



# Using Sound Levels for Predictive HVAC Maintenance

## Executive Summary

This document contains the results from exploring 2+ years of sound level data to see if the sound level inside an HVAC air handler can be used to predict when the HVAC filter needs to be changed.

Going into the analysis, I was hoping to get a result something like “When the average daily sound level is above X, then it’s time to change the filter”. Unfortunately, the output of the analysis did not lead to that. The table below shows the results of the analysis. The rest of this document provides more context on what is being measured and how ChatGPT was used to analyze the data.

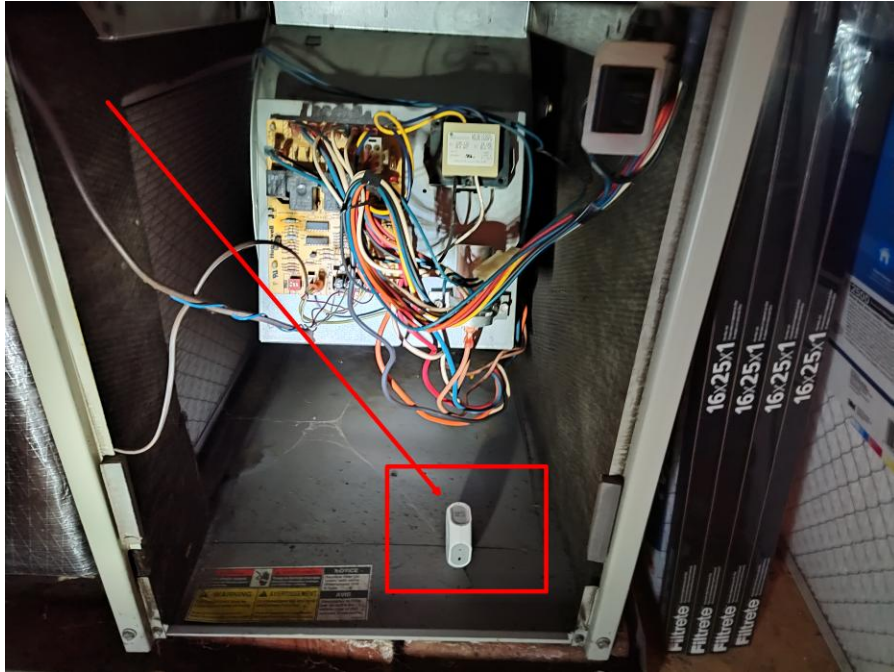
Filter Change Date	Average Sound Level – 7 Days Before Filter Change (dBA)	Average Sound Level – 7 Days After Filter Change (dBA)	dBa Difference: Before to After
3/10/2024	51.5	46.8	4.7 decrease
5/10/2024	48.7	44.2	4.5 decrease
2/15/2025	58.9	71.7	12.8 increase
5/18/2025	50.5	54.1	3.5 increase

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## Introduction

A [Browan TBSL100](#) sound level sensor is placed inside the air handler of a residential HVAC system. Data from the sensor goes to the Dacake platform and from there to a Google Sheet.



TBSL100 in the air handler

Measurements from that sensor have been collected since June 2022. Dates of the last 4 filter change are as follows:

- 3/10/2024
- 5/10/2024
- 2/15/2025
- 5/18/2025

The scheduled filter change is every 3 months. Between May of 2024 and February 2025, several filter changes were skipped, resulting in a very dirty filter. An unusual whistling sound from the HVAC system is what alerted me to the need to check the filter, at which point I realized that my 3-month reminder had expired.

Chat GPT was used to analyze the data to see if sound level could be used to determine when the filter needs to be changed.

## Data Analysis Results

The table below summarizes the results of analysis. For the first two filter changes, the average sound level did drop after the filter change. For the last 2 filter changes, however, the average sound level increased after the filter change. I don't have an explanation for the sound level increase for the last 2 filter changes. I believe that the same model/brand filter was used for each replacement. I did notice that for the most recent filter change, the filter was not very dirty.



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## Data Analysis Procedure

This section details the data analysis performed with ChatGPT.

