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TOWARDS CLEAN AIR IN KARACHI: SCIENTIFIC FRAMEWORK AND IMPERATIVE FOR A COMPREHENSIVE REAL-TIME AIR QUALITY MONITORING SYSTEM

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Abstract:

Karachi's complex urban landscape, characterized by seven districts, industrial zones, trading ports, and bustling commercial sectors, underscores the gravity of air pollution's multifaceted impacts. This study systematically dissects the intricate web of pollution sources, including poor fuel quality, industrial emissions, open burning practices, vehicular traffic congestion, and maritime shipping activities. These sources collectively introduce a wide array of harmful particulates, gases, and toxins into the atmosphere, profoundly affecting air quality and public health.

The absence of a real-time air quality monitoring system exacerbates the city's pollution challenges. The study conducted in late 2020 meticulously analyzes air quality at 90 distinct locations of residential, commercial and industrial areas through environmental laboratories, out of the 90 locations examined, a staggering 51 locations exhibit air quality measurements that surpass the permissible limits set by SEPA. The findings unequivocally substantiate the critical issue at hand, as levels of fine particulate matter ($PM_{2.5}$) and (PM_{10}) substantially exceed the World Health Organization's stipulated guidelines & Sindh Environmental Quality Standards. This data forms the scientific backbone for the compelling call to action presented in this paper.

Against this backdrop, SEPA proposes the establishment of an advanced air quality monitoring infrastructure. This proposed system would comprise strategically positioned online continuous monitoring stations, designed to operate in synergy with the city's Integrated Command Control Centre. By continuously generating real-time data on air pollutant concentrations, this infrastructure would facilitate the development of an Air Quality Index (AQI), a universally recognized metric for gauging air quality levels. In doing so, the AQI would empower stakeholders with a nuanced understanding of pollution gradients, enabling evidence-based policy formulation and corrective interventions.

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This paper is positioned as a scientific clarion call, advocating for the establishment of a comprehensive air quality monitoring system as a formidable tool in addressing Karachi's environmental challenges. By amalgamating precise scientific methodologies, technological advancements, and sustainable practices, this initiative aspires to pave the way for a healthier, resilient, and ecologically balanced Karachi. As the complexities of urban environments persist, the scientific rigor underlying this proposal marks a critical step towards reclaiming Karachi's air quality and securing a sustainable future for its inhabitants.

Keywords: Urban air pollution: Air quality monitoring Karachi: Particulate matter ($PM_{2.5}$): Environmental impact: Sustainable development: Pollutant sources: Air quality index (AQI): Public health: Environmental sustainability.

1. Introduction

Air pollution has significant effects on public health and environmental sustainability, making it a serious threat to world peace. The amount of dangerous chemicals that are being released into the atmosphere from a variety of sources, including natural processes, automobile emissions, and industrial activity, is alarmingly high. The seriousness of this widespread problem was highlighted by the World Health Organization (WHO), which revealed that air pollution causes an astounding 7 million fatalities globally each year.

Pakistan's air quality ranked sixth globally, primarily as a result of emissions from industrial and traffic sources as well as agricultural burning. According to estimates, air pollution shortens Pakistani people's lives on average by around four years. The transportation industry in Karachi is a major source of air pollution as a result of the different pollutants it emits. Air quality is deteriorated by rickshaws, motorcycles, two- and three-cylinder cars, heavy-duty trucks with diesel engines, and outdated buses. The following primary species are released into the exhaust when conventional petroleum fuels like gasoline and diesel burn in engines: nitrogen, water, CO_2, O_2, NO_x, CO, unburned hydrocarbons (VOCs), and PM. It is also possible to create secondary species such as ammonia, N_2O, SO_2, and aldehydes. This research article focuses on Karachi, Pakistan, a city dealing with growing air pollution issues. This paper will examine the scientific foundation and necessity of a thorough real-time air quality monitoring system in Karachi, emphasizing the need to address the complex interactions between fuel use, industrial expansion, and pollutant creation. Because Karachi is located at the crossroads of rapidly expanding automobile congestion, burgeoning industrialization, and urbanization, it is imperative to

comprehend the dynamics of air pollution in order to develop effective mitigation solutions.

Air pollution is a worldwide threat with far-reaching effects that transcends regional boundaries. The WHO's 2019 report emphasizes the pervasiveness of this issue by demonstrating the large-scale, cross-continental impact of air pollution-related fatalities. The complex interplay of indoor and outdoor sources contributes to the detrimental effects of air pollution on human health. Particulate matter has become a significant issue due to its role in a number of respiratory and cardiovascular disorders [1].

Investigating the mechanisms underlying pollutant generation becomes crucial to understanding the intricacies of air pollution. The criterion pollutants—particulate matter, lead, ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide—act as reference points for determining the acceptable exposure limits. Comprehending the source, makeup, and consequences of these contaminants offers a fundamental structure for formulating focused remedies [2,3].

Industrial pollutants undergo a variety of intricate transformations. Primary pollutants that exit combustion processes instantly interact with one another to produce secondary pollutants in the atmosphere. Sulfur and nitrogen oxides, the two main components of secondary particulate matter, vary depending on a number of factors, such as the fuel type and combustion conditions. Pakistan's industrial sector is growing, thanks in large part to a development in the manufacturing sector, which releases a lot of harmful pollutants into the environment.

