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Araştırma Makalesi - Research Article

The Importance of Pocket Parks on Air Quality: A Comparative Approach

Hava Kalitesinde Cep Parklarının Önemi: Karşılaştırmalı Bir Yaklaşım

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ABSTRACT

Population growth, increasing construction, and impervious surfaces are among the factors leading to the deterioration of the natural balance. Increasing population density has led to a gradual decrease in green areas for living spaces, transport routes and car parks. In addition, the rate of urbanisation and related environmental problems are one of the biggest threats to the sustainability of open green spaces. Accurate identification of problems, such as air, water, and soil pollution is critical to addressing current environmental problems and preventing future problems. Air pollution poses a significant threat to the global community and has sequential impacts on health systems, ecosystems and economies in both developed and developing countries. Cities are home to 50 per cent of the world's population and are expected to reach 70 per cent by 2050. The rapid urbanisation process leads to the transformation of natural and semi-natural landscapes into impervious surfaces and increased heat absorption rates. This study focuses on Jumeirah Island in Dubai. This artificial island is home to many businesses that support social life. Each café in these areas is located with public green areas in front of it and its own open spaces. In the study, 40 measurement points were established in two contrasting environmental conditions and air quality measurements were made manually. The stations are divided into blue and red stations and have contrasting characteristics. While the red measurement points have more green areas, water elements, qualified landscape texture, the blue measurement points have these characters to a lesser extent. Thanks to this comparison, the effect of vegetation texture and pocket parks on air quality in the study area was analysed. As a result of the analyses, the air quality in both areas was found to be good and acceptable, while the results at the red measurement points were found to be of better quality than the blue measurement stations. As a result of the study, the effect of water elements, qualified landscape design and vegetative texture on air quality has been proved with numerical data.

***Keywords**- Air Quality, Landscape and Air Quality, Artificial Island, Dubai*

ÖZ

Yoğun nüfus, artan yapılaşma ve geçirimsiz yüzeylerin doğal dengenin bozulmasına yol açan etmenler arasındadır. Artan nüfus yoğunluğu, yaşam alanları, ulaşım yolları ve otoparklar için yeşil alanların giderek azalmasına neden olmuştur. Ayrıca, şehirleşme hızı ve buna bağlı çevresel sorunlar, açık yeşil alanların sürdürülebilirliğine en büyük

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tehditlerden biridir. Hava, su ve toprak kirliliği gibi sorunların doğru bir şekilde tanımlanması, mevcut çevresel sorunların giderilmesi ve gelecekteki sorunların önlenmesi açısından kritik öneme sahiptir. Hava kirliliği, küresel toplum için önemli bir tehdit oluşturmakta ve hem gelişmiş hem de gelişmekte olan ülkelerde sağlık sistemleri, ekosistemler ve ekonomiler üzerinde ardışık etkiler yaratmaktadır. Kentler, dünya nüfusunun %50'sine ev sahipliği yapmakta ve bu oranın 2050 yılında %70'e ulaşması beklenmektedir. Hızlı şehirleşme süreci, doğal ve yarı doğal manzaraların geçirimsiz yüzeylere dönüşmesine ve ısı emme oranlarının artmasına neden olmaktadır. Bu çalışma, Dubai'deki Jumeirah Island bölgesine odaklanmaktadır. Bu yapay ada, sosyal yaşamı destekleyen birçok işletmeye ev sahipliği yapmaktadır. Bu bölgelerdeki her kafe, önünde kamuya açık yeşil alanlar ve kendi açık alanları ile birlikte bulunmaktadır. Çalışmada, iki zıt çevresel koşulda 40 ölçüm noktaları oluşturulmuş ve manuel olarak hava kalitesi ölçümleri yapılmıştır Istasyonlar mavi ve kırmızı istasyonlar olarak ikiye ayrılmakta ve birbirine zıt karakterde özelliklere sahiptir. Kırmızı ölçüm noktaları yeşil alanlara, su öğelerine, nitelikli peyzaj dokusuna daha çok sahipken, mavi ölçüm noktaları bu karakterlere daha az oranda sahiptir. Bu karşılaştırma sayesinde çalışma alanındaki bitkisel dokunun ve cep parklarının hava kalitesine olan etkisi incelenmiştir. İncelemeler sonucunda her iki alanında hava kalitesi iyi ve Kabul edilebilir oranlarda çıkarken kırmızı ölçüm noktalarındaki sonuçlar mavi ölçüm istasyonlarına göre daha kaliteli olduğu ortaya çıkmıştır. Çalışmanın sonucunda su öğelerinin, nitelikli peyzaj tasarımının, bitkisel dokunun hava kalitesine etkisi sayısal veriler ile ispatlanmıştır.

Anahtar Kelimeler- Hava Kalitesi, Peyzaj ve Hava Kalitesi, Yapay Ada, Dubai

I. INTRODUCTION

The increase in impermeable surfaces such as asphalt and concrete, resulting from population density and mechanization in urban environments, has caused a disruption in the natural balance. With increasing population density, green spaces for living areas, transportation axes, and parking lots have gradually diminished. In cities, in particular, open green spaces with regulatory functions, such as residential, industrial, business, traffic, and recreational areas, are becoming increasingly unable to fulfill their functions. In the early 19th century, open green spaces in urban planning were designed with an aesthetic function. Later, this changed, and open green spaces such as sports fields, parks, and gardens gained significant importance due to their perceived health benefits to the public (Çinçinoğlu, 2001). In this context, contemporary landscape design aims to serve people, provide opportunities for socialization, and ensure comfort, considering anthropometric measurements. In outdoor design decisions centered around human movement, spaces are created to harmonize with nature and adapt to natural conditions. This is also addressed through daily activities that directly affect human movement, such as air-humidity phenomena, water movement, and sunlight duration. Additionally, slower processes like soil and surface events, climate and temperature changes, and vegetation shifts are essential components of the urban ecosystem (Gürbüz and Arıdağ, 2013).

