



# PolChecker: Prototype for Air Pollution Monitoring to Increase Awareness and Public Engagement

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## ABSTRACT

Pollution is one of the most significant environmental problems in Indonesia. Pollution occurs when harmful substances in the form of gases, liquids, or solids are released into the air. They potentially threaten the health of living beings and the balance of ecosystems. Nine major types of pollution can currently be identified: water, air, light, sound, soil, heat, heavy metals, radioactive, and visual. Pollution contaminates air, water and soil. One type of pollution that must be considered is air pollution. According to the World Health Organization (WHO), air pollution is air pollution caused by the introduction of harmful substances in quantities that exceed safe limits. Therefore, the researcher aims to design and develop a PolChecker prototype to help reduce the risk of exposure to harmful air pollution. The approach used in this research is Research and Development. Researchers conducted a needs analysis, designed a connection scheme of the materials to be used and tested the PolChecker prototype. PolChecker prototype testing was carried out for 15 minutes to measure PM2.5, CO<sub>2</sub>, NH<sub>3</sub>, CH<sub>4</sub>, and CO concentrations every minute without external interference. The data obtained from the Serial Monitor Arduino IDE was processed using Microsoft Excel and Google Colab to produce graphs and tables. The results show that in the experiment with matches, carbon monoxide and ammonia had a small increase, while Carbon Dioxide showed a more significant increase. Looking at these results, it can be concluded that the PolChecker design has reached the development stage and will be tested directly by experts.

## ABSTRAK

Polusi merupakan salah satu masalah lingkungan yang paling signifikan di Indonesia. Polusi terjadi ketika zat berbahaya dalam bentuk gas, cairan, atau padatan dilepaskan ke udara. Mereka berpotensi mengancam kesehatan makhluk hidup dan keseimbangan ekosistem. Sembilan jenis polusi utama saat ini dapat diidentifikasi yaitu air, udara, cahaya, suara, tanah, panas, logam berat, radioaktif, dan visual. Polusi mencemari udara, air, dan tanah. Salah satu jenis polusi yang harus diperhatikan adalah polusi udara. Menurut Organisasi Kesehatan Dunia (WHO), polusi udara adalah pencemaran udara yang disebabkan oleh masuknya zat berbahaya dalam jumlah yang melebihi batas aman. Maka dari itu, peneliti bertujuan untuk merancang dan mengembangkan prototype PolChecker untuk membantu mengurangi resiko paparan polusi udara yang berbahaya. Pendekatan yang digunakan dalam penelitian ini adalah Research and Development. Peneliti melakukan analisis kebutuhan, perancangan skema koneksi dari bahan yang akan digunakan dan pengujian prototype PolChecker. Pengujian prototype PolChecker dilakukan selama 15 menit untuk mengukur konsentrasi PM2.5, CO<sub>2</sub>, NH<sub>3</sub>, CH<sub>4</sub>, dan CO setiap menit tanpa gangguan eksternal. Data yang diperoleh dari Serial Monitor Arduino IDE diolah menggunakan Microsoft Excel dan Google Colab untuk menghasilkan grafik dan tabel. Hasil menunjukkan bahwa dalam percobaan dengan korek api, karbon monoksida dan amonia mengalami peningkatan kecil, sementara Karbon Dioksida menunjukkan peningkatan yang lebih signifikan. Melihat dari hasil tersebut dapat disimpulkan bahwa perancangan PolChecker telah sampai pada tahap pengembangan dan akan diuji secara langsung oleh ahli.

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## KEYWORDS

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## INTRODUCTION

Pollution is one of the many environmental problems in Indonesia (Humas, 2023). Pollution occurs when hazardous materials, whether in the form of gas, liquid, or solid, are released into the environment. These pollutants can

endanger the health of living things and the balance of nature. The pollution released can contaminate the environment, including the air, water, and soil (Prabowo, 2022). In this modern era, there are many types of pollution that we can find around us. These types of pollution are divided into 9 types based on the contaminated media, such as Water Pollution, Air Pollution, Light Pollution, Noise Pollution, Soil Pollution, Heat Pollution, Heavy Metal Pollution, Radioactive Pollution, and Visual Pollution (Yuda, 2023).

One type of pollution that is an environmental problem is air pollution. According to the World Health Organization (WHO), air pollution is contamination that occurs in the air due to the entry of pollutants that exceed normal limits. The normal limits applied by the Ministry of Environment and Forestry are stipulated in Forestry Regulation No. 14 of 2020 concerning the Air Pollutant Standard Index. The Air Pollutant Standard Index is applied to seven parameters, namely Particulate Matter (PM<sub>10</sub>), Particulate Matter (PM<sub>2.5</sub>), Nitrogen Dioxide (NO<sub>2</sub>), Sulfur Dioxide (SO<sub>2</sub>), Carbon Monoxide (CO), Ozone (O<sub>3</sub>), and Hydrocarbons (HC) (Chaniago et al, 2020). The causes of air pollution generally occur due to two factors, namely human factors and natural factors. Pollution caused by human factors usually occurs due to the large number of motor vehicles, industrial smoke, and also the result of burning garbage and forest fires. Pollutants caused by nature include volcanic eruptions and the activities of micro-sized living creatures (microorganisms).

