC'S in Maryoutia before asphalt | 115 | 169 | 141.90 | 14.709 | P<0.0001 |
| Concentration of VOC'S in Maryoutia immediately after asphalt | 1753 | 1895 | 1832.73 | 27.235 | |
| Concentration of VOC'S in El Zomor before asphalt | 156 | 225 | 193.70 | 21.324 | P<0.0001 |
| Concentration of VOC'S in El Zomor immediately after asphalt | 1985 | 2315 | 2209.47 | 103.343 | |

The p-value is < .00001. The result is significant at p<0.5.

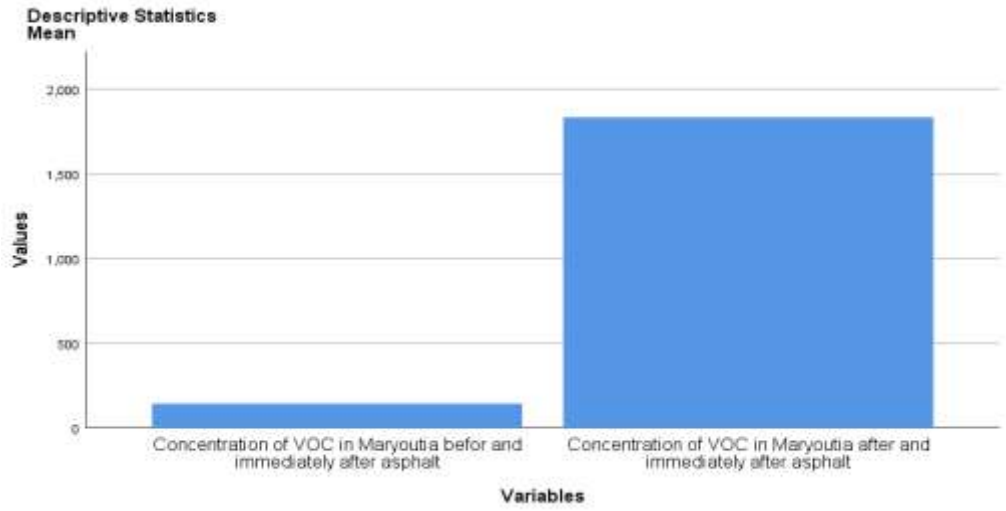


**Fig. (1):** Concentration of VOC'S in Maryoutia before and immediately after asphalt per ppm

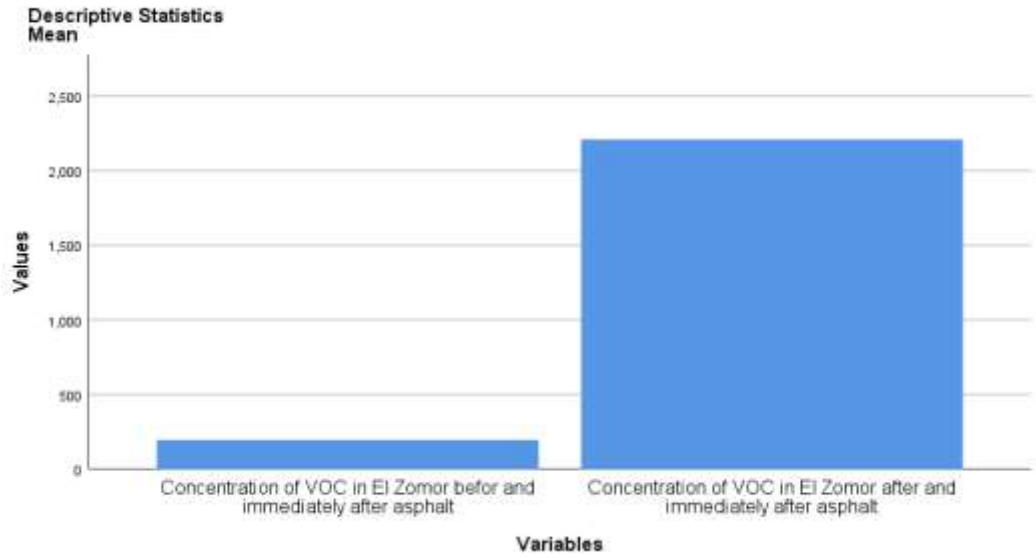


**Fig. (2):** Concentration of VOC'S in El Zomor before and immediately after asphalt per ppm

**Table (3):** Concentration of Air Pollutants in El-Orouba St. and Feisal St. before and immediately after asphalt per ppm