Open green spaces contribute significantly to urban landscapes in ecological, economic, health, and social aspects. They provide services such as maintaining the carbon and oxygen balance to prevent air pollution, ensuring energy savings by stabilizing temperature, preserving biodiversity, regulating wind, noise, humidity, and dust factors, offering flood control, attracting tourism, and increasing property values (Şefik et al., 2016; Karaşah and Sarı, 2023). In terms of health and social benefits, they offer opportunities for outdoor activities such as walking, jogging, social interaction, relaxation, recreation, reading, bird watching, photography, and landscape viewing. They also help regulate the climate, improve air quality, and assist in pollination and fertilization (Karaşah and Sarı, 2023; Gülpinar Sekban 2022; Gülpinar Sekban, Düzgünes, 2021).

The most significant threat to the sustainability of open green spaces is the pace of urbanization and the environmental issues that come with it. Especially in countries with high living standards, urbanization and the living conditions created by technological and industrial developments have exacerbated negative impacts on the environment. To eliminate or reduce current environmental problems and prevent future issues, it is crucial to accurately identify the sources of these problems (Yılmaz and Sezen Öz, 2004). The most critical of these problems are air, water, and soil pollution. Urban green spaces are an effective carbon sink. In addition to increasing the capacity of ecosystem carbon sinks through plant photosynthesis, they can mitigate the urban heat island effect and indirectly promote a reduction in carbon emissions (Karaşah and Sarı, 2023).

Air pollution poses a significant threat to global society, causing successive impacts on individuals, medical systems, ecosystems, and economies in both developing and developed countries. According to the World Health Organization (WHO), more than 90% of people live in areas where air pollution exceeds safe levels. Cities, where 50% of the world's population lives, produce 78% of carbon emissions and airborne particulate pollutants among all ecosystems. While air pollution affects all regions, there are significant regional differences in pollution levels. Many factors, including physicochemical transformations, meteorology, and emissions, influence air quality (Liang and Gong, 2020).

Most air pollution studies focus on assessing the effects of pollutants on the urban landscape. Very little is known about the relationships in small and medium-sized cities compared to megacities (Liang and Gong, 2020). Cities, as living organisms, have evolved into continuously growing volumes. Today, more than 50% of the world's population lives in urban areas, and it is projected that this figure will reach 70% by 2050 (Koç et al., 2017). Such a population increase elevates energy consumption, and the increased use of fossil fuels leads to urban heat islands. Moreover, the rapid urbanization process significantly alters the underlying surface, transforming the natural and semi-natural landscape that initially suited the regional ecological environment into an impermeable landscape, increasing heat absorption rates (Li et al., 2024).

Fuel consumption in urban areas, linked to population growth, causes air pollution, negatively impacting air quality. Pollutants that cause air pollution exist in both particulate (PM2.5 – particles smaller than 2.5 microns and PM10 – particles between 2.5 and 10 microns) and gas (ozone O3, nitrogen dioxide-NO2, sulfur dioxide-SO2) forms (Coşkun Hepcan and Cangüzel, 2021). These substances are released from fossil fuel combustion and vehicle emissions, remaining suspended in the atmosphere and negatively impacting human and animal life (Correa et al., 2016). Research shows that particulate matter and sulfur dioxide remain suspended in urban air masses. Pollutants, particularly affecting the respiratory and cardiovascular systems, cause various health problems. Elderly individuals and children are more affected by these conditions. Epidemiological studies conducted globally on the effects of air pollution indicate that gas pollutants and particulate matter have the potential to cause serious health effects such as respiratory and cardiovascular diseases, carcinogenic effects, and cardio-pulmonary mortality (Karakuş and Yıldız, 2019). Deaths linked to particulate matter have increased in recent years, with a study in the UK estimating that 5.4% of deaths were related to particulate matter (PM10) (Koç et al., 2017).

Increased use of fossil fuels to meet heating demands in winter intensifies the feeling of air pollution. However, air pollution is not just a winter issue. Extreme hot and dry weather can also increase the concentration of pollutants in the atmosphere (Coşkun Hepcan and Cangüzel, 2021).

Addressing environmental problems in urban environments first requires reducing the sources of these problems and developing alternatives. Given the rapid and intensive continuation of human activities, it is impossible to reduce pollutant sources to zero. In areas with excessive interference with natural spaces, climatic and topographical sensitivities emerge, causing pollutants to create disturbing levels of air pollution (Barış and Koç, 1997).

Plants, especially trees, provide numerous ecosystem services/functions such as shading, cooling the air, reducing the heat island effect, storing CO2, removing pollutants, enriching the soil with organic material like leaves, branches, and fruits, aerating the soil with their roots, providing food and shelter for wildlife, preventing rainwater from flowing superficially, feeding underground water sources, reducing wind and rainfall erosion, filtering noise, reducing energy consumption, and increasing property values. These functions, also referred to as ecosystem services, vary depending on the species, age, and characteristics of the environment in which the plants are located. For example, a tree in a park collects significantly more pollutants from the atmosphere than a street tree. Similarly, the tree in the park captures more carbon dioxide (Coşkun Hepcan and Hepcan, 2017).

II. STUDY AREA AND METHOD

The study focuses on the Jumeirah Island area in Dubai. Jumeirah Island is a notable artificial island that features over 700 villas and more than 50 residential units. The island not only offers housing options but also houses numerous businesses that support social life. Among these businesses are cafes, restaurants, markets, and various courses, providing residents with a wide range of social activities. Within the study, a public area was selected where social businesses are densely located in Jumeirah Island. In this region, each cafe has public green spaces in front of it, and each establishment offers its own outdoor area. Additionally, there are curbside parking spaces in front of these businesses, ensuring easy access for visitors. These areas promote public use while also integrating natural and social life (Figure 1).

Figure 1. Study area (Google Earth Pro®)

When examining the social facilities within the study area and the open green spaces in front of them, it is observed that these facilities are generally concentrated in six central points (Figure 2).