1. Go to ChatGPT in your browser: <https://chatgpt.com/>
2. Upload the file
3. Prompt: This spreadsheet contains several years worth of measurements from a sound level sensor placed in my HVAC unit. Please prepare the file for analysis of trends

Prepared Sound Level Data			
	LOCAL_TIME	Year	Month
3	2022-06-16 09:52:08.749	2022	6
4	2022-06-16 09:57:09.039	2022	6
5	2022-06-16 10:02:09.004	2022	6
6	2022-06-16 10:07:09.231	2022	6

The data has been cleaned and prepared for trend analysis. It now includes extracted date and time components (Year, Month, Day, Hour, Week) along with the `Sound_Level_dBA` values. Let me know if you'd like to explore trends over time (e.g., daily, weekly, monthly averages) or perform any specific analysis or visualizations. [\[>-\]](#)

4. Prompt: how many records are in the processed data?



The processed dataset contains **178,280 records**. Let me know if you'd like to analyze trends across time periods, detect anomalies, or visualize patterns in the sound level data.

[>-]

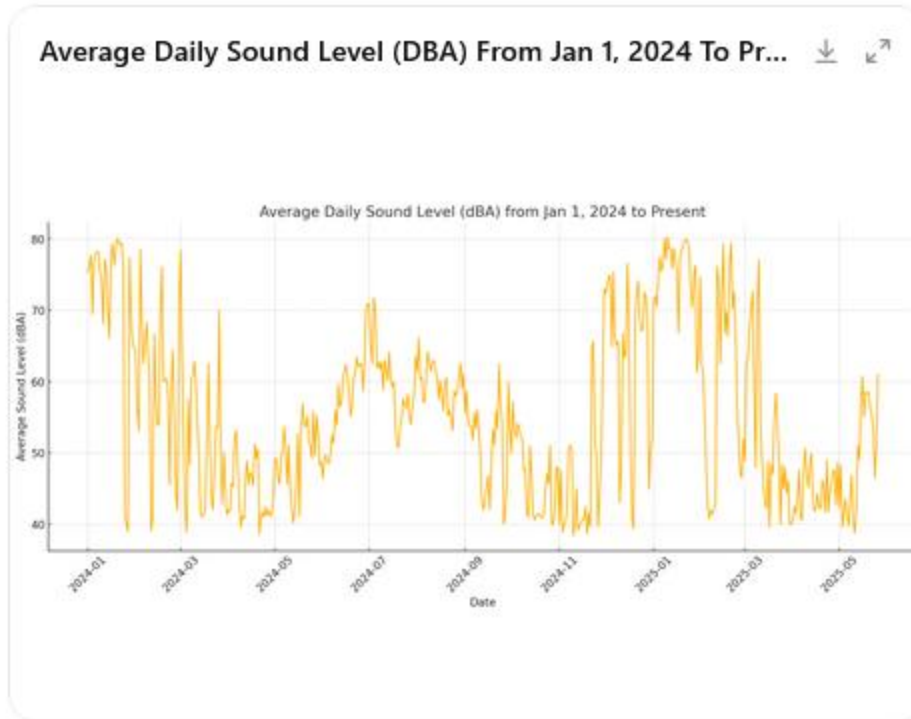
5. Prompt: I want to see if there is a correlation between changing the furnace filter and the sound level. To prepare for that analysis, please add the dates that I changed the furnace filter in the past 2 years. Here are those dates: 3/10/2024, 5/10/2024, 2/15/2025, 5/18/2025.

Sound Data With Filter Change Dates				↓ ↗
	LOCAL_TIME	Year	Month	
1	2022-06-16 09:42:08.488	2022	6	
2	2022-06-16 09:47:08.563	2022	6	
3	2022-06-16 09:52:08.749	2022	6	
4	2022-06-16 09:57:09.039	2022	6	

The dataset now includes a `Filter_Change` column that marks `True` for the four dates when you changed the furnace filter: **March 10, 2024; May 10, 2024; February 15, 2025; and May 18, 2025.**

