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WHITE PAPER

Air Quality Analysis Using Secondary Parameters

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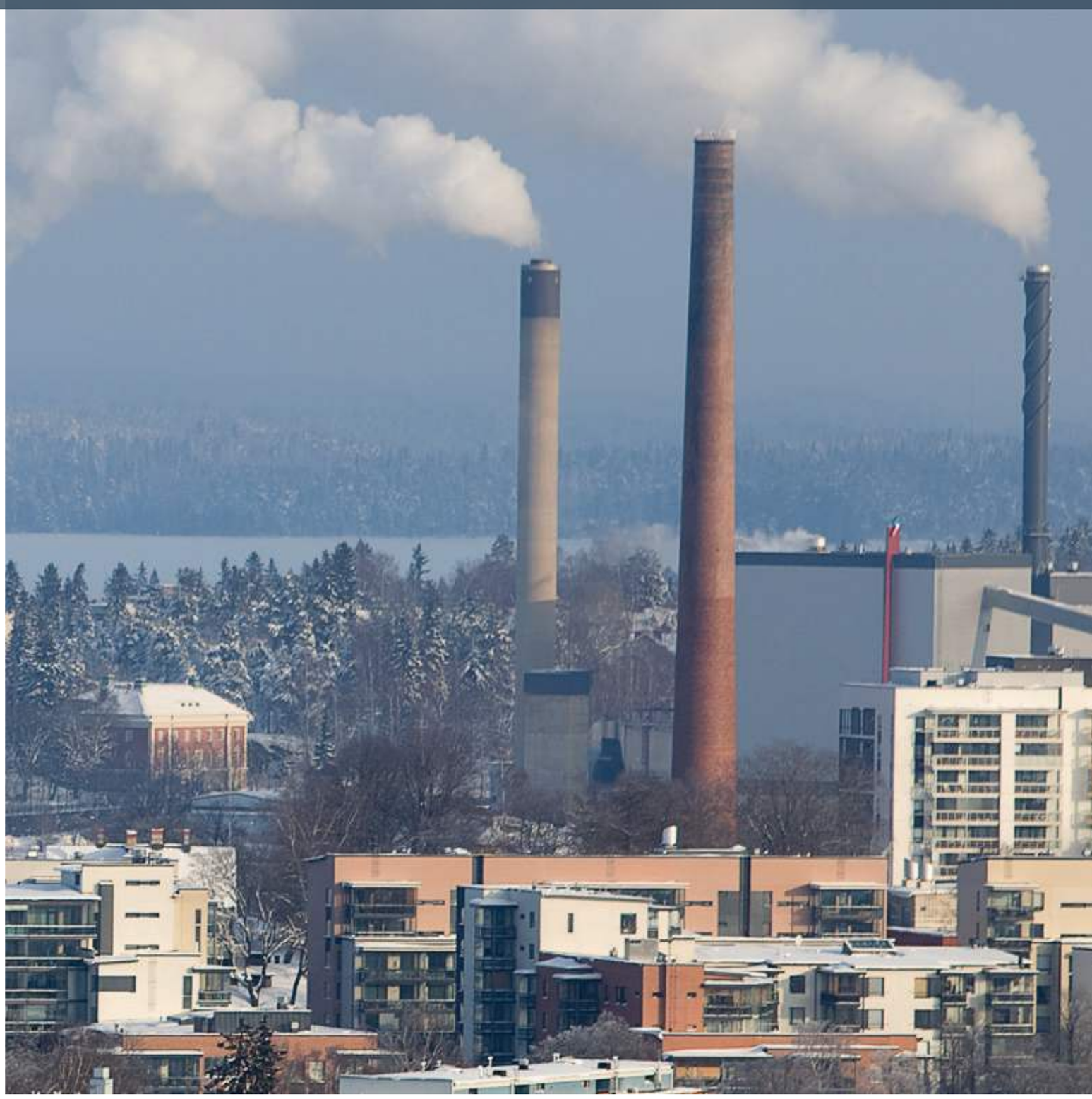
December 2022