Figure 2. Distribution of social facilities in the study area from the central point (Google Earth Pro®)

III. METHODOLOGY

The study established 40 measurement stations, evenly distributed across two contrasting environmental conditions: the blue and red strips. The blue stations are located in areas far from water elements, near roads, with limited green space, and outside of pocket parks. On the other hand, the red stations are positioned within pocket parks, close to water features, and surrounded by high-quality green spaces. These stations were selected for their contrasting characteristics to ensure reliable comparisons. This approach strengthens the study's validity by capturing a range of environmental conditions, allowing for clearer observation of differences in the results (Figure 3).

- 40 measurement stations were established, divided into two contrasting categories: blue and red strips.
- Blue stations are near roadways with less greenery and no water elements.
- Red stations are located in green spaces, close to water features and parks.
- The contrasting locations allow for reliable comparisons between different environments.

🟦

20 measuring stations.

Blue coloured measurement points represent measurement stations with less open green areas, not in the pocket park, far from the water element and close to the highway compared to the measurement stations with red points.

🟥

20 measuring stations.

Measurement points in red colour represent measurement stations with a large extent of open green space, within the pocket park, close to the water feature and far from the roadway.

Figure 3. 40 measurement stations of study area (Google Earth Pro®)

IV. FINDINS

A. Evaluation of Measurement Results

The air quality measurements were conducted using highly sensitive and advanced technology, meticulously carried out to analyze the environmental conditions' effects on human health. Critical parameters such as Particulate Matter 2.5 (PM2.5), Particulate Matter 10 (PM10), Formaldehyde (HCHO), Total Volatile Organic Compounds (TVOC), Carbon Monoxide (CO), and Carbon Dioxide (CO2) were measured manually with handheld infrared devices, which accurately detected instantaneous changes due to their high sensitivity. Measurements taken at various time intervals were analyzed in detail and averaged to integrate into advanced analytical systems. The resulting average air quality index outcomes highlighted the potential impacts of environmental pollution on human health, creating a valuable database for regional air quality management and improvement efforts (Table 1-2).

Table 1. Average particulate matter *Blue* measurement stations

Blue Measurement Stations Particulate Matter							
Stations	**PM$_{2.5}$**	**PM$_{10}$**	**HCHO**	**TVOC**	**CO**	**CO$_2$**	**Average AQI**
1	161,87 µg/m^3	168,85µg/m^3	0,011µg/m^3	0,011µg/m^3	1,04µg/m^3	302,52µg/m^3	156,36µg/m^3
2	160,54 µg/m^3	162,45µg/m^3	0,015µg/m^3	0,012µg/m^3	1,57µg/m^3	256,74µg/m^3	162,74µg/m^3
3	158,64 µg/m^3	164,52µg/m^3	0,010µg/m^3	0,009µg/m^3	1,27µg/m^3	348,14µg/m^3	165,44µg/m^3
4	152,65 µg/m^3	157,84µg/m^3	0,012µg/m^3	0,008µg/m^3	2,04µg/m^3	284,75µg/m^3	159,74µg/m^3
5	161,78 µg/m^3	163,74µg/m^3	0,013µg/m^3	0,010µg/m^3	1,16µg/m^3	234,67µg/m^3	165,74µg/m^3
6	146,57 µg/m^3	148,75µg/m^3	0,021µg/m^3	0,016µg/m^3	1,57µg/m^3	214,74µg/m^3	152,74µg/m^3
7	142,57µg/m^3	143,57µg/m^3	0,020µg/m^3	0,017µg/m^3	1,50µg/m^3	327,64µg/m^3	150,47µg/m^3
8	138,74µg/m^3	157,60µg/m^3	0,021µg/m^3	0,018µg/m^3	1,34µg/m^3	249,74µg/m^3	142,36µg/m^3
9	122,97µg/m^3	148,22µg/m^3	0,011µg/m^3	0,009µg/m^3	1,64µg/m^3	206,57µg/m^3	130,74µg/m^3
10	157,64µg/m^3	149,34µg/m^3	0,009µg/m^3	0,006µg/m^3	1,34µg/m^3	204,36µg/m^3	165,74µg/m^3
11	127,42µg/m^3	136,74µg/m^3	0,021µg/m^3	0,018µg/m^3	1,34µg/m^3	210,74µg/m^3	130,74µg/m^3
12	134,85µg/m^3	128,36µg/m^3	0,022µg/m^3	0,018µg/m^3	1,27µg/m^3	221,67µg/m^3	141,85µg/m^3
13	124,37µg/m^3	119,46µg/m^3	0,021µg/m^3	0,016µg/m^3	1,46µg/m^3	237,49µg/m^3	130,74µg/m^3
14	119,74µg/m^3	106,63µg/m^3	0,014µg/m^3	0,011µg/m^3	1,43µg/m^3	241,37µg/m^3	125,74µg/m^3
15	117,46µg/m^3	121,45µg/m^3	0,006µg/m^3	0,003µg/m^3	1,37µg/m^3	243,17µg/m^3	125,74µg/m^3
16	115,57µg/m^3	108,96µg/m^3	0,010µg/m^3	0,009µg/m^3	1,82µg/m^3	274,11µg/m^3	120,74µg/m^3
17	108,46µg/m^3	100,34µg/m^3	0,011µg/m^3	0,007µg/m^3	1,48µg/m^3	213,76µg/m^3	134,74µg/m^3
18	104,76µg/m^3	98,85µg/m^3	0,018µg/m^3	0,014µg/m^3	1,41µg/m^3	207,64µg/m^3	120,57µg/m^3
19	142,37µg/m^3	136,48µg/m^3	0,022µg/m^3	0,019µg/m^3	1,47µg/m^3	202,10µg/m^3	145,57µg/m^3
20	141,78µg/m^3	146,35µg/m^3	0,021µg/m^3	0,015µg/m^3	1,36µg/m^3	213,87µg/m^3	145,36µg/m^3

Among the results analyzed, the highest PM2.5 value was recorded at 161.87 µg/m^3 at measurement point 1, while the lowest value of 104.76 µg/m^3 was noted at measurement point 18. Overall, a noticeable fluctuation in air quality was observed between the measurement points; the high value at point 1 is believed to be due to its proximity to intense traffic sources. On the other hand, the value of 104.76 µg/m^3 at point 18 indicates better air quality, suggesting that this area might be less exposed to pollution sources. Additionally, the close proximity of the measurement points implies that the effects on air quality may arise from local sources. This situation highlights the need for environmental regulations to improve air quality in regions with elevated values (Figure 4).