| Time (min.) | Before asphalt | | After asphalt | |
|---|---|---|---|---|
| | El Orouba | Feisal | El Orouba | Feisal |
| 1 | 149 | 115 | 1730 | 1550 |
| 2 | 150 | 116 | 1753 | 1561 |
| 3 | 154 | 117 | 1770 | 1573 |
| 4 | 159 | 119 | 1790 | 1575 |
| 5 | 143 | 125 | 1794 | 1576 |
| 6 | 146 | 121 | 1810 | 1590 |
| 7 | 147 | 123 | 1810 | 1597 |
| 8 | 149 | 130 | 1810 | 1597 |
| 9 | 148 | 128 | 1813 | 1598 |
| 10 | 149 | 127 | 1820 | 1603 |
| 11 | 144 | 131 | 1820 | 1610 |
| 12 | 159 | 133 | 1821 | 1613 |
| 13 | 156 | 134 | 1823 | 1619 |
| 14 | 156 | 135 | 1825 | 1621 |
| 15 | 160 | 137 | 1830 | 1621 |
| 16 | 167 | 138 | 1833 | 1625 |
| 17 | 168 | 131 | 1834 | 1630 |
| 18 | 169 | 131 | 1834 | 1635 |
| 19 | 161 | 132 | 1835 | 1636 |
| 20 | 160 | 129 | 1841 | 1639 |
| 21 | 154 | 125 | 1843 | 1639 |
| 22 | 153 | 127 | 1843 | 1640 |
| 23 | 154 | 124 | 1844 | 1643 |
| 24 | 149 | 129 | 1848 | 1656 |
| 25 | 160 | 123 | 1849 | 1660 |
| 26 | 164 | 124 | 1851 | 1660 |
| 27 | 163 | 126 | 1854 | 1661 |
| 28 | 160 | 133 | 1860 | 1667 |
| 29 | 155 | 132 | 1891 | 1669 |
| 30 | 150 | 130 | 1895 | 1680 |

**Table (4):** Study of VOC'S in El Orouba and Feisal before and immediately after asphalt

| Difference in Concentration of VOC'S in El-Orouba and Feisal before and immediately after asphalt | | | | | |
|---|---|---|---|---|---|
| | **Min.** | **Max.** | **Mean** | **Std. Deviation** | **p-value** |
| Concentration of VOC'S in El Orouba before asphalt | 143 | 169 | 155.20 | 7.151 | p<0.0001 |
| Concentration of VOC'S in El Orouba immediately after asphalt | 1730 | 1895 | 1825.80 | 34.745 | |
| Concentration of VOC'S in Feisal before asphalt | 115 | 138 | 127.50 | 6.010 | p<0.0001 |
| Concentration of VOC'S in Feisal immediately after asphalt | 1550 | 1680 | 1621.47 | 34.247 | |

The p-value is < .00001. The result is significant at p < .05.

**Table (5):** Study of VOC'S in Feisal in winter season and El-Zomor in summer season after asphalt representing temperature effect

| Difference in Concentration of VOC'S in Feisal in winter season and El Zomor in summer season before and after asphalt representing temperature effect. | | | | | |
|---|---|---|---|---|---|
| | **Min** | **Max** | **Mean** | **Std. Deviation** | **p-value** |
| Concentration of VOC'S in Feisal before asphalt | 115 | 138 | 127.50 | 6.010 | p < 0.0001 |
| Concentration of VOC'S in El Zomor before asphalt | 156 | 225 | 193.70 | 21.324 | |
| Concentration of VOC'S in Feisal immediately after asphalt | 1550 | 1680 | 1621.47 | 34.247 | p< 0.0001 |
| Concentration of VOC'S in El Zomor immediately after asphalt | 1985 | 2315 | 2209.47 | 103.343 | |

The p-value is < .00001. The result is significant at p < .05.