Introduction

Air Quality monitoring has become crucial in order to discover underlying principles or patterns which might give insights into the severity of the problem. It helps in assessing the impacts caused by poor air quality and ensuring whether it is meeting the air quality standards. Proper air quality analysis gives insights into the polluted areas and devises pollution control programs. Air Quality data represent concentrations of the air pollutants present in the ambient air. The concentration of air quality is affected by various physical, chemical, and topographical features of the region which are of keen importance while interpreting air quality data. These aspects are known as Secondary Parameters of air quality. They provide an indirect relation with the primary parameters and their influence varies on a spatial and time scale.

The fundamental secondary parameters are as follows :
Noise
Light/UV
Humidity
Temperature

Noise

Noise is defined as the unwanted or disturbing sound that blemishes the quality of life for the community and ecosystem. Noise pollution has severe mental and physical effects such as stress-related illnesses, high blood pressure, speech interference, hearing loss, sleep disruption, and lost productivity. In countries like India, noise pollution has been synonymous with greenhouse gasses and the advent rise in AQI (Air Quality Index).

For instance, heavy traffic in an area for a particular bracket of time gives rise to significant noise pollution primarily from rigorous honking and exhaust of the vehicles stuck in the same. This is coupled with rising in air pollutants such as CO, NOx, SOx, O_3, and particulate matter (PM). Heavy-duty vehicles running on Diesel emit CO and unburned HC in the diesel exhaust, compensated by high concentrations of NOx and CO_2.[1]

Similarly, Exposure to the sounds of Fireworks leads to mental distress and seizures and also induces air pollutants such as carbon dioxide, carbon monoxide, and nitrogen. The occasion of Diwali (2019) saw the concentrations of air-borne pollutants to be pushed above 500 in the AQI[2]. The Fireworks also create Ozone (O3) in the troposphere, which is a secondary pollutant and greenhouse gas.[3]

A study in London, over two major festivals that are celebrated with fireworks, found increased gas-phase pollutant levels of nitric oxide (NOx) and sulfur dioxide (SO_2), which are primary. This study also found elevated mass concentrations of fine particulates, and trace concentrations of heavy metals, specifically strontium (Sr), magnesium (Mg), potassium (K), barium (Ba), and lead (Pb).[4]

The following graph depicts a rise in noise pollution in a heavy traffic area compared with the rise in air pollutants inducing a relation between the two.[5]

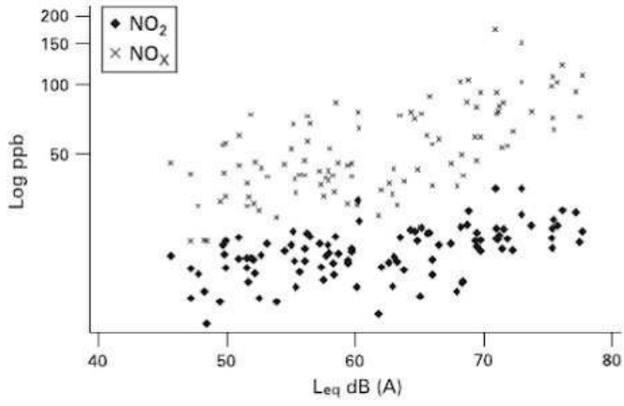


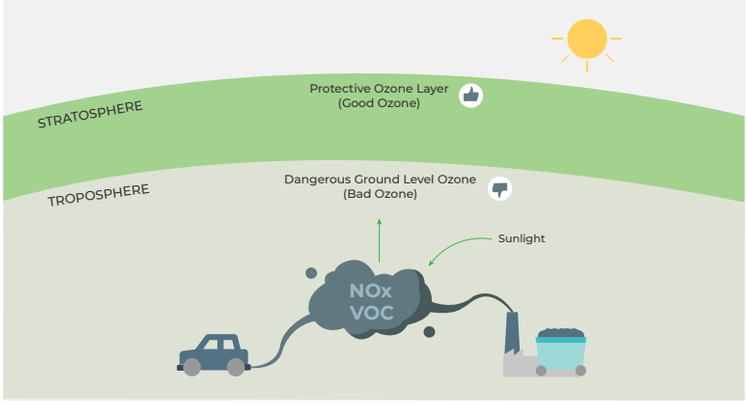
Figure 1 NO_2 and NOx concentrations by noise level (Leq 5 min) at 103 measurment sites around Metro Vancouver, BC