Air pollution can cause respiratory diseases such as runny nose, sneezing, sore throat, coughing, phlegm, and can even cause acute respiratory infections (ARI) such as pneumonia, asthma attacks, and chronic obstructive pulmonary disease (COPD) (WHO, 2024). The impact of this pollution is felt in Indonesia, where around 90% of the population is exposed to air pollution above the standards set by the World Health Organization (WHO) (Ritchie, & Roser, 2024). More than 123 thousand people die in Indonesia every year due to air pollution (WHO, 2024). Air pollution is also the fifth leading cause of death in Indonesia after high blood pressure, smoking, diabetes, and obesity (Susanto, 2023). If this problem is not addressed, it could hinder Indonesia's progress toward Sustainable Development Goals 1.5 and 13.2, namely building community resilience to environmental, economic, and social disasters, and integrating climate change measurements into policy and planning.

Seeing the significant impact of air pollution on human health, especially on the respiratory system, this study focuses on designing a PolChecker prototype as an air pollution monitoring tool, including Methane Gas (CH<sub>4</sub>), Carbon Monoxide (CO), Ammonia (NH<sub>3</sub>), Particulate Matter (PM<sub>2.5</sub>), and Carbon Dioxide Gas (CO<sub>2</sub>). Based on the analysis of the problem and its urgency, the researchers want to take the initiative to create a technological innovation for real-time pollution monitoring in urban areas in the form of the "PolChecker Prototype Pollution Monitoring to Increase Public Awareness and Participation in Air Quality Control." With this prototype, it is hoped that Indonesia can achieve the Sustainable Development Goals and realize Indonesia Emas 2045.

## METHODS

The development stage of PolChecker uses the 4D model. The 4D method is used for the following purposes: 1) To analyze requirements based on journals and data from IQAIR; 2) To design a connection scheme for sensors and microcontrollers; 3) To develop the PolChecker tool by searching for information that can be used to develop a prototype of the PolChecker tool based on literature studies.

### 1. Define

At this stage, researchers conducted a needs analysis with the following objectives: 1). To gather information about air quality in Indonesia, particularly in the Jakarta area, and the dangers of air pollution to the general public; 2). To find guidelines for designing a prototype of the PolChecker device using literature such as journals, books, and websites. This needs analysis was conducted through a literature study.

### 2. Design

The next stage is the design stage. At this stage, researchers use literature such as journals, books, documentaries, and websites. At this stage, researchers design a series of tool prototypes using the TinkerCad application. TinkerCad was chosen because it provides device design features and can test the planned coding.

### 3. Development

At this stage, researchers test the sensors that will be used. The condition of the sensors is tested using ArduinoIDE. By utilizing the Serial Monitor feature and the ESP8266 microcontroller, researchers can test the condition of the sensors that will be used. After conducting the tests, the researchers began the design phase. The design phase began with entering the sensor schematic with the microcontroller. Once the connection schematic was designed, the coding was entered using the Arduino IDE application. Arduino IDE was chosen because it can act as an intermediary between the laptop and the microcontroller via a USB

Type B and Type USB cable.

4. Disseminate

Disseminate is the final stage of creating 4D learning resources. When a product undergoes testing in the development stage and receives positive reviews from experts and demonstrates consistent performance, it can be said to have reached the final stage of production (development). The product is ready for widespread use once it has been proven to be suitable for use. This dissemination level consists of three steps: validation testing, packaging, and diffusion and adoption. (Ghofur, 2020).

**RESULTS AND DISCUSSIONS**

Testing was conducted on the PolChecker prototype. The test results were obtained based on the results of several experiments, such as sensor testing under several conditions and normal sensor testing..

1) Sensor Testing Results

Sensor changes were tested through several experiments. The experiments and changes are shown in the following table :

Table 1. Sensor Test Results with Several Actions

Experiment	PM2.5 ( $\mu\text{g}/\text{m}^3$ )	CO2 (ppm)	NH3 (ppm)	CH4 (ppm)	CO (ppm)
Lighter	695,9	193,7	75,645	39,24	9,25
Burnt Tissue	696,23	243,88	249,18	33,8	97,02
Dust Testing	695,9	144,59	56,13	26,31	3,76

2) Prototype PolChecker Testing Results

Prototype testing was conducted to examine the overall design of the PolChecker prototype. This test was carried out by allowing the sensor to measure without interference. The test lasted for 15 minutes, and the data was collected every minute. The measured data was displayed on the Arduino IDE Serial Monitor. The sensor measurement results displayed on the Serial Monitor were processed using Microsoft Excel and Google Colab to generate graphs and tables from the measurement results. The following is a graph of the prototype sensor measurements.

