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EVALUATING AIRTHINGS VIEW PLUS AND WAVE MINI FOR INDOOR AIR QUALITY RESEARCH: A MINI REVIEW

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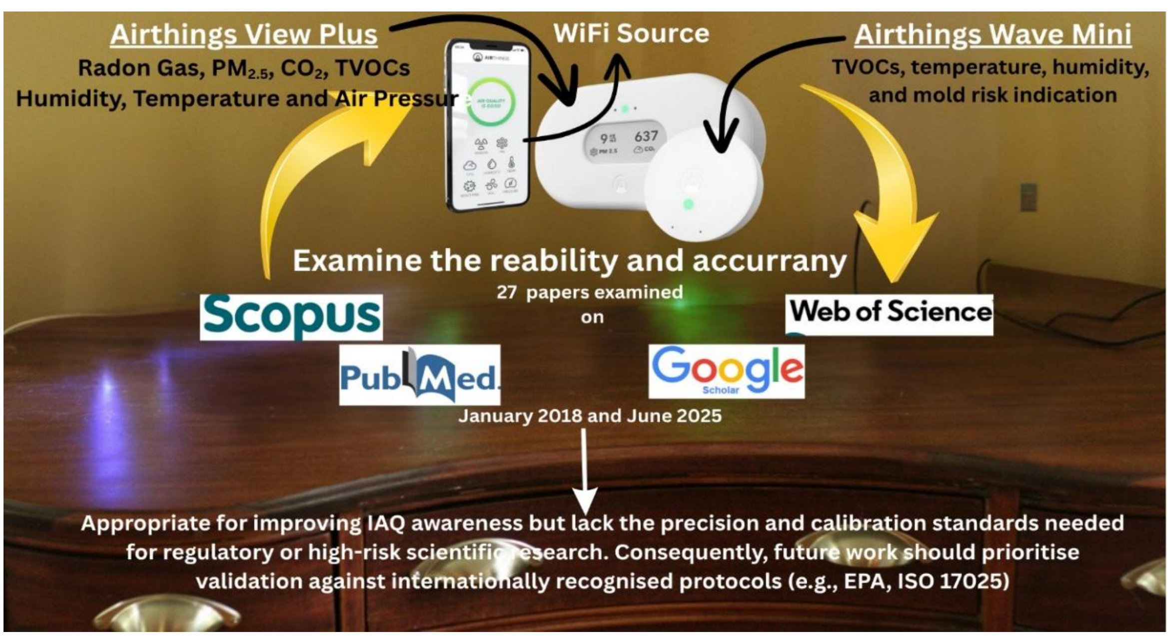
Abstract

Indoor air quality has a significant impact on human health. It affects respiratory health, cognitive performance, and overall well-being. The demand for low-cost air quality monitoring equipment such as Airthings View Plus and the Wave Mini is becoming popular in indoor air quality monitoring, particularly in residential and educational contexts. This necessitated the examination of their accuracy and reliability for both personal and research purposes. A peer-reviewed literature published in Scopus, Web of Science, Google Scholar and PubMed between January 2018 and June 2025 was searched. A total of 27 suitable papers were examined, with fewer than half containing direct comparisons to reference-grade instruments. The review discovered that both Airthings devices provide practical solutions for small-scale and personal IAQ monitoring; however, their metrological accuracy varies significantly depending on pollutants and ambient conditions. The View Plus showed moderate agreement with reference devices for CO_2 and VOC readings. However, it had performance constraints for $PM_{2.5}$ in high-humidity conditions. The Wave Mini was much preferred for its portability and ease of use but cannot detect PM2.5. It also shows fluctuation in VOC accuracy due to poor calibration. While both devices are appropriate for improving IAQ awareness and use in community-based and educational programmes. They currently lack the precision and calibration standards needed for regulatory or high-risk scientific research. Future work should prioritise validation against internationally recognised protocols (e.g., EPA, ISO 17025) and look at machine learning-based calibration models to solve long-term sensor drift.

Keywords: *Indoor Air Quality (IAQ), Airthings View Plus, Wave Mini, Low-Cost Sensors, Air Quality Monitoring,*

Graphical Abstract



1.0 INTRODUCTION

Spent Indoor air quality (IAQ) is increasingly recognised as a fundamental determinant of public health, with extensive scientific evidence linking indoor pollutant exposure to a range of adverse health-related outcomes [1]. These include respiratory illnesses, diminished cognitive function, cardiovascular stress, and other conditions that significantly reduce quality of life [2]. Such concerns are underscored by global standards, notably the World Health Organisation (WHO) guidelines. The WHO, as a global public health authority, sets exposure limits for key pollutants such as $PM_{2.5}$, CO_2, and radon to mitigate health risks in indoor environments.