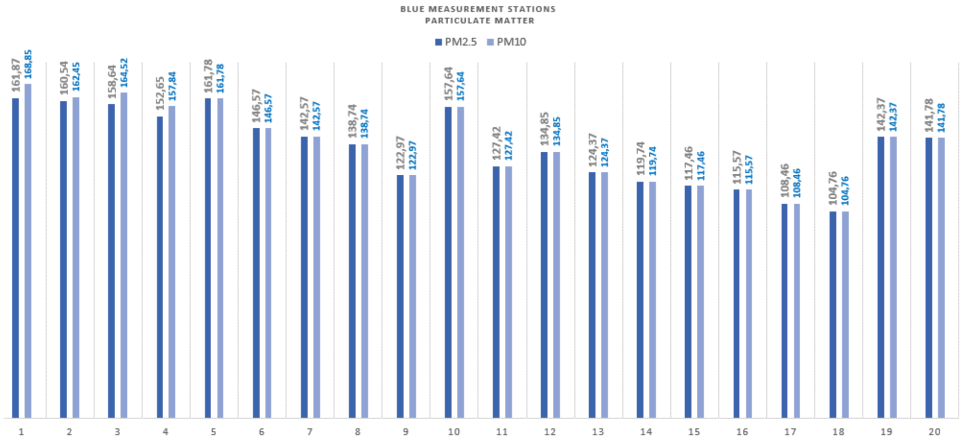

Figure 4. $PM_{2.5}$ ve PM_{10} measurement value graph

Among the analyzed results, the highest CO value was recorded at 2.04 µg/m³ at measurement point 4, while the lowest value was determined at 1.04 µg/m³ at measurement point 1. Overall, the data between these measurement points indicate a certain level of stability in air quality. Notably, the value of 2.04 µg/m³ at measurement point 4 shows a significant increase compared to the other points, suggesting that this may be attributed to specific pollution sources in that area. In contrast, the values at other measurement points were observed to range between 1.16 µg/m³ and 1.82 µg/m³. This situation implies that these areas may have been exposed to fewer pollution sources, resulting in generally better air quality (Figure 5).

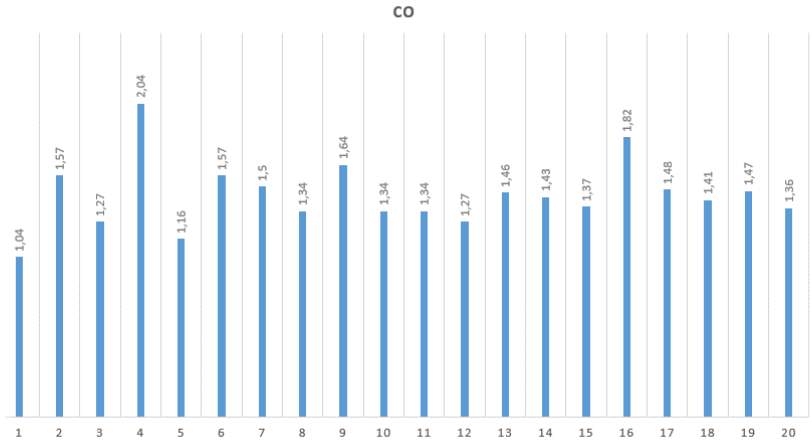

Figure 5. CO measurement value graph

Among the analyzed results, the highest CO2 value was recorded at 348.14 µg/m³ at measurement point 3, while the lowest value was noted at 202.10 µg/m³ at measurement point 19. Overall, a noticeable fluctuation in the measurement values was observed; particularly, the high value at measurement point 3 suggests that this area is likely close to intense pollution sources. In contrast, the values at other measurement points ranged between 204.36 µg/m³ and 327.64 µg/m³, indicating that some areas may have lower air quality and more significant environmental pollution effects. Additionally, the value of 202.10 µg/m³ at point 19 indicates generally better air quality, suggesting that this area is likely less exposed to pollution sources (Figure 6).

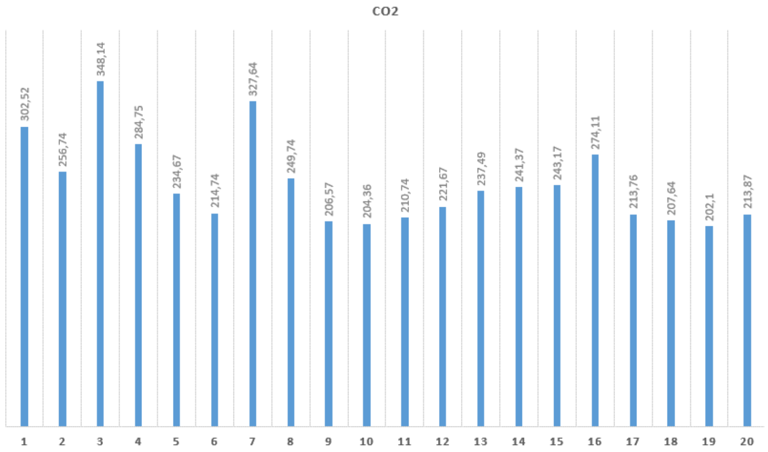

Figure 6. CO_2 measurement value graph

When examining the HVOC (High Volatile Organic Compounds) values, a range of measurements representing air quality was observed, with values fluctuating between 0.006 µg/m³ and 0.022 µg/m³. Generally, these measurement values remain at quite low levels. The highest value of 0.022 µg/m³ was recorded at measurement point 12, while the lowest value of 0.006 µg/m³ was noted at point 15. The low measurement values indicate that the air quality in these areas is generally quite good. However, the proximity of the measurement values suggests that the effects on air quality may stem from local sources.

