Unlocking Urban Insights: A Case Study on Impact of Urban Vegetation on Volatile Organic Compounds (VOCs) Variability Across Different Areas of Reggio Emilia, Italy

Vittoria Marsili¹, Luca Forti¹ and Laura Arru¹,*

¹Department of Life Sciences, University of Modena and Reggio Emilia, IT

Abstract: The Po Valley is one of the European regions most severely affected by air pollution. Within the spectrum of airborne molecules, Volatile Organic Compounds (VOCs) represent a significant component, derived from both natural processes and anthropogenic sources. All VOCs influence air quality, as they are precursors to ozone (O₃), secondary organic aerosol (SOA), and particulate matter (PM). While naturally occurring VOCs contribute to the formation of air pollutants, they also have beneficial effects on human health. Furthermore, vegetation plays a fundamental role in air purification and improvement of air quality both directly, through the metabolic processes of leaves, and indirectly, through physical mechanisms.

This study aims to evaluate the qualitative and quantitative fluctuations of VOCs in different zones within the city of Reggio Emilia (Italy), characterized by varying percentages of vegetation cover and proximity to high-traffic roads. The collected data suggest that air quality may be influenced by the spatial distribution and type of urban area, with urban parks and green zones showing lower concentrations of total VOCs compared to areas with less vegetation cover. These observations can contribute to formulating strategies to improve air quality in urban areas and emphasize the importance of vegetation in an urban context.

Keywords: Air pollution, Particulate Matter (PM), Urban air quality, Vegetation cover, Volatile Organic Compounds (VOCs).

INTRODUCTION

The geographical area known as the Po Valley, located in northern Italy, is characterized by a high population density and intense industrial and agricultural activities. These factors, associated with particular meteorological conditions which can favour the accumulation of polluting substances in the atmosphere, have contributed to making the Po Valley one of the most polluted areas in Europe. Previous studies [1-3], have documented the serious air pollution situation in this area. The most widespread and worrying air pollutants include particulate matter (PM 2.5 and PM 10), tropospheric ozone (O₃), nitrogen oxides (NOₓ), sulfur dioxide (SO₂), and Volatile Organic Compounds (VOCs). As demonstrated by some researchers [1, 4-6], these pollutants have significant impacts on human health and the environment, making it essential to understand the sources and dynamics of these substances.

VOCs are a class of molecules containing carbon-hydrogen covalent bonds, often with functional groups that determine their chemical-physical behaviour and reactivity. They have a molecular weight usually less than 300 Da and can easily evaporate at room temperature (with vapor pressure ≥ 0.01 kPa at 20 °C). Despite having different structures, they all share these important features. [7-9]. VOCs come from natural sources (like isoprene, terpenes, and oxygenated compounds such as alcohols, aldehydes, and ketones) or human activities (such as aromatic hydrocarbons) [10, 11].

Several factors like human activities, weather, meteorological conditions, area topography, and seasonality, affect the mix of VOCs in the air [9, 12-14]. Areas with limited air circulation tend to accumulate more air pollutants [15, 16]. Seasonality also affects how much plants release VOCs. In warmer months, plants may emit more VOCs, as already noted by Meneguzzo al. (2019) and Antonelli et al. (2020) [17, 18].

These compounds, with their structures and chemical reactivity, can play a key role in the formation of air pollutants, such as ozone (O₃), secondary organic aerosol (SOA), and particulate matter (PM), through photochemical oxidation processes [19]. VOCs such as benzene, formaldehyde, toluene, and xylene have demonstrated adverse effects on respiratory, cardiovascular, nervous, and digestive systems [20].

Not all VOCs are harmful to human health. Some VOCs emitted by plants, such as limonene and pinene, are associated with beneficial effects, showing...
oxidant, anti-inflammatory, analgesic, anxiolytic, and antidepressant activities [18]. Others, emitted by typical Mediterranean vegetation, stimulate the immune system, enhancing the activity of natural killer (NK) cells [21], and reducing airway inflammation [22].

