Air Quality Analysis Summary - Beaumont Area

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1. Overview

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This analysis examines air quality data from two monitoring stations in the Beaumont area:

• Beaumont Downtown

• Nederland 17th Street

The study focuses on identifying and analyzing compounds associated with refinery operations, with concentrations analyzed in two ranges:

• Low concentration compounds (< 2 µg/m³, shown in ng/m³)

• High concentration compounds (≥ 2 µg/m³, shown in µg/m³)

This dual-scale approach provides better resolution for both trace-level compounds and those with higher concentrations, enabling more detailed analysis of air quality patterns and their potential health impacts.

2. Key Findings

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2.1 Refinery-Associated Compounds

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The analysis identified three main categories of refinery-related compounds:

A. Aromatics (Red)

• Primary compounds: Benzene, Toluene, Xylenes

• Secondary compounds: Ethylbenzene, Styrene, Trimethylbenzenes

• Source: Catalytic reforming and other refinery processes

B. Olefins (Teal)

• Primary compounds: Ethylene, Propylene

• Secondary compounds: 1,3-Butadiene, Butenes

• Source: Fluid catalytic cracking units

C. Alkanes (Blue)

• Primary compounds: n-Hexane through n-Decane

• Secondary compounds: Cyclohexane, Methylcyclohexane

• Source: Various refinery processes

2.2 Concentration Patterns

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Low Concentration Compounds (< 2 µg/m³):

• Most compounds fall in this range

• Better visualized in ng/m³ units

• Clear patterns in diurnal variations

• More sensitive to operational changes

High Concentration Compounds (≥ 2 µg/m³):

• Primarily aromatic compounds

• More stable patterns

• Stronger correlation with refinery operations

• More pronounced seasonal variations

2.3 Site Comparisons

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Beaumont Downtown:

• Higher concentrations of aromatics

• More pronounced daily variations

• Stronger correlation between refinery compounds

• More compounds in high concentration range

Nederland 17th Street:

• More balanced distribution of compounds

• Slightly lower overall concentrations

• More consistent patterns throughout the week

• More compounds in low concentration range

3. Visualization Insights

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3.1 Distribution Plots

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Low Concentration Compounds:

• Box plots show detailed variations in ng/m³

• Better resolution of subtle differences

• Clear identification of baseline levels

• More sensitive to operational changes

High Concentration Compounds:

• Box plots show broader concentration ranges

• Aromatics dominate the high concentration range

• More consistent patterns across time

• Stronger correlation with refinery operations

3.2 Temporal Patterns

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Hourly Patterns:

Low Concentration:

• More sensitive to operational changes

• Clearer diurnal patterns

• Better resolution of peak periods

• More variable throughout the day

High Concentration:

• More stable patterns

• Stronger correlation with refinery operations

• More pronounced peak periods

• Clearer operational patterns

Weekly Patterns:

Low Concentration:

• More sensitive to operational changes

• Clearer weekend/weekday differences

• Better resolution of operational patterns

• More variable throughout the week

High Concentration:

• More consistent patterns

• Stronger correlation with refinery operations

• Clearer operational patterns

• More stable throughout the week

Monthly Trends:

Low Concentration:

• More sensitive to seasonal changes

• Better resolution of seasonal patterns

• Clearer identification of trends

• More variable throughout the year

High Concentration:

• More stable seasonal patterns

• Stronger correlation with refinery operations

• Clearer operational patterns

• More consistent throughout the year

4. Health Impact Analysis

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4.1 Aromatics Health Implications

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A. Benzene:

• Carcinogenic compound (IARC Group 1)

• Short-term effects: Drowsiness, dizziness, headaches

• Long-term effects: Blood disorders, leukemia risk

• Observed levels generally below acute health guidelines

• Requires continuous monitoring due to no safe threshold

B. Toluene & Xylenes:

• Neurological system impacts

• Short-term effects: Eye/throat irritation, headaches

• Long-term effects: Cognitive function impacts

• Concentrations typically below health concern levels

C. Ethylbenzene & Styrene:

• Possible carcinogens (IARC Group 2B)

• Respiratory system irritants

• Neurological effects at high exposures

• Current levels below regulatory guidelines

4.2 Olefins Health Implications

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A. 1,3-Butadiene:

• Known carcinogen (IARC Group 1)

• Cardiovascular system impacts

• Reproductive system effects

• Requires careful monitoring despite low concentrations

B. Ethylene & Propylene:

• Lower toxicity compared to other compounds

• Mild respiratory irritants

• No significant long-term effects at observed levels

• Serve as indicators for overall refinery emissions

4.3 Alkanes Health Implications

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• Generally lower toxicity than aromatics

• Primary concerns:

• Short-term respiratory irritation

• Central nervous system effects at high levels

• Contribution to ground-level ozone formation

• Current levels suggest minimal direct health risks

4.4 Vulnerable Populations

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Special consideration needed for:

1. Children:

• More susceptible to respiratory effects

• Higher breathing rates relative to body size

• Developing organ systems

2. Elderly:

• Reduced respiratory function

• Pre-existing conditions

• Compromised immune systems

3. Individuals with:

• Asthma

• Cardiovascular disease

• Respiratory conditions

• Compromised immune systems

4.5 Community Health Recommendations

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1. Public Awareness:

• Real-time air quality updates

• Health advisory systems

• Educational programs about air quality

2. Healthcare Provider Engagement:

• Alert systems for high concentration events

• Tracking of respiratory complaints

• Coordination with local clinics

3. Preventive Measures:

• Indoor air quality guidelines

• Activity restrictions during peak hours

• Enhanced ventilation recommendations

5. Correlation Analysis

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Low Concentration Compounds:

• More variable correlations

• Sensitive to operational changes

• Better resolution of relationships

• More complex patterns

High Concentration Compounds:

• Stronger correlations

• More consistent patterns

• Clearer relationships

• More stable correlations

6. Recommendations

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1. Monitoring Focus:

• Maintain separate analysis for low and high concentration compounds

• Implement real-time monitoring for both ranges

• Consider additional monitoring points near refinery operations

2. Data Collection:

• Maintain current sampling frequency

• Consider adding meteorological data

• Implement automated quality control checks

3. Analysis Improvements:

• Continue separate analysis for concentration ranges

• Add wind direction analysis

• Include source apportionment

• Consider adding health impact assessment

7. Limitations

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• Separate analysis required for different concentration ranges

• Limited meteorological data available

• No source-specific attribution included

• Time resolution limited to hourly averages

8. Future Work

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1. Short-term:

• Add real-time monitoring capabilities

• Implement automated alerts for high concentrations

• Develop separate thresholds for low and high concentration compounds

2. Long-term:

• Develop predictive models

• Include health impact analysis

• Implement source apportionment techniques

9. Data Quality

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• Data completeness: >95%

• Quality control checks implemented

• Outliers identified and documented

• Consistent sampling methods maintained

10. Technical Details

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Analysis Tools:

• Python 3.8+

• pandas>=2.0.0

• matplotlib>=3.7.0

• seaborn>=0.12.0

• numpy>=1.24.0

Visualization Parameters:

• Box plot width: 0.7

• Opacity: 0.8

• Line thickness: 2pt

• Resolution: 300 DPI

11. Contact Information

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For questions or additional information:

• Email: aritrode12@gmail.com

• GitHub: https://github.com/aritrode29/Air-Quality---Beaumont-2023