In contrast, the TVOC (Total Volatile Organic Compounds) measurement values ranged from 0.003 µg/m³ to 0.019 µg/m³. The highest value of 0.019 µg/m³ was recorded at measurement point 18, while the lowest value of 0.003 µg/m³ was noted at point 15. Overall, these measurement values also remain low, indicating that air quality is generally good. The low levels of measurement suggest minimal air pollution in these areas, reflecting the effectiveness of environmental management practices. Notably, the value of 0.003 µg/m³ at measurement point 15 signifies a remarkable low level, indicating that this area enjoys clean air quality (Figure 7).

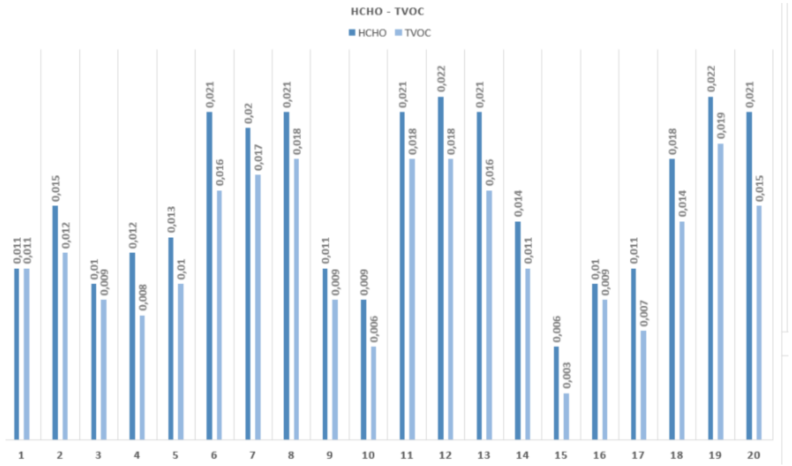

Figure 7. HCHO and TVOC measurement value graph

Another measurement point of the study is the red measurement points. In line with these measurement data, PM2.5, PM10, HCHO, TVOC, CO, CO2 measurement values were calculated (table x). in line with these calculations, the average air quality was determined (Table 2).

Table 2. Average particulate matter Red measurement stations

Red Measurement Stations Particulate Matter							
Stations	**$PM_{2.5}$**	**PM_{10}**	**HCHO**	**TVOC**	**CO**	**CO_2**	**Average AQI**
1	130,58 µg/m³	135,65 µg/m³	0,014 µg/m³	0,003 µg/m³	1,25 µg/m³	185,47 µg/m³	138,85 µg/m³
2	125,74 µg/m³	130,57 µg/m³	0,004 µg/m³	0,001 µg/m³	1,06 µg/m³	178,36 µg/m³	135,85 µg/m³
3	120,78 µg/m³	141,65 µg/m³	0,002 µg/m³	0,011 µg/m³	1,27 µg/m³	180,77 µg/m³	118,89 µg/m³
4	105,85 µg/m³	110,54 µg/m³	0,011 µg/m³	0,014 µg/m³	1,67 µg/m³	168,57 µg/m³	103,41 µg/m³
5	104,65 µg/m³	106,81 µg/m³	0,009 µg/m³	0,018 µg/m³	1,67 µg/m³	155,37 µg/m³	102,54 µg/m³
6	107,36 µg/m³	115,91 µg/m³	0,018 µg/m³	0,014 µg/m³	1,08 µg/m³	165,37 µg/m³	104,64 µg/m³
7	98,65 µg/m³	106,74 µg/m³	0,019 µg/m³	0,015 µg/m³	1,45 µg/m³	120,85 µg/m³	99,74 µg/m³

8	99,74 µg/m³	101,63 µg/m³	0,014 µg/m³	0,009 µg/m³	1,18 µg/m³	160,45 µg/m³	96,48 µg/m³
9	98,37 µg/m³	100,58 µg/m³	0,013 µg/m³	0,017 µg/m³	1,47 µg/m³	158,74 µg/m³	100,84 µg/m³
10	101,37 µg/m³	103,64 µg/m³	0,017 µg/m³	0,015 µg/m³	1,35 µg/m³	154,39 µg/m³	102,69 µg/m³
11	102,30 µg/m³	104,64 µg/m³	0,011 µg/m³	0,017 µg/m³	1,15 µg/m³	150,37 µg/m³	103,69 µg/m³
12	106,48 µg/m³	108,96 µg/m³	0,007 µg/m³	0,018 µg/m³	1,06 µg/m³	146,84 µg/m³	107,96 µg/m³
13	102,36 µg/m³	104,65 µg/m³	0,011 µg/m³	0,011 µg/m³	1,37 µg/m³	160,57 µg/m³	99,85 µg/m³
14	101,45 µg/m³	103,64 µg/m³	0,018 µg/m³	0,014 µg/m³	1,04 µg/m³	158,64 µg/m³	95,14 µg/m³
15	98,34 µg/m³	99,52 µg/m³	0,017 µg/m³	0,017 µg/m³	1,17 µg/m³	155,57 µg/m³	94,16 µg/m³
16	96,17 µg/m³	9949 µg/m³	0,018 µg/m³	0,009 µg/m³	1,14 µg/m³	149,68 µg/m³	93,17 µg/m³
17	81,75 µg/m³	85,85 µg/m³	0,019 µg/m³	0,007 µg/m³	1,18 µg/m³	150,37 µg/m³	80,14 µg/m³
18	98,34 µg/m³	100,54 µg/m³	0,011 µg/m³	0,015 µg/m³	1,21 µg/m³	147,67 µg/m³	96,15 µg/m³
19	99,47 µg/m³	100,58 µg/m³	0,014 µg/m³	0,017 µg/m³	1,27 µg/m³	146,68 µg/m³	96,48 µg/m³
20	99,87 µg/m³	101,75 µg/m³	0,006 µg/m³	0,008 µg/m³	1,26 µg/m³	143,87 µg/m³	93,14 µg/m³

When we analyse the PM2.5 results from the red measurement points, the results obtained show a distribution between 81.75 µg/m³ and 130.58 µg/m³. The highest measurement value was recorded at measurement point 1 with 130.58 µg/m³, which indicates that this region is potentially exposed to more pollutant sources. On the other hand, the lowest value at measuring point 16 with 81.75 µg/m³ indicates that the air quality is relatively better. In general, the measured values vary between 81.75 µg/m³ and 130.58 µg/m³, indicating that air quality varies between the various locations. Furthermore, the value of 99.74 µg/m³ at measuring point 8 suggests that the air quality is at an average level. Another highlight is the value of 81.75 µg/m³ at measurement point 16, which represents an area with generally good air quality, but also emphasises the need for measures to be taken regarding air pollution (Figure 8).