In contemporary built environments that is characterised by airtight construction, inadequate ventilation, and high occupant density, elevated concentrations of indoor pollutants are frequently observed [3]. Given that individuals in industrialised societies spend approximately 90% of their time indoors (i.e., at home, at work, in schools, or in healthcare facilities) their is a need for accurate and continuous indoor air monitoring has never been more urgent [4].

Historically, IAQ monitoring has relied on regulatory-grade instruments such as gas chromatographs, photoionisation detectors, and beta attenuation monitors, which offer precise and highly reliable pollutant detection [5]. However, these sophisticated instruments are often constrained by high operational costs, complex calibration requirements, and the need for trained personnel for operation and maintenance. These limitations make large-scale, decentralised, or long-term monitoring in residential, educational, and resource-limited settings challenging. Consequently, there is growing interest in affordable, scalable alternatives capable of delivering meaningful IAQ insights to a wider range of users, including researchers, educators, and the general public.

This interest lead to the emerges of low-cost sensor (LCS) technologies, offering portable, user-friendly, and relatively inexpensive tools for indoor pollutant monitoring. Notable examples include the Airthings View Plus and Airthings Wave Mini, consumer-grade devices designed to measure multiple IAQ parameters. The View Plus monitors carbon dioxide (CO_2), volatile organic compounds (VOCs), particulate matter ($PM_{2.5}$), temperature, humidity, radon, and atmospheric pressure [6], while the Wave Mini measures VOCs, temperature, humidity, and mould risk, albeit with more limited capabilities [11]. Both devices are integrated with mobile applications and cloud services. Thus, enabling real-time data visualisation, historical trend analysis, and remote access to IAQ data [6].

Despite the growing popularity of consumer-grade IAQ monitors, significant uncertainties remain regarding their measurement accuracy, long-term reliability, and scientific validity. Issues such as sensor drift, sensitivity to environmental conditions (e.g., humidity influencing $PM_{2.5}$ readings), and the absence of standardised validation protocols have raised concerns in the scientific community [8, 9, 12]. These limitations reduce the credibility of such devices in academic research and hinder cross-study comparability.

Moreover, existing reviews on LCS technologies tend to focus broadly on sensor types or pollutant categories [10], with limited attention to device-specific performance evaluation, particularly for Airthings products. Likewise, pollutants such as radon, a critical IAQ concern remain under-represented in such evaluations. This lack of targeted investigation creates a critical evidence gap, particularly as Airthings monitors are increasingly deployed in citizen science projects, school-based IAQ studies, and decentralised research environments [19].

This review addresses these gaps by conducting the first focused evaluation of the Airthings View Plus and Wave Mini in both laboratory-controlled and real-world settings. It synthesises peer-reviewed evidence on their performance across key IAQ parameters such as CO_2, VOCs, $PM_{2.5}$, radon, temperature, and humidity and critically examines their applicability in diverse research contexts.

The study also identifies methodological and technical challenges that could hinder the broader adoption of these devices in formal research and environmental surveillance systems. By providing a consolidated assessment of accuracy, reliability, and practical utility, this review offers an evidence base to guide researchers, public health practitioners, educators, and policymakers in determining whether these consumer-grade monitors can be integrated into structured IAQ monitoring frameworks.

This effort aligns directly with the United Nations Sustainable Development Goals, particularly SDG 3 (Good Health and Well-Being) and SDG 11 (Sustainable Cities and Communities) by promoting accessible, evidence-based environmental monitoring solutions that advance public health and sustainable living for all [21].

2.0 METHODOLOGY

This systematic review was carried out in accordance with established best practices, which focus on evidence-based synthesis. Thus, accentuating transparency, reproducibility, and methodological rigor. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were strictly followed [10].

