CLEANING KARACHI'S AIR

A STUDY OF AIR QUALITY TRENDS AND MAJOR SOURCES OF POLLUTION

Acknowledgements

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Synopsis

Karachi, the provincial capital of Sindh, is the largest city in Pakistan, and among the most populated in Asia and the world. With a human population of more than 25 million, the high levels of air pollution result in a considerable environmental and public health burden on the entire country. With the exception of a few academic studies, this overall impact has not been assessed due to the absence of or incomplete Air quality data and assessments.

The Clean Air Karachi project, initiated by Darya Lab, has sought to address the evidence gaps by bringing forth new research and information, in order to make advocacy more effective and develop policies pertinent to Air pollution mitigation.

This report is hence an exploratory study and a policy analysis, which may be highly useful for concerned policymakers, members of the civil society, city-managers and administrators, and researchers and academia.

Methodology

This assessment uses secondary data sources, to generate a regional profile of various sectors which are dependent on petroleum products. Biomass burning, particularly of waste, is separately accounted for.

Regional profile information

(a) Sindh Development Statistics for Karachi division-level information
(b) Oil Companies Advisory Council (OCAC) for total Fuel Retail sales in PSH

Air-quality data has been acquired through both Satellite and on-ground monitoring instruments. The analysis takes into account the paucity of air-quality data available for the region, and reproduces measurements from open-access datasets to fill in gaps.

Data sources for Air Quality

(a) Any available Air Quality Monitoring Station (AQMS) for PM
(b) Any available Low-cost Monitor (LCM) for PM
(c) Copernicus Atmospheric Monitoring Service (CAMS) for Air Pollutants

Pollutant quantities for Emissions Inventory are calculated based on emission factors for Tier 1 approach defined by the European Energy Agency (EEA).

Limitations

The analysis has several limitations, which have been listed below:

i. Limited on-ground or in-situ measurements of air quality
ii. Limited academic research available on air quality
iii. Limited primary data-gathering for the Study
iv. Limited time-period duration for the Study
v. No chemical composition analysis for the Study
vi. Inaccuracies or error margins within data gathered from secondary sources
vii. Incomplete emissions inventory data due to variables which could not be estimated

Air Quality Profile

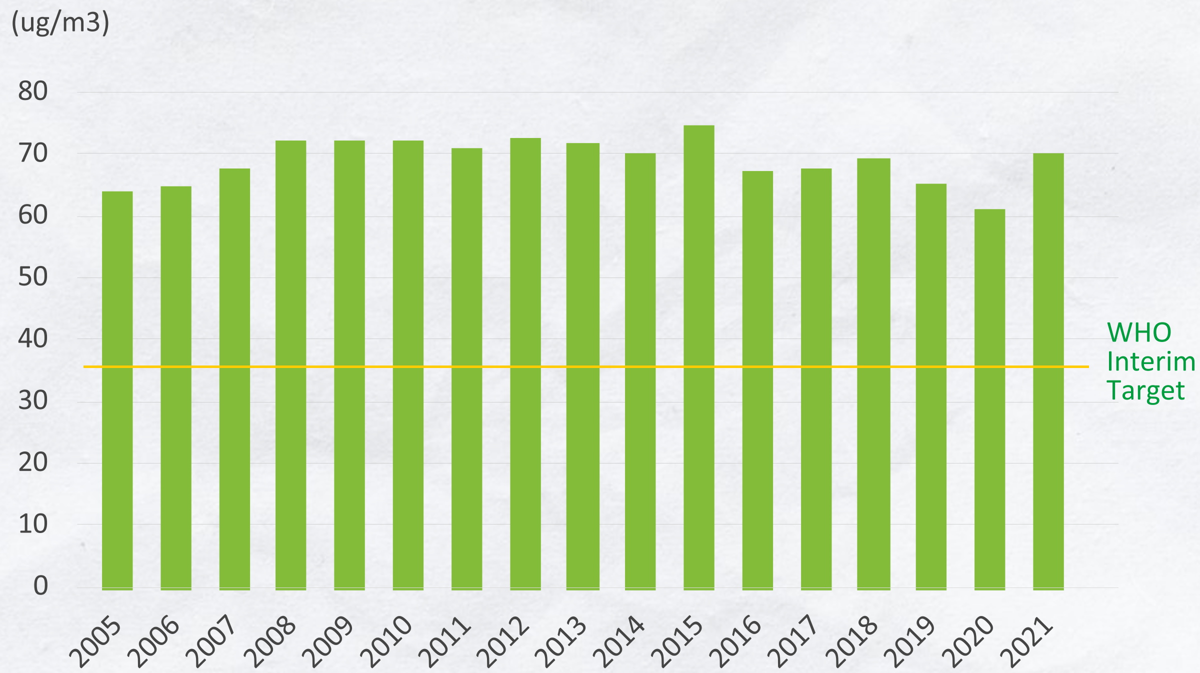
To gain a bird's eye view of the status of Air quality, the whole of Karachi Division has been analysed, and various datasets – from satelite and on-ground monitors – have been used to create an updated air quality profile of the city.

