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Determination of Critical Indoor Air Quality Parameters in Environmental Chemistry Laboratory of President University

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Abstract
The Environmental Engineering Laboratory at President University is obliged to systematically identify and manage Environmental Health and Safety (EHS) aspects to comply with LAM Engineering Regulation No. 1 of 2025, which mandates Higher Education Institutions in Engineering to ensure the provision of appropriate laboratory infrastructure and continuous monitoring of EHS conditions within their facilities. Through a systematic identification process that aligns activities and working conditions with relevant regulations, 9 critical parameters have been established, including temperature, humidity, CO2, PM2.5, PM10, lighting, noise, airflow, and Total Suspended Particles (TSP). These findings were obtained based on the identification of potential pollution risks based on laboratory experiments based on study program modules, measurements of dimensions and equipment as well as indoor air circulation conditions and literature review on indoor air quality study and regulation. The results of the critical parameter determination provide a comprehensive picture of critical indoor air quality parameters in laboratories, thus forming the basis for the development of an appropriate EHS management system at President University laboratories. Based on these research results, it is recommended to regularly monitoring indoor air quality with monitoring device, move the furnace as source of particulates, and maintaining humidity by installing a dehumidifier to ensure a healthy and standard-compliant learning environment.
Keywords: *indoor air quality, environmental laboratory, environmental chemistry*

Abstrak
Laboratorium Teknik Lingkungan di President University berkewajiban untuk secara sistematis mengidentifikasi dan mengelola aspek Kesehatan dan Keselamatan Lingkungan (K3L) untuk memenuhi Peraturan LAM Teknik No. 1 tahun 2025, yang mengatur Perguruan Tinggi Teknik untuk memastikan penyediaan infrastruktur laboratorium yang sesuai dan pemantauan terus menerus terhadap kondisi K3L di dalam fasilitas mereka. Melalui proses identifikasi sistematis yang menyelaraskan kegiatan dan kondisi kerja dengan regulasi yang relevan, 9 parameter kritis telah ditetapkan, termasuk suhu, kelembaban, CO2, PM2.5, PM10, pencahayaan, kebisingan, aliran udara, dan Total Suspended Particles (TSP). Temuan ini diperoleh berdasarkan identifikasi potensi risiko pencemaran berdasarkan aktivitas eksperimen laboratorium yang didasarkan pada modul program studi, pengukuran dimensi dan peralatan, kondisi sirkulasi udara dalam ruangan dan studi literature pada studi dan regulasi yang berkaitan dengan kualitas udara dalam ruangan. Hasil penentuan parameter kritis memberikan gambaran yang komprehensif mengenai parameter kritis kualitas udara di laboratorium, sehingga menjadi dasar pengembangan sistem manajemen K3L yang tepat di laboratorium President University. Berdasarkan hasil penelitian ini, disarankan untuk memantau kualitas udara dalam ruangan secara teratur dengan alat pemantau, memindahkan tungku sebagai sumber partikulat, dan menjaga kelembapan dengan memasang dehumidifier untuk memastikan lingkungan belajar yang sehat dan sesuai standar.
Kata Kunci: *kualitas udara dalam ruangan, laboratorium lingkungan, kimia lingkungan*

1. Introduction

Indoor air pollution has emerged as a critical concern in recent times, primarily due to its adverse implications for human health [1]. Research findings indicate that modern urban lifestyles confine individuals to indoor settings for over 90% of their daily lives [2]. Pollution levels indoors also can be up to several times higher than outdoors [3]. In higher education institutions, experimental technical knowledge is mostly taught through practical activities in campus laboratories. Given that prolonged exposure to chemical, physical, and biological hazards in laboratories can seriously affect health [4], universities must monitor the environmental quality of their supporting facilities.

Based on Appendix 11 of the LAM Teknik Regulation No. 1 Year 2025 (Undergraduate Assessment Matrix Section V), technical higher education institutions are required to establish adequate laboratory infrastructure and conduct environmental health and safety monitoring of their facilities [5]. The President University Engineering Laboratory is located in the Jababeka Industrial Estate [6], which also affects indoor air quality due to its proximity to industry. The Environmental Engineering Laboratory at President University is now developing a systematic framework to identify environmental health and safety aspects in accordance with applicable standards. An initial attempt to identify health and safety risks in experimental activities at the Environmental Engineering Laboratory of President University has indicated potential respiratory hazards, however the effort is still preliminary and necessitates further investigation [7].

This study aims to determine the critical indoor air quality parameters that need to be controlled in environmental chemistry laboratory, taking into account the risks arising from experimental activities. The identification of these parameters is expected to provide a scientific basis for effective monitoring and control strategies. Furthermore, the findings are intended to serve as a practical reference for laboratory managers in developing and implementing an environmental health and safety management system that is both relevant and sustainable.

2. Material and Methods

Fig. 1 illustrates the research framework of this study. The process began with identifying laboratory type, dimensions, and experimental activities based on the Environmental Engineering study program module