

Air Quality *Retrospective 2023*

NAFAS ANNUAL REPORT

Retrospective of Air Quality 2023



2023 was an important year for Indonesia as air pollution finally received serious attention from the government, even becoming one of the topics in the presidential candidate debate in January 2024.

In mid-2023, many citizens fell ill, with high pollution suspected as the cause, including many children. President Jokowi and his team held a closed meeting to discuss air pollution issues. This led to the establishment of seven steps to handle and control air pollution in Jakarta, Bogor, Depok, Tangerang, and Bekasi, based on Minister of Environment and Forestry Regulation No. 929. Three of these steps include identifying sources of air pollution, monitoring vehicle exhaust emissions, and overseeing compliance with permits for power plants and waste incineration.

Hopefully, the government can soon implement comprehensive measures to address air pollution, allowing the public to once again enjoy clean air and avoid various health risks.

Warm regards,
Nafas Indonesia

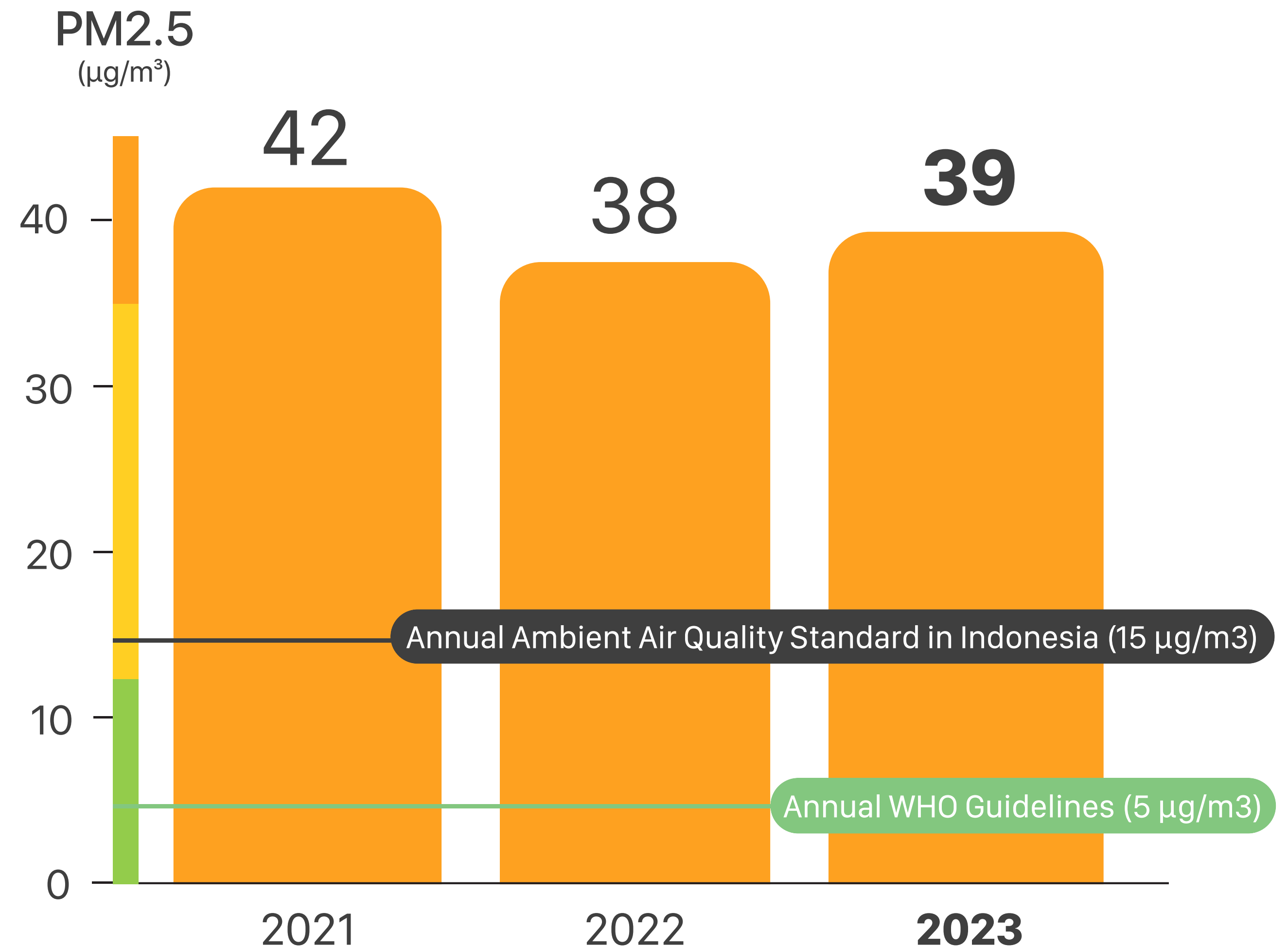
Average Annual Air Pollution in 2023 Slightly Increased Compared to 2022

There was an increase in PM2.5 by 1 $\mu\text{g}/\text{m}^3$ for the annual average air pollution across all areas in the Nafas network sensors (Java Island, Bali, and Belitung) in 2023 compared to the previous year.

In the last three years, the highest annual average air pollution is still held by the year 2021.

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy

PM2.5 Levels in the Nafas Sensor Network (Java Island, Bali, Belitung) 2021-2023



How Can Pollution in 2023 Be Higher Than the Previous Year?

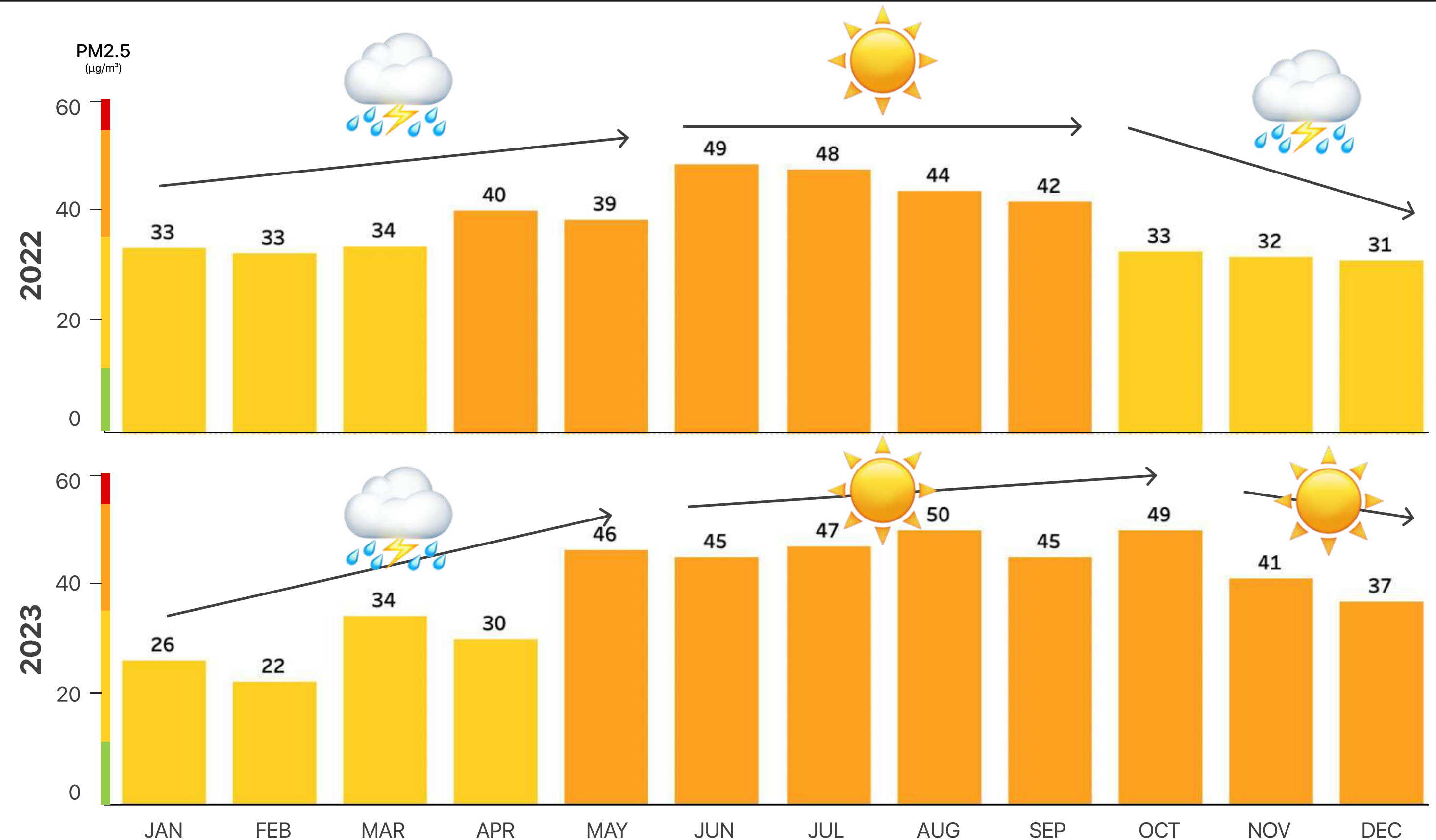
This is due to the **El Niño and positive Indian Ocean Dipole (IOD+)** phenomena in 2023. The combination of these two phenomena supports dry and hot weather conditions, making the atmosphere more stable and winds tend to be calm. As a result, pollution often accumulates near the surface, which is detected as high pollution levels.

There is a quite contrasting pollution trend between 2022 and 2023.

The pollution trend in 2022 formed a **'mountainous' trend**, with pollution being low at the beginning and end of the year but high in the middle of the year.

In contrast, in 2023, **the pollution trend continued to increase** towards the end of the year. Air pollution only began to decrease in November and December, but it was still higher compared to the pollution trend during the same period in 2022.

*These hot and dry weather conditions can give rise to secondary pollution, which is pollution that reacts in the atmosphere to produce new pollutants.





City Rankings

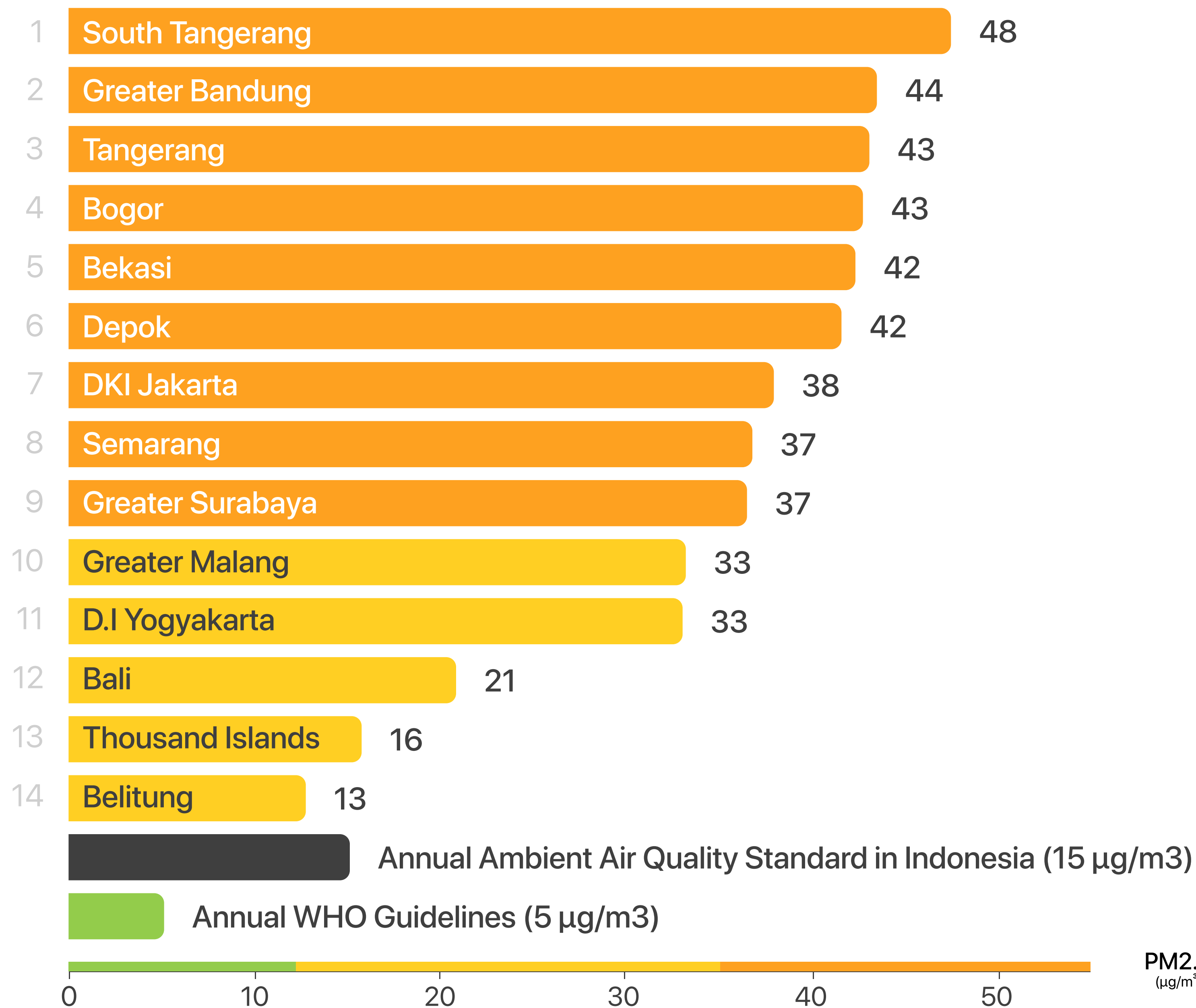
2023

Taking the average air pollution levels for a full year, South Tangerang takes the pollution champion title (PM2.5 48 $\mu\text{g}/\text{m}^3$) for the year 2023. This exceeds the National Annual Ambient Air Quality Standard of Indonesia by more than 3 times, which is set at 15 $\mu\text{g}/\text{m}^3$.

Following closely is the Greater Bandung area in second place with PM2.5 at 44 $\mu\text{g}/\text{m}^3$.

Meanwhile, the capital city, often in the spotlight as the 'most polluted city in the world,' ranks seventh with PM2.5 at 38 $\mu\text{g}/\text{m}^3$.