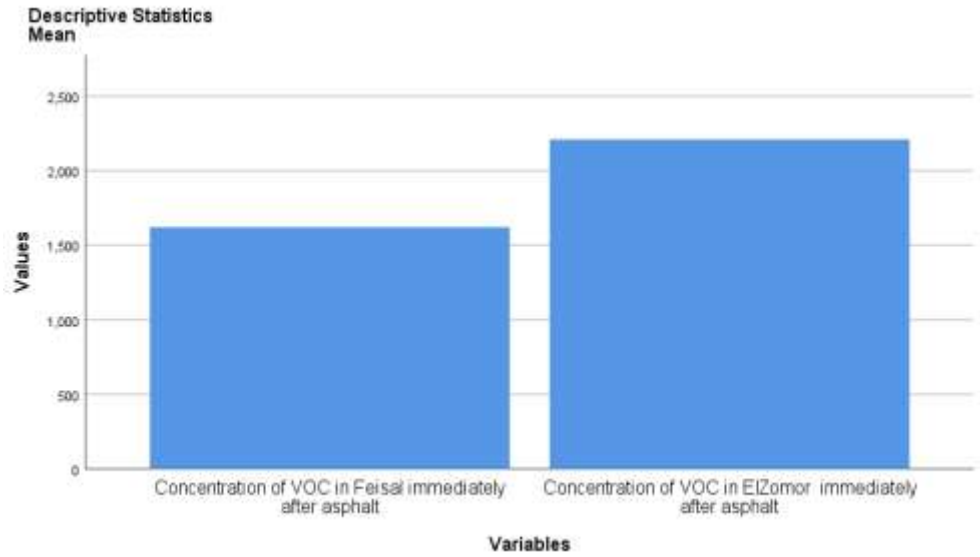


**Fig (3):** Concentration of VOC'S in Feisal in winter season and El Zomor in summer season after asphalt representing temperature effect.

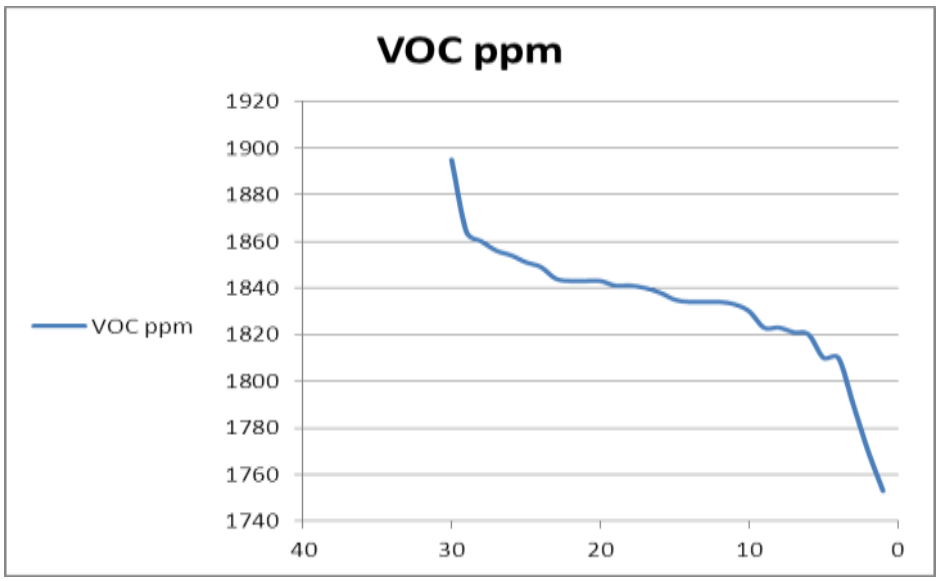


**Fig (4):** Concentration of VOC'S in Maryotia in spring during 30 min. after asphalt representing increasing concentration with time

## DISCUSSION

Volatile organic compounds (VOC'S) emission from consumer and commercial products are a significant contributing factor in the creation of air pollution in urban areas (CEPA 1999). These emissions contribute the formation of ground-level ozone and fine particulate matter, which increase the smog formation.

The measured VOC's which summarized in Table 1 shows a significant increase of VOC'S (minimum, maximum, mean and St deviation level) from 115,169,141.90 and 14.709 ppb respectively to 1753,1895,1832.73 and 27.235 ppm respectively after asphalt pavement in Maryoutia St. with p-value <0.0001 and a significant increase of VOC'S (minimum, maximum, mean and St deviation level) from 156,225,193.7 and 21.324 ppm respectively to 1985,2315,2209.47 and 103.343 ppb respectively after asphalt pavement in El-Zomor St. with p-value <0.0001 as obtained by statistical study in table 2 which indicate an extremely statistically significant increase of VOC'S due to asphalt pavement. By conventional criteria, this difference in Maryotia St. and El Zomor St. is considered to be extremely statistically significant as shown in Fig. 1 and Fig. 2 respectively.