The presence of vegetation in urban areas can significantly contribute to air quality, both through direct pollutant absorption and as a physical barrier that influences their dispersion [23]. Pollutant concentrations can be reduced by up to 85% with the presence of trees near pollution sources due to their ability to reduce wind speed based on the height and porosity of the canopy [24]. Plants can cool the air locally and lower pollutant levels, as shown by Novak et al. (2014) [25]. They can also catch pollutants on their leaves and release them with rain, either depositing them on the ground or absorbing them through tiny openings called stomata [25-27].

This research aims to highlight a possible correlation between the role of trees and vegetation in air quality in different areas of the city of Reggio Emilia, a town located in the highly polluted Po Valley, taking into account factors like VOC emissions, meteorological conditions, and the extent of vegetation cover.

MATERIALS AND METHODS

Location of Study Areas

Figure 1 shows the location of the eight studied areas of the city of Reggio Emilia, Emilia Romagna region, Italy. In particular, three urban parks were chosen (Parco del Popolo - S1; Parco delle Caprette - S2; Parco Alcide Cervi - S3); two areas with a good percentage of vegetation cover but very close to key points of city traffic (S4 very close to the A1 motorway and S5 very close to the Reggio Emilia Central Station), a square in the historic center of the city in a Traffic Zone Limited (Piazza Fontanesi - S6) and two areas with reduced vegetation cover and high traffic (S7 and S8). The areas are between 44°40'49" and 44°43'22" N latitude, between 10°36'28" and 10°39'11" East longitude, and between 39 and 75 m above sea level. Table 1 provides the geographic coordinates of the eight zones under study and their elevation above sea level.

Figure 1: Geographic distribution of the 8 studied areas within of Reggio Emilia, Emilia Romagna region, Italy (https://earth.google.com/).
Vegetation Cover

In Table 2 is reported the percentage of vegetation coverage in square meters (m$^2$), calculated over an area of 1000 m$^2$ using the Java-based imaging program ImageJ [28].

Table 2: Percentage of Vegetation Coverage in m$^2$ Calculated over a 1000 m$^2$ Area (S = study site) and Tree Species Present at the Sampling Sites. (Areas are Listed in Descending Order of Vegetation Coverage)

<table>
<thead>
<tr>
<th>Area</th>
<th>Vegetation Cover (m$^2$)</th>
<th>Tree Species</th>
</tr>
</thead>
</table>
| S1 (Parco del Popolo, RE, IT) | 6851,1 | Aesculus hippocastanum L.  
Carpinus betulus L.  
Cedrus deodora  
Cedrus libani  
Fraxinus excelsior L.  
Picea abies L.  
Pinus nigra  
Platanus occidentalis L.  
Styphnolobium japonicum L. |
| S2 (Parco delle Capette, RE, IT) | 6255,3 | Acer campestre  
Aliantus altissima Mill.  
Carpinus betulus L.  
Cedrus deodora  
Cedrus libani  
Celtis australis L.  
Morus alba L.  
Populus alba L.  
Quercus robur L.  
Robinia pseudoacacia  
Tilia cordata Mill. |
| S3 (Parco Alcide Cervi, RE, IT) | 5768,2 | Acer negundo L.  
Acer pseudoplatanus L.  
Cedrus deodora  
Fraxinus excelsior L.  
Juglans nigra L.  
Magnolia grandiflora L.  
Morus nigra L.  
Populus alba L.  
Prunus laurocerasus L.  
Quercus robur L.  
Taxus baccata L.  
Tilia cordata Mill. |
| S4 | 5203,4 | Populus alba L.  
Populus nigra L. |
| S5 | 4820,6 | Quercus robur L.  
Carpinus betulus L.  
Fraxinus excelsior L.  
Acer campestre  
Prunus avium L.  
Juglans regia L.  
Populus nigra L.  
Prunus spinosa L. |
| S6 (Piazza Fontanesi, RE, IT) | 3395,2 | Tilia cordata Mill. |
| S7 | 1363,6 | Acer campestre L.  
Cenchrus setaceus  
Platanus occidentalis L.  
Populus alba L.  
Populus nigra L.  
Pyrus cordata Desv.  
Salvia yangii B.T. Drew |
| S8 | 1264,3 | Celtis australis L.  
Populus alba L.  
Robinia pseudoacacia L. |

For this study were selected three urban parks based on demonstrating the highest percentage of vegetation coverage. In descending order, these parks...
are as follows: Parco del Popolo (S1) with a coverage of 6851.1 m$^2$, Parco delle Caprette (S2) with 6255.3 m$^2$, and Parco Alcide Cervi (S3) with 5768.2 m$^2$. These areas share certain plant species, including the Cedar of Lebanon, Atlas Cedar, and broad-leaved trees such as poplar, lime, and ash.