Literature searches were performed across four major electronic databases (PubMed, Scopus, Web of Science, and Google Scholar). These databases were chosen to ensure thorough coverage of the scientific, engineering, and health literatures. The period of the study was July 1, 2018, to June 30, 2025. The use of

a mixed keyword techniques and restricted vocabulary was employed. The search terms used were 'Airthings', 'View Plus', 'Wave Mini', 'indoor air quality', 'IAQ', and 'air quality monitoring'. To optimise search sensitivity, a database-specific syntax and boolean operators were also adopted. Supplementary materials such as technical documentation, product specifications, and manufacturer-funded validation reports were also reviewed on the official Airthings website [8].
Specific inclusion and exclusion criteria were defined to guide the selection of relevant studies. The studies that employed the Airthings View Plus or Wave Mini for indoor air quality monitoring were included. The report includes performance evaluation, calibration, or usability findings that were conducted in indoor environments such as homes, schools, or workplaces. Eligible documents included peer-reviewed journal articles, conference proceedings, and systematic reviews published in English between January 2016 and July 2025. Studies were excluded if they lacked methodological transparency, did not focus on either device, or were published as blog posts, non-peer-reviewed reports, or non-academic sources.
From an initial pool of 322 records, 42 duplicates were removed, and 222 records after abstracts/titles were reviewed and excluded. 58 full-text articles were finally assessed. The screening and selection were conducted independently by two reviewers and disagreements were resolved by consensus to arrive at 27 full-text articles. While the studies that met all inclusion criteria were retained and analyzed for the study
Data extraction was carried out using a standardised template developed to capture core attributes of each study. Extracted variables included study setting, research design, IAQ device used, pollutants measured, validation method, sample size, and key findings. For performance-focused studies, sensor accuracy, bias, and agreement with reference instruments were also documented. To assess methodological quality and risk of bias, the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies was used [9]. Following global best practice, a PRISMA flow diagram was developed to illustrate the study selection process. This parameter includes the number of records identified, screened, excluded, and retained. The visual representation of the PRISMA is provided below (Figure 1).

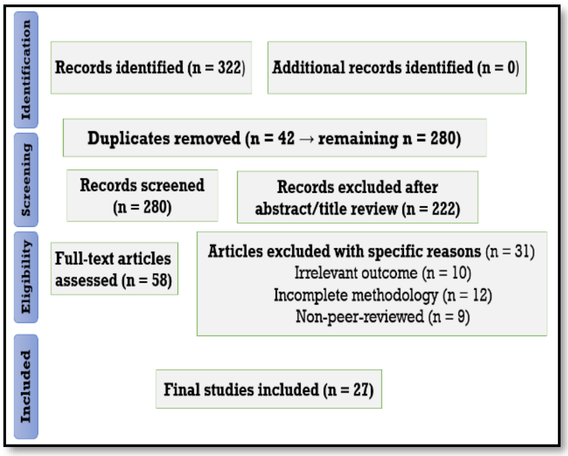


Figure 1. PRISMA Flow Diagram of the Study Selection Process

3.0 RESULTS AND DISCUSSION

3.1 Search Strategy and Retrieval Summary

A comprehensive literature search was conducted across four major academic databases (PubMed, Scopus, Web of Science, and Google Scholar) between July 1 and July 2, 2025. The search terms focused on the Airthings View Plus and Wave Mini devices in conjunction with "indoor air quality" (IAQ). Table 1 presents the database-specific search strings and corresponding results retrieved.

Table 1. Search Log Overview

Date of Search	Database	Results Retrieved	Search Terms Used
2025-05-01	Google Scholar	130	"Airthings indoor air monitoring"
2025-05-10	Scopus	75	("Airthings" AND "indoor air quality")
2025-06-02	PubMed	54	("Airthings" OR "View Plus" OR "Wave Mini") AND ("IAQ")
2025-06-15	Web of Science	63	("View Plus" OR "Wave Mini") AND ("indoor air quality")

From the initial pool, 27 peer-reviewed articles met the eligibility criteria and were included in the final review.

3.2 Study Characteristics and Sensor Deployment Contexts

A representative sample of five studies is summarized in Table 2 to illustrate the diversity of settings, pollutants measured, validation techniques employed, and key insights related to sensor performance.