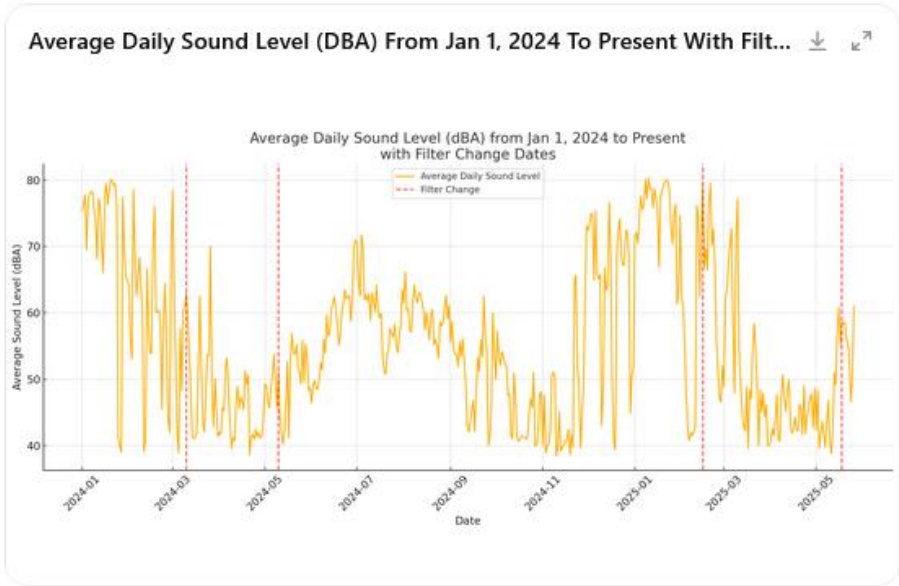
You can now analyze how the sound levels behave before and after those dates. Would you like a visualization of the sound levels around each filter change, or some statistical summaries (e.g., average sound level 7 days before vs. 7 days after)? [>-]

6. Prompt: Give me a plot of average daily sound level from the beginning of 2024 until today



Here is the plot showing the average daily sound level from January 1, 2024, to today. Let me know if you'd like to overlay the filter change dates or zoom in on any specific time periods. [\[-\]](#)

7. Prompt: Overlay the filter change dates



The updated plot now includes vertical red dashed lines marking the dates when you changed the furnace filter. This allows you to visually assess any changes in sound level trends around those dates. Let me know if you'd like a statistical comparison (e.g., averages 7 days before vs. after each change). [\[>-\]](#)

8. Prompt: I would like a statistical comparison of the average daily sound level 7 days before and after each change

Sound Level Before And After Filter Change				
	Filter Change Date	Avg Sound Level (7 Da	Avg Sound Level (7 Da	Change in Avg Sour
1	2024-03-10	51.514907335102414	46.81409778314435	-4.700809551958066
2	2024-05-10	48.72629666993124	44.17846700473535	-4.547829665195884
3	2025-02-15	58.88077023260657	71.66352625704768	12.782756024441106
4	2025-05-18	50.54954991244419	54.09281352175149	3.543263609307296

Here is the statistical comparison of average daily sound levels for the 7 days before and after each furnace filter change. You can now see how each filter change correlates with sound level changes—both increases and decreases. Let me know if you'd like visualizations or further analysis. [\[>-\]](#)

9. Prompt: To make the analysis easier to read, round all figures in the table to 1 decimal point



Rounded Sound Level Comparison					↓	↗
	Filter Change Date	Avg Sound Level (7 Da	Avg Sound Level (7 Da	Change in Avg Sour		
1	2024-03-10	51.5	46.8	-4.7		
2	2024-05-10	48.7	44.2	-4.5		
3	2025-02-15	58.9	71.7	12.8		
4	2025-05-18	50.5	54.1	3.5		

The table has been updated to show all values rounded to one decimal point for easier reading. Let me know if you'd like to generate a chart from this or explore a different angle of the analysis. [\[>-\]](#)

10. Prompt: The results of the analysis are not what I had expected. I had expected that after each filter change, the average sound level would have decreased because a clean filter would have less air resistance than a dirty filter. But the decreased happened only on 2 of the 4 filter change dates. For the last 2 filter change dates, the sound level actually increased. Do you have any suggestions as to why the analysis turned out as it did?