Following in descending order of vegetation coverage, S4 is the next zone with a coverage of 5203.4 m$^2$, characterized by white and black poplars. Next is zone S5 with 4820.6 m$^2$ of coverage, and S6 (Piazza Fontanesi) with 3395.2 m$^2$, exclusively dominated by lime trees.

Two areas with lower vegetation coverage percentages and high traffic were also analyzed, namely S7 with 1363.6 m$^2$ and S8 with 1264.3 m$^2$. In these zones, vegetation mainly consists of broad-leaved trees and lacks conifers.

**Sampling**

The surveys were conducted in the autumn season of 2022 (September-November) at fifteen-day intervals. Table 3 presents the meteorological data for each of the sampling days (Source: weather data recorded by the regional monitoring network RIRER managed by Arpae-Simc).

The quantitative analysis was conducted using the TIGER LT instrument (Ion Science-Italia, BO, IT). The chemical characterization of VOCs was performed using GC-MS (Agilent Technologies, Inc) on carboxen/polydimethylsiloxane (Supelco, Bellefonte, PA; Carboxen/PDMS, coating thickness of 75 µm) SPME fibers. The air collected at the sampling sites was stored in specific Tedlar Bags (CEL Scientific) designated for this purpose and analyzed using the Tiger LT detector.

VOC present in the air sample were detected by GC–MS using the solid-phase microextraction (SPME) sampling technique. Volatile compounds occurring in the air collected in specific Tedlar Bags were analyzed using a 1 cm needle containing a fiber coated with 75 µm Carboxen/polydimethylsiloxane bonded to a flexible fused silica core (Supelco, Sigma–Aldrich Co, USA). The needle was inserted into the bag through the septum and the fiber was exposed to volatiles for 10 minutes at room temperature. Afterward, the needle was inserted into the injector port and the fiber was exposed for 5 min. GC–MS analyses were performed on an Agilent (USA) 7890A- MSD 5977B gas chromatograph–mass spectrometer equipped with a HP-5 column (25 m x 0.2 mm, 0.5 µm film thickness) coated with (5%)-diphenyl-(95%)-dimethylpolysiloxane copolymer. VOC were identified by comparing their respective mass fragmentation patterns (EI, 70 eV) with the database library NIST11 (MS Library Software Varian, USA). Temperature program: 40°C, hold for 4 min, 10°C/min to 260°C, hold for 4 min, Detector 270 °C, Injector 270 °C.

**RESULTS**

Figure 2 illustrates the trend of VOC measurements in ppb for each of the areas considered in this study. The x-axis represents the number of measurements taken with the Tiger over time (10 minutes of monitoring), and the y-axis represents VOC levels (ppb). Each color represents a sampling day (blue: September 9; orange: September 23; gray: October 7; yellow: October 21; light blue: November 4; green: November 18).