Table 2. Summary of Representative Studies Using Airthings Devices

Device(s) Used	Pollutants Measured	Setting	Validation Method	Key Findings	Study (Author, Year)
View Plus	CO_2, VOCs, $PM_{2.5}$	Classrooms	Co-location with calibrated monitors	High CO_2 accuracy, moderate $PM_{2.5}$ performance	[22]
Wave Mini	VOCs	Residential	Field comparison with VOC sensor	High variability in VOC readings	[23, 26]
View Plus & Wave Mini	VOCs, Temp., Humidity	Smart Homes	Device log correlation with surveys	High usability, inconsistent sensor performance	[24]
View Plus	$PM_{2.5}$, CO_2	Urban Buildings	Parallel certified sensors	$PM_{2.5}$ underreporting under humid conditions	[24, 25]
Wave Mini	VOCs, Temp., Humidity	Schools & Residences	Descriptive observational data	Useful for public awareness, limited for policy research	[26, 27]

3.3 Comparative Device Performance by Pollutant

Table 3, below consolidates findings on pollutant-specific performance across both devices.

Table 3. Summary of Measurement Accuracy by Pollutant

Device	$PM_{2.5}$	CO_2	VOCs	Humidity & Temp.
View Plus	Inconsistent under high humidity [14]	Moderate–High accuracy [12, 14]	Calibration-dependent; variable [15]	Stable under controlled conditions
Wave Mini	Not supported	Not applicable	Low–Moderate; lacks calibration [15]	High usability; minor signal drift observed

3.4 Integrated Analysis and Expert Interpretation

The body of evidence reviewed reflects both promising and limitations of low-cost IAQ monitors, particularly the Airthings View Plus and Wave Mini for applied indoor air quality monitoring. The Airthings View Plus consistently demonstrated acceptable performance for CO_2 monitoring. As several studies reporting strong correlation with reference-grade instruments in controlled indoor environments such as classrooms and offices. Its use of optical scattering for $PM_{2.5}$ detection, however, revealed notable sensitivity to ambient humidity, resulting in potential underreporting or overestimation depending on particle hygroscopic properties and atmospheric moisture content. This aligns with established findings on the susceptibility of low-cost optical sensors to humidity-induced artifacts. In contrast, the Wave Mini, which is a more affordable and compact model lacks capabilities for $PM_{2.5}$ and CO_2 detection. Thus, confining it's uses to monitoring VOCs, temperature, and humidity. The VOC readings across studies exhibited considerable variability and often failed to align with calibrated laboratory-grade instruments. These differences were frequently attributed to the absence of built-in calibration mechanisms. Thus, increasing its sensitivity to environmental fluctuations, particularly temperature.

Despite these shortcomings in analytical precision, both devices earned high marks for usability. Studies consistently praised their seamless integration with mobile applications and cloud-based dashboards. This cloud-based dashboard helps to facilitated real-time exposure awareness and user engagement. These characteristics features make the instrument stands out, particularly for sciences, public education, and preliminary screening in settings where the traditional monitoring equipment is either cost-prohibitive or logistically unfeasible.

4.0LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The systematic review offers critical insights into the performance, accuracy, and practical utility of the Airthings View Plus and Wave Mini devices for indoor air quality (IAQ) monitoring. However, several limitations must be acknowledged. These limitations not only contextualize the current findings but also underscore key areas for future investigation and methodological refinement.

4.1 Language and Literature Scope

First, this review was limited to peer-reviewed articles published in English, potentially excluding relevant studies conducted in other languages. This linguistic restriction may have inadvertently overlooked valuable data, especially from regions with significant indoor air pollution burdens where research is published in local journals. Additionally, while the search was comprehensive across four major scientific databases (PubMed, Scopus, Web of

Science, and Google Scholar). It did not systematically include gray literature sources such as technical white papers, institutional reports, dissertations, or manufacturer-led evaluations. These sources may contain empirical evidence on device performance, particularly in applied or commercial contexts, that is absent from academic publications.

4.2 Evidence Base and Validation Inconsistencies

Second, the overall evidence base remains relatively limited, with only 27 studies meeting the inclusion criteria. Of these, fewer than one-third conducted direct co-location experiments with certified reference instruments. The heterogeneity of methodologies, ranging from observational studies to small-scale deployments further complicates the synthesis of findings into generalized conclusions. Many studies did not specify calibration protocols, firmware versions, or the environmental conditions under which devices were tested. All of which are critical to ensuring consistency and reproducibility. These omissions weaken the reliability of comparative assessments and underscore the need for standardized reporting frameworks.

4.3 Lack of Statistical Aggregation and Longitudinal Data

Third, the absence of standardized quantitative metrics across studies precluded the use of meta-analytic techniques. Most included research presented findings descriptively, without reporting error margins, bias metrics, or statistical correlations that could support effect size estimation or pooled accuracy assessments. Furthermore, few studies extended beyond short-term observation periods, with the majority evaluating performance over weeks or, at most, a few months. Longitudinal analyses examining sensor drift, firmware degradation, or consistency across environmental cycles remain largely unexplored, despite being central to the deployment of IAQ monitors in real-world settings.