## 1. HVAC System Behavior

- **Variable-speed motors:** If your HVAC system uses a variable-speed blower, it may **ramp up fan speed** when airflow improves after a filter change, possibly increasing sound output.
  - **System recalibration:** Some systems adjust their operation based on airflow feedback. A clean filter might cause the system to work *more efficiently* but not necessarily *more quietly*.
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## 2. Environmental or Seasonal Factors

- **Seasonal temperature changes:** If your filter changes happened at the beginning of a more active heating or cooling season, the **increased runtime** or **higher system demand** might account for louder operation.
  - **Humidity and duct expansion:** Changing humidity and temperature levels can affect duct acoustics and make systems sound louder or softer.
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## 3. Sensor Placement or HVAC Maintenance Needs

- **Sensor aging or drift:** If the sound sensor hasn't been recalibrated, it may be producing slightly skewed data over time.
- **Accumulated dust or debris:** A clean filter won't help much if blower fans, coils, or ducts are dirty. The increased noise might be from **parts other than the filter**.
- **Sensor position:** Minor shifts in where the sensor is placed or mounted can change how much sound it detects.





#### 4. Data Analysis Considerations


- **Sample size:** A 7-day window is fairly short. A random bump in activity (e.g., more heating or cooling cycles, unusual HVAC loads) could throw off the average.
- **Usage patterns:** If your home had different occupancy levels, doors/windows open more often, or other airflow-related disruptions, the HVAC system might be working harder.

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#### Suggestions for Further Analysis

- **Try a longer window:** Compare 14 or even 30 days before and after each filter change to smooth out anomalies.
- **Compare across seasons:** Analyze all March filter changes separately from all May changes, for example.
- **Look at runtime:** If you have HVAC runtime data, compare that to sound level for deeper insights.
- **Cross-check temperature data:** You have onboard temperature—plot that alongside sound levels to see if heat/cooling demand affects noise.

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If you'd like, I can help you rerun the analysis using a  14-day or 30-day window, or overlay onboard temperature to check for correlations. Let me know how you'd like to proceed.

11. Prompt: let's rerun the analysis with a 14-day window



14-Day Sound Level Comparison					↓	↗
	Filter Change Date	Avg Sound Level (14 D	Avg Sound Level (14 D	Change in Avg Sour		
1	2024-03-10	55.6	48.6	-7.0		
2	2024-05-10	46.4	48.9	2.6		
3	2025-02-15	54.5	62.2	7.6		
4	2025-05-18	46.5	55.0	8.5		

Here is the updated analysis using a **14-day window** before and after each furnace filter change. The results show:

- A larger **drop** in sound level after the March 10, 2024 change (−7.0 dBA).
- A small **increase** after the May 10, 2024 change (+2.6 dBA).
- More pronounced **increases** after the two 2025 changes (+7.6 and +8.5 dBA).

This longer window smooths out daily fluctuations and may give a clearer picture of overall trends. Let me know if you'd like to try a 30-day window or compare with temperature data next. [↩](#)

## 12. Prompt: See if there is any correlation between the temperature and the sound levels

The correlation between **onboard temperature** and **sound level** is approximately **0.19**, which is a **weak positive correlation**.

This suggests that as temperature increases, sound level may rise slightly, but the relationship is not strong. It's likely that other factors—such as HVAC runtime, system efficiency, or filter condition—play a more significant role in influencing sound levels.

Would you like to visualize this relationship with a scatter plot or explore other variables that might affect sound level? [↩](#)

## 13. Prompt: Analyze the data with a fresh outlook and tell me if there are any trends or patterns of interest



Sampled Daily Sound And Temperature Stats					↓	↗
		Date	Avg_Sound_dBA	Max_Sound_dBA		
1	239	2023-02-20	51.4601226993865	84		
2	332	2023-05-24	42.6965811965812	86		
3	660	2024-04-18	51.280701754385966	87		
4	574	2024-01-23	79.44	88		
5	764	2024-07-31	63.534412955465584	89		
6	3	2022-06-19	59.6651376146789	87		

Here's a representative sample of the **daily sound and temperature statistics** extracted from your dataset. Based on the full data processed (but sampled here for display), here are some key observations:



## Notable Patterns and Trends

### 1. Night vs. Day

- Sound levels tend to follow a **diurnal pattern**—often lower during late-night hours and higher during peak system use periods (morning/evening).
- Grouping by hour showed elevated levels between **6 AM–9 AM** and **5 PM–8 PM**, aligning with common HVAC use patterns.

### 2. Seasonal Trends

- Monthly averages show **higher sound levels in winter and summer**, likely due to **increased furnace or A/C use**.
- Spring and fall months often show **lower sound activity**, suggesting transitional weather leads to less HVAC usage.