Light/UV

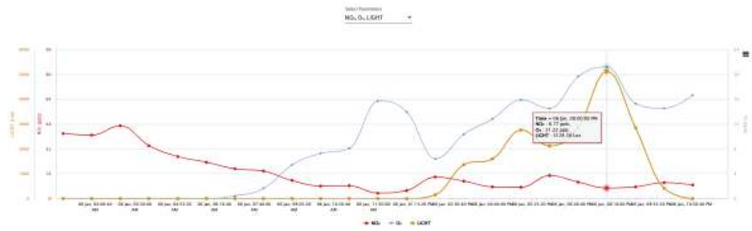
Sunlight and high-temperature trigger chemical reactions among primary air pollutants which includes nitrogen oxides and oxygen, causing a chemical response that generates Ozone. The hotter the day and the greater the intensity of the solar, the more ozone is formed.

Ozone is a very lively oxidant, which exacerbates lung diseases consisting of bronchial asthma and might cause respiratory difficulties even in healthy people. The extreme heat and stagnant air during a heat wave increase the amount of ozone pollution and particulate pollution.

Ground-level ozone is a secondary air pollutant formed primarily from the photochemical reactions of other air pollutants, specifically nitrogen oxides (NOx) and volatile organic compounds (VOCs). It is formed by the reaction of sunlight with air containing NOx and hydrocarbons directly at sources or at areas downwind of major sources of NOx and VOC where O_3 or its precursors are carried by the winds. In the summers and especially during extreme heat waves, ozone often reaches dangerous levels in cities or nearby rural areas



Plotting the levels of Light, NO_2, and O_3 in a time series gives a clear picture of the chemical reactions taking place in real-time. The graph below is a snapshot of the concentrations of air pollutants monitored along with Light as its influencing secondary parameter. As the light values increases, indicating the presence of sunlight in the air, the NO_2 concentration starts to decrease and consequently the O_3 concentration rises illustrating the chemical reactions taking place in the atmosphere during the formation of ground-level ozone..



Heat and sun additionally transform primary particles into secondary, smaller debris that may be extra toxic. These secondary particles, which are photochemically produced by means of sunlight, are of critical importance; they're ubiquitous and can make up around 90% of the total PM. Secondary particles are smaller than 1000th of a millimeter.[6]

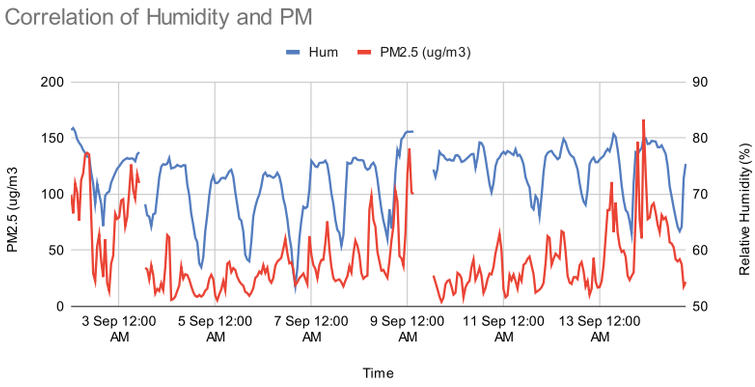
Humidity

Humidity is defined as the concentration of water vapor present in the ambient air and is largely affected by the Temperature and Pressure of the surroundings. The presence of humidity in the atmosphere can have major impacts on Health and Environment Negatively or Positively depending upon the concentration.