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy

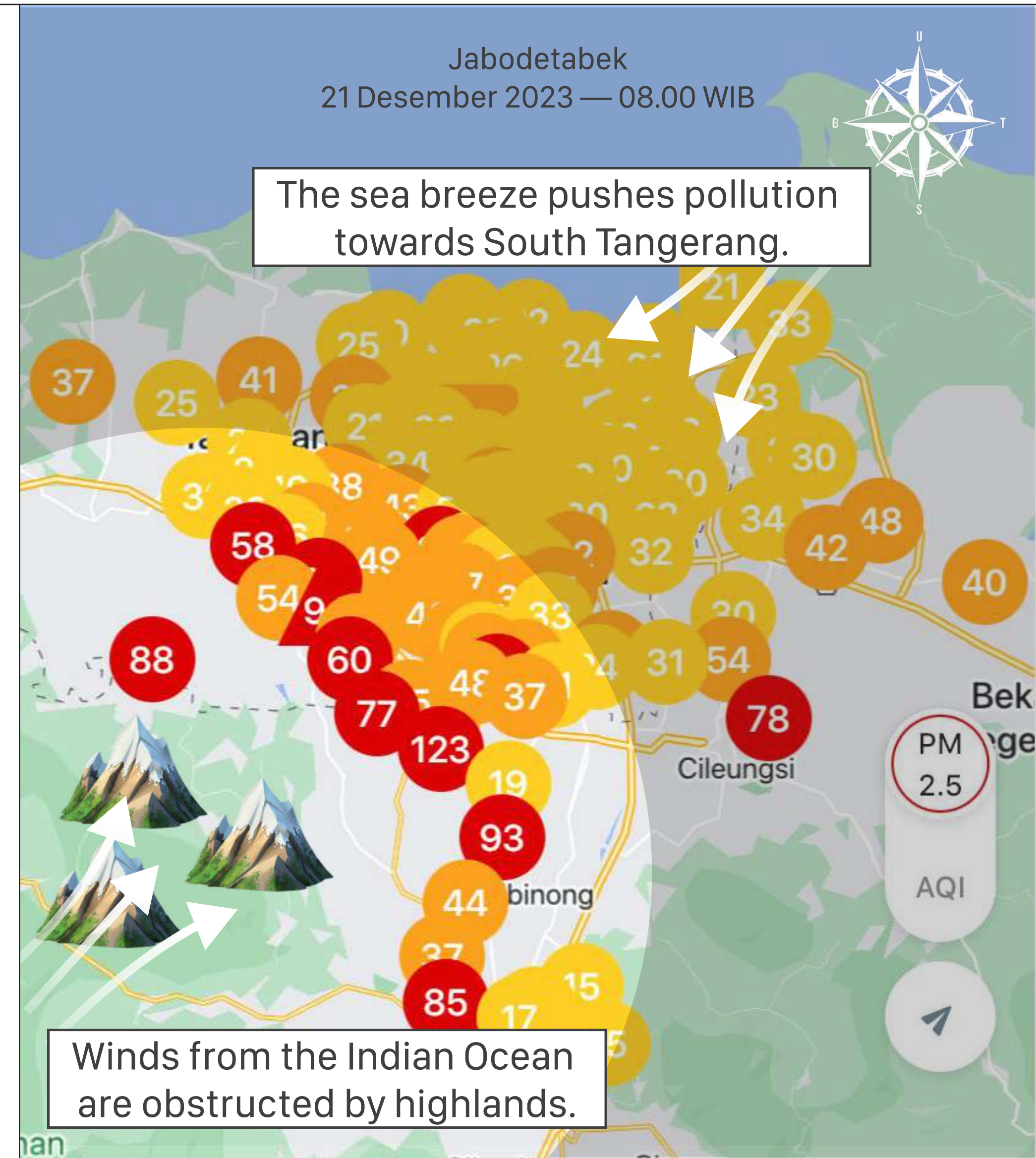


Tangerang Selatan Champion #1 in Pollution for 2023. What are the supporting factors?

Geographically, South Tangerang is strategically located in a high-pollution area. This is due to the abundance of hyperlocal pollution and pollution originating from surrounding areas.

The presence of highlands on the southwest side of South Tangerang also contributes to the accumulation and trapping of air pollution. An indirect impact is transboundary pollution driven by sea breezes trapped in this area. Additionally, **wind supply from the Indian Ocean**, which should spread pollutants in this region, is obstructed by these highlands.

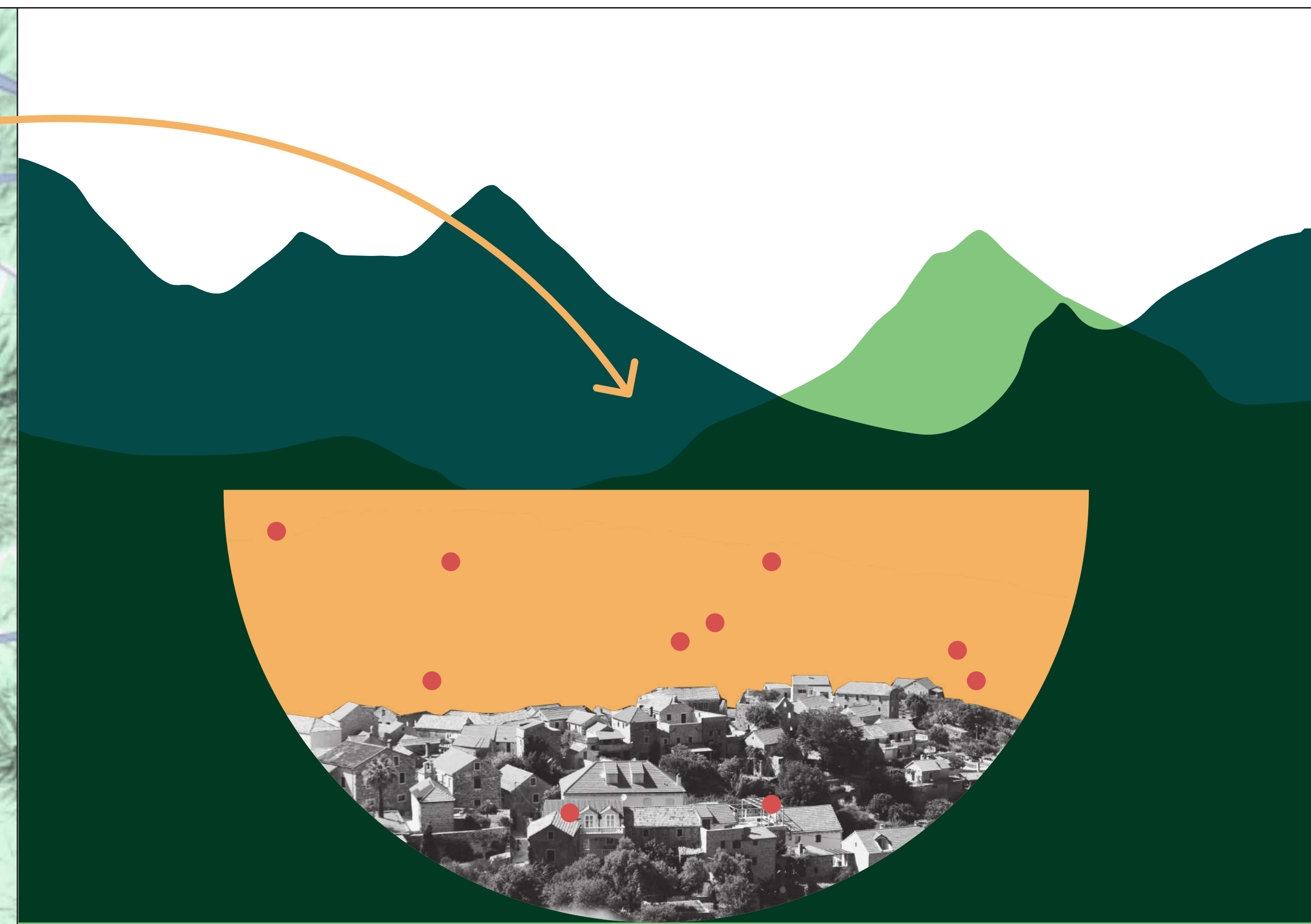
- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy



Greater Bandung Area Wins #2 in Pollution for 2023.

The geographical location and topography of Bandung greatly support the **accumulation of pollutants, leading to high pollution levels**. Known as the Bandung basin (shaped like a bowl), the abundance of pollution emitted from various sources within it can be trapped at the bottom of the basin.

This makes it difficult for large-scale winds or external pollutants to enter the basin, resulting in pollution not easily dispersing and accumulating within it.





Pollution from Month to Month Throughout the Year 2023

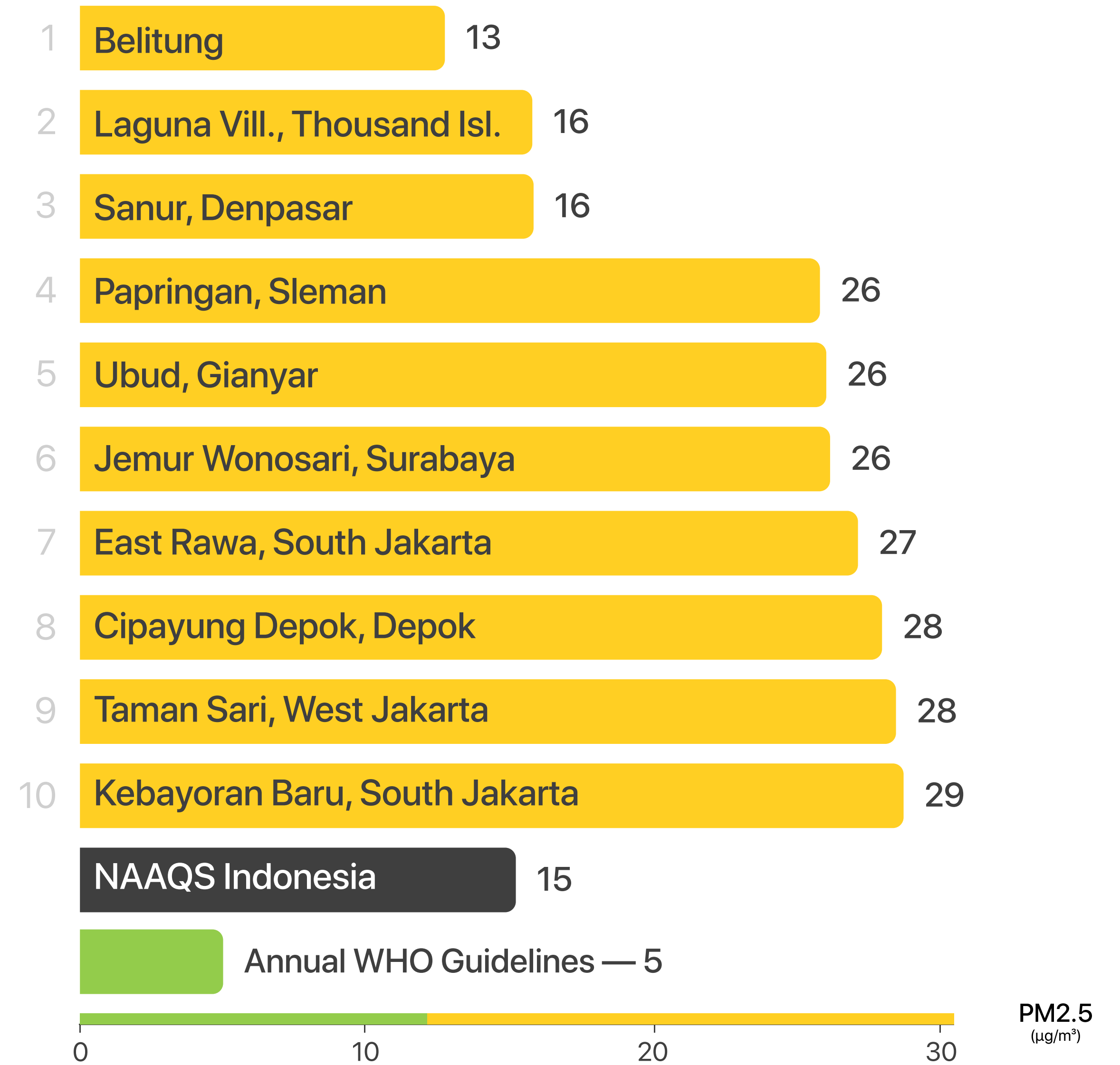
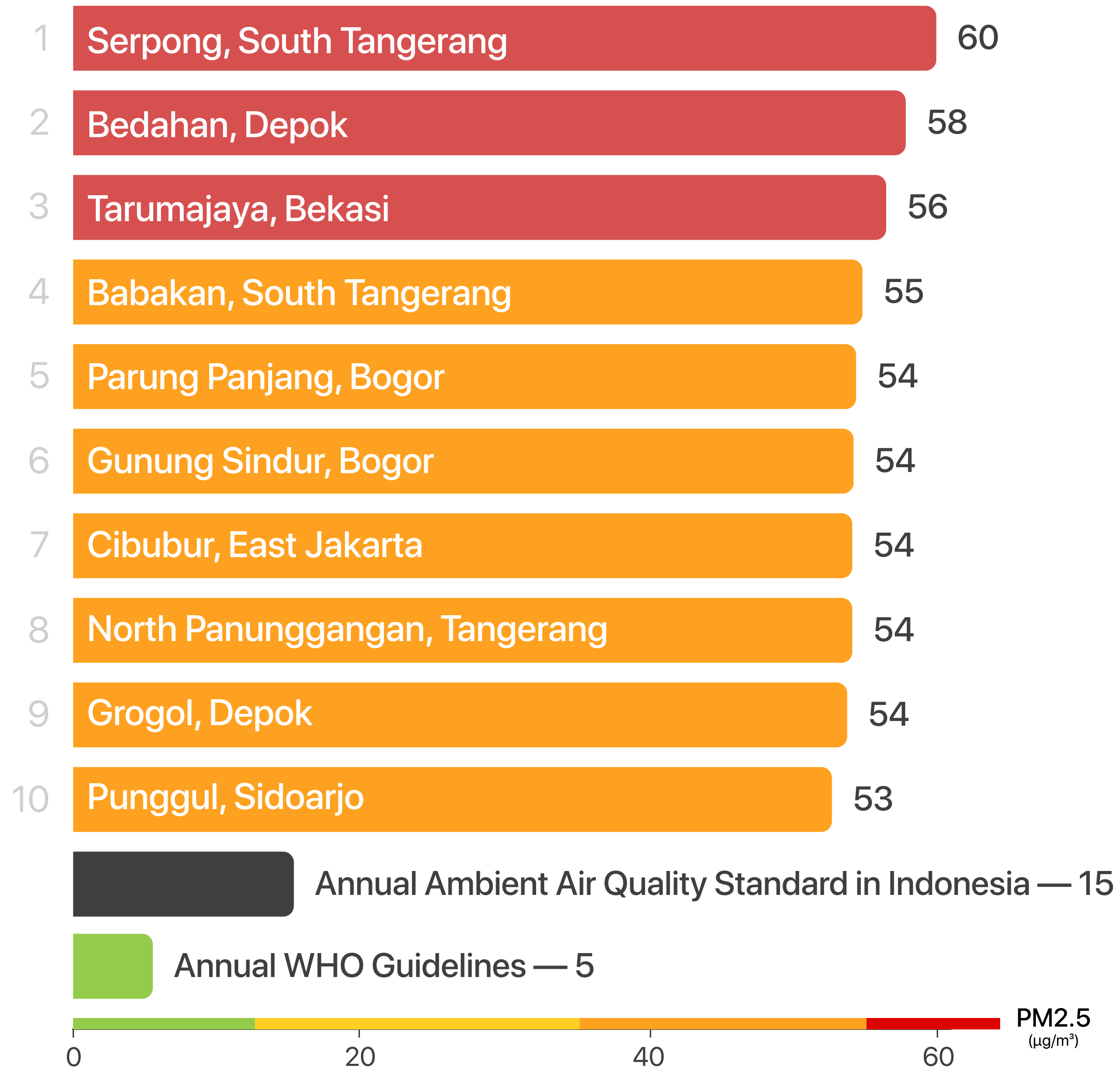
If broken down into monthly averages, it is clear that the air quality, categorized as Unhealthy (both for general public and sensitive groups), dominates the majority of areas in the Nafas sensor network.

It can be concluded that except for Bali, the Thousand Islands, and Belitung, **all areas only experience periods of relatively good air quality in January, February, and April.** Meanwhile, the rest are polluted.