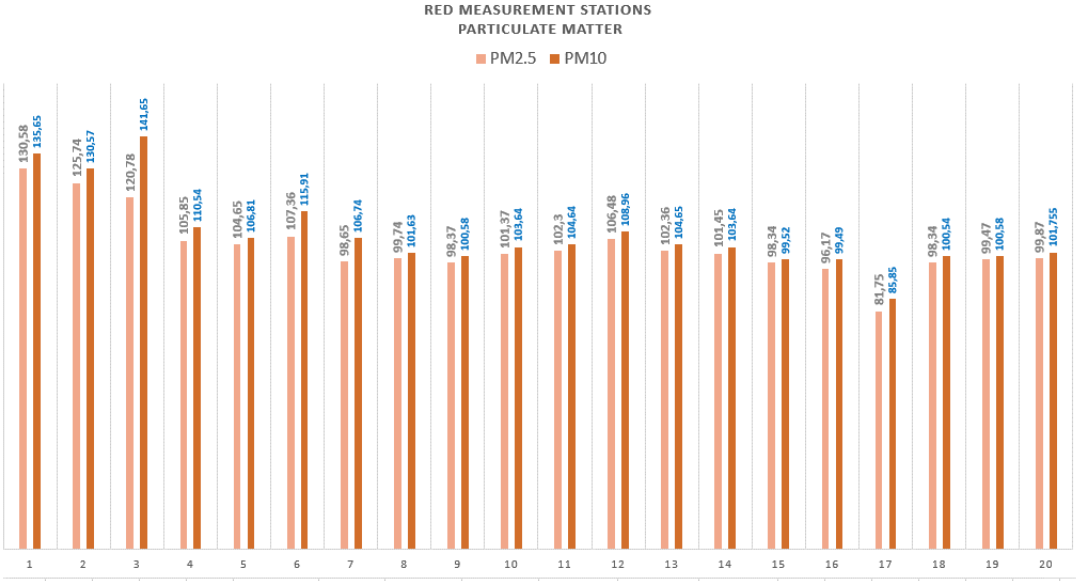

Figure 8. PM2.5 ve PM10 measurement value graph

When CO values from the red measurement points are analysed, the values obtained vary between 1.04 and 1.67. The highest value was recorded at measurement points 4 and 5 with 1.67, suggesting that these areas are potentially exposed to more pollutant sources. The lowest value was recorded at measurement point 14 with 1.04, suggesting that this region has better air quality. In general, the measured values vary between 1.04 and 1.67, indicating that the air quality varies between various locations. The value of 1.45 at measurement point 7 represents an average air quality level, while the value of 1.06 at measurement point 12 indicates that the air quality is at an acceptable level.

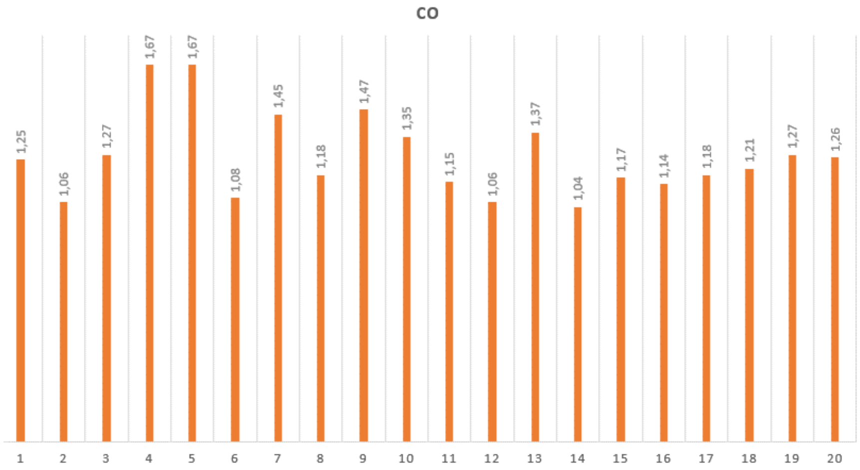

Figure 9. CO measurement value graph

These measurement data provide important information for monitoring carbon dioxide (CO_2) levels in a given region. The values obtained range from 120.85 to 185.47. The highest value was recorded at measurement point 1 with 185.47, indicating that this region is potentially exposed to more carbon dioxide emissions. The lowest value was recorded at measurement point 7 with 120.85, indicating that the air quality in this region is better. In general, the measured values show a distribution between 120.85 and 185.47, indicating that carbon dioxide levels vary at various points. The value of 160.45 at measurement point 8 represents an average carbon dioxide level, while the value of 146.84 at measurement point 12 indicates that the air quality is at an acceptable level (Figure 10).