**Table 3: Weather data recorded by the regional monitoring network RIRER managed by Arpae-Simc**

<table>
<thead>
<tr>
<th>Date</th>
<th>Daily average air temperature at 2 meters above ground level (°C)</th>
<th>Daily average relative humidity at 2 meters above ground level (%)</th>
<th>Instantaneous atmospheric pressure at station level at 2 meters above ground level at 11:00 AM (Pa)</th>
<th>Daily average scalar wind speed at 10 meters above ground level (m/s)</th>
<th>Daily prevailing wind direction at 10 meters above ground level (Degree True)</th>
<th>Daily cumulative precipitation (Kg/m$^2$) (equivalent to mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/09/2022</td>
<td>22.90</td>
<td>67</td>
<td>100350.0</td>
<td>1.4</td>
<td>180</td>
<td>0.2</td>
</tr>
<tr>
<td>23/09/2022</td>
<td>16.66</td>
<td>48</td>
<td>101230.0</td>
<td>0.9</td>
<td>45</td>
<td>0.0</td>
</tr>
<tr>
<td>07/10/2022</td>
<td>19.05</td>
<td>68</td>
<td>101700.0</td>
<td>1.2</td>
<td>225</td>
<td>0.0</td>
</tr>
<tr>
<td>21/10/2022</td>
<td>15.82</td>
<td>90</td>
<td>101080.0</td>
<td>1.0</td>
<td>90</td>
<td>0.0</td>
</tr>
<tr>
<td>04/04/2022</td>
<td>14.40</td>
<td>66</td>
<td>99600.0</td>
<td>1.9</td>
<td>270</td>
<td>3.8</td>
</tr>
<tr>
<td>18/04/2022</td>
<td>12.01</td>
<td>82</td>
<td>99300.0</td>
<td>1.4</td>
<td>270</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Below is a summary of the variations in VOC levels in different areas:

- In S1, levels range from 0 to 50 ppb in September and October, but significantly increase in November, reaching 200-300 ppb.
- In S2, VOC levels vary between 0 and 100 ppb on all sampling days.
- In S3, VOC levels fluctuate between 0 and 50/70 ppb.
- In S4, there are significant changes, with levels exceeding 1000 ppb on two days in October (gray and yellow) and on November 18 (green).
- In S5, fluctuations remain below 100 ppb, with peaks at 220 ppb on October 7 and 390 ppb on November 4. October 21 and November 18 show similar patterns.
- In S6, VOC levels briefly exceed 100 ppb only on November 18.
- In S7, fluctuations range from 0-100 ppb, with a peak of 200 ppb on November 18.
- In S8, levels fluctuate between 100 and 200 ppb, with notably high peaks (1000 ppb) on November 4.

Figure 3 shows VOC concentrations in the 8 urban areas of Reggio Emilia (Italy) recorded in September.
2022. On the first sampling day, September 9th (Figure 3a), there was notable variability in VOC concentrations among the monitored zones, with a significant difference between the averages of S2 and S7. S2 showed an average concentration of 57 ppb, while S7 had an average of 45 ppb.

From the analysis of the chemical composition of VOCs on September 9th (Figure 3b), it is noted that in the three urban parks (S1, S2, and S3), over 70% of VOCs consist of natural molecules like isoprene, monoterpenes, sesquiterpenes, acids, aldehydes, ketones, esters, and alcohols. In contrast, in other areas, the percentage of artificial molecules, like hydrocarbons, has significantly increased. On September 23rd (Figure 3c), there was a significant decrease in VOC concentrations in S2, with an average of 35 ppb. Despite this reduction, S2 remains significantly different from other zones, except for S8, which has a VOC average value similar to S2 (39 ppb) and is significant compared to several other zones.

During this sampling, the qualitative analysis (Figure 3d) showed a lower presence of hydrocarbons in urban parks (S1, S2, and S3) and a significant increase in areas with less vegetation cover (S4-S8).

The analysis of the data collected in October (Figure 4) provides additional details about the dynamics of VOC concentrations. Figures 4a and 4c highlight an increasing trend in VOC concentrations compared to September monitoring.

At the beginning of October (October 7th), the average VOC concentrations were higher than in the two previous monitoring periods. In particular, in S4, an average value of 126 ppb was observed, which was statistically higher compared to all other zones (Figure 4a). This result is relevant, considering that 57% of this concentration comes from hydrocarbons, suggesting a notable contribution of anthropogenic compounds. In line with previous days, urban parks, especially S1 (Parco del Popolo), had lower concentrations of...
hydrocarbons, with 50% of VOCs being monoterpenes and only 11% being hydrocarbons (Figure 4b).

At the end of October (day 21), a trend similar to the beginning of the month is observed, with a significantly higher average VOC concentration in S4, reaching 191 ppb (Figure 4c). In this case as well, 50% of this concentration comprises hydrocarbons, confirming the substantial contribution of anthropogenic compounds in this area. While significant differences in total VOC concentrations were observed for the other zones, these concentrations never exceeded 100 ppb (Figure 4d).