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
South Tangerang	27	23	41	32	59	56	60	63	56	60	45	42
Greater Bandung	30	23	37	37	46	48	44	54	48	57	49	47
Tangerang	25	22	37	27	50	49	52	56	57	55	45	39
Bogor	29	24	35	32	51	48	53	60	48	54	41	37
Bekasi	30	22	36	33	52	51	55	53	48	51	42	40
Depok	31	24	39	35	50	48	51	54	45	51	41	38
DKI Jakarta	24	21	32	28	45	43	47	48	44	48	40	36
Semarang	32	26	32	33	41	43	40	41	39	42	36	34
Greater Surabaya	31	26	38	31	40	42	38	37	36	39	40	40
Greater Malang	22	22	32	28	40	39	30	42	37	47	34	26
D.I Yogyakarta	24	28	33	29	35	35	31	43	38	44	34	26
Bali	15	16	22	16	24	27	15	21	23	30	26	19
Thousand Islands	5	4	3	6	17	20	20	26	27	28	24	9
Belitung	6	5	5	9	14	15	14	16	22	25	13	10

10 Locations with Highest vs Lowest Pollution in 2023



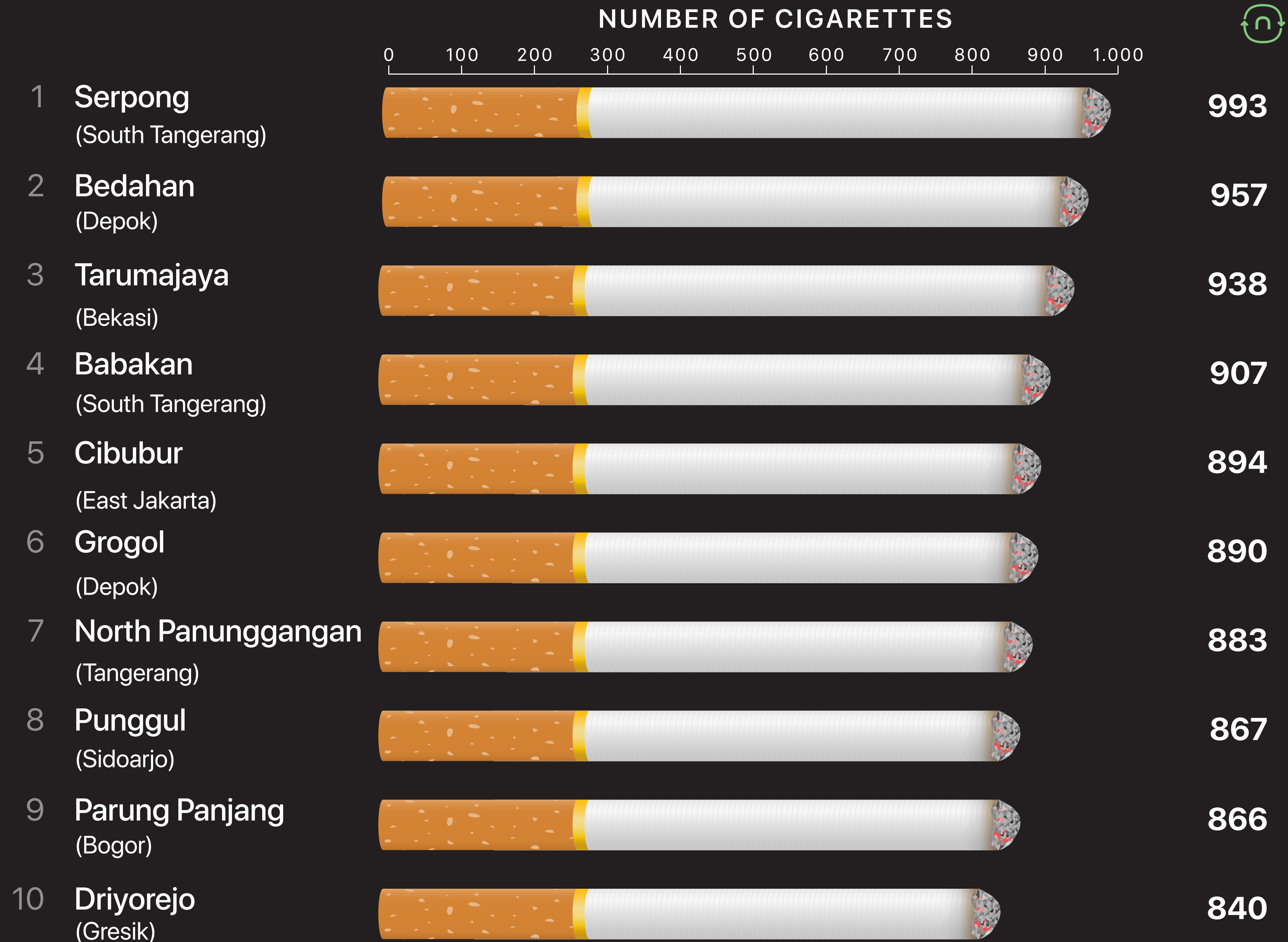
Top 10 Equivalent Number of Cigarettes

January - December 2023

Which locations recorded the highest equivalent number of cigarettes during 2023?

The measurement of cigarette equivalence is based on the average PM2.5 pollution per day, where 22 $\mu\text{g}/\text{m}^3$ is equivalent to 1 cigarette.

*) Measurement method by [berkeleyearth.org](https://www.berkeleyearth.org)





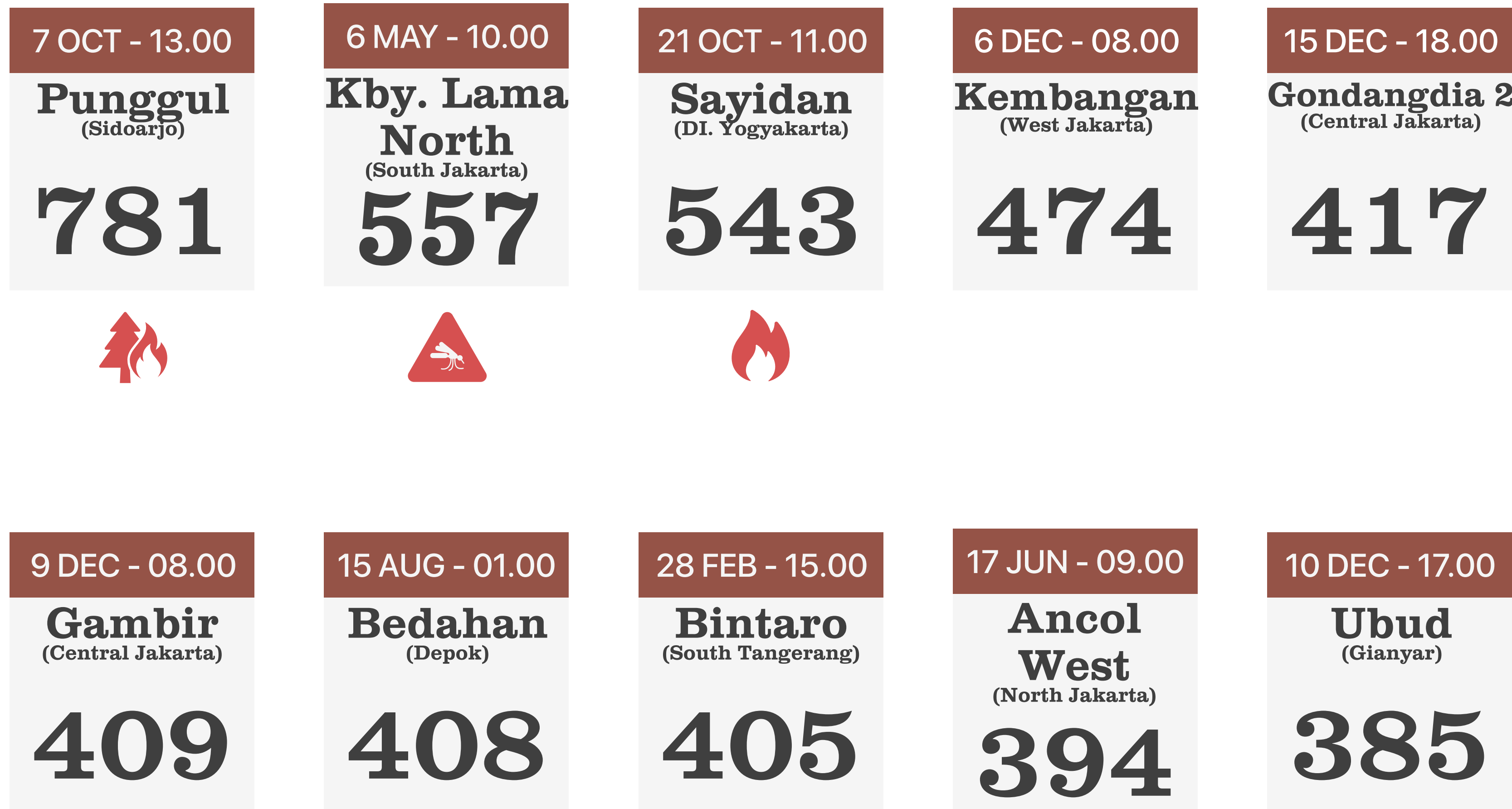
Top 10 Days of Highest Pollution Throughout 2023

This ranking indicates the times of the highest pollution occurrences at 10 sensor locations throughout 2023.

Editor's Note:
When PM2.5 levels reach the Toxic category, don't panic! Pay attention to any alerts present, such as those caused by mosquito fogging activities. However, a significant increase in PM2.5 levels can also be caused by other factors.

*) in $\mu\text{g}/\text{m}^3$ unit

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy
- Very Unhealthy
- Hazardous



*) Poor air quality caused by mosquito fogging, waste burning, or land fires.

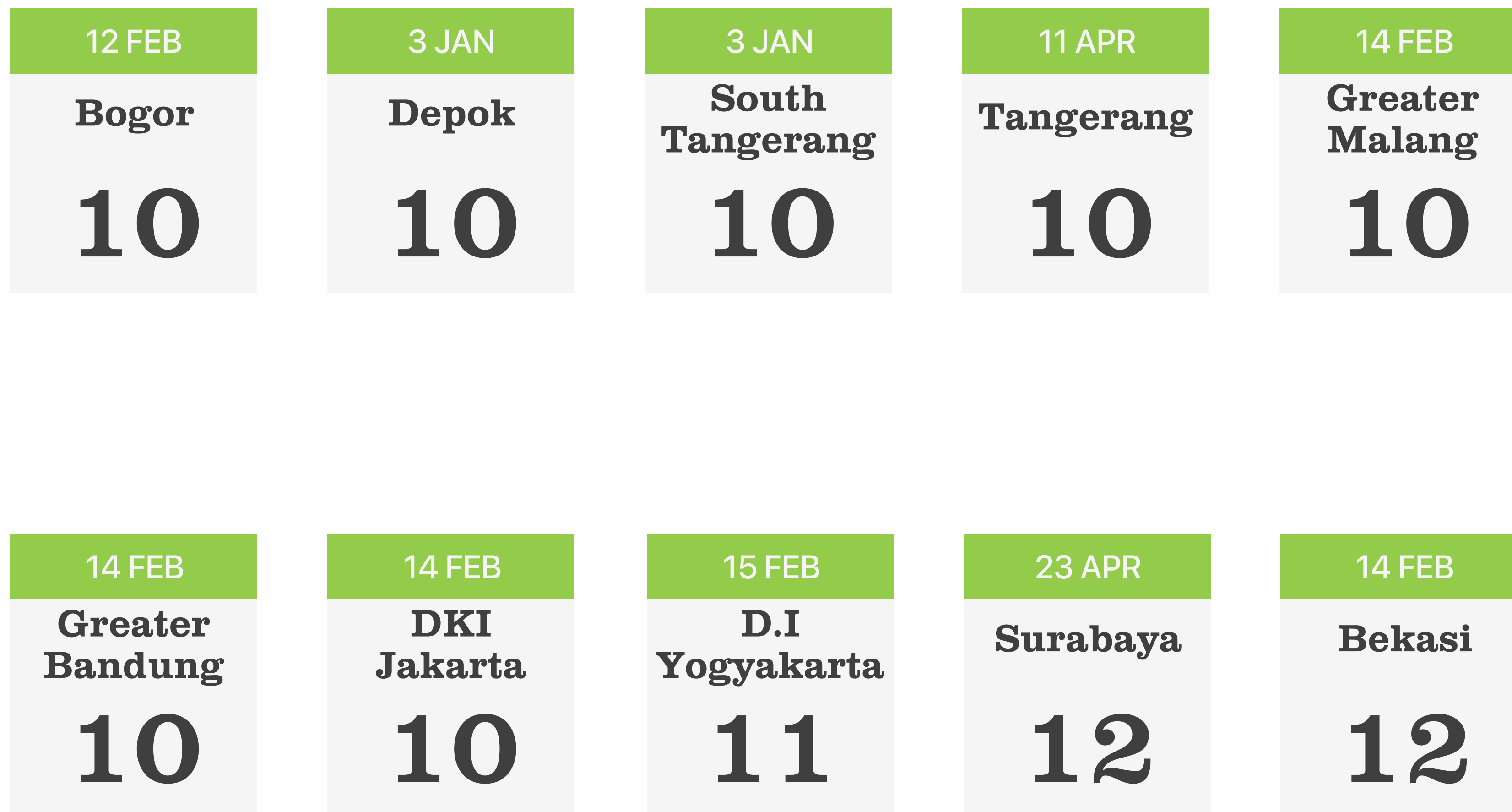


Top 10 Days of Lowest **Pollution** Throughout **2023**

This ranking indicates the times of the lowest pollution occurrences at 10 sensor locations throughout 2023.

*) in $\mu\text{g}/\text{m}^3$ unit

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy
- Very Unhealthy
- Hazardous



Unhealthy Air Periods* Dominated Throughout 2023

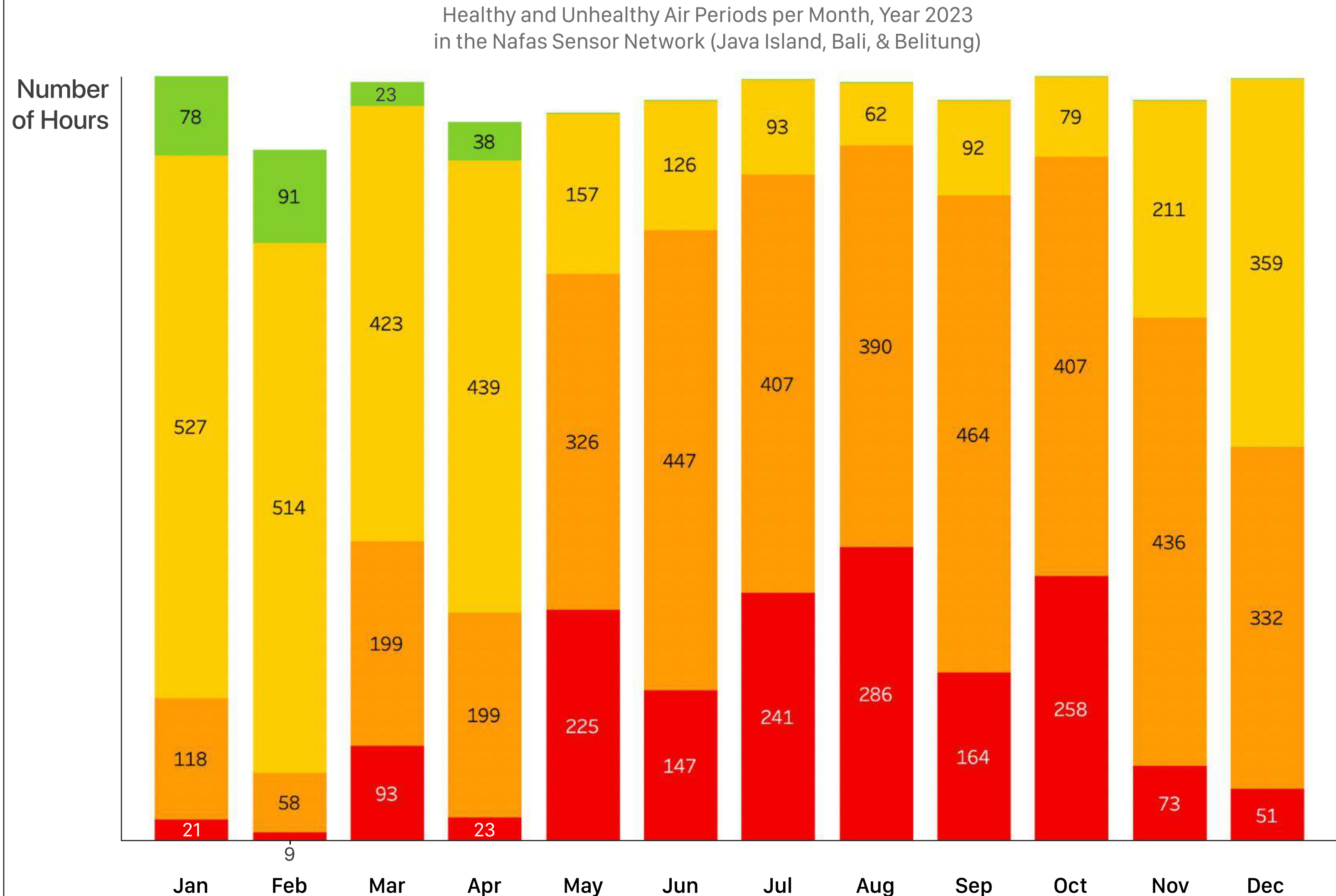
UNHEALTHY AIR DOMINATES

Out of all the Nafas sensor network, healthy air can only be enjoyed from January to April 2023. Whereas November to December, known for clean air, had no healthy air periods in 2023.