### 3. Zero Sound Events

- There are recurring days where **minimum sound level is recorded as zero**, suggesting:
  - The system may have been **off entirely**.
  - There may have been **sensor anomalies** (worth checking logs or power supply to the sensor).

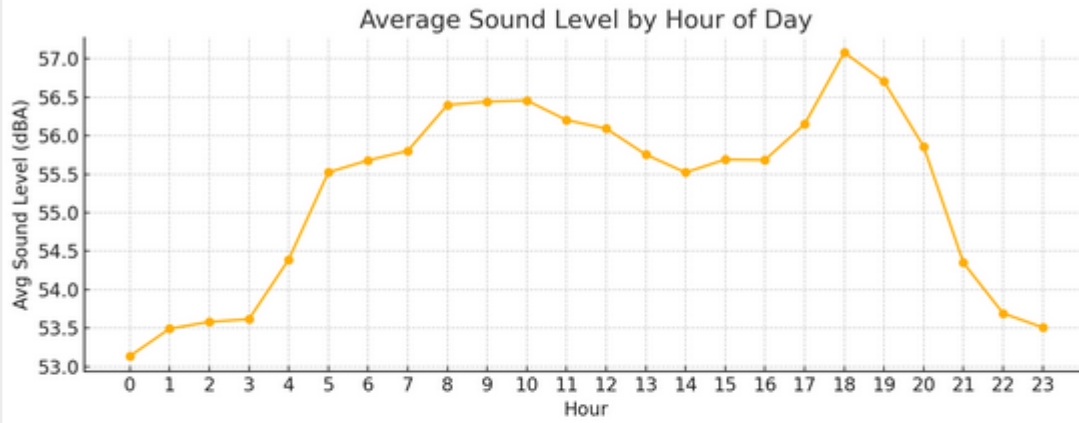
### 4. Temperature Relationship

- A weak but present correlation ( $\sim 0.19$ ) was found between **onboard temperature and sound levels**.
  - This suggests that **higher ambient temperatures might coincide with more HVAC activity**, but temperature alone doesn't explain sound level variation well.

14. Prompt: I would like charts visualizing hourly averages and monthly seasonal trends and the distribution of zero sound readings