The crucial role that fuels play in generating pollution is at the center of the conversation about air pollution. Pakistan's industrial sector uses a variety of fuels, each with special qualities of its own. Compressed natural gas, coal, diesel, firewood, and furnace oil [4,5]

Urbanization and an expanding industrial sector are posing challenges to Karachi, one of South Asia's largest and most populous cities. The different sources of pollution in the city, including natural processes, automobile emissions, and industrial activities, are intimately linked to the city's air quality. The consequences of decreasing air quality are numerous, ranging from detrimental impacts on health to devastation of the environment [6].

This issue emanates from various sources, including industrial activities, vehicular emissions, uncontrolled waste burning in urban areas, and deficiencies in drainage, sanitation, and waste disposal systems.

The Sindh Environmental Protection Agency (SEPA) plays a crucial role in addressing environmental concerns in the region. As an authoritative body responsible for environmental protection in Sindh, SEPA has implemented measures to mitigate air pollution. These efforts encompass initiatives such as the establishment of vehicle emission standards, rigorous inspection programs, the promotion of alternative fuels and renewable energy sources and the enforcement of industrial emission standards.

However, despite these proactive measures, challenges persist. SEPA's endeavors to regulate and monitor pollutants effectively are hampered by this gap, particularly in a city like Karachi, where industrial growth and vehicular density are on the rise.

As the research paper unfolds, detailed insights into specific pollutants, their formation mechanisms, and the dynamic nature of industrial emissions will contribute to a nuanced understanding. By integrating scientific knowledge with practical solutions, this research aims to pave the way for sustainable development and a healthier environment in Karachi and other region of Sindh.

The need for comprehensive techniques for monitoring and managing pollutants is growing along with the global awareness of the detrimental effects that air pollution has on human health. The study "Towards Clean Air in Karachi" becomes more important in this regard, with the goal of adding to the larger conversation about reducing air pollution and promoting environmental sustainability.

2. Experimental work

Material & Method

Ambient Air Quality Analysis Method (Electrochemical Sensing method & Light Scattering techniques) are used for Ambient Air Quality testing:

Instrumentation:

Air pointer (Air Quality Monitoring system) Model AQM-006 used to detect the following parameters NO (ug/m3), NO2 (ug/m3), SO2 (ug/m3), CO (mg/m3) O3 (ug/m3), PM 2.5 (ug/m3) PM 10 (ug/m3).

Sensing method and Selection of location

Air Quality Station (Air pointer) is being calibrated and installed approximately 4 m above the ground at the designated Area Ambient Air Analysis at each particular Area of all assigned districts in Karachi. Due to High amount of Smog in Pakistan, This Experiment is focused on improving

Air Quality by conducting Ambient Air Quality Analysis, of PM2.5 and PM10 Parameter Specially.

3. Results and Discussions

The Experiment is conducted to monitor Air pollution load in Karachi, to improve Air Quality and regulate the Air pollution limitation as per SEQS,

AIR QUALITY OF KARACHI

The Sindh Environmental Protection Agency (SEPA) has outlined the PM2.5 & PM10 in air quality Analysis of all districts of Karachi city (District South, District Central, District East, District East, District Korangi, District Malir,) in November 2020.

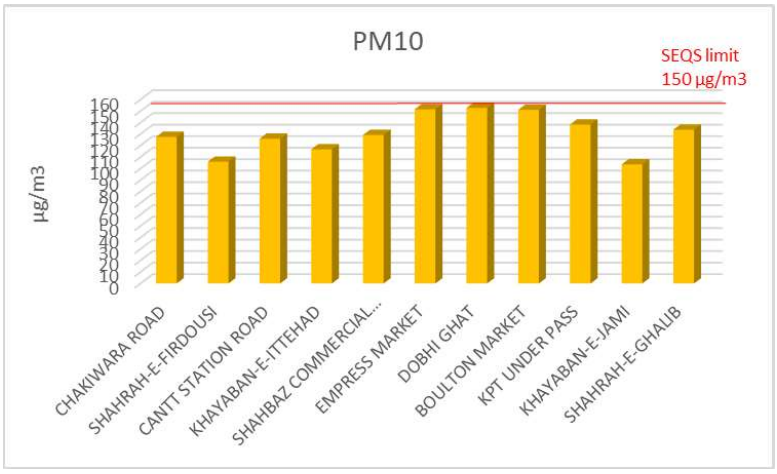
District South

As part of ongoing testing, 11 sites (Area's) in the Southern District of the Karachi city were selected and were tested for ambient air quality. During this activity, the air quality was evaluated based on fine particulate matters $PM_{2.5}$, PM_{10} an Air Quality Index (AQI) is also calculated.