The varying levels of pollution each month are not only influenced by the different pollution sources in each area but also by rainfall, wind, and inversion conditions** in each region every month.

* Unhealthy for both general and sensitive groups
 ** A condition where warm air is trapped above cold air, resulting in limited air circulation and increased accumulation of air pollution at the surface

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy



*The difference in the number of hours is due to the varying number of days in each month.

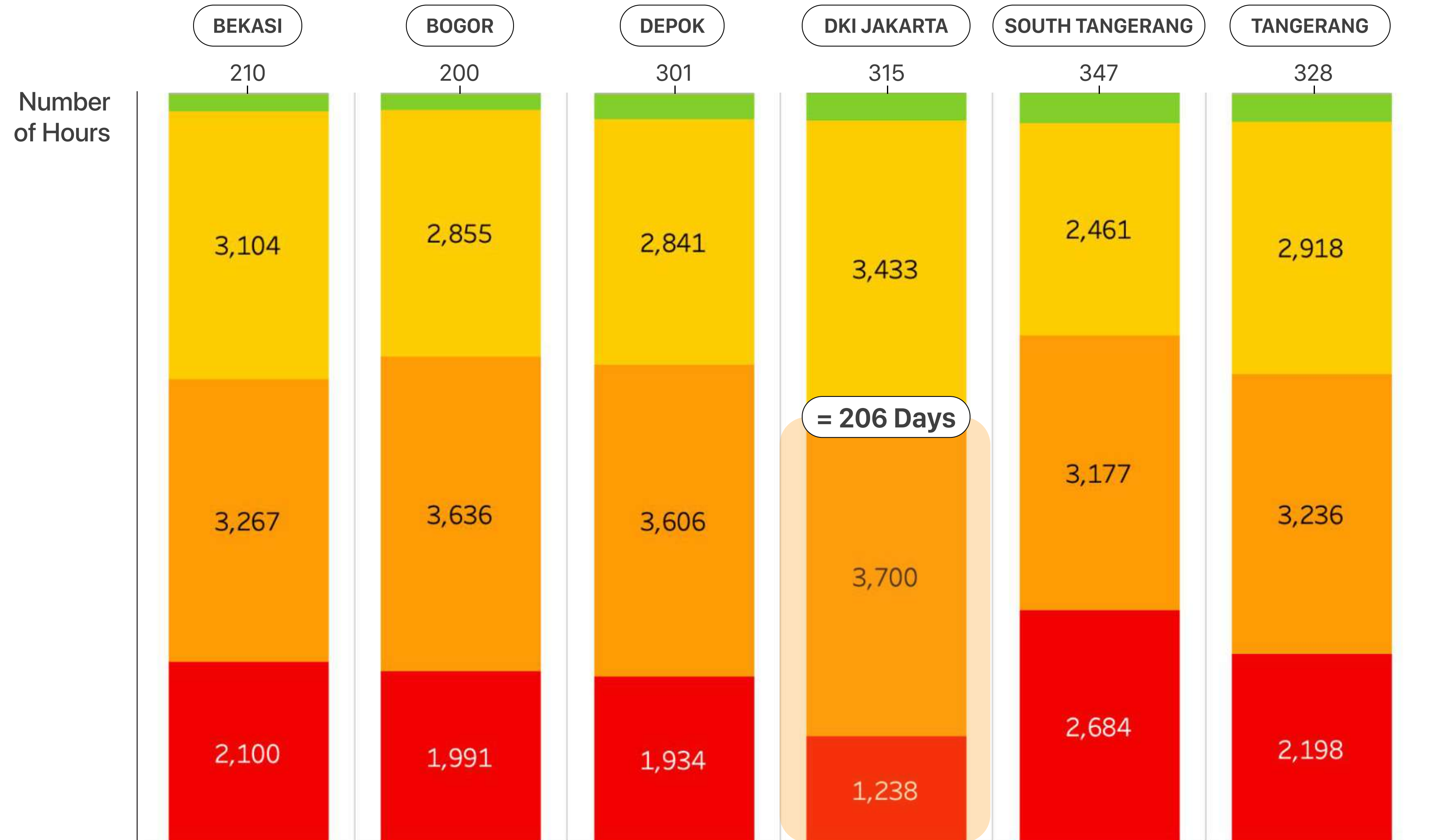
Air Quality in Jabodetabek Unhealthy* for More Than 200 Days in 2023

Unhealthy air periods in Jabodetabek averaged between **4,938 hours (206 days)** and **5,861 hours (244 days)**.

Of all the cities in Jabodetabek, DKI Jakarta is observed to have the least total hours of Unhealthy air compared to its surrounding areas, approximately **206 days**.

* Unhealthy for both general and sensitive groups

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy



*The difference in the number of hours is due to the varying number of days in each month.

The occurrence of high pollution in DKI Jakarta is the least. Why?

This is supported by the fact that DKI Jakarta is close to the sea, allowing sea breezes to enter more easily compared to its surrounding areas, especially coastal areas like North Jakarta.

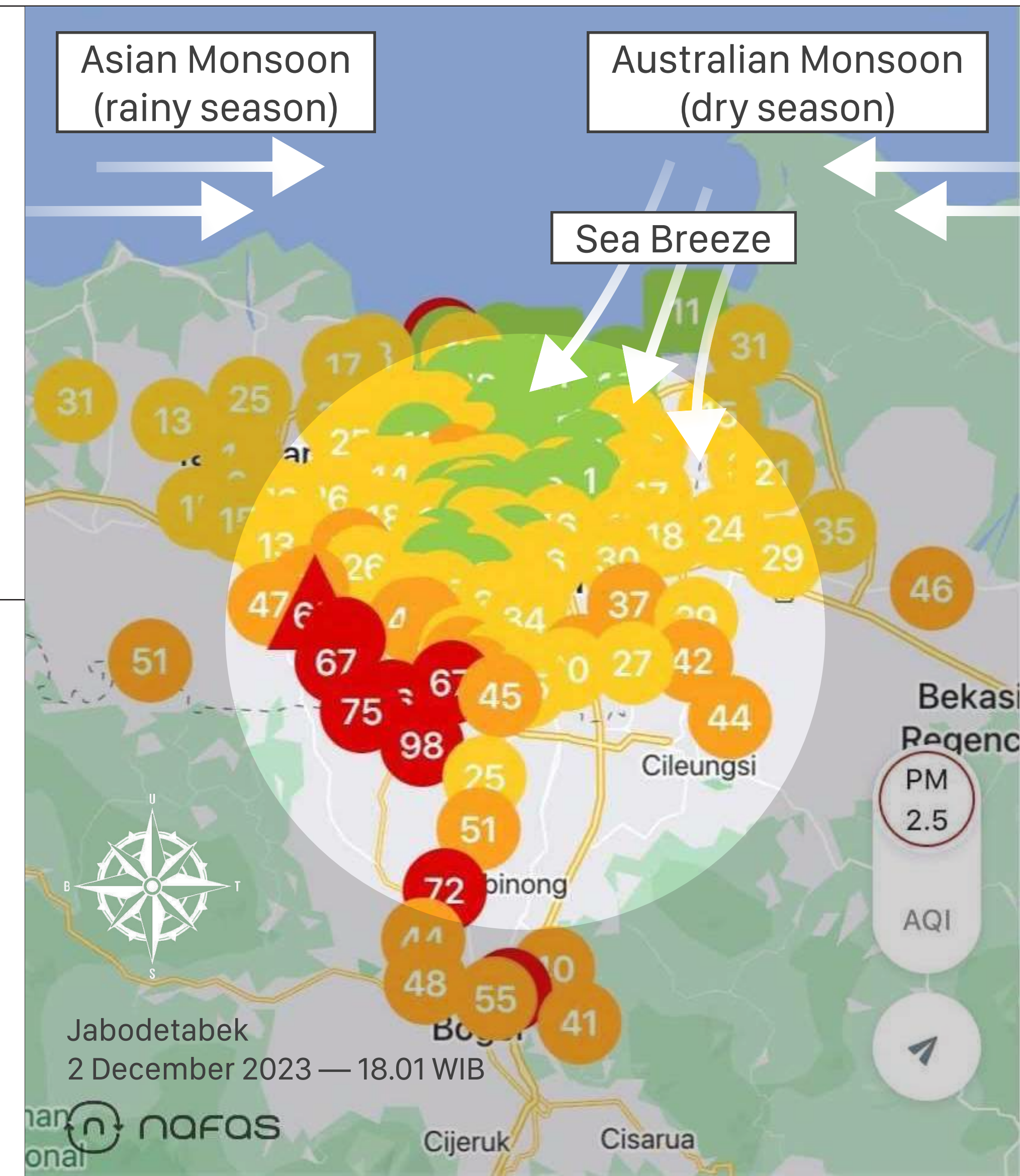
Additionally, **the geographical location of DKI Jakarta is strategically positioned to be traversed by large-scale** winds from the West (Asian monsoon) and East (Australian monsoon), making pollution tend to disperse more easily.

Furthermore, relatively strong winds most frequently occur in the Jabodetabek region.

TANGERANG SELATAN MOST POLLUTED?

Meanwhile, South Tangerang becomes the most polluted area. Besides the presence of highlands on the southwest side, which can trap pollution, this is also evidenced by wind data showing **calm winds* occurring 83% of the time during 2023.**

*Average wind speed per hour: 0.3 - 1.5 m/s



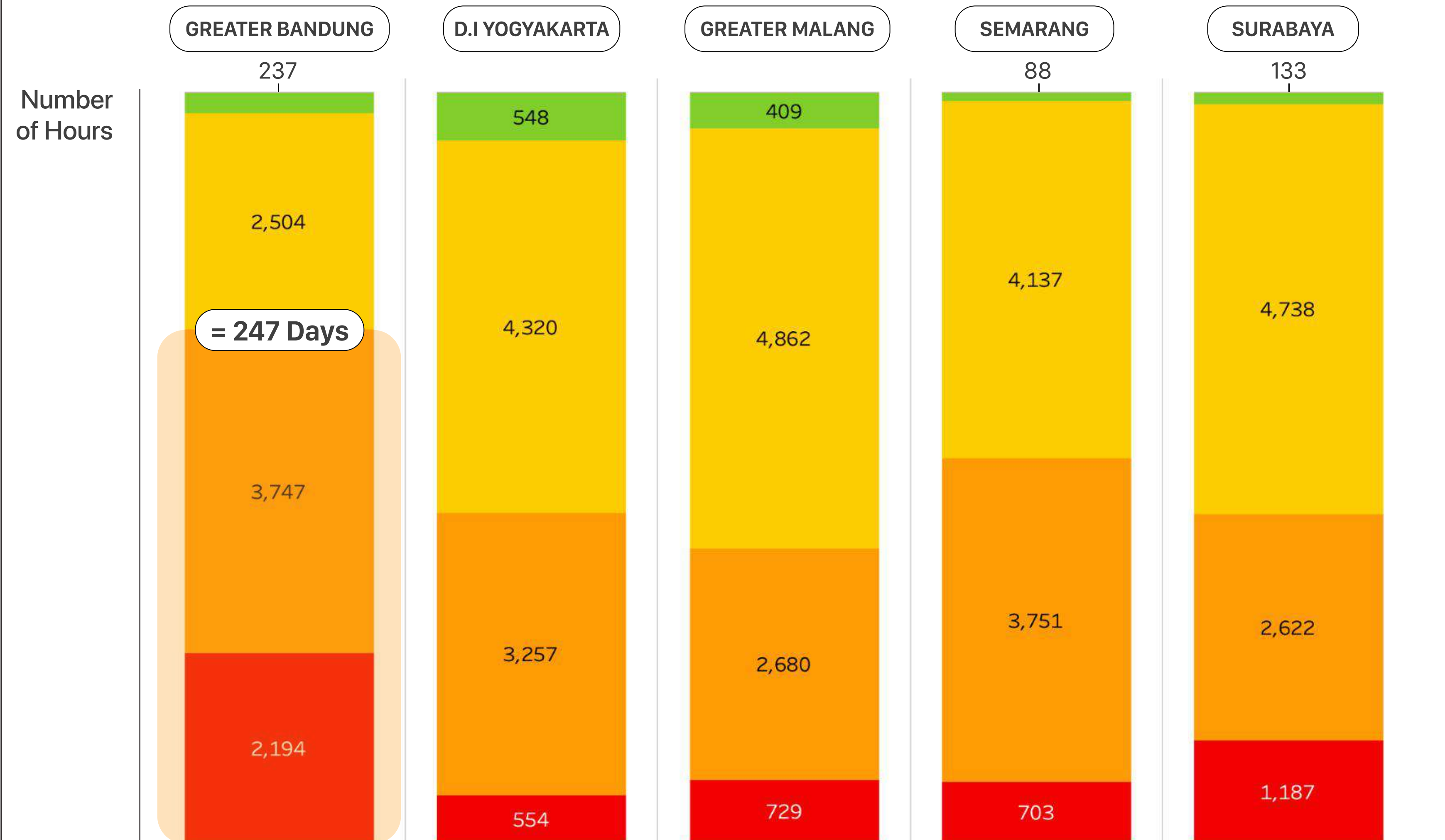
Greater Bandung Area Experiences High Pollution More Frequently Than Surabaya

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Among all major cities in Java Island, the Greater Bandung Area has the highest number of Unhealthy hours, amounting to **5,941 hours** or **approximately 247 days**.

This is due to its topographical condition, which forms a basin, hindering the dispersion of pollution.

- Good
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*The difference in the number of hours is due to the varying number of days in each month.

Belitung Has the Highest Number of Healthy Air Periods in 2023

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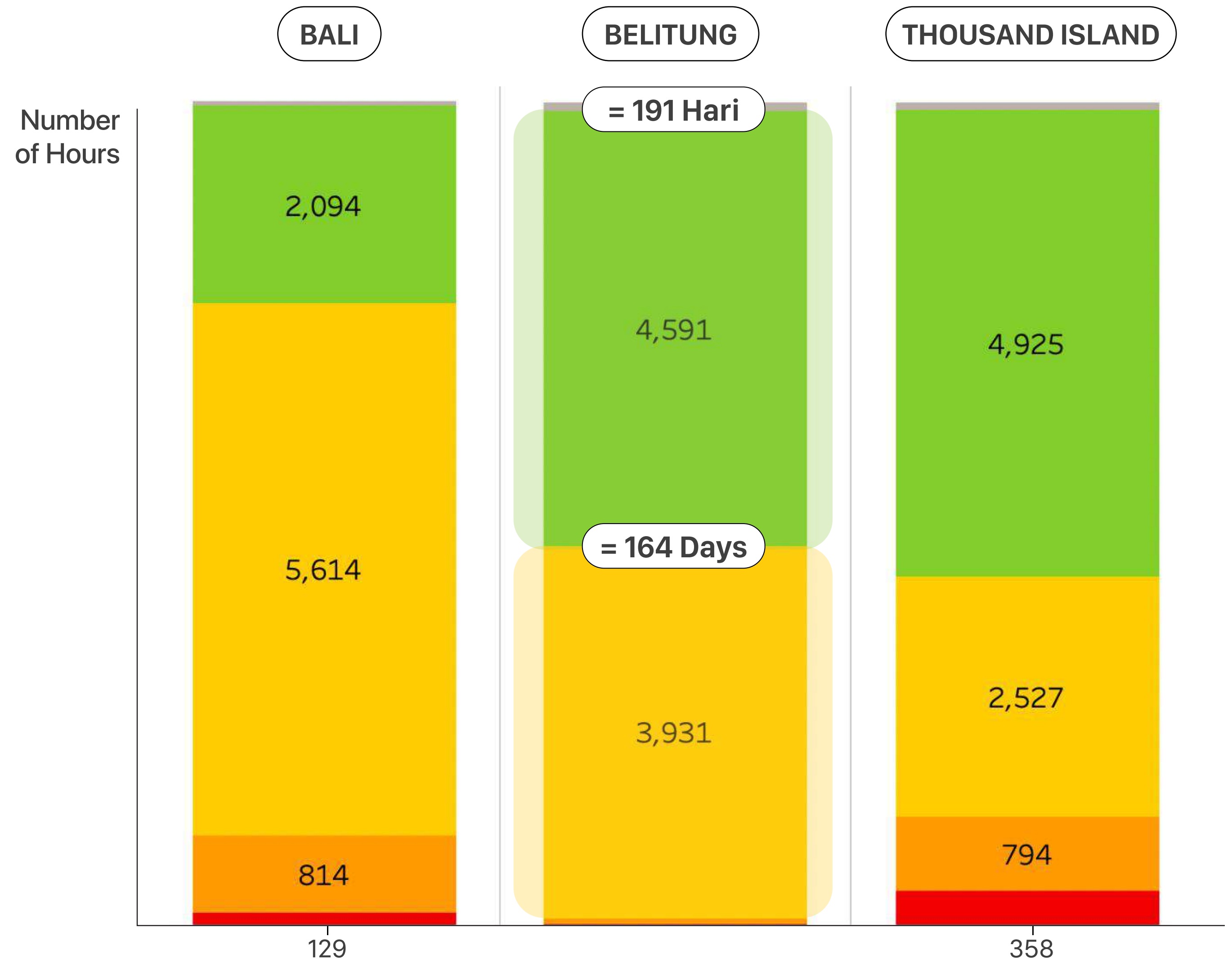
Areas located in islands often have better air quality compared to large cities. This is supported by the coastal conditions, allowing sea breezes to easily disperse pollution.