The human body is said to be most comfortable when the relative humidity of the area ranges between 20 and 60%. The recommended average relative humidity for indoors is 30 to 50%, when the outside temperature is 20°F or more. If the indoor relative humidity is above 60%, mold and mildew begin to form and these can pose quite a problem to the health of the inmates. Less than 30% of relative humidity can cause static electricity problems, irritation of the skin, and dry eyes.[7]

Research conducted at the University of Manitoba indicates that humidity has a strong and significant impact on the indoor air quality at a stagnant pollution level, the perceived air quality decreases with increasing air humidity.[8]

In the Ambient Atmosphere, water vapor aggregates the Particulate Matter (PM) via attractive forces creating a much bigger particle in size. This causes huge variations in readings of Air Quality. This also leads to the formation of Aerosols, a suspension of fine solid particles or liquid droplets in air or another gas. Aerosols degrade air quality and are dangerous to human health. Inhalation of these tiny particles can damage lung tissue and lead to lung diseases.



Correlating the relative humidity with PM concentrations gives a clear indication of its influence.

Temperature

As one the crucial secondary parameters of Air Quality, Temperature has identical effects on Air Quality regardless of location measured. Air temperature affects the movement of air, and thus the movement of air pollution.

At high temperatures, the density of matter in air decreases, and particles become lighter. The warmer, lighter air at the surface rises, by the principle of convection and the cooler, heavier air in the upper troposphere sinks. While at low temperature, high-density air forms thick smog by combining with the pollutants in the region. It is evident as when the weather is cold, exhaust from vehicles, chimneys, and smokestacks is more visible.

Warm, low-density air near the ground lifts pollution away, but during the winter the layer of warm air acts as a lid keeping cold air at the surface. This creates a thermal inversion, which forms when a layer of warm air above traps cool air and pollution close to the ground.[10]

A study conducted in Chile[11] showed that at the site of temperature inversion, the black carbon concentration is 57% higher than without inversion. While $PM_{2.5}$ was found to be 35% compared to the absence of the thermal inversion process.

Similarly, a Canada-based study[12] revealed the variation of air quality in the daytime and nighttime thermal Inversions. The nighttime saw a significant increase in pollutants - 49% and 54% rise in NO_2 and $PM_{2.5}$ respectively. On the other hand, Daytime inversions resulted in an 11% increase in NO_2 but a 14% decrease in $PM_{2.5}$.

Air Quality Data Interpretation

To ensure the quality of data, analytical quality control and guidelines for monitoring and calibration, repair of instruments, and evaluation of ambient air quality monitoring stations are musts. The above discussed parameters are to be taken in mind during the process of air monitoring regardless of discipline. Air Quality data is used by atmospheric scientists, data analysts, climatologists, policymakers, and others to iden

tify sources and trends in air pollution, furthermore, take legal action against the same. Knowledge of these relationships is pivotal for the interpretation of accurate data.

Oizom's Offerings

Oizom's simple, cost-effective and highly-scalable solution for Environmental Data Monitoring & Analytics is capable to monitor more than 30 different parameters including gaseous pollutants like carbon monoxide (CO), sulfur dioxide (SO_2), nitric oxide (NO) nitrogen dioxide (NO_2); dust particulates like $PM_{2.5}$, PM_{10}, noise and weather parameters like temperature, humidity, light, UV, rainfall, wind speed, and wind direction. The data is transmitted to our data-analytics platform Envizom.