This area covers the entire urbanized part of the city, as well as semi-urban outskirts of the city. For this area, the satellite-based dataset of the Copernicus Atmosphere Monitoring Service (CAMS) has been acquired to assess long-range annual and monthly PM2.5 levels and establish trends of air pollution in the region.

Based on the data from CAMS, PM2.5 levels have been higher than both the current and interim WHO guideline targets in all years. The annual mean in 2005 was 63.2 μg/m3. It can be further observed that the highest PM2.5 annual mean was recorded in 2015, at 74.1 μg/m3. For all available years, the PM2.5 amount is more than 4 times above the current annual limit of 15 μg/m3, as defined under the Provincial Environment Quality Standards (SEQS) for Ambient Air.

Annual Averages

Particulate Matter (<2.5)



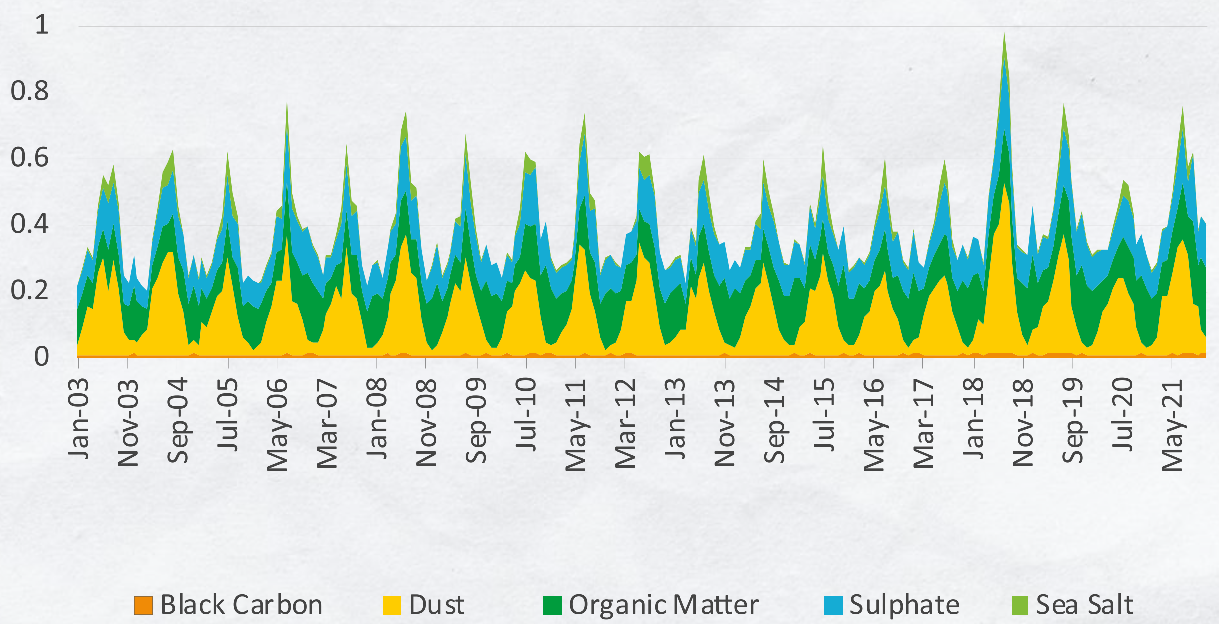
Separately, the PM2.5 measurements from a BAM-1020 Air Quality monitoring station (AQMS), located at the US Consulate in Karachi has also been acquired, which is available from May 2019 till date. Although this data-set is very limited, the in-situ measurements allow for more sensitive and hyper-local analysis for seasonal and annual changes. While Satellite-based assessments provide regional information, the on-ground monitors are more useful for micro-level data, which is essential for local air-quality management.