In Figure 5, the data related to samplings conducted in November are reported. The concentrations detected at the beginning of November (November 4th) and at the end (November 27th) differ significantly from the data in September (Figure 3) and October (Figure 4).

At the beginning of the month, a notable variation in VOC concentrations is observed among the monitored urban zones. The highest concentrations were observed in S1 with 260 ppb and in S8 with 329 ppb (Figure 5a). Qualitative analysis of VOCs reveals significant differences in chemical composition between the two zones. In S1, 80% of the molecules are of natural origin, while in S8, 50% of the molecules are anthropogenic, including hydrocarbons and synthetic alcohols (Figure 5b).

At the end of November (November 27th), total VOC concentrations are even higher than in the previous monitoring periods. In particular, in S5, a VOC concentration of 279 ppb is observed, which is statistically significant compared to all other zones. Also, in S1 (192 ppb) and S4 (140 ppb), VOCs are elevated and statistically significant compared to other average values. These results confirm the importance of vegetation in reducing TVOC concentrations, with S5 and S1 showing lower concentrations compared to other zones (Figure 5c).
The qualitative trend of VOCs (Figure 5b and 5d) appears to be similar to what was observed in September (Figure 3) and October (Figure 4). Urban parks (S1, S2, and S3) continue to show low levels of hydrocarbons, especially S2, where hydrocarbons constitute only 8% of the detected molecules. On the other hand, in areas with less tree coverage (S4-S8), an increase in the presence of hydrocarbons is observed (Figure 5d).

The analysis of Volatile Organic Compounds (VOCs) in Reggio Emilia's urban areas reveals distinct patterns across zones. Notably, urban parks consistently exhibit lower percentages of anthropogenic molecules, underscoring the role of vegetation in reducing pollutants. The data from October and November demonstrate increasing VOC concentrations, with vegetation-rich areas maintaining lower levels compared to less vegetated zones. The findings highlight the dynamic interplay between vegetation, urban characteristics, and VOC composition.

**DISCUSSION**

The correlation between vegetation coverage, volatile organic compounds (VOCs), and atmospheric conditions in urban air quality is a topic of growing interest in scientific literature [29-31]. This topic is particularly relevant in a global context where an increasing number of people live in urban areas, and air pollution poses a significant threat to public health and the environment. In this study, eight different zones in the city of Reggio Emilia, located in the Emilia Romagna region, Italy, were considered to attempt to extrapolate elements for assessing the complex interaction between vegetation coverage, VOC emissions, and local atmospheric dynamics. The selection of study zones was guided by various considerations, including vegetation coverage, proximity to critical points of city traffic, and

![Figure 5: VOCs concentrations in the 8 urban areas of Reggio Emilia (IT) recorded in November 2022. a and c) histograms of the quantitative averages of measured VOCs in ppb on November 4th (a) and November 27th (c). b) and d) graphs representing the percentage of different classes of molecules detected in GC/MS on November 4th (b) and November 27th (d).](image-url)
geographical characteristics. The eight zones considered are as follows:

- S1 - Parco del Popolo
- S2 - Parco delle Caprette
- S3 - Parco Alcide Cervi
- S4 – Area near the A1 motorway
- S5 – Area near the Central Station of Reggio Emilia
- S6 - Piazza Fontanesi, in the historical center, in a Limited Traffic Zone
- S7 – Area with reduced vegetation coverage and high traffic
- S8 – Area with reduced vegetation coverage and high traffic