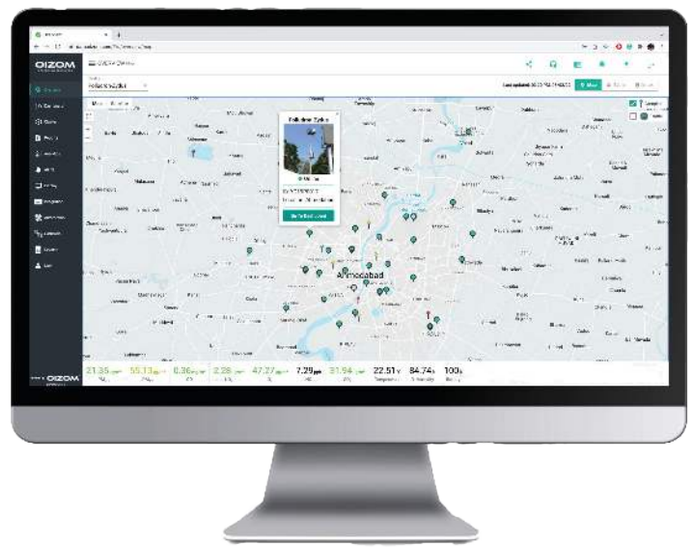
Oizom products have the capability of simultaneous monitoring of secondary parameters like noise, temperature, humidity, and light intensity along with contributing air pollutants like NOx, SOx, O_3, and particulate matter. This allows the user to easily interpret the air quality and take necessary actions to control air pollution.

Envizom is an Air quality monitoring software for real-time air quality data acquisition, visualization, and analytics. With our web-based air quality monitoring software – Envizom, the professionals can access and analyze the air quality data remotely from anywhere. After monitoring the environmental data, its analysis and visualization become essential to comprehend the entire scenario.

The Advances Analytics module in Envizom allows comprehensive analysis of data with 3 different methods.

- Parameter comparison: Comparing multiple parameters of a single device (Eg. PM_{10} and Humidity)
- Device Comparison: Comparing a single parameter of up to 10 devices (E.g. Variation of SO_2 in all devices)
- Pollution rose: Creating pollution rose chart for identifying pollution load at a specific location

The Parameter comparison analysis allows the user to visualize the effect of the secondary parameters influencing the air quality and interpret its effect on the concentration and trends of the air pollutants.



References

[1] Bhandarkar, S. (2013). Vehicular pollution, their effect on human health and mitigation measures. Veh. Eng, 1(2), 33-40.

[2] https://www.forbes.com/sites/grrlscientist/2019/12/31/festive-fireworks-create-harmful-pall-of-pollution/?sh=739c0bac2853

[3] https://www.nature.com/articles/35082634

[4] Godri, K. J., Green, D. C., Fuller, G. W., Dall'Osto, M., Beddows, D. C., Kelly, F. J., ... & Mudway, I. S. (2010). Particulate oxidative burden associated with firework activity. Environmental science & technology, 44(21), 8295-8301.

[5] Davies, H. W., Vlaanderen, J. J., Henderson, S. B., & Brauer, M. (2009). Correlation between co-exposures to noise and air pollution from traffic sources. Occupational and environmental medicine, 66(5), 347-350.

[6] https://www.teqoya.com/air-pollution-the-heat-factor/

[7] https://www.generalfilters.com/wholesaler-center/How-Relative-Humidity-Affects-Indoor-Air-Quality_AE146.html

[8] Impact of Temperature and Humidity on the Perception of Indoor Air Quality

[9] Fang, L., Clausen, G., & Fanger, P. O. (1998). Impact of temperature and humidity on the perception of indoor air quality. Indoor air, 8(2), 80-90.

[10] UCAR Center for Science Education, "How Weather Affects Air Quality"

[11] Gramsch, E., Cáceres, D., Oyola, P., Reyes, F., Vásquez, Y., Rubio, M. A., & Sánchez, G. (2014). Influence of surface and subsidence thermal inversion on PM2. 5 and black carbon concentration. Atmospheric Environment, 98, 290-298.

[12] Wallace, J., & Kanaroglou, P. (2009). The effect of temperature inversions on ground-level nitrogen dioxide (NO2) and fine particulate matter (PM2. 5) using temperature profiles from the Atmospheric Infrared Sounder (AIRS). Science of the Total Environment, 407(18), 5085-5095.

About the Authors

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Bhumik Nayak manages global projects at Oizom, with experience as a Research & Development Engineer with Electronics & Communication background, he deals with the technical aspects of global deployments.

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With experience in environmental engineering and research, Kruti Davda currently leads environmental analysis at OIZOM, where she puts her mind to gross air pollution data and extrude insights through environmental research and analysis.

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