Therefore, it is also important to expand the network of on-ground monitoring, with both Reference-standard AQMSs and LCMs deployed around the city to get an accurate representation of city-wide air pollution.

Breakdown by type of

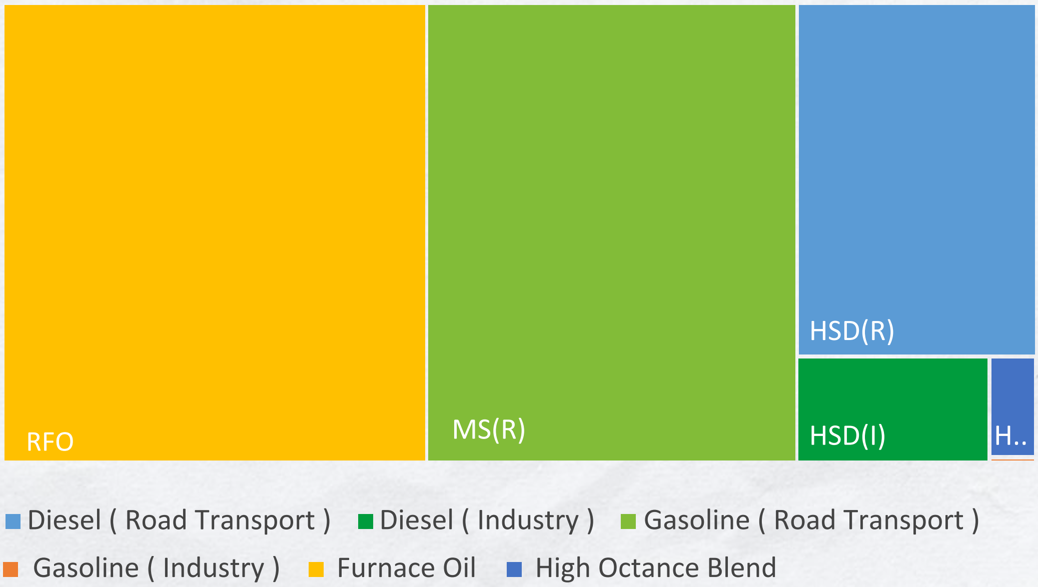
Aerosol

Annual averages



In recent years, with the exception of 2020, which saw the city going into "lockdown" due to the COVID-19 pandemic, the PM2.5 levels continue to range between 65-70 µg/m3. As stated earlier, the available data indicates that Karachi continue to exceed the National or Provincial standards for annual PM2.5 average. Given that Karachi's population is estimated to be 25 million people, the resultant population-weighted public health impact is the highest in Pakistan. Poor Air quality is causing not only significant public health burdens and cost, it is likely greatly reducing the economic productivity of the city's population.

2021
Petroleum Use



The results of emissions calculations focus on 5 key air pollutants, namely Oxides of Nitrogen (NOX), Sulphur Dioxide (SO2), Black Carbon (BC), Particulate Matter (PM) and Non-methane Volatile Organic Compounds (NMVOCs). Various guidelines have been establised by the European Energy Agency (EEA), International Energy Agency (IEA) and Intergovernmental Panel on Climate Change (IPCC) for calculating emissions inventory, through pre-determined Emissions factors. This assessment uses EEA Tier 1 methodology, which accounts for low-quality of datasets by adjusting through confidence intervals.