The average air quality in Belitung throughout 2023 is good, with the number of healthy air periods totaling **4,591 hours (191 days)** and fair air periods for **3,931 hours (164 days)**.

On the other hand, the air quality in the Thousand Islands is often poor (**equivalent to 48 days of unhealthy air per year**), but it can also be good at times.

Stay tuned for our analysis on the next page!

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy



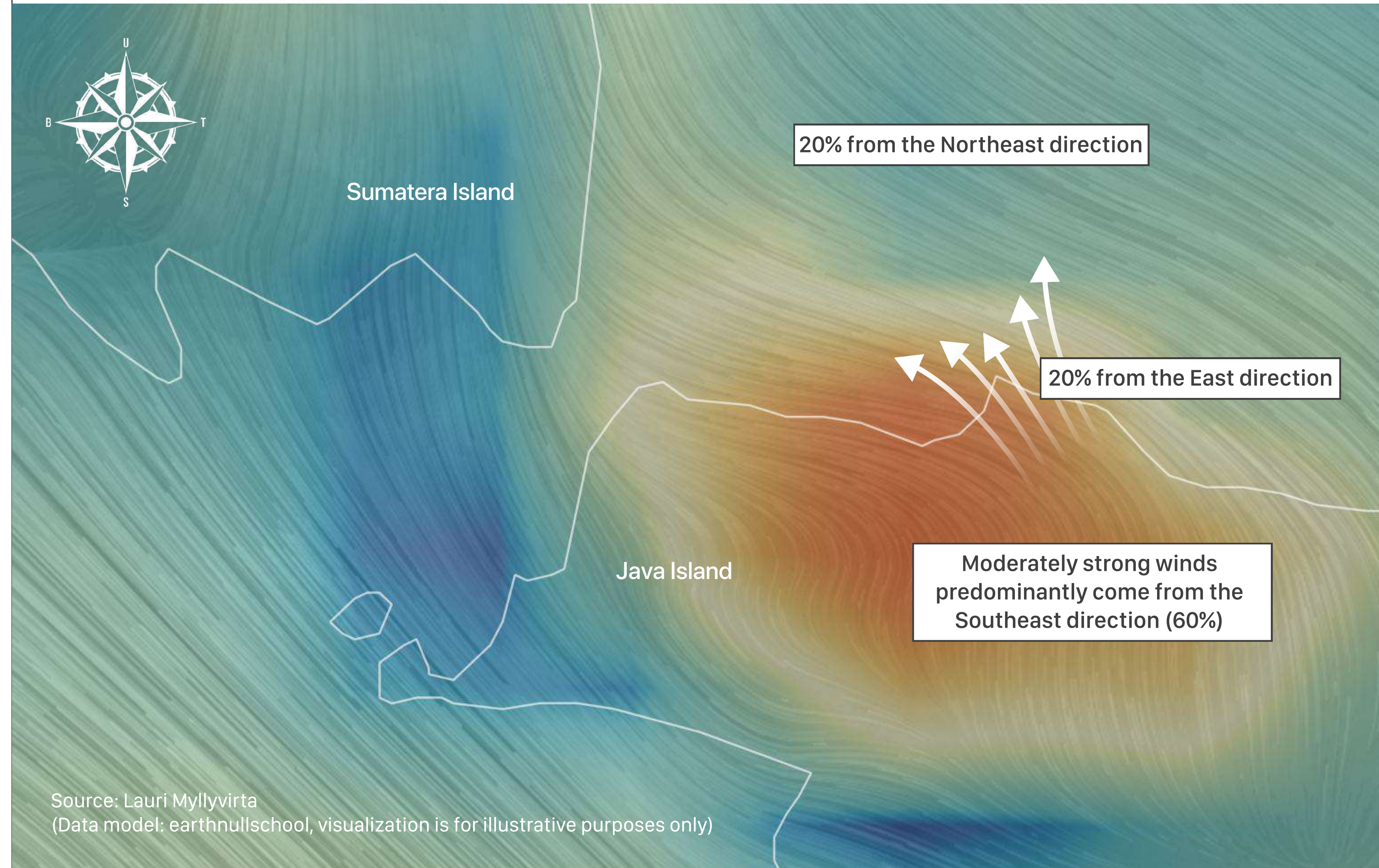
*The difference in the number of hours is due to the varying number of days in each month.

Why is the air quality in the Thousand Islands often unhealthy?

The Thousand Islands often receive pollution from the direction of Jabodetabek. This affects the fluctuation of pollution in the Thousand Islands, which can vary significantly compared to other islands; it can suddenly worsen or even improve.

An example of this occurred in September 2023, where the Australian monsoon winds were still prevalent. Almost the majority of dominant winds came from the Southeast direction of the Thousand Islands.

Here is a visualization of wind direction during high pollution events in the Thousand Islands in September 2023.



Source: Lauri Myllyvirta
(Data model: earthnullschool, visualization is for illustrative purposes only)

* This analysis requires further research

Throughout the year 2023, the Clean Air Zone successfully provided clean and healthy air in schools, offices, gyms, yoga studios, and beauty salons.

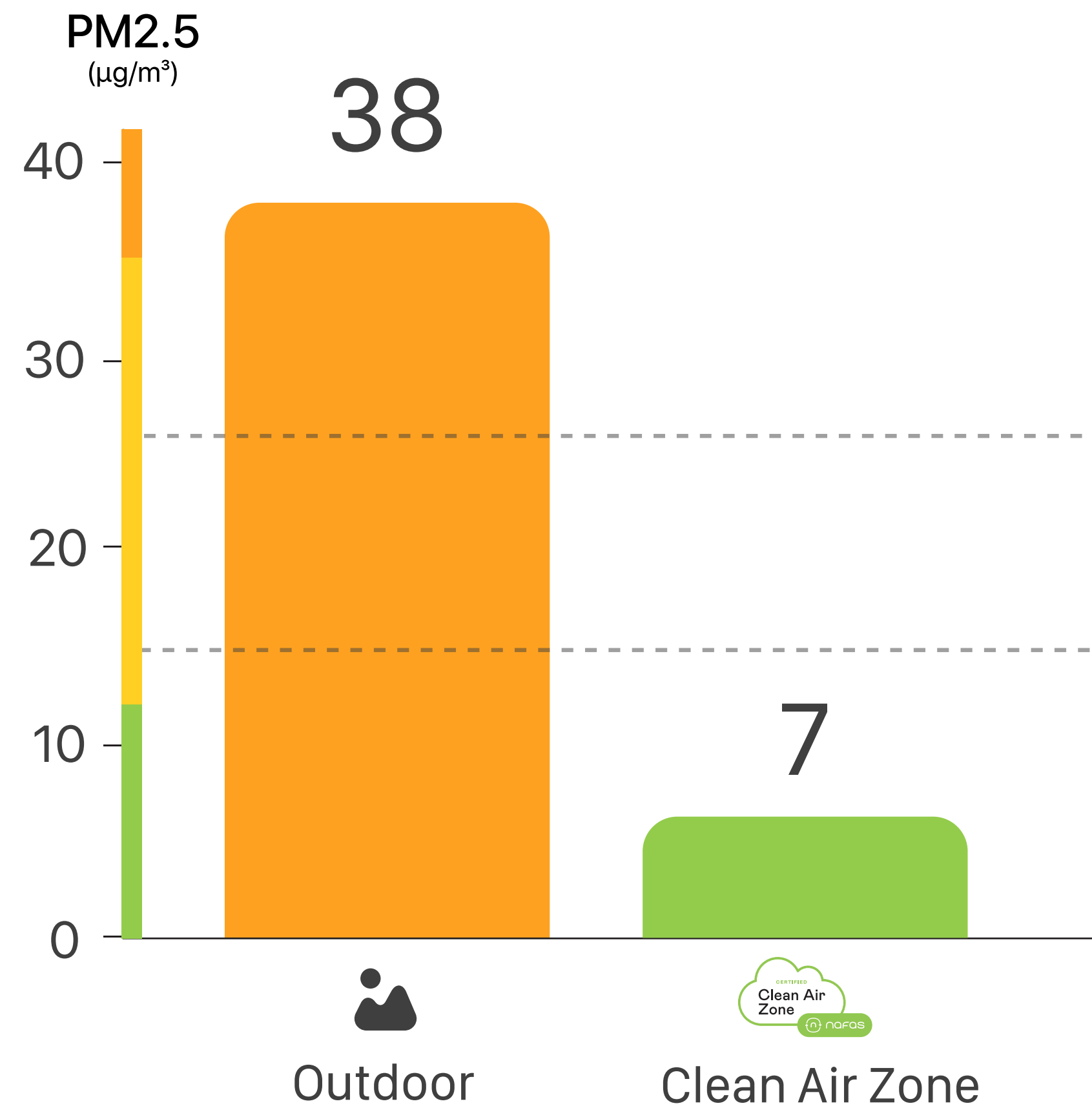


The average indoor air quality in the Clean Air Zone is

82% better

compared to outdoor and non-Clean Air Zone locations.

- Good
- Moderate
- Unhealthy for Sensitive Group
- Unhealthy



* CAZ data is only during operating hours

✓ Good indoor air quality reduces the risk of chronic diseases and decreases productivity loss.

26 µg/m³

서울대학교
SEOUL NATIONAL UNIVERSITY

Risk of heart disease

↑ 33%

15 µg/m³

KMJ
KOSIN MEDICAL JOURNAL

Risk of asthma attacks in children increases

↑ 9% one day after PM2.5 increases by 10 µg/m³ from the baseline of 15 µg/m³.