The selection of these zones reflects the goal of investigating a diverse range of environmental conditions and vegetation coverage, allowing for a more comprehensive analysis of the effects of these variables on air VOC concentrations. Before delving into data analysis, it is crucial to carefully consider the concept of "vegetation coverage." Often, this coverage is measured in terms of the land area occupied by plants or trees. However, this definition may not fully account for the importance of plant species diversity and health. The ability to absorb atmospheric pollutants can vary significantly depending on these factors. For instance, plants like greater duckweed (Spirodela polyrhiza) and Blumea malcolmii can break down complex organic pollutants into simpler molecules through the action of hydrolytic enzymes and metabolites [32-34]. Regarding particulate matter (PM), some studies show that among different types of forests, coniferous forests tend to have a higher capacity for PM collection compared to broad-leaved forests [35]. This ability is linked to the intricate leaf structures of conifers [36,37]. Additionally, certain woody species like Populus nigra L. and Camellia sasanqua absorb and effective disperse ozone and organic pollutants, such as methyl ethyl ketone, primarily through stomatal action [38]. Furthermore, it is crucial to assess the quality of green area management, including factors like irrigation and maintenance, as these can significantly influence the effectiveness of vegetation in reducing atmospheric pollutants [39]. Large, healthy trees, with diameters exceeding 77 cm, remove approximately 70 times more air pollution per year (1.4 kg/year) compared to small trees with diameters less than 8 cm (0.02 kg/year) [40].

In a study by Endreny et al. (2017) [41] the benefits of tree canopy cover for reducing air pollution and carbon emissions in London, UK, where highlighted, emphasizing the importance of nature conservation in cities, which can contribute to human well-being.

The collected data reveal significant variations in VOC levels among the monitored zones. In urban parks (S1, S2, and S3), VOC concentrations remain relatively contained during September (Figure 3) and October (Figure 4), with a predominance of molecules of natural origin. However, November (Figure 5) shows a notable increase in VOC concentrations in some zones, particularly in S1 and S8. This variation underscores the importance of vegetation coverage in mitigating VOC concentrations, highlighting a direct correlation between vegetation presence and detected pollutant levels. A crucial aspect to consider is the chemical composition of VOCs. Throughout the study, it has become evident that in urban parks, the majority of VOCs consist of molecules of natural origin, such as isoprene, monoterpenes, and other biogenic compounds. In contrast, in urban areas with limited vegetation coverage, the percentage of anthropogenic molecules, such as hydrocarbons, significantly increases. These resultssuggest that the type of urban area plays a key role in determining the chemical composition of VOCs, with a higher presence of anthropogenic compounds in less green areas.

The data analysis of October (Figure 4) highlighted a general increase in VOC concentrations compared to September (Figure 3), with S4 showing the highest concentrations, primarily due to hydrocarbons. At the end of October, a similar trend occurred, confirming the significant contribution of anthropogenic compounds in this zone. It is important to note that, despite the variations, VOC concentrations in all zones remain relatively contained, except for S4.

The analysis of the data collected in November (Figure 5) provides further food for thought. At the beginning of the month, a notable variation in VOC concentrations is observed among the different monitored zones (Figure 5a and 5b). The highest concentrations were observed in S1 and S8, corresponding to the zones with the highest and lowest vegetation coverage, respectively. At the end of November, VOC concentrations are even higher, confirming the importance of vegetation in mitigating such concentrations. In terms of chemical composition,
the qualitative trend of VOCs appears to be similar to what was observed in September (Figure 3) and October (Figure 4). Urban parks (S1, S2, and S3) continue to show low levels of hydrocarbons, while in urban zones with less tree coverage, an increase in the presence of hydrocarbons is observed. The November results confirm the importance of vegetation in mitigating VOC concentrations and suggest a direct correlation between vegetation coverage and VOC levels. Areas with greater vegetation coverage show lower concentrations, while zones with reduced vegetation coverage highlight higher levels, especially of anthropogenic molecules. These results underscore the crucial role of vegetation as an effective strategy in managing air quality in urban areas, with significant benefits for the environment and public health.

**RELATIONSHIP BETWEEN ANTHROPOGENIC MOLECULES AND PERCENTAGE OF VEGETATION COVERAGE**

The relationship between the percentages of anthropogenic molecules present in different study zones and the percentage of vegetation coverage is a key element in understanding how vegetation influences the chemical composition of urban air. The analysis of this relationship, as shown in Figure 6, reveals a series of important trends that repeat on all sampling days.

In particular, urban parks (S1, S2, and S3) with higher vegetation coverage exhibit relatively low percentages of anthropogenic molecules, never exceeding 30% of the molecules present. These parks represent areas where vegetation significantly

---

**Figure 6**: percentage of anthropogenic molecules (on the ordinate axis) present in each studied area in relation to the percentage of vegetative cover (areas ordered decreasingly from left to right). Day 1; b) Day 2; c) Day 3; d) Day 4; e) Day 5; f) Day 6.
contributes to reducing the presence of anthropogenic compounds, such as hydrocarbons.