Based on provincial petroleum supply data, it is estimated that Karachi region consumed approximately 2,938,880 tons of petroleum fuel products during 2021. This is further broken down on the basis of petroleum type and sector usage. All Furnace Oil is assumed to be utilized by Power and Industries. Diesel generator-sets are not separately accounted for, although Diesel usage in the region includes any proportion used by domestic, commercial and industrial use of gen-sets.

Based on these combustion activities, it is estimated that 322.06 Giga-grams (Gg) of air pollutants were emitted in Karachi region during 2021. While the combined emissions of Power & Industry are the highest, the single biggest polluting sector is transport, with 119.6 Gg or 37.12% of the total emissions, as shown below.

Major Emission Sources

In order to understand what are the major sources of pollution, this study uses a top down approach, and focuses primarily on Petroleum consumption. Previous studies in various cities of Pakistan have confirmed that among anthropogenic sources, usage of various petroleum products across sectors results in the biggest portion of a city's emissions. The sectors responsible for emissions include Transport, Industry, Power, and Domestic use. In addition to this, the practice of Waste burning, in the shape of open-air solid-waste incineration also adds to the city's pollution burden.

Significant gaps in data and records exist relevant to all above sectors, while anecdotal information also indicates that available data may not be completely accurate. Information on the Domestic and Commercial sectors is particularly scanty, other than some indications of province-wise fuel supply information. Therefore, several such data-points have been extrapolated where limited information or at least a single variable is available. The highest accuracy among all would be for the Transport sector, followed by Industry.

Transport sector emissions are based on the consumption of High-speed Diesel (HSD) and Motor Gasoline (MS) in the Karachi region. While estimates based on private sector sales suggest 5-7 million vehicles of different types ply on the roads of Karachi, the official data-keeping by Sindh Excise & Taxation Department remains un-updated since 2015, making it extremely difficult to carry out detailed emissions calculations. Due to lack of updated Motor-vehicle statistics, it is likely that emissions are underestimated.

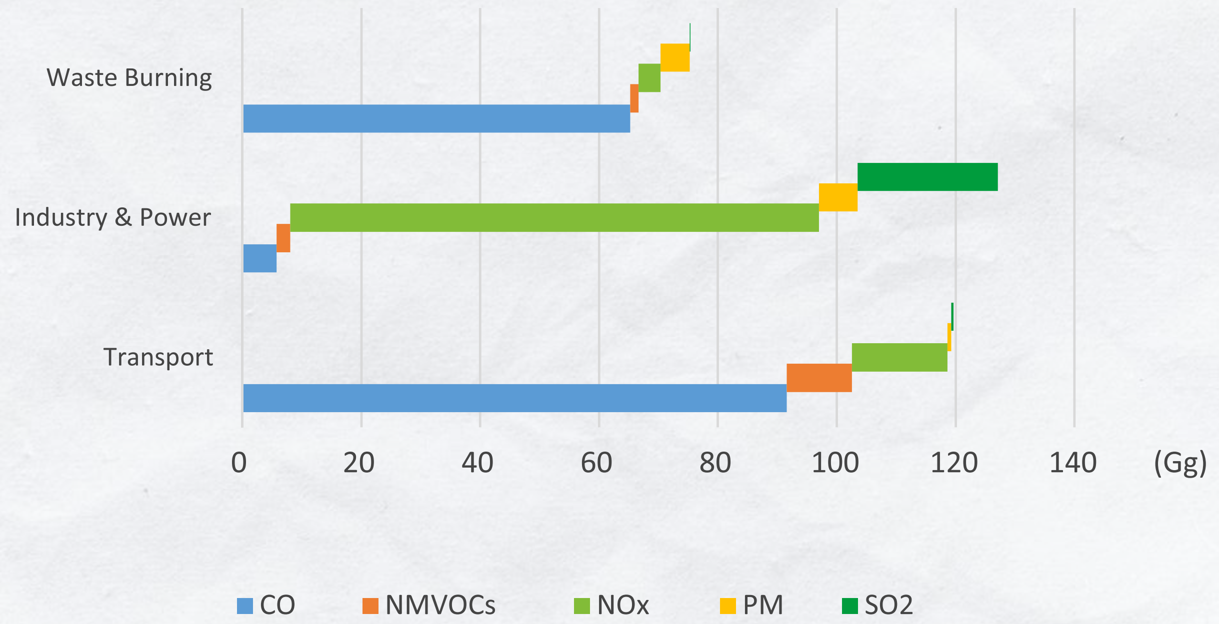
Industry sector is similarly complicated, as the government data is either incomplete or outdated. The number of Industrial units has, however, been reported by the Judicial Water Commission. The size of the units and their fuel usage is also not properly recorded. This lack of book-keeping suggests that the government has made few efforts to assess the quantum of emissions. Emissions calculations for Industry is, hence, based on reported petroleum consumption by Industrial customers. Separately, these figures may not be inclusive of informal, small-scale industrial activities. Due to these reasons, the Industry sector profile may be considered limited only to official reported numbers.