The measured VOC's are summarized in Table 3 shows a significant increase of VOC'S (minimum, maximum, mean and St deviation level) from 143,169,155.2 and 7.151 ppm respectively to 1730,1895,1825.8 and 34.745 ppm respectively after asphalt pavement in El-Orouba St. with p-value <0.0001 and a significant increase of VOC'S (minimum, maximum, mean and St deviation level) from 115,138,127.5 and 6.01 ppm respectively to

1550,1680,1621.47 and 34.247 ppm respectively after asphalt pavement in Feisal St with p-value <0.0001 as obtained by statistical study in Table 4 which indicate an extremely statistically significant increase of VOC'S due to asphalt pavement.

Comparative study between the measured VOC's in El Zomor asphalt pavement project before and after asphalt pavement which have been carried out in summer with relatively high temperature and Feisal asphalt pavement project before and after asphalt pavement which have been carried out in winter with relatively low temperature are summarized in Table 5.

An increase of VOC'S (minimum, maximum, mean and St deviation level) before asphalt pavement in El Zomor 156,225,193.7 and 21.324 than before asphalt pavement in Feisal 115,138,127.5 and 6.01 before asphalt with p-value < 0.0001.

An increase of VOC'S (minimum, maximum, mean and St deviation level) after asphalt pavement in El Zomor 1985,2315,2209.47 and 103.343 than after asphalt pavement in Feisal 1550,1680,1621.47 and 34.247 after asphalt with p-value <0.0001.

By conventional criteria, this difference is considered to be extremely statistically significant the increase in VOC's level due to seasonal temperature increase from Winter (Feisal pavement project) to summer (El-Zomor pavement project) as shown in Fig 3.

Statistical study of the increase in VOC's level during 30 min readings is shown in table 1 and shown in fig 4.

## CONCLUSION AND RECOMMENDATION

This paper has presented evidence of a previously uninvestigated point source for VOC's. More research should be conducted to investigate this subject and to determine the scale of pollution from asphalt VOC's.

Asphalt should not be poured during peak ozone months. Time temperature and other meteorological factors should be assessed.

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# التأثير البيئي للمركبات العضوية الطيارة المنبعثة من الخلطات الاسفلتية [١]

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## المستخلص

مزيج الاسفلت الساخن (HMA) هو مادة رئيسية تستخدم لبناء الطرق، ومدارج المطارات، ومواقف السيارات. خلال استخدام HMA تنبعث كمية هائلة من المركبات العضوية المتطايرة (VOC's) من خليط الاسفلت الساخن مما ينتج مخاطر صحية محتملة للعمال فى الموقع. وقد حققت دراسات قليلة في الاثار الصحية المحتملة من المركبات العضوية المتطايرة المتولدة فى عملية الرصف HMA. يعرض هذا البحث نتائج دراسة جمعت فيها عينات هواء فى مواقع ونقاط زمنية متعددة من عدة مشاريع خلال عملية الرصف HMA. وعلى الرغم من ان التركيزات تأكد ارتفاعها نتيجة عملية السفلته، إلا أن تأثيرها الجماعى على صحة الانسان لا زال غير معروف ولا يمكن تجاهله. يساهم هذا البحث فى معرفة تركيزات المركبات العضوية المتطايرة المتولدة فى بناء رصيف الاسفلت والمخاطر الصحية المحتملة على العمال، وتدابير التخفيف الممكنة.

وبدراسة المواد العضوية المتطايرة فى أربع مناطق بمحافظة الجيزة فى الاربع مواسم للتعرف على مستويات المواد العضوية المتطايرة من عملية السفلته فى الشتاء والصيف والربيع والخريف، وهل توجد فروق بين هذه المستويات نتيجة استخدام الاسفلت ونتيجة اختلاف درجات الحرارة، تم الحصول على نتائج فى الاربع مناطق (المريوطية – الزمر – العروبة – فيصل) بمتوسطات ما قبل الاسفلت (127.5 ppb،155.2،193.7،141.9) على التوالي وبمتوسطات ما بعد الاسفلت (1621،1825،2209،ppb1832) على التوالي ومعدلات ثقة (P value < 0.0001)، كما وجد ان اقل ارتفاع للمواد المتطايرة حدث فى فصل الشتاء بمنطقة فيصل واعلاها فى فصل الصيف بمنطقة الزمر، كما وجد ان الارتفاع يكون متناسباً طرديا مع الوقت ما بعد اضافة الأسفلت.