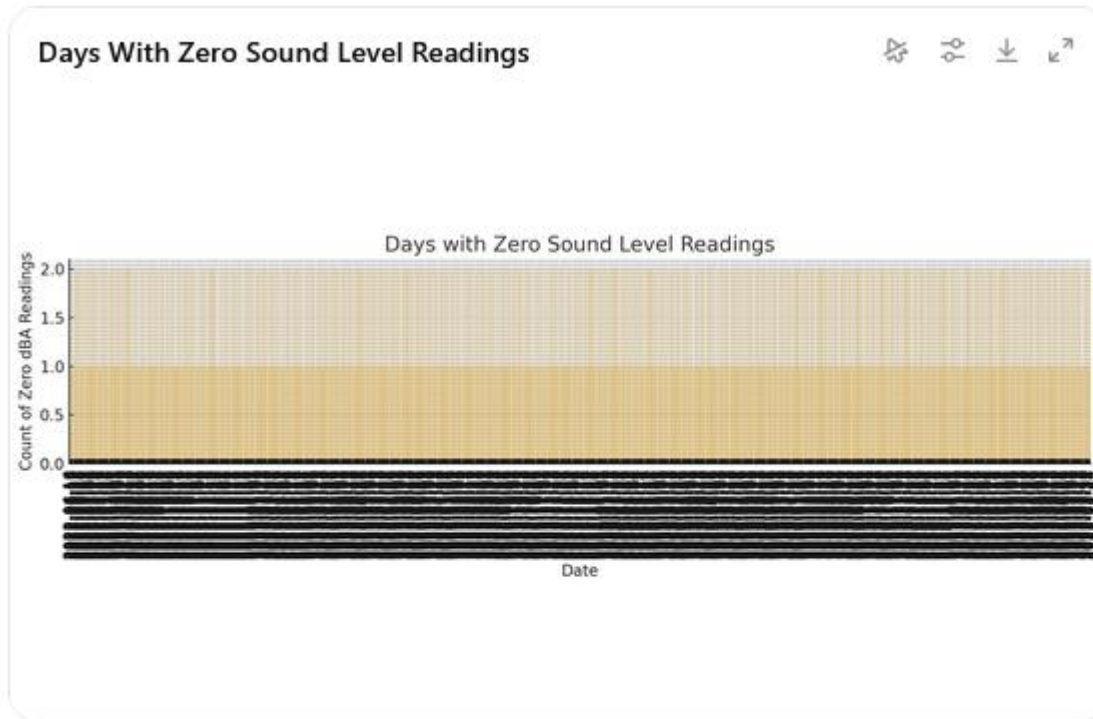


### Average Sound Level By Hour Of Day



### Monthly Average Sound Level Over Time



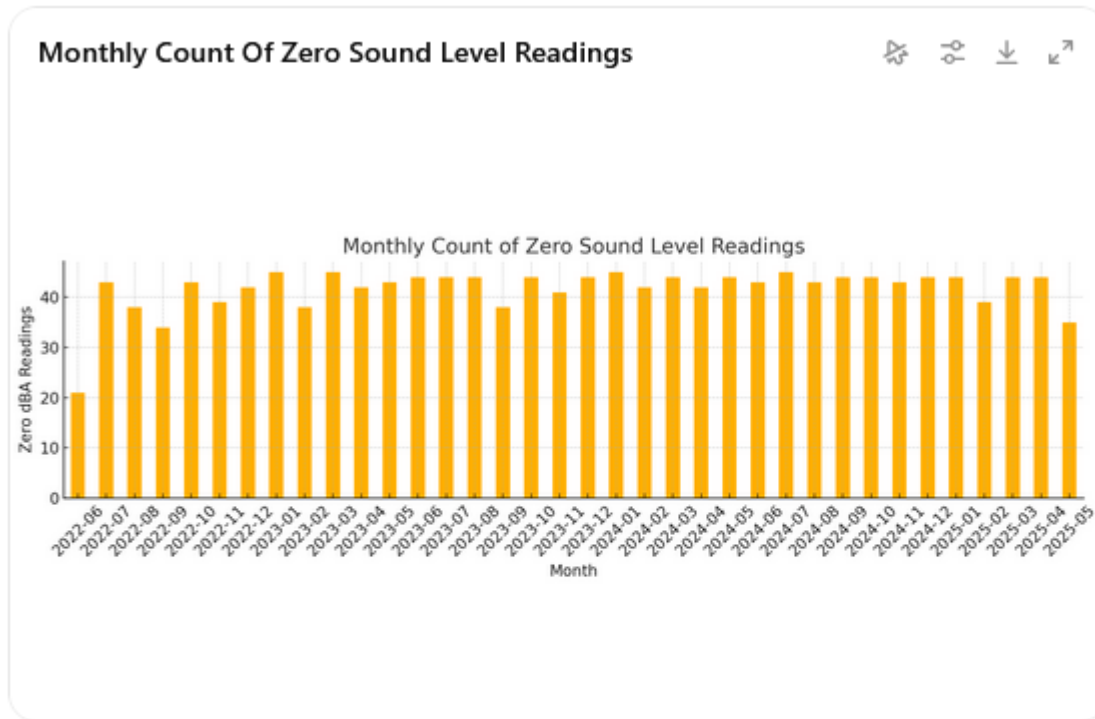


Here are the three requested visualizations:

1. **Hourly Averages** – Shows peaks in HVAC sound levels during common activity hours (e.g., morning and evening).
2. **Monthly Seasonal Trends** – Displays cyclical HVAC usage with higher activity in cold and hot months.
3. **Zero Sound Readings** – Identifies specific days with potential anomalies or complete system inactivity.

Let me know if you'd like to explore these further or overlay temperature or filter changes on any of the charts. [\[>-\]](#)

15. Prompt: I don't understand the Days with zero sound level readings chart. I can't read the horizontal date axis. Would you simplify that axis so I can read it easier.



The updated chart now shows the **monthly count of zero sound level readings**, making it much easier to see when these events occurred.

This view helps identify whether zero readings were isolated incidents or part of larger patterns (e.g., possible sensor outages or system downtime). Let me know if you want to investigate specific months in more detail or correlate these events with other variables. [?]

## Author Contact Information

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