Power sector contributes significantly to air pollution in Karachi, as several major Furnace-Oil (RFO) based power-plants operate in the city. Major Industrial units also use RFO and HSD for power and heating generation. While former (grid-power generation) is well-reported in terms of statistics, the latter (industry power generation) is not. Emissions calculation are also based on reported fuel consumption.

Waste burning while usually ignored in policy discussions is also a big concern. Academic studies and private sector estimates suggest that Karachi produces 14-17 thousand tons of solid waste every day. While some of it is recycled, and much of it ends up in landfills, a part of it also gets burned in various parts of the city. Based on these estimates, emissions for this burned proportion have also been calculated.

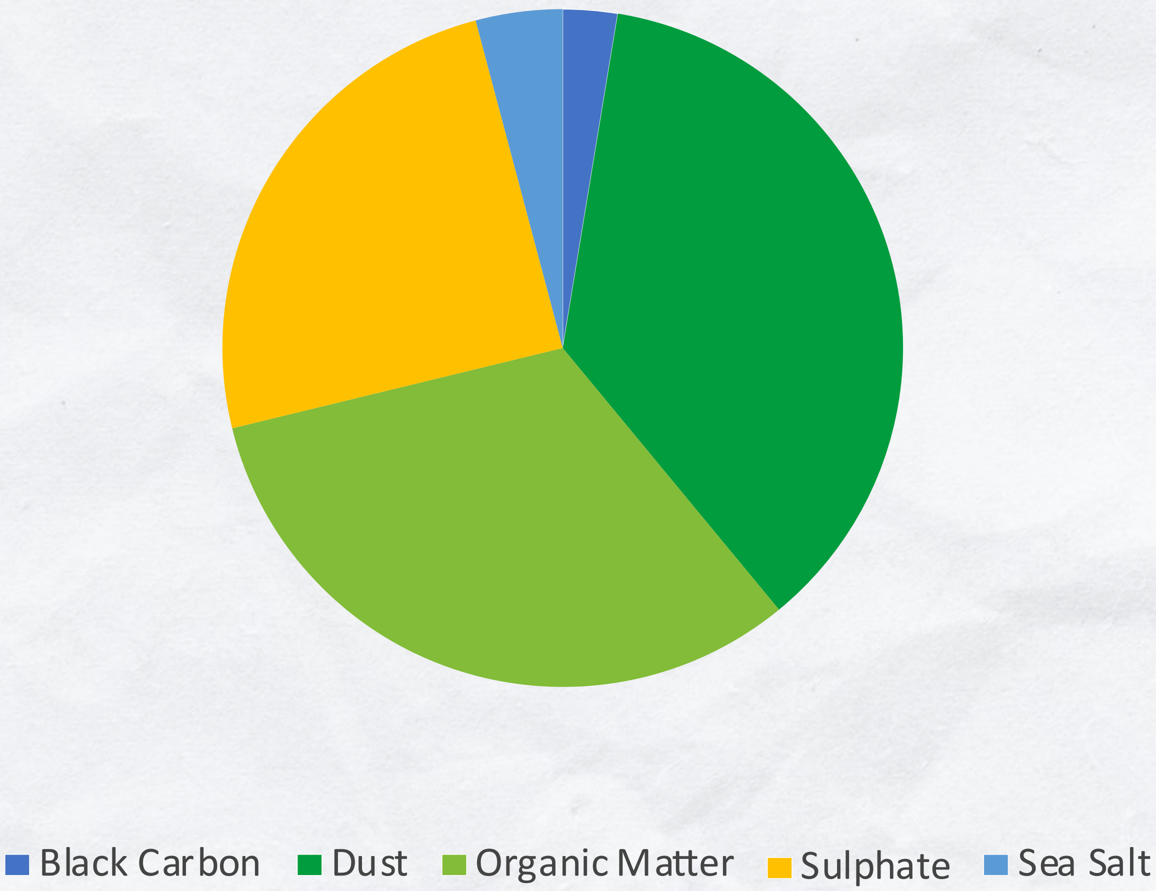
Emissions from

Petroleum Products



As previously described, Aerosols data can also be obtained through CAMS, to assess the breakdown of pollutants responsible for pollution. Due to meteorological conditions, urban management and lack of green-spaces, many cities in Pakistan suffer from Dust aerosol. Separately, non-dust aerosols are largely emitted as a result of combustion processes. Sulphate aerosol is also known to originate from volcanic activity, but no such contribution is possible in the analysis area. Black Carbon, also known as soot, are solid particles, which form a fraction of the total particulate matter. However, it is also a climate pollutant. The breakdown by type of Aerosol average proportions for 2021 is also shown below, which shows that nearly 1/3rd of the suspended particulate is dust, likely because of poor urban management and low vegetation.

Aerosol Proportions
in 2021



Recommendation

Based on the analysis presented above, it is important to start leveraging the evidence to develop solutions and interventions which help mitigate air pollution.

1. Expanding monitoring capacity should be a top priority, which will increase public awareness and enable precautionary measures. Monitoring needs to particularly focus on Industrial clusters, and major roads and intersections. As a starting point, a minimum of 100 low-cost monitors need to be deployed around the city to record PM2.5 levels, along with at least 10 reference-standard air-quality monitoring station.