Table 2. Sensor Test Results in the Absence of Interference

No	PM2.5 ( $\mu\text{g}/\text{m}^3$ )	CO2 (ppm)	NH3 (ppm)	CH4 (ppm)	CO (ppm)
1	635.66	122.05	67.63	87.61	5.45
2	610.41	120.28	63.61	84.58	4.92
3	617.06	81.89	44.51	91.07	3.23
4	615.4	90.14	52.62	66.77	3.86
5	611.24	97.45	55.24	74.6	3.97
6	614.56	94.48	52.62	73.25	3.76
7	612.37	93.44	50	72.3	3.65
8	617.06	81.89	44.51	91.07	3.23
9	615.4	90.14	52.62	66.77	3.86
10	611.24	97.45	55.24	74.6	3.97
11	614.56	94.48	52.62	73.25	3.76
12	612.9	89.44	50	69.37	3.65
13	617.05	82.92	45	91.88	3.23
14	615.45	100.11	53	72	3.56
15	614.56	93.01	54.35	73.25	3.76

**Discussion**

Prototype testing was conducted to examine the overall condition and performance of the PolChecker design. At this stage, the sensor was allowed to measure without interference. The test was conducted for 15 minutes, with data recorded every minute. The sensor measurement results were displayed via the Arduino IDE Serial Monitor. The data

was then processed using Microsoft Excel and Google Colab to produce graphs and tables of measurement results.

The test results proved that the PolChecker prototype works well. However, this tool still has room for further development, both in terms of design, component selection, and the programming code used. In addition, a formula is needed to calibrate the sensors so that the data produced is more accurate and can be displayed in the appropriate units. There are several limitations in this study that need to be considered, one of which is that data transmission has not been tested.

Therefore, further research can be conducted to deepen these findings by using existing applications, such as Blynk, or by developing our own application. Based on the results and discussion obtained, it can be concluded that this prototype has shown good performance. However, there are still opportunities for further development, for example, by using ESP32 and integrating it with the applications mentioned above.

## CONCLUSIONS

The results of this study show that the PolChecker sensor works well. This is evidenced by the data listed in Table 8 in the research results section. The PolChecker sensor is responsive to changes in several conditions. However, the sensor is not reactive to dust testing. This research can still be developed in various ways. This research can still be developed by using ESP32 as the main microcontroller to improve the performance of the sensor data transmission. Then, the display of the data results can be integrated into software to make it easier for people who will use this tool. With this prototype, it is hoped that it can inspire other researchers to realize this tool to the fullest so that Indonesia can achieve Sustainable Development Goals 13.2.

## REFERENCES

- Albert. (2024). QElectroTech: Open-source software for designing electronic circuits.
- Azmi, R. (2018). Potensi gas metana dalam pemanasan global. Surabaya: Penerbit Ilmiah Lingkungan. Belssing, L. T. M., & Chakrabarti, A. (2009). DRM: A design research methodology. Springer.
- Budianto, H., & Sumanto, B. (2024). Perancangan sistem monitoring kualitas udara dalam ruangan berbasis Internet of Things.
- Chaniago, A., et al. (2020). Indeks Standar Pencemar Udara (ISPU) dan implementasinya di Indonesia. Humas. (2023). Laporan kualitas udara di Indonesia: Tantangan dan solusi.
- Maksum, A. (2022). Debu PM2.5: Karakteristik dan dampaknya terhadap kesehatan. Medan: Penerbit Udara Bersih.
- Nurdin, A. (2023). Amonia sebagai polutan: Karakteristik dan pencegahan. Yogyakarta: Penerbit Kimia Hijau. Prabowo, A. (2022). Jenis-jenis polusi dan dampaknya terhadap lingkungan.
- Prasetyawan, R. (2016). Peran karbon dioksida dalam pemanasan global. Yogyakarta: Penerbit Lingkungan Hijau.
- Putra, D. D. M., et al. (2024). Perancangan alat monitoring karbon monoksida (CO) dan partikel debu PM2.5 dalam ruangan berbasis ESP32 Devkit C V4 dan LCD OLED.
- Ritchie, H., & Roser, M. (2024). Air pollution: Impact on health and environment. Our World in Data. Retrieved from <https://ourworldindata.org/>
- Rizaldi, I. (2022). Karbon monoksida: Sumber dan dampaknya terhadap kesehatan manusia. Jakarta: Penerbit Polusi Udara.
- Salasa, G. M., et al. (2021). Perancangan alat monitoring polusi udara berbasis mikrokontroler menggunakan sensor gas TGS-2442.
- Susanto, B. (2023). Dampak polusi udara terhadap kematian di Indonesia: Laporan WHO.
- World Health Organization. (2024). Ambient air pollution and health. Retrieved from <https://www.who.int/> Yuda, P. (2023). Jenis-jenis polusi dan upaya pengendaliannya di Indonesia.