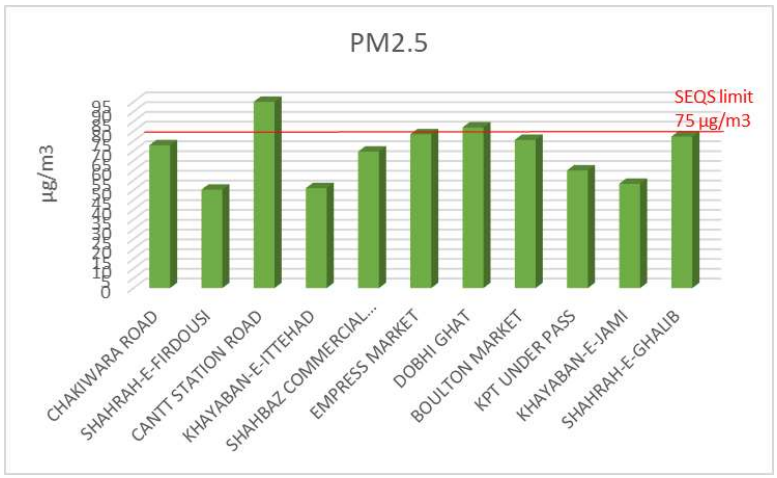
Location	PM_{10}	$PM_{2.5}$	AQI	
	($\mu g/m^3$)	($\mu g/m^3$)	PM_{10}	$PM_{2.5}$
CHAKIWARA ROAD	127.5	72.83	216.8	159.9
SHAHRAH-E-FIRDOUSI	105.9	50.2	177	137.3
CANTT STATION ROAD	125.9	95	177.3	171.3
KHAYABAN-E-ITTEHAD	116.7	51	182.6	138.3
SHAHBAZ COMMERCIAL AREA	129.2	69.6	189	158.2
EMPRESS MARKET	151.5	78.4	200.5	162.8
DOBHI GHAT	152.7	81.95	203.2	164.6
BOULTON MARKET	151	75.6	201.5	161.3
KPT UNDER PASS	138.2	60	193.6	151.3
KHAYABAN-E-JAMI	103.6	53.2	175.8	143.6
SHAHRAH-E-GHALIB	133.8	77.3	191.4	162.2
SEQS Limits	**150**	**75**		

Whereas, PM_{10} levels in 27.27 % locations had exceeded the SEQS limit i.e., 150 µg/m^3 which include Boulton market, Empress market and Dobhi ghat.

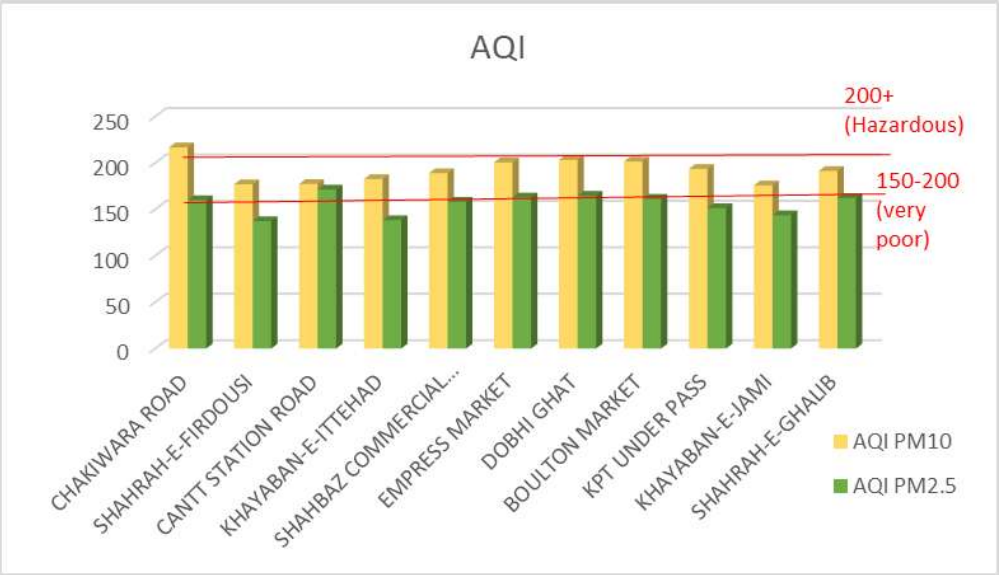
Graphical Representation



For $PM_{2.5}$, 45.45 % points had found to surpassed the SEQS limit i.e., 75 µg/m^3 which include Boulton market, Shahrah-e-Ghalib, Empress market, Dobhi ghat and Cantt station road.



In terms of Air Quality Index (AQI), 36.36 % locations were found to have hazardous (200+) air quality while the rest contained very poor air quality (150-200).