Conversely, in urban areas with less abundant vegetation coverage, the percentage of anthropogenic molecules, especially hydrocarbons, tends to increase. This is particularly evident in zone S4, where the highest concentrations of anthropogenic molecules are observed (54% on day 1, 50% on day 2, 50% on day 3, and 42% on day 6). These data indicate that the decrease in vegetation coverage correlates positively with the increase in anthropogenic molecules, reflecting the influence of human activities and the lack of vegetation in raising VOC concentrations.

Furthermore, interesting observations are made regarding zones S7 (day 4) and S6 (day 5), which also show high percentages of anthropogenic molecules (50% in S7 and 43% in S6). These results suggest that, even though these are not urban parks, the presence of significant vegetation coverage can contribute to limiting the presence of anthropogenic molecules, although not to the level of greener parks.

This analysis reinforces the importance of vegetation in urban areas in mitigating the presence of anthropogenic molecules, especially hydrocarbons. It also reinforces the idea that the presence of vegetation in urban areas can be an effective strategy in managing air quality and reducing pollutant concentrations. In recent years, phytoremediation has garnered immense interest from researchers, not only for soil reclamation but also for the removal of various types of atmospheric pollutants such as PM, VOCs, inorganic pollutants (CO2, SO2, NO2, O3), and heavy metals. This system, in addition to being economically advantageous, also enhances the aesthetic value of cities [42, 43]. In particular, the absorption of VOCs occurs through leaf stomata, as well as through the cuticle, and with their diffusion in intercellular spaces. They react with the water film covering the inner surfaces of the leaves, forming acids that will be transported and stored in various plant organs through the phloem [43, 44].

It should be noted that, despite recent studies highlighting the involvement of VOCs released by plants in the formation of atmospheric pollutants, the benefits and ecosystem services offered by urban greenery far outweigh the drawbacks. These benefits include the removal of atmospheric pollutants and carbon sequestration, noise reduction, ecosystem services related to microclimates, and benefits for human health, such as stress reduction, mood enhancement, and the reduction of respiratory-related issues [45]. Additionally, the use of phytoremediation, a system that utilizes plants for soil reclamation and the removal of atmospheric pollutants such as PM, VOCs, inorganic pollutants, and heavy metals, offers an effective and economical solution for urban environmental management [25, 41].

**CONCLUSIONS**

This study provides a comprehensive overview of the correlation between vegetative cover, concentrations of volatile organic compounds (VOCs), and atmospheric conditions in urban air. The results indicate that vegetation plays a crucial role in reducing concentrations of air pollutants, particularly anthropogenic VOCs. This underscores the need to consider vegetation as an essential component in urban planning and air quality management. The presence of green areas in cities not only contributes to air purification but also provides a range of benefits for the environment, human health, and the overall well-being of urban communities. Future research should continue to explore this complex relationship between vegetation and air pollution to develop sustainable management strategies for the cities of the future.

We declare that each contribution to our project from the work(s) of other peoples published works or unpublished sources have been acknowledged and source of information have been referenced. We certify that we are solely responsible for any incomplete reference that may remain in our work.

We have read and understood the rules on plagiarism. We hereby declare that this piece of written work is the result of our own independent scholarly work, and that in all cases material from the work of others is acknowledged, and quotations and paraphrases are clearly indicated. No material other than that listed has been used. This written work has not previously yet been published.

**REFERENCES**


Urban Vegetation’s Impact on VOCs in Reggio Emilia

Global Journal of Botanical Science, 2023 Vol. 11


[40] Nowak D J. The effects of urban trees on air quality. USDA Forest Service 2002; 96-102.


Received on 08-11-2023  Accepted on 06-12-2023  Published on 15-12-2023

DOI: https://doi.org/10.12974/2311-858X.2023.11.06

© 2023 Marsili et al.; Licensee Savvy Science Publisher.

This is an open access article licensed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/3.0/) which permits unrestricted, non-commercial use, distribution and reproduction in any medium, provided the work is properly cited.