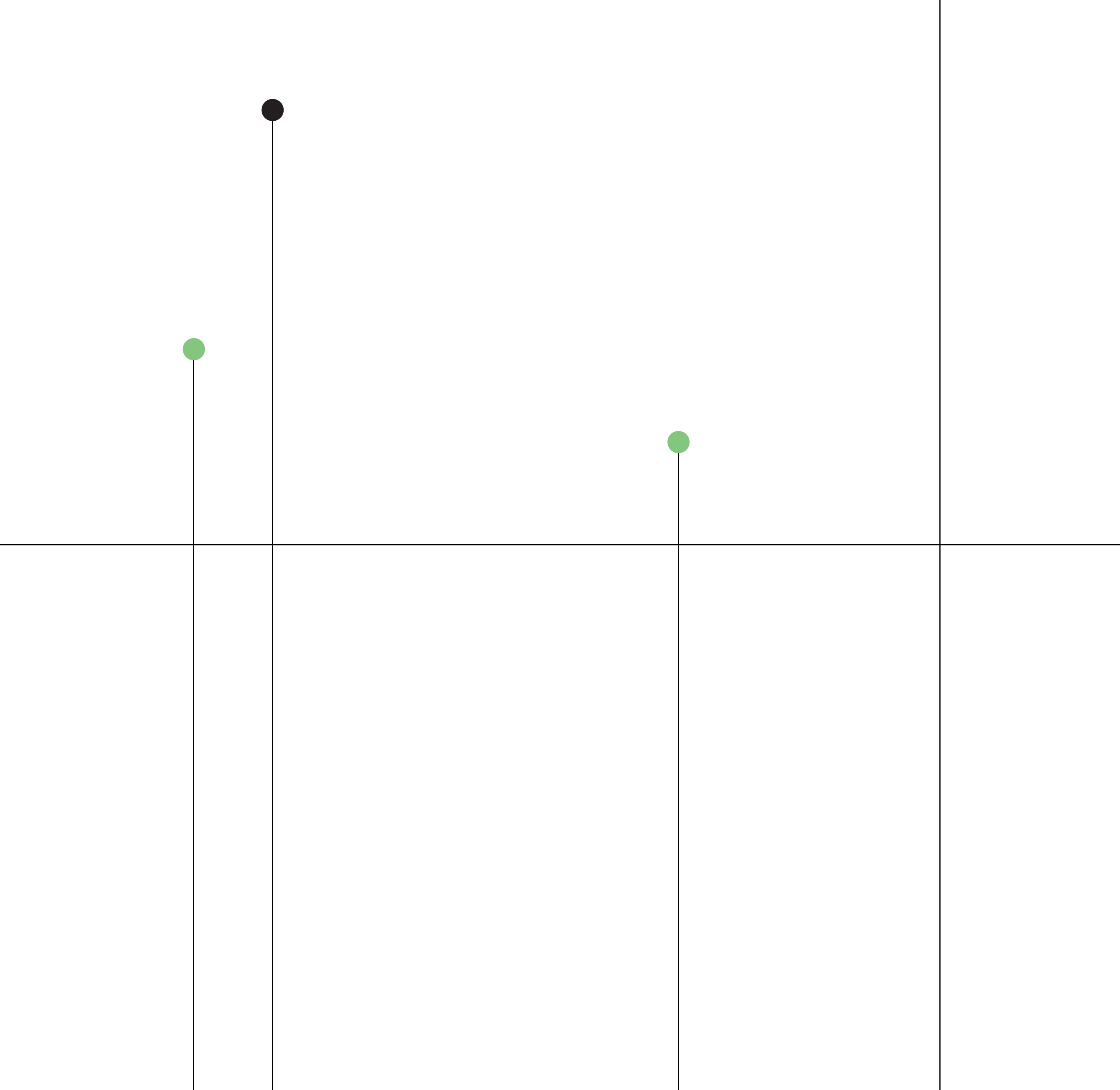
USC

Employee productivity is potentially decreased

6%

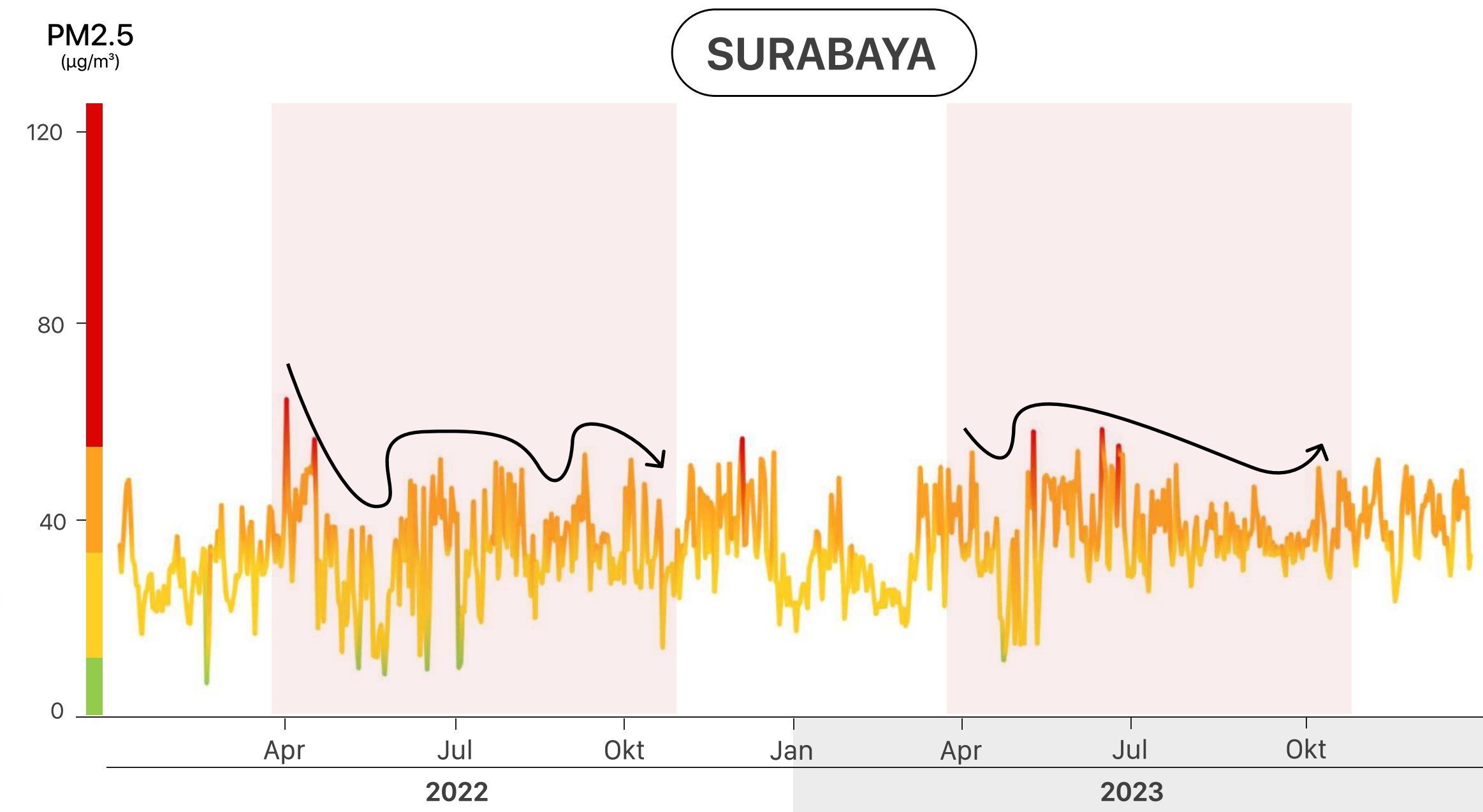
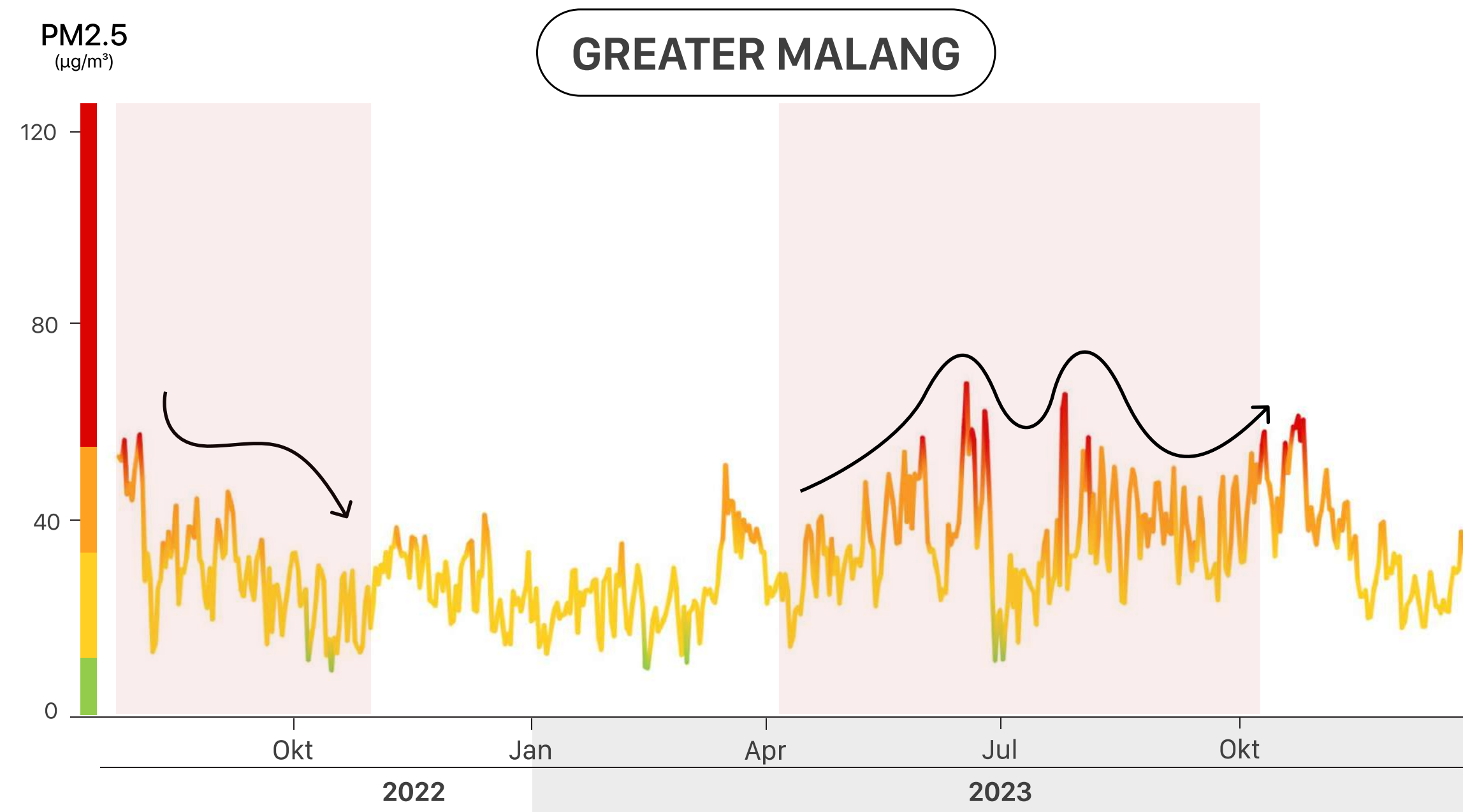
Air Pollution Trends

2022 vs 2023



Air Pollution Trends 2022 vs 2023

East Java

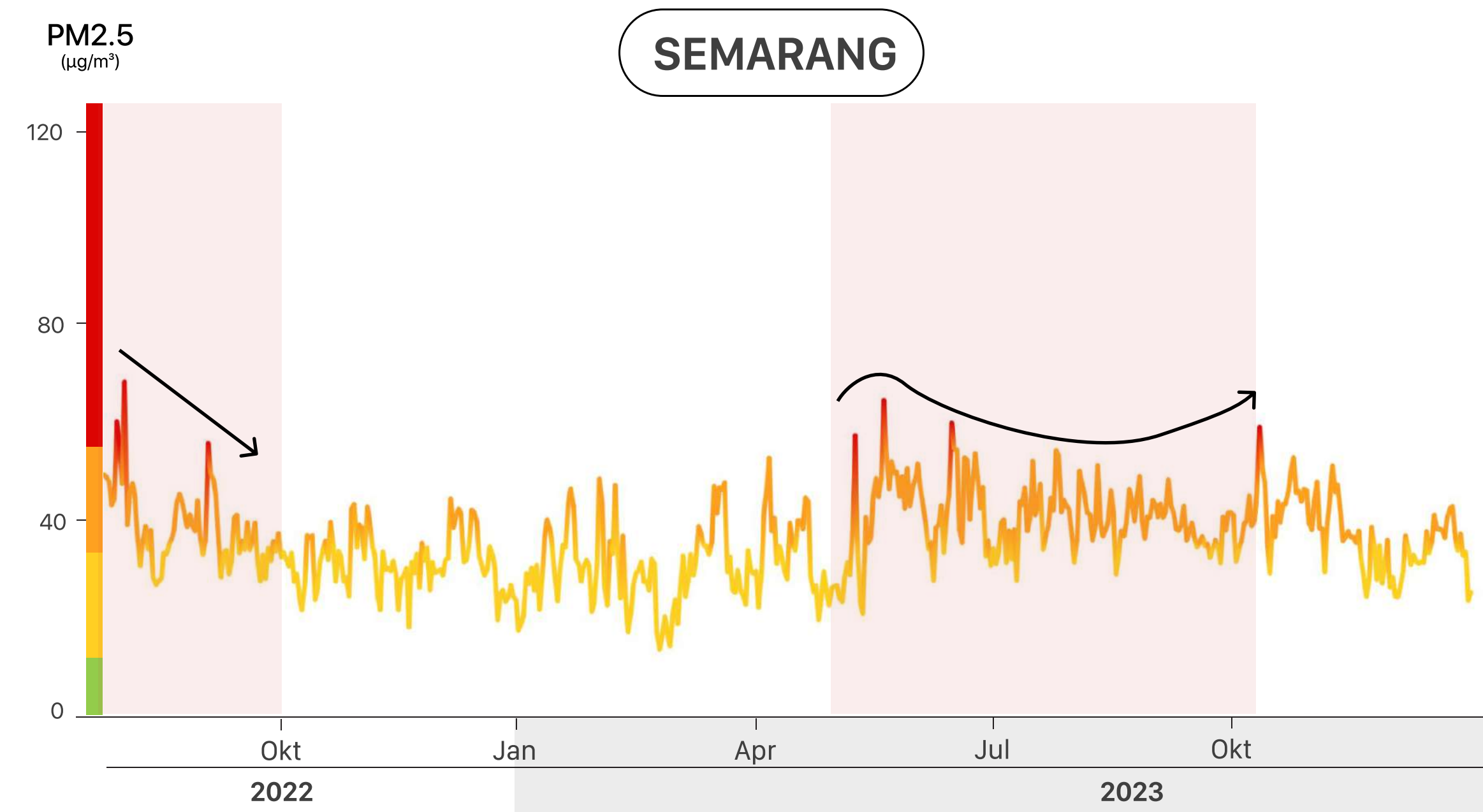
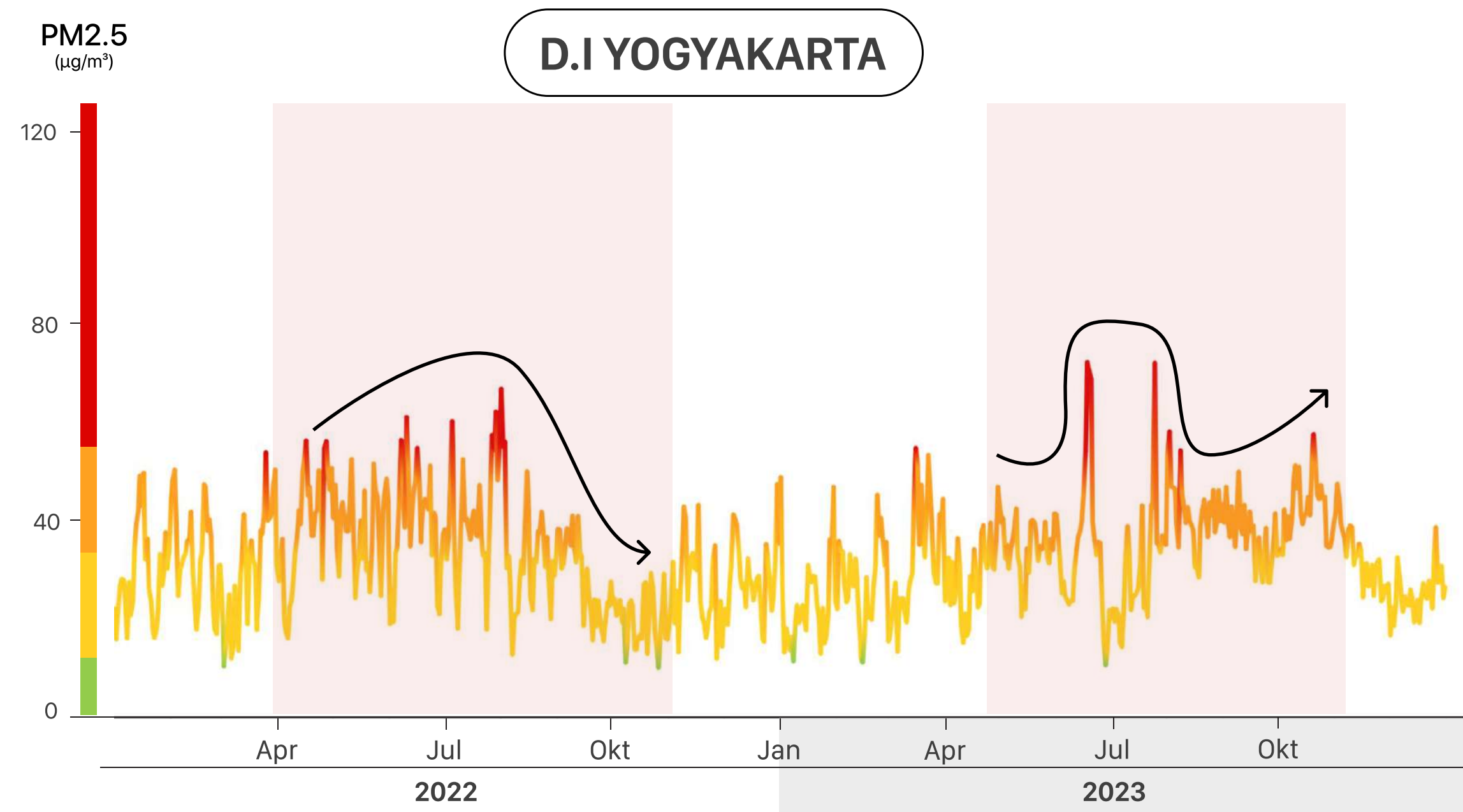


The Malang region appears to be more polluted in 2023. In the previous year (2022), the pollution trend tended to decline towards the end of the year, contrasting with the end of 2023 which shows the opposite trend.

Pollution trends in Surabaya were observed to be highly fluctuating throughout 2022, unlike 2023 where Unhealthy air quality tended to dominate.