4.4 Limited Device and Contextual Diversity

Fourth, the review focused exclusively on two devices (Airthings View Plus and Wave Mini) thereby narrowing the scope of generalizability. While this focus allows for an in-depth assessment, it excludes potentially informative comparisons with other emerging low-cost IAQ technologies. Moreover, the reviewed studies predominantly examined performance in temperate, urban, or institutional indoor environments (e.g., schools, offices, homes), with minimal data on use in rural, industrial, or climatically extreme settings. These gaps limit the applicability of findings to low-resource or climate-vulnerable contexts, where device performance may be fundamentally different due to environmental stressors or infrastructure constraints.

4.5 Strategic Recommendations for Future Research

To address these limitations and strengthen the scientific foundation of low-cost IAQ monitoring. Future studies should adopt internationally recognized validation frameworks, such as those established by the U.S. Environmental Protection Agency (EPA), the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO). These international validation frameworks should include rigorous calibration routines, Co-location with reference-grade instruments, Comprehensive documentation of sensor specifications, environmental conditions, and firmware versions.

The study should also Integrate Computational Techniques for real-time calibration and signal correction. As this can enhance pollutant detection accuracy and mitigate environmental or temporal drift effects.

The Expantion of Geographical and Environmental Coverage spanning diverse building types, climate zones, and socioeconomic contexts will be essential to test device robustness and ensure broader applicability.

A Comparative Assessments of future research should include head-to-head comparisons between Airthings products and other low-cost or mid-tier IAQ monitors to situate their performance within the broader sensor ecosystem and guide consumer and institutional decision-making.

A Longitudinal Monitoring Studies of over 6 months should be prioritized to evaluate long-term reliability, firmware resilience, and performance degradation trends.

5.0 CONCLUSION

The analysis reveals that, while both devices demonstrate strong user-friendliness, digital integration, and multi-pollutant detection capabilities, their scientific validity is highly dependent on the type of pollutant measured, the environmental conditions, and the presence (or absence) of calibration and validation controls. The View Plus exhibited moderate to high accuracy in measuring carbon dioxide (CO_2) and temperature under stable indoor environments, making it a viable option for preliminary exposure assessments in educational, occupational, and community-based settings. However, its particulate matter ($PM_{2.5}$) sensing capability was significantly compromised by high humidity, consistent with known limitations of low-cost optical sensors. The device's limited long-term validation and susceptibility to environmental

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and firmware variability further reduce its reliability for regulatory or precision research applications. The Wave Mini, while notable for its affordability and portability, is constrained by a narrower sensor array and demonstrated inconsistent volatile organic compound (VOC) readings across studies. Its suitability appears highest for public awareness, basic household screening, and informal education, rather than for data-driven interventions or high-stakes policy implementation.

A recurrent theme across the literature was the absence of standardized validation protocols and inconsistent calibration practices, which undermines confidence in cross-study comparability and hinders the extrapolation of findings to broader contexts. Without standardized benchmarks, both devices despite their technological promise remain insufficiently equipped for clinical, epidemiological, or regulatory-grade deployment.

Nonetheless, Airthings' devices serve an important role in democratizing access to IAQ data, particularly in settings with limited resources or technical capacity. Their integration with mobile apps and cloud-based platforms enhances real-time data accessibility and supports participatory environmental engagement critical for advancing indoor health literacy at the community level.

To advance their scientific legitimacy, future research must emphasize Rigorous methodological standardization, Robust longitudinal performance evaluations, and The incorporation of data-driven calibration models. Such developments will be pivotal in transforming these consumer-grade tools into credible components of the global IAQ monitoring infrastructure, supporting informed decision-making in both research and public health policy.

Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability Statement:

All data supporting this study are available upon request from the corresponding author.

Authors' Contribution

All authors contributed substantially to the conception, design, data analysis, interpretation, and manuscript preparation. Each author has reviewed and approved the final version of this manuscript.

Authors' Declaration

The manuscript is original, has not been published elsewhere, and is not under consideration by any other journal. The authors accept full responsibility for the content and any claims arising from this work.

Ethical Declarations Human/Animal Studies

The authors declare that no human/animal was used for the studies

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