2. Encouraging higher Public Transport usage, through better accessibility, incentives, and public communications. To increase accessibility, Feeder routes are required, as well as improving walkability and Non-motorized transport (e.g. bicycles) access towards BRT Stations through creation of crossings, buffer-zones and bicycle lanes, and speed-breakers near pedestrian zones. Further, incentives such as reduced-fares should be implemented during peak-hours and weekends. The revenue costs of these measures should be recovered from private transport users in the form of pollution or green taxes, which are applicable on vehicles during peak-hours. Lastly, 'car-pooling' may be introduced as a government policy, which enshrines that private cars with less than two-thirds occupancy may not be allowed during peak-hours, as it may discourage individual use of cars for daily journeys to offices and schools.

3. Aligning Urban Forestation efforts strategically with Air Quality management. Planting trees is known to be a useful climate change mitigation strategy. Urban forests remove carbon and reduce urban heat. However, its role in air quality management is indirect and requires strategic placement to work. Trees do not effectively 'filter' or remove air pollutants such as PM, CO, SO2, etc, and are primarily CO2 absorbers during the photosynthesis process. While pollutant gases cannot be removed, leafy trees act as barriers to the spread of PM particles. This technique allows the creation of barriers between urban/industrial zones and residential zones. Additionally, as the study shows high-levels of Dust to be a contributing factor to air pollution, planting trees alongside major roads and intersections will help reduce transport of road-side dust during dry weather.

4. Increasing role of civil society, universities, startups and private sector, by streamlining efforts and creating forums for collaboration. As already shown, that air quality management will require widespread collaboration across various public and private entities, and civil society, it is recommended to further opportunities of collaboration and interaction. This can be done in the form of Innovation Funds/Challenges dedicated to Air quality solutions, Quarterly forums and newsletters to review progress, and organizing trainings for capacity building on various aspects of air quality management. This approach will also catalyze the development of local expertise and technology, which will be increasingly required for sustainable management.