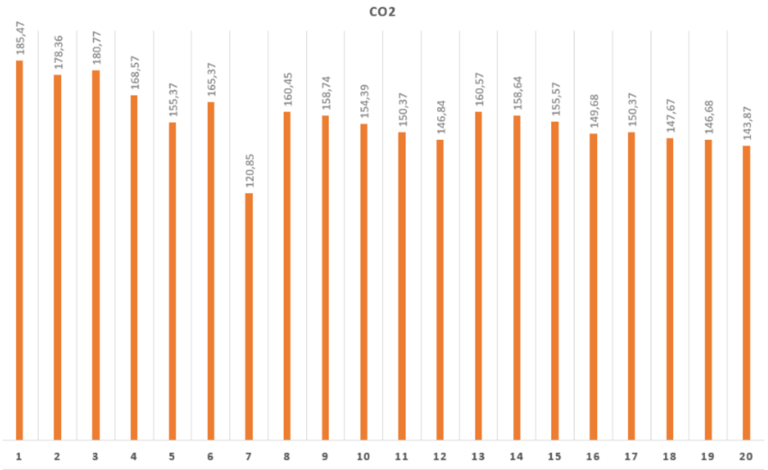

Figure 10. CO_2 measurement value graph

These measurement data provide important information on the monitoring of formaldihyde (HCHO) levels in a given area. The values obtained vary between 0.002 and 0.019. The highest value of 0.019 was recorded at measurement points 7 and 18, indicating that these areas are potentially exposed to more formaldihyde emissions. The lowest value was recorded at measuring point 3 with 0.002, indicating that the air quality is better at this point. In general, the measured values show a distribution between 0.002 and 0.019, indicating that formaldehyde levels vary between different points. The value of 0.007 at measurement point 12 indicates that the air quality is at an acceptable level (Figure 11).

According to the results, it provides important data regarding the monitoring of total volatile organic compounds (TVOC) levels in the study area. The measurement results vary between 0.001 and 0.018. The highest value was recorded at measurement points 5 and 12 with 0.018, indicating that there are more volatile organic compounds in these areas. The lowest value was recorded at measurement point 2 with 0.001, suggesting that the air quality is better at this point. The measurement values are generally in the range between 0.001 and 0.018, indicating that TVOC levels vary at various points. Especially the value of 0.007 at the 7th measurement point indicates that the air quality is at acceptable levels (Figure 11).

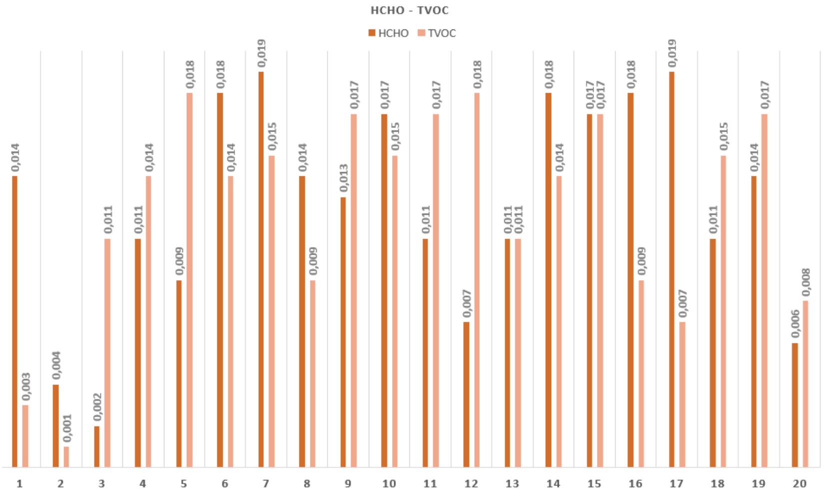

Figure 11. HCHO and TVOC measurement value graph

When the average air quality indices of both areas are compared, the highest value of 165,74 µg/m³ at the blue measurement points was determined as 138,85 µg/m³ at the red measurement points, i.e. the measurements taken from inside the park. While the highest value is 165.74 µg/m³ in areas not near the park, this value decreases to 138.85 µg/m³ inside the park. This shows that the green area and vegetation provided by the park has a positive effect on air quality. Lower particle density was observed in the areas around the park. The lowest result obtained at the blue measurement points was 120.57 µg/m³ and the lowest result in the park area was 80.14 µg/m³. While the lowest value is 120.57 µg/m³ in the remote areas of the park, this value decreases to 80.14 µg/m³ inside the park. This difference clearly shows that there is cleaner air and lower particulate matter concentrations inside the park (Figure 12).

Figure 12. Average air quality comparisons of both study areas

V. CONCLUSION AND RECOMMENDATIONS

Within the scope of this study, two areas that play an important role in determining air quality were compared. Both areas have different landscape features and these features were selected within the scope of the study. In order to make a reliable comparison, the locations of the areas were also taken into consideration. In addition, the study sites are located very close to each other, which means that the emissions from both sites are common. The measurements focused on carbon dioxide (CO2), carbon monoxide (CO), fine particulate matter (PM2.5 and PM10), total volatile organic compounds (TVOC) and formaldehyde (HCHO) levels.

In the comparison, a significant difference was observed between the carbon monoxide (CO) values of the area close to the roadside and the CO values of the pocket park. The CO values of the roadside area ranged between 1.04 µg/m³ and 2.04 µg/m³ between measurements, while the CO values in the car park area ranged between 1.04 µg/m³ and 1.67 µg/m³. These results show that the area close to the roadside has generally higher

CO levels than the pocket park. For example, the highest measurement at the roadside was 2.04 µg/m³, while the highest measurement at the car park was only 1.67 µg/m³. This shows that the roadside area is more exposed to traffic-related emissions and is therefore characterised by higher CO values. On the other hand, green spaces such as pocket parks appear to have the potential to improve ambient air quality. These findings emphasise the importance of open green spaces in improving air quality and demonstrate the necessity of integrating green spaces in urban planning.

There is a significant difference between the carbon dioxide (CO2) values of the roadside area and the CO2 values of the pocket park. The CO2 values of the roadside area vary between 202.10 µg/m³ and 348.14 µg/m³ between measurements. Most of these values are above the 200 µg/m³ level, with the highest measurement recorded at 348.14 µg/m³. This indicates that the roadside area is characterised by higher CO2 levels due to its exposure to traffic emissions and other pollution sources. On the other hand, the CO2 values of the pocket park vary between 120.85 µg/m³ and 185.47 µg/m³. These values are significantly lower compared to the area close to the roadside. The highest measurement was 185.47 µg/m³, while the lowest measurement was 120.85 µg/m³. These results suggest that green spaces, especially pocket parks, have the potential to improve ambient air quality. In this context, it can be said that open green spaces have a great importance in terms of reducing air pollution and thus improving the quality of life in the city. These findings emphasise the necessity of protecting and increasing green spaces in urban planning.