Air Pollution Trends 2022 vs 2023

D.I Yogyakarta & Central Java

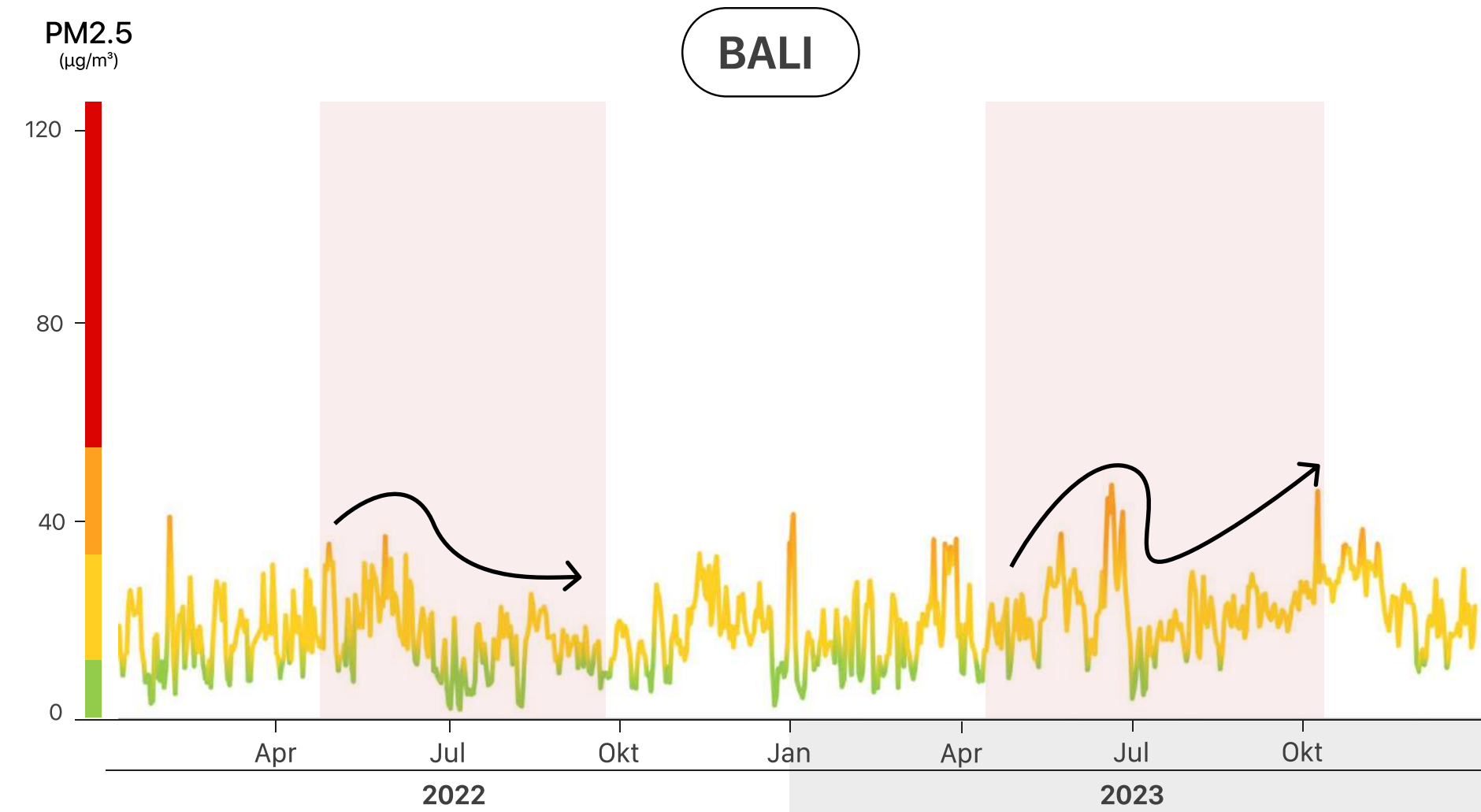
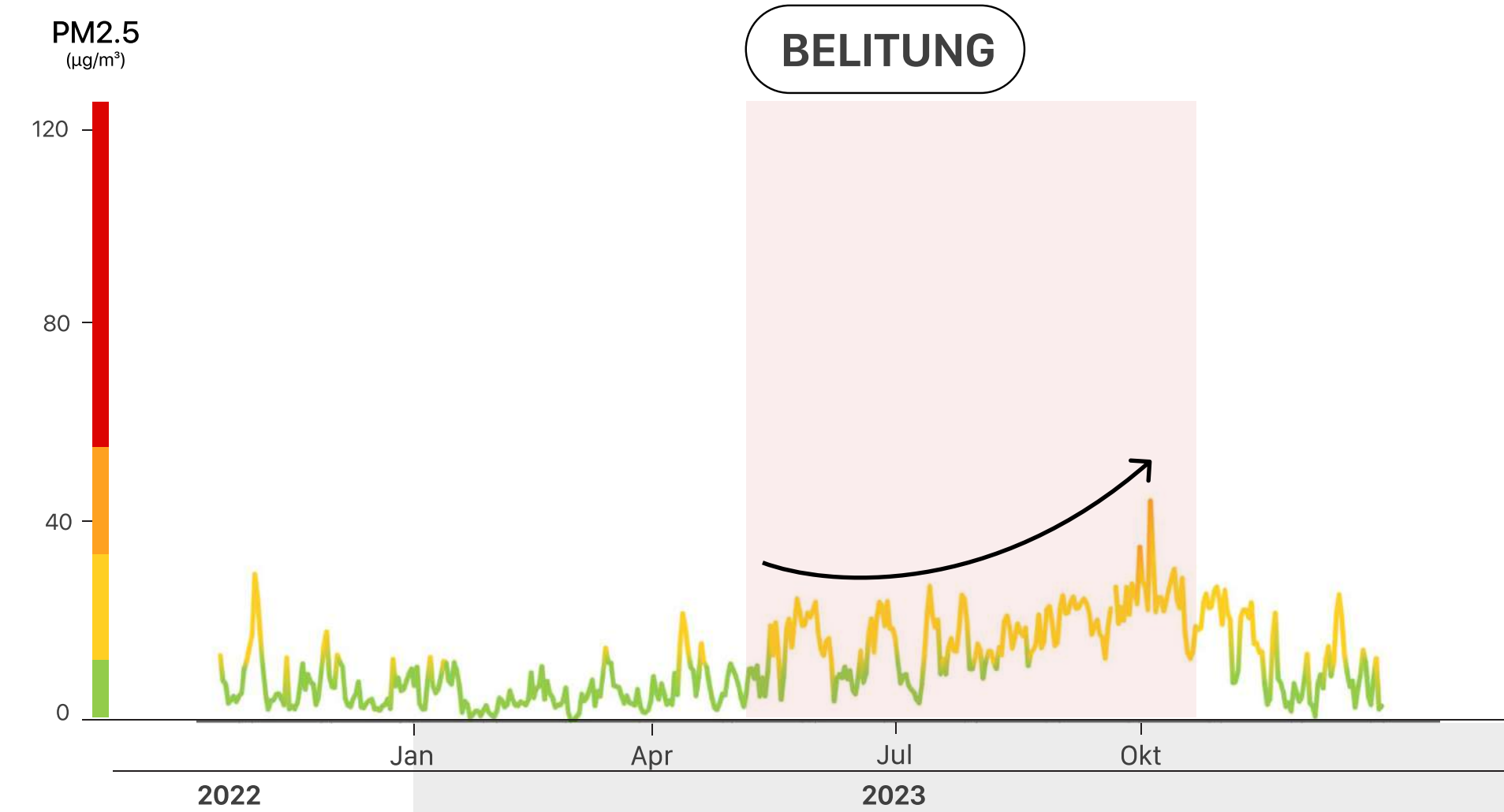
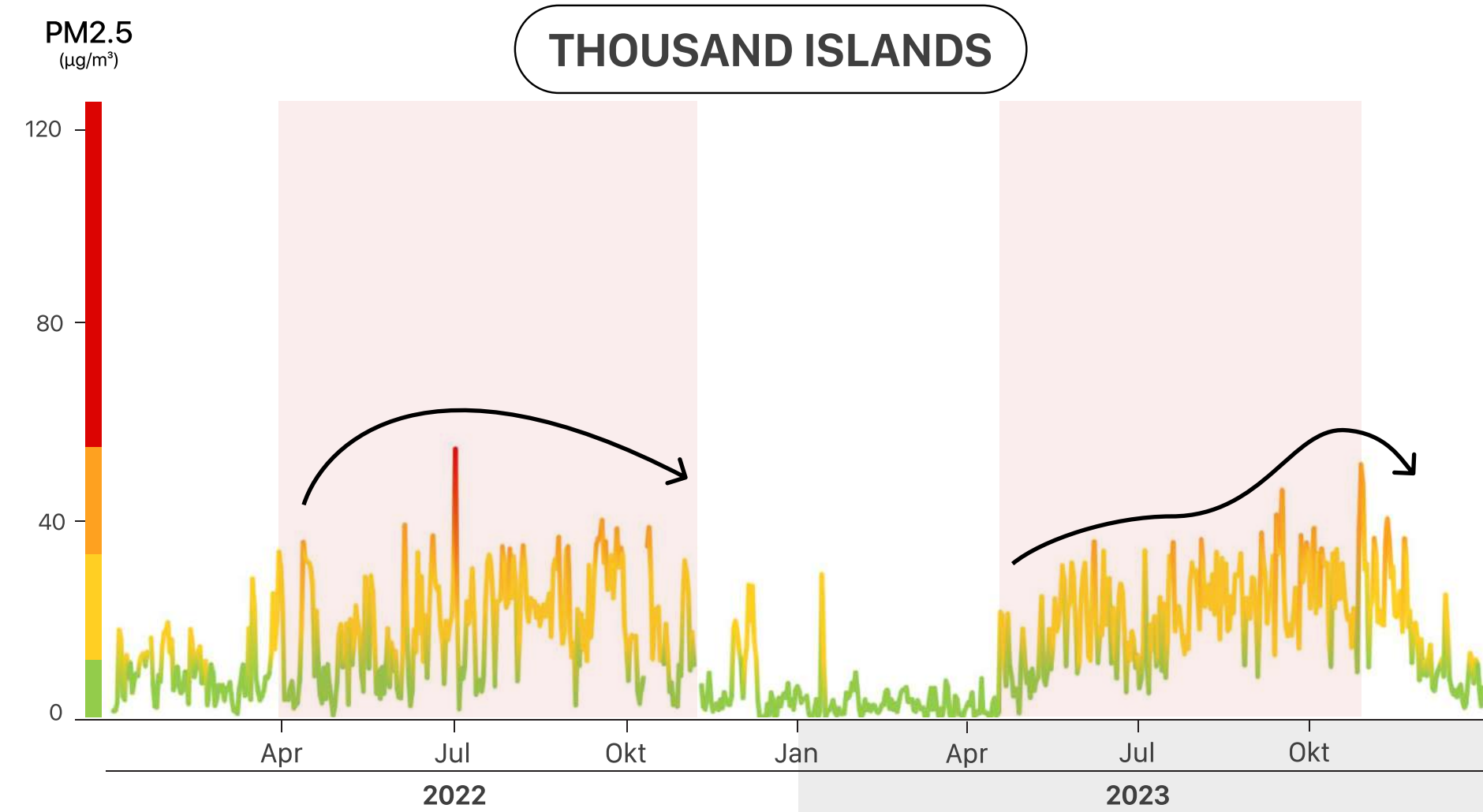


In Yogyakarta, pollution trends in 2022 were declining, but in the past year of 2023, they tended to consistently remain in the unhealthy for sensitive groups.

Similar conditions are seen in Semarang, where pollution trends declined in 2022, but in 2023 they remained quite stagnant within the unhealthy for sensitive groups.

Air Pollution Trends 2022 vs 2023

Archipelago Region

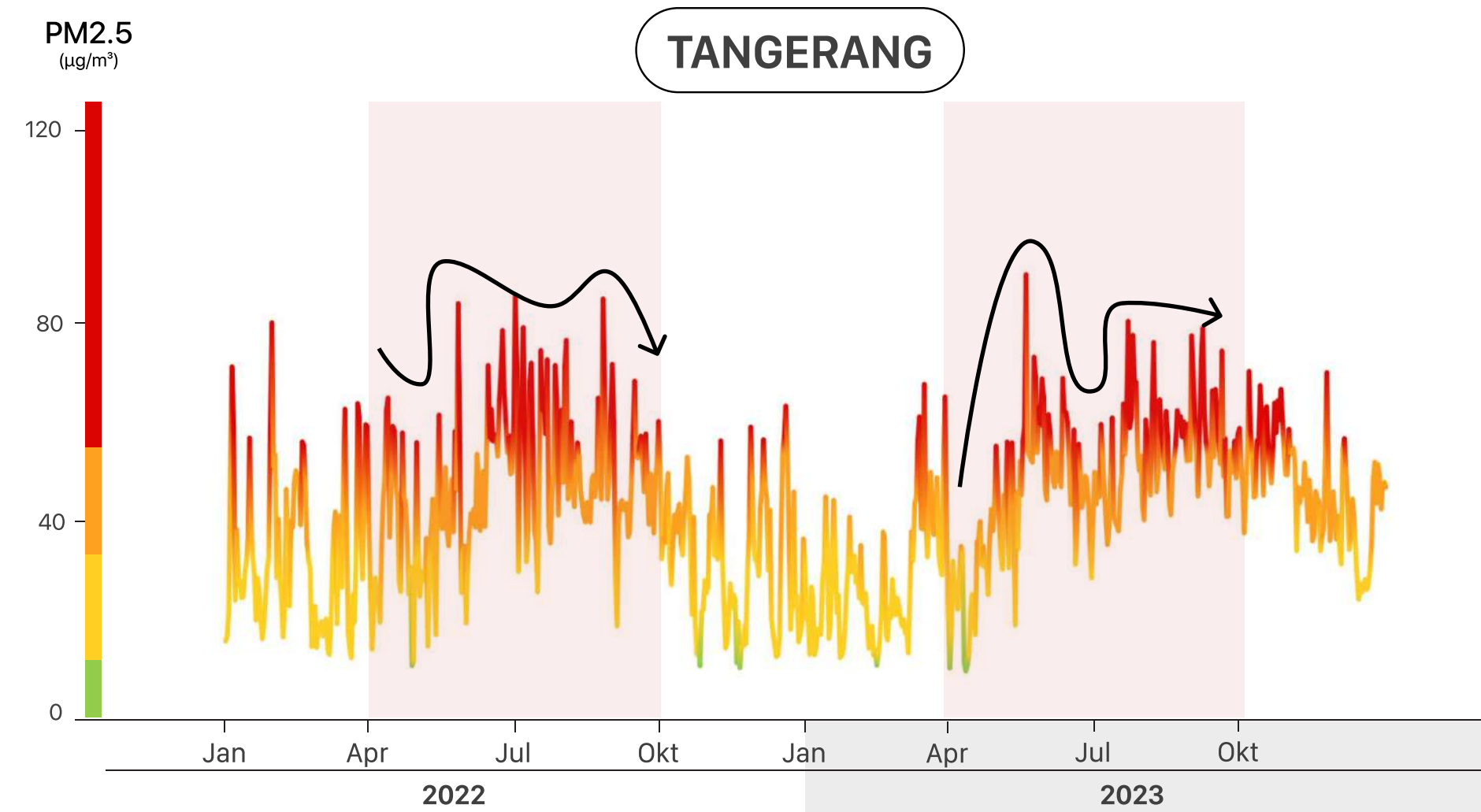
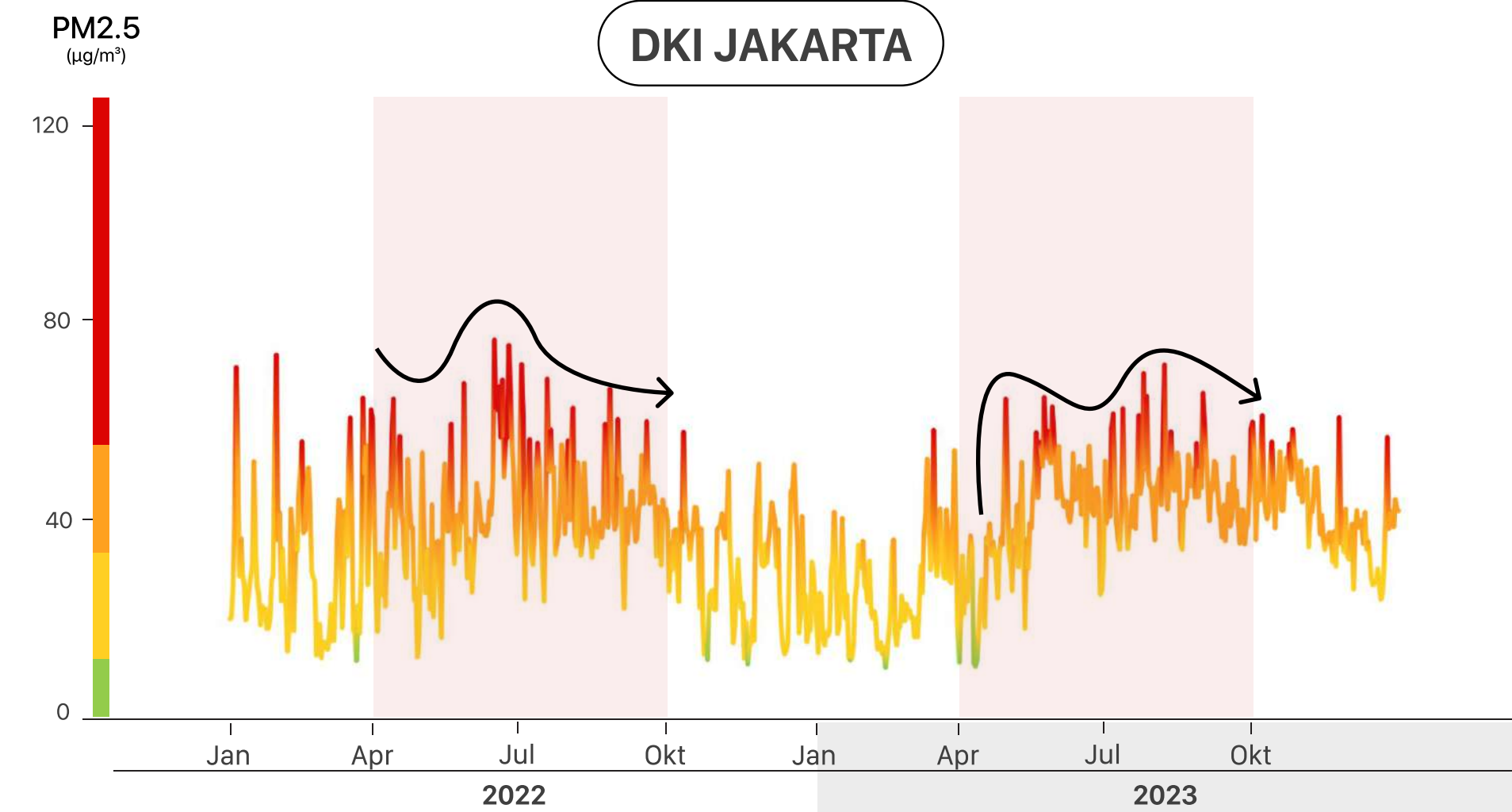
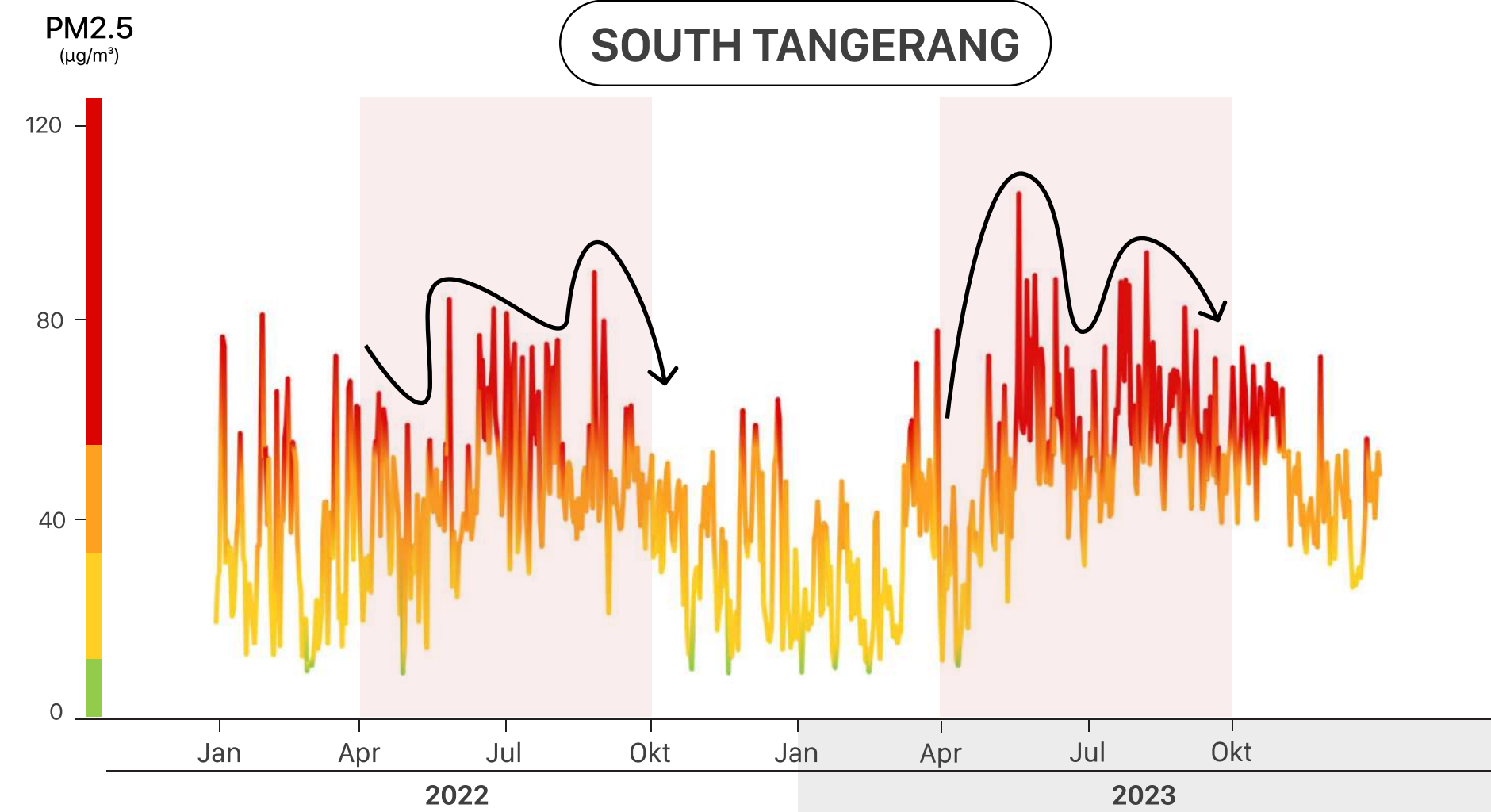