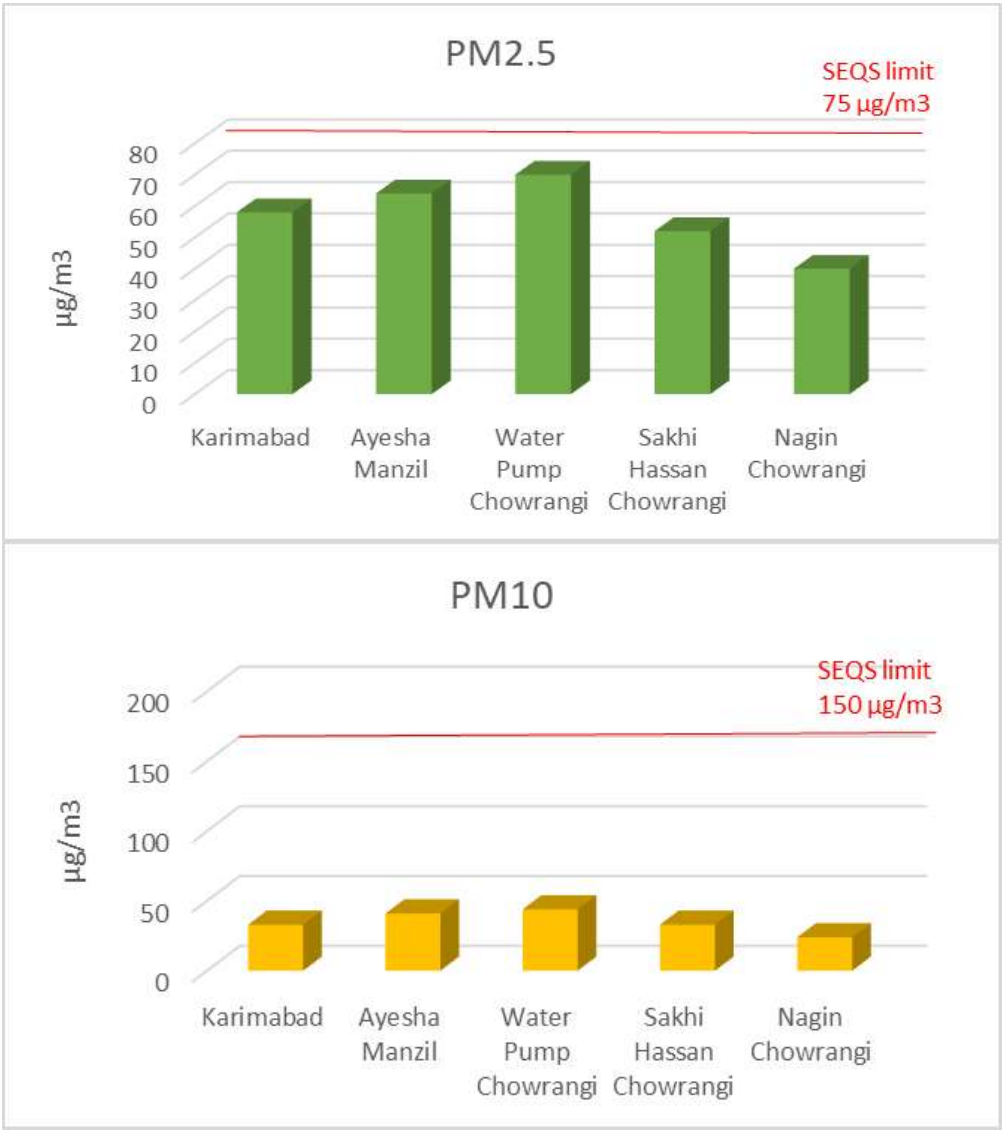
District Central

Sindh Environmental Protection Agency (SEPA) Conducted monitoring of air quality at five sites (Area's) of (Central District) Karachi City $PM_{2.5}$, PM_{10} an Air Quality Index (AQI) is also calculated.

Location	**PM2.5**	**PM10**	**AQI**
	µg/m3	**µg/m3**	
Karimabad	58	33	Fine
Ayesha Manzil	64	41	Fine
Water Pump Chowrangi	70	44	Fine
Sakhi Hassan Chowrangi	52	33	Fine
Nagin Chowrangi	40	24	Fine
SEQS Limits	**75**	**150**	

No location has exceeded the SEQS limits.

Graphical Representation



No location has surpassed the SEQS limit of 75 µg/m^3 for $PM_{2.5}$, 500 µg/m^3 for $PM_{1.0}$ and 150 µg/m^3 for PM_{10}.

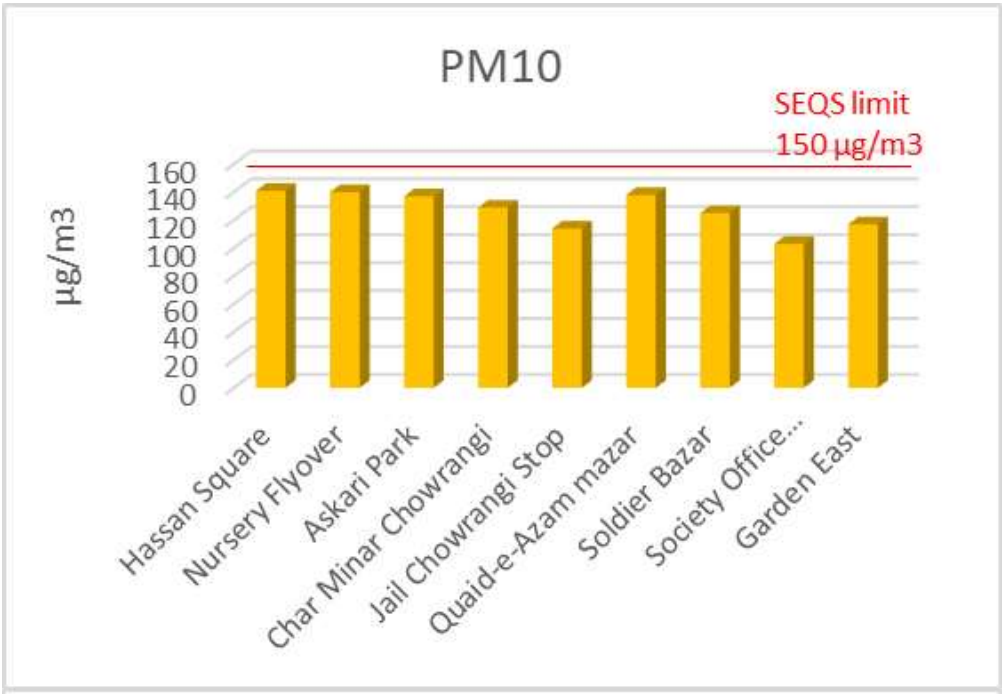
District East

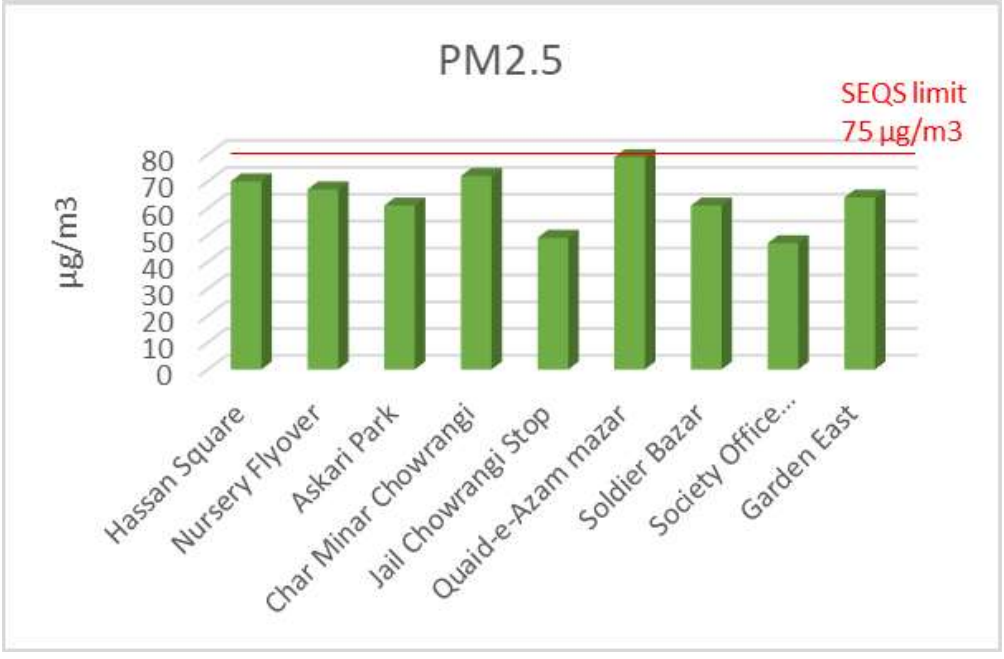
Air quality monitoring of District East Karachi.

Location	PM_{10}	$PM_{2.5}$
	µg/m3	µg/m3
Hassan Square	141	70
Nursery Flyover	140	67
Askari Park	137	61
Char Minar Chowrangi	129	72
Jail Chowrangi Stop	114	49
Quaid-e-Azam mazar	138	79
Soldier Bazar	125	61
Society Office Chowrangi	103	47
Garden East	117	64
SEQS Limit	**150**	**75**

No location had surpassed the SEQS limit for PM_{10} (150 µg/m^3). Whereas, only the location of Quaid-e-Azam mazar had exceeded the SEQS of $PM_{2.5}$ (75 µg/m^3).

Graphical Representation





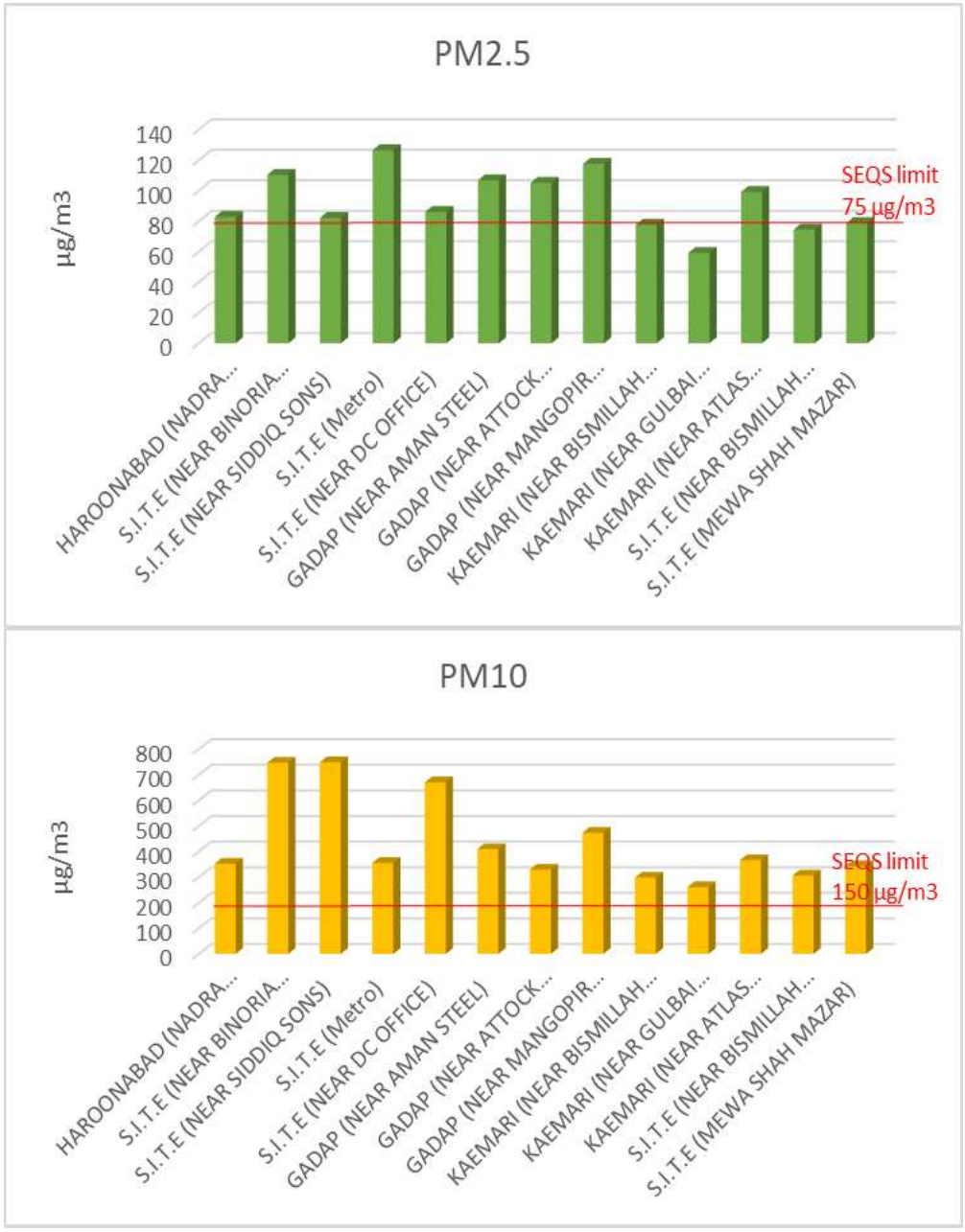
West District

Sindh Environmental Protection Agency (SEPA) Conducted monitoring of air quality at 14 sites (Area's) of (District west) Karachi $PM_{2.5}$, PM_{10}

Location	PM2.5	PM10
Units	µg/m3	µg/m3
HAROONABAD (NADRA MEGA FRANCHISE)	82.8	352.6
S.I.T.E (NEAR BINORIA HOTEL)	110.4	746.8
S.I.T.E (NEAR SIDDIQ SONS)	82.2	748.6
S.I.T.E (Metro)	126.5	355.3
S.I.T.E (NEAR DC OFFICE)	86.1	670.4
GADAP (NEAR AMAN STEEL)	106.8	409.5
GADAP (NEAR ATTOCK PETROL PUMP)	105.1	329.4
GADAP (NEAR MANGOPIR MAZAR)	117.6	473.2
KAEMARI (NEAR BISMILLAH MASJID)	77.7	298.1
KAEMARI (NEAR GULBAI WEGHBRIDGE)	59.2	261
KAEMARI (NEAR ATLAS BATTERY)	99.1	366.3
S.I.T.E (NEAR BISMILLAH HOTEL)	74.5	306.4
S.I.T.E (MEWA SHAH MAZAR)	78.8	342.9
SEQS Limit	**75**	**150**

In air analysis, 84.62 % locations had transcended the SEQS limit for $PM_{2.5}$ (75 µg/m^3), except Kaemari (near Gulbai weghbridge) and S.I.T.E (near Bismillah hotel). While, 100 % locations had surpassed the SEQS limit for PM_{10} (150 µg/m^3).

Graphical Representation

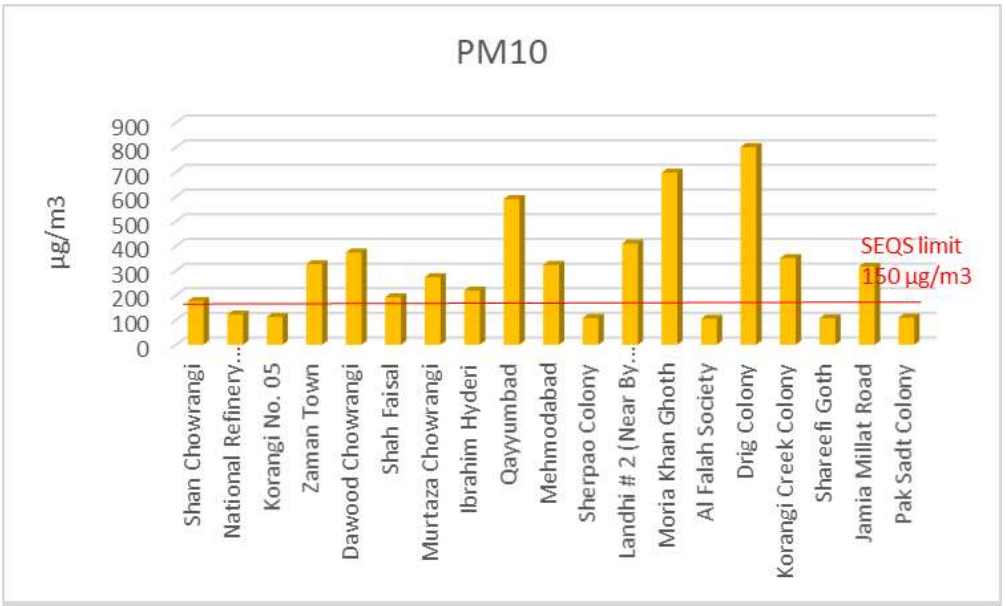


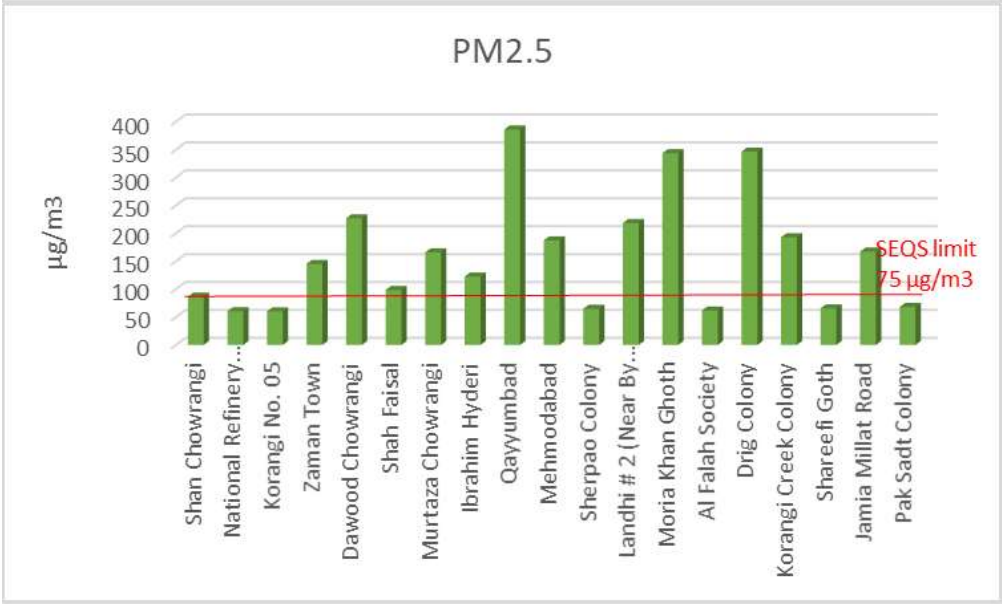
Korangi District

SEPA monitored the levels of $PM_{2.5}$, PM_{10} OF 19 locations in Korangi district of Karachi.

Location	PM2.5	PM10
	µg/m3	**µg/m3**
Shan Chowrangi	86.501	176.94
National Refinery Back Side	60.405	122.086
Korangi No. 05	60.29	112.425
Zaman Town	145.24	326.1
Dawood Chowrangi	227	373.62
Shah Faisal	98.544	192.264
Murtaza Chowrangi	165.846	273.46
Ibrahim Hyderi	122.563	219.096
Qayyumbad	385.979	589.829
Mehmodabad	187.376	323.123
Sherpao Colony	64.96	108.06
Landhi # 2 (Near By Govt. College)	218.5	409.96
Moria Khan Ghoth	343.5	697.16
Al Falah Society	61.75	104.98
Drig Colony	346.42	801.2
Korangi Creek Colony	193	351
Shareefi Goth	65.48	107
Jamia Millat Road	167.41	316.1
Pak Sadt Colony	68.16	109.35
SEQS Limit	**75**	**150**

No location has exceeded the SEQS limit (85 dB) for noise. Whereas, 68.42 % locations had transcended the SEQS limits for both $PM_{2.5}$ (75 µg/m^3) and PM_{10} (150 µg/m^3).


PM10
µg/m3
900
800
700
600
500
400
300
200
100
0
SEQS limit
150 µg/m3
Shan Chowrangi
National Refinery...
Korangi No. 05
Zaman Town
Dawood Chowrangi
Shah Faisal
Murtaza Chowrangi
Ibrahim Hyderi
Qayyumbad
Mehmodabad
Sherpao Colony
Landhi # 2 (Near By...
Moria Khan Ghoth
Al Falah Society
Drig Colony
Korangi Creek Colony
Shareefi Goth
Jamia Millat Road
Pak Sadt Colony

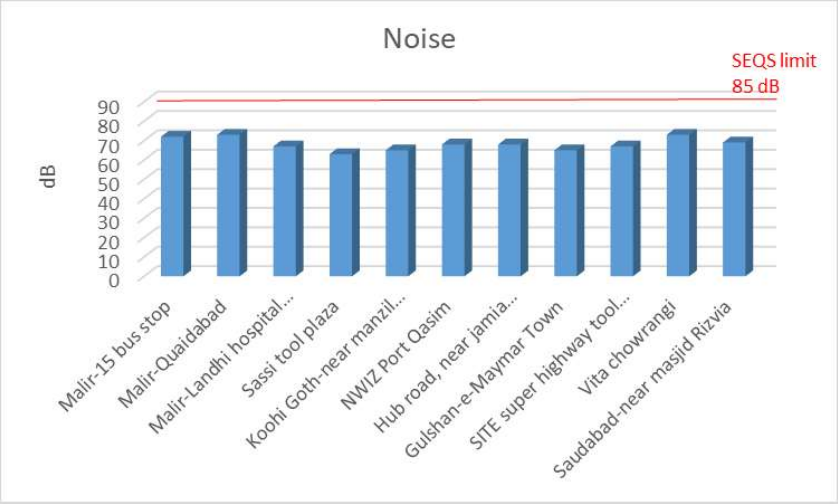

PM2.5
µg/m3
400
350
300
250
200
150
100
50
0
SEQS limit
75 µg/m3
Shan Chowrangi
National Refinery...
Korangi No. 05
Zaman Town
Dawood Chowrangi
Shah Faisal
Murtaza Chowrangi
Ibrahim Hyderi
Qayyumbad
Mehmodabad
Sherpao Colony
Landhi # 2 (Near By...
Moria Khan Ghoth
Al Falah Society
Drig Colony
Korangi Creek Colony
Shareefi Goth
Jamia Millat Road
Pak Sadt Colony

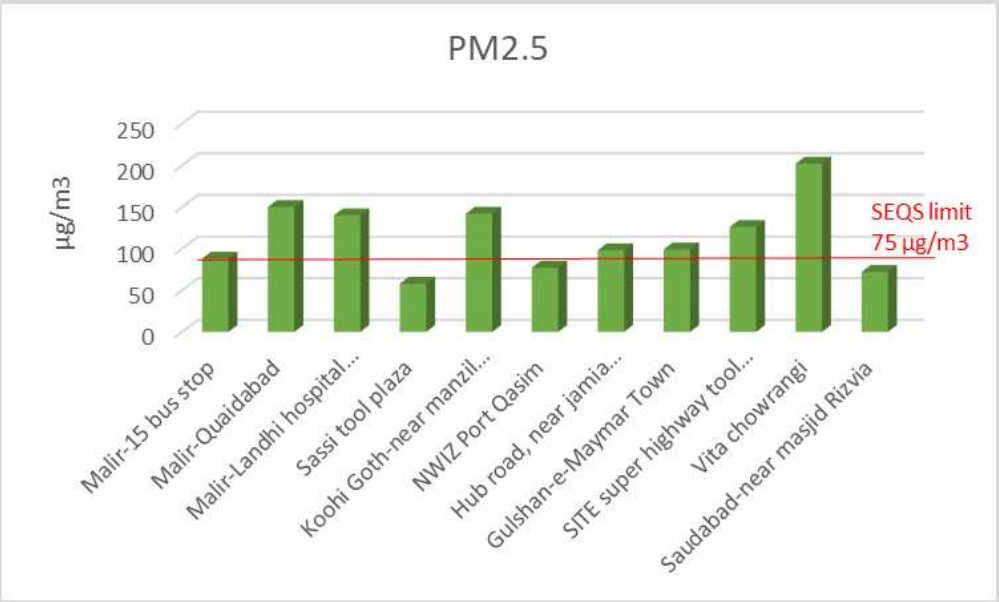
Malir District

As part of ongoing testing, 11 sites in the Malir District of the city were selected and were tested for air quality.

PERAC RESEARCH AND DEVELOPMENT FOUNDATION		
Location		**PM2.5**
		µg/m3
Malir-15 bus stop		88
Malir-Quaidabad		150
Malir-Landhi hospital chowrangi		140
Sassi tool plaza		58
Koohi Goth-near manzil pump		142
NWIZ Port Qasim		77
Hub road, near jamia Farooqia		98
Gulshan-e-Maymar Town		99
SITE super highway tool plaza		126
Vita chowrangi		202
Saudabad-near masjid Rizvia		72
SEQS Limit		**75**

The SEQS limit for $PM_{2.5}$ (75 µg/m^3) had surpassed by all locations except two i.e., Sassi tool plaza and Saudabad-near masjid Rizvia.





The Analysis of PM2.5 & PM10 in air quality Analysis of all districts of Karachi city results the violation of more than 60% of District results in Air pollution.it is observed that the above parameter exceed due to presence of volatile organic materials from industrial sources as well as market sources as the reference District south Karachi has no industrial zone nearby but the Area's named impress market, Dhobi Ghat, Boltan Market their PM2.5 & PM10 values exceed from SEQS limit that shows these particulate matter present in Air are polluting the Air Quality due to the Market in that Area that contain different Volatile materials, Organic Materials and Surfactant and others, This lead us to health problem which is major concern of Air pollution, addressing the issue of air quality in Karachi is not merely a matter of public health; it is a testament to our commitment to creating livable, resilient urban spaces. A low-cost sensor network strategically placed across Karachi becomes a sentinel, providing real-time insights into the ebb and flow of pollutants. This information is not just data; it is a catalyst for informed decision-making, influencing urban planning, policy formulation, and community awareness.

As we embark on this journey to improve air quality in Karachi and beyond, we envision a future where the air becomes a symbol of vitality, not a source of concern. The integration of low-cost sensors into the fabric of these cities represents a step towards a more inclusive, sustainable urban environment, where the well-being of citizens is intricately tied to the quality of the air they breathe.

4. Conclusion

The Air Quality of District Karachi is Analyzed by Electrochemical Sensor Method more than 90 locations are Analyzed Approximately and observe that the Area that are heavy populated and that has industrial zones are major cause of pollution, the Area with no industrial zone with markets are also effected to this pollution this research is designed to get Air Quality Profile of Karachi city to make sustainable and environmental Friendly Air Quality System throughout the Karachi City.

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