Total volatile organic compounds (TVOC) values of the roadside area vary between 0.003 µg/m³ and 0.019 µg/m³. The highest measurement was 0.019 µg/m³, while the lowest value was 0.003 µg/m³. These results show that the roadside area is exposed to various emissions and therefore TVOC levels vary. On the other hand, the TVOC values of the pocket park are at lower levels. The measurements in the park vary between 0.001 µg/m³ and 0.018 µg/m³. The highest TVOC value was 0.018 µg/m³, while the lowest value was recorded as 0.001 µg/m³. These findings indicate the capacity of green areas to improve ambient air quality. As a result, the TVOC levels of the roadside area are significantly higher compared to the pocket park. This shows the impact of roadside traffic and other pollution sources. Therefore, the importance of open green spaces in improving air quality is emphasised once again.

The formaldehyde (HCHO) values of the roadside area vary between 0.006 µg/m³ and 0.022 µg/m³. The highest value was 0.022 µg/m³ and the lowest value was 0.006 µg/m³. This suggests that roadside traffic and emissions have an impact on formaldehyde levels. On the other hand, HCHO values in the pocket park are lower. Measurements in the park vary between 0.002 µg/m³ and 0.019 µg/m³. The highest formaldehyde value was 0.019 µg/m³, while the lowest value was 0.002 µg/m³. These findings indicate that the park offers a healthier ambient air quality.

When PM2.5 and PM10 values in the roadside area and the pocket park are compared, the roadside area has significantly higher particulate matter (PM) concentrations. This comparison clearly shows that roadside areas with heavy traffic are in a worse condition in terms of air pollution compared to green areas such as pocket parks. Roadside PM2.5 values: 161.87 µg/m³ to 104.76 µg/m³. The highest value is 161.87 µg/m³ and the lowest value is 104.76 µg/m³. Mobile Park PM2.5 values: 130.58 µg/m³ to 81.75 µg/m³. The highest value is 130.58 µg/m³ and the lowest value is 81.75 µg/m³. These results show that the roadside area is much more polluted in terms of PM2.5. The highest PM2.5 value measured at the roadside (161.87 µg/m³) is about 24% higher than the highest value at the pocket park (130.58 µg/m³). Furthermore, even the lowest PM2.5 value measured at the roadside is quite close to the highest value at the pocket park, indicating that the roadside area is constantly exposed to high PM2.5 levels.

Roadside PM10 values: 168.85 µg/m³ to 98.85 µg/m³. The highest value is 168.85 µg/m³ and the lowest value is 98.85 µg/m³. Mobile Park PM10 values: 135.65 µg/m³ to 85.85 µg/m³. The highest value is 135,65 µg/m³ and the lowest value is 85,85 µg/m³. In terms of PM10, the pollution level of the roadside area is much higher. The highest PM10 value measured at the roadside (168.85 µg/m³) is 24.5% higher than the highest value measured at the pocket park (135.65 µg/m³). Moreover, even the lowest PM10 value measured at the roadside (98.85 µg/m³) is almost the same as the highest value in the pocket park. As a result, for both types of particulate matter (PM2.5 and PM10), the roadside area has higher pollution levels than the pocket park. This confirms the impact of roadside traffic and vehicle emissions on air pollution. The pocket park makes a significant contribution to clean air quality with lower emission levels, especially for PM2.5 values. PM10 values also show a similar trend, emphasising once again how effective green areas are in improving air quality. This study clearly shows that green areas, especially pocket parks, have an important role in improving air quality and reducing particulate matter concentration. In the light of the findings obtained in the study, the following suggestions were made for future studies;

- Improving green infrastructure in densely populated areas and along roadsides can be achieved through the expansion of small-scale green spaces, especially pocket parks and green corridors. These areas play a key role in improving air quality, while also providing healthy living spaces.

Afforestation contributes to the reduction of harmful particles, especially PM2.5 and PM10, by supporting particulate matter absorption.

- In urban planning, it is necessary to create tree-filled buffer zones between heavily trafficked roads and residential areas. These buffer zones can significantly reduce roadside air pollution. In addition, integrating bicycle and pedestrian routes with green areas will both create sustainable transport opportunities and make the urban transport network environmentally friendly.
- Limiting the use of vehicles in areas with heavy traffic or restricting access to private vehicles in some areas will also be an effective solution. In these areas, sustainable transport options such as public transport, cycling and walking routes should be encouraged. Increasing the use of electric vehicles will provide a significant environmental benefit by reducing the emission of CO, CO2 and other harmful gases.
- The number of pocket parks should be increased in densely built-up urban areas. These parks not only improve air quality, but also provide rest and breathing spaces for city dwellers. By integrating biofiltration systems into pocket parks, rainwater can be treated naturally and environmental sustainability can be increased.
- Public awareness should be raised about the positive effects of green spaces on air quality. To this end, people should be encouraged to be environmentally conscious and contribute to the protection of green areas. In addition, educational programmes should be organised through schools and communities.
- Installation of more air quality monitoring stations throughout the city will facilitate the development of solutions based on instant data. Thanks to these systems, rapid intervention can be made in areas with high pollution, and green space and traffic regulations can be optimised according to this data. Increasing the use of public transport, bicycles and electric vehicles will improve air quality by reducing emissions. More pedestrian and bicycle paths should be built to encourage city dwellers to use environmentally friendly modes of transport.

In conclusion, the air quality examined in this study is a pioneering region in Dubai's ecological research. The United Arab Emirates has undertaken many efforts to enhance, develop and improve air quality and these efforts are ongoing. One of the most important reasons for the high quality of the results achieved is the influence of the vision and policies in the management of the city. Decision makers and policies implemented are of great importance on these results. The most important component of the professional discipline of landscape architecture is plants. Therefore, landscape architects have an important influence on this issue. It can be said that this situation is clearly seen in the results of the study. In addition, the study was carried out with the data obtained from a region with a hot and desert climate. It is thought that these results will form the basis for future studies.

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