Of all the island regions in the Nafas sensor network, only the Thousand Islands have quite fluctuating pollution trends, both in 2022 and 2023.

Meanwhile, last year, in 2023, the three regions of Bali, Belitung, and the Thousand Islands had the same increasing trend towards the end of 2023.

Air Pollution Trends 2022 vs 2023

DKI Jakarta & Banten

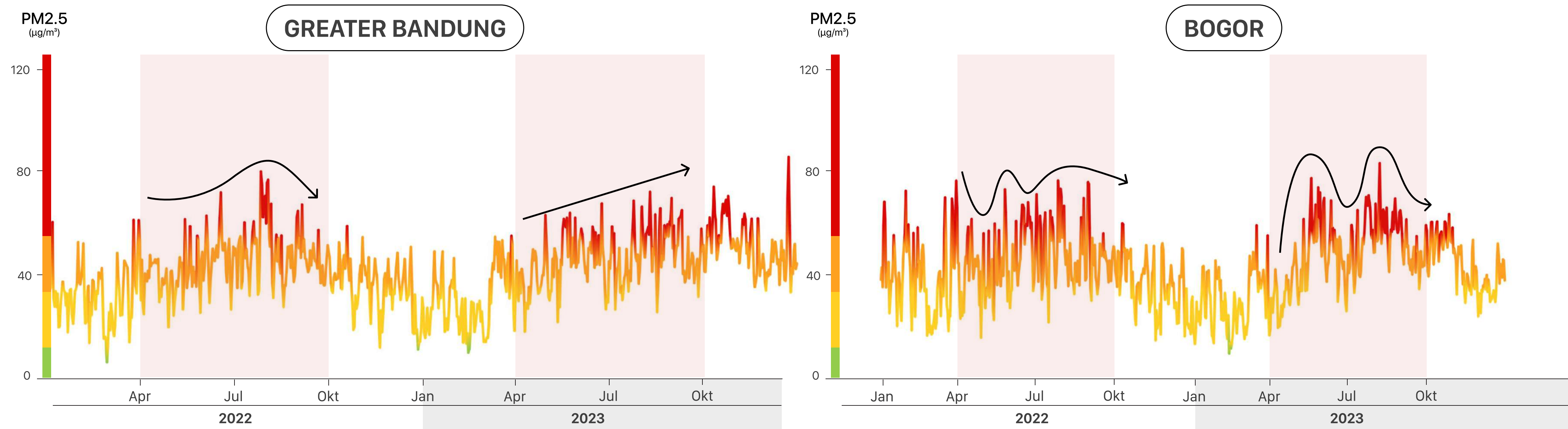


These three areas are known for their high pollution levels, with South Tangerang being the champion.

The pollution trends in these three regions in 2022 and 2023 appear to be similar. However, upon closer examination, the pollution pattern in 2023 is not as fluctuating as in 2022.

Air Pollution Trends 2022 vs 2023

West Java (I)

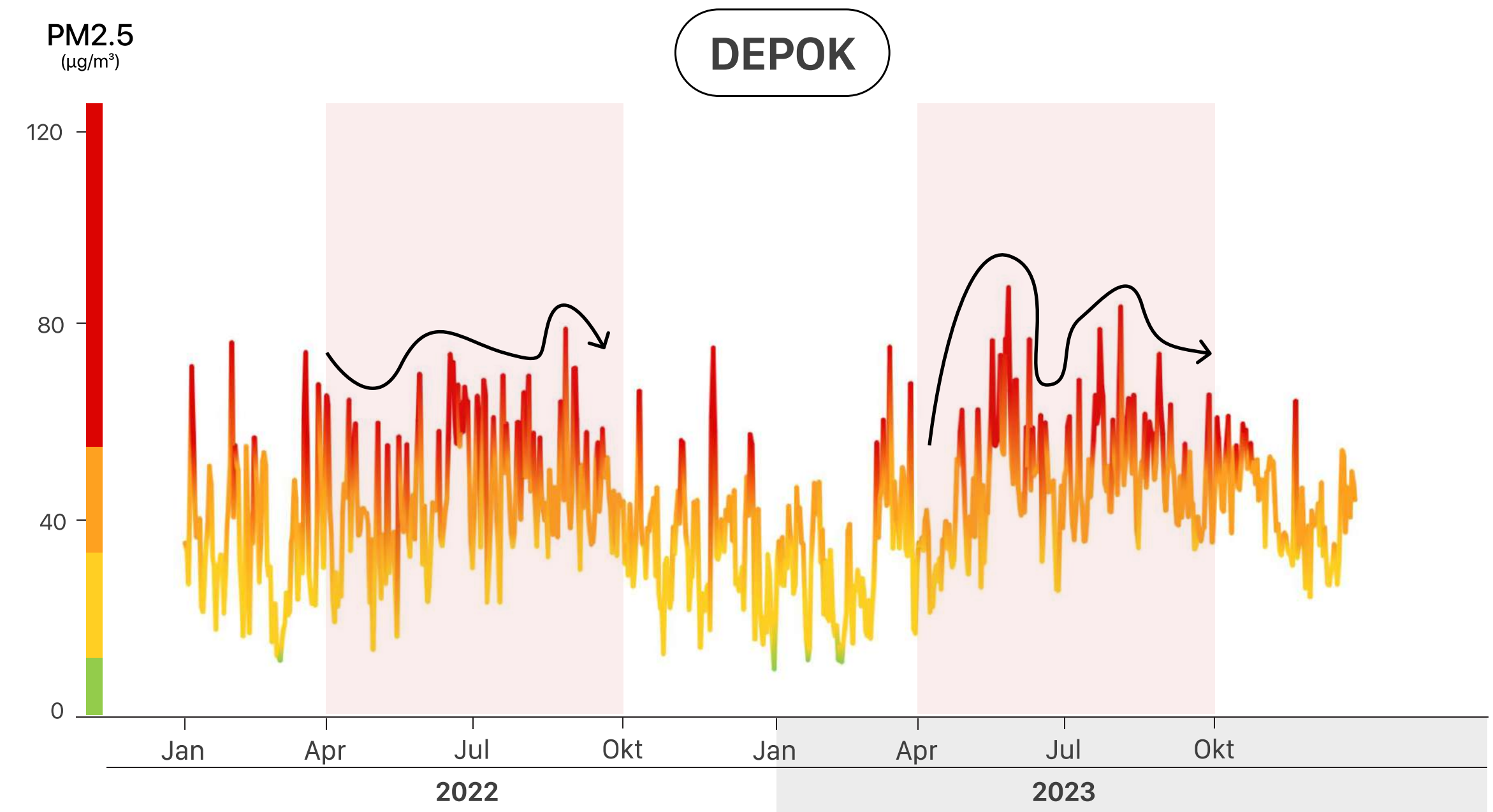
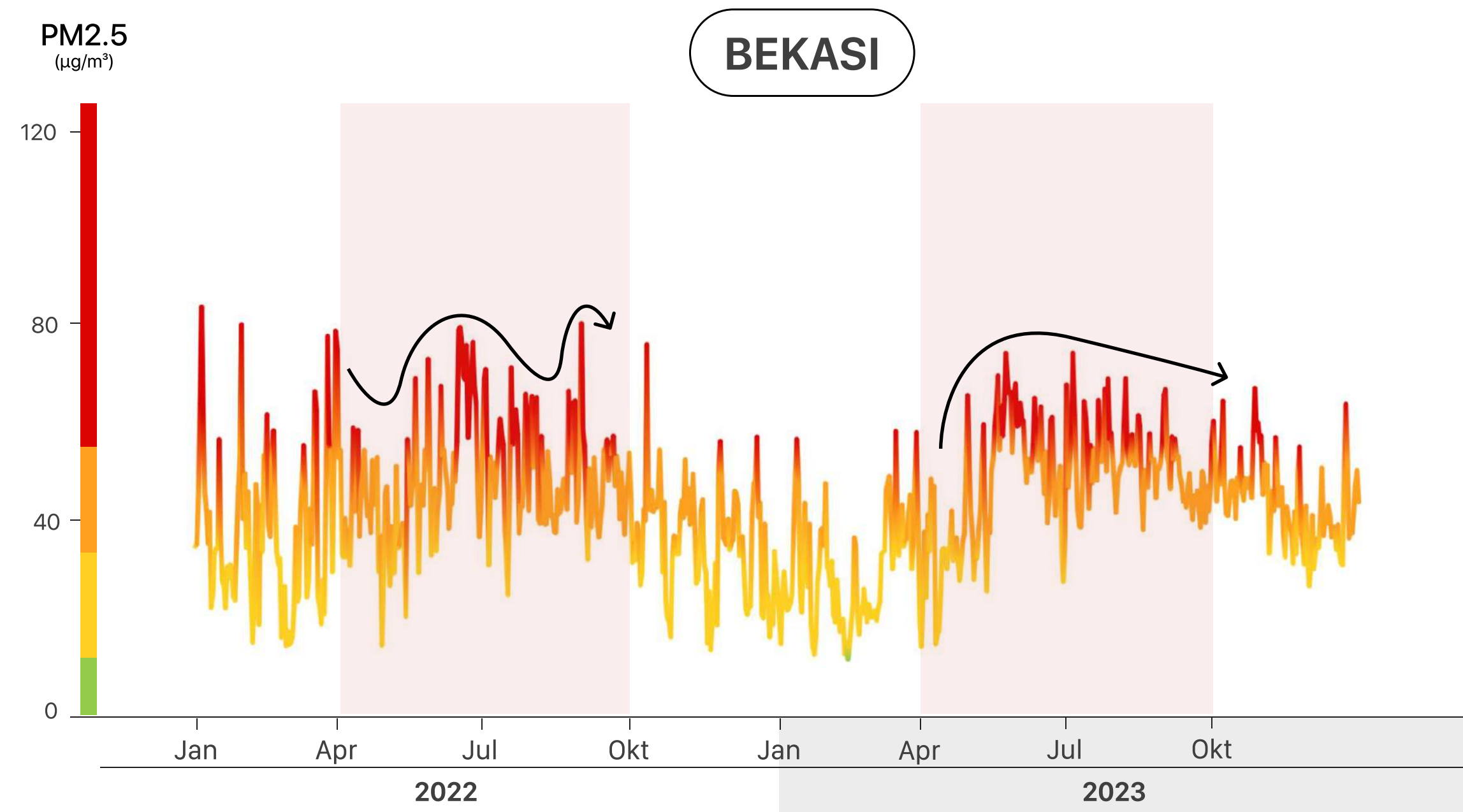


Pollution trends in the Greater Bandung Area gradually decreased in the middle to the end of 2022. In contrast, in 2023, the pollution trend consistently increased until the end of the year.

Unlike Bandung, the Bogor area (City & Regency) had quite fluctuating air pollution trends during the period of 2022. Meanwhile, in 2023, high pollution events were more frequent, resulting in air quality falling into the Unhealthy category more often.

Air Pollution Trends 2022 vs 2023

West Java (II)



In the middle to the end of 2022, Bekasi and Depok had fairly similar fluctuation patterns. The difference lies in the level of PM2.5 pollution concentration.

* This analysis requires further research

Meanwhile, in 2023, pollution patterns were observed to be more fluctuating in Depok compared to the Bekasi area. This is likely supported by Depok's location, which is traversed by local winds (mountain-valley winds), which can contribute to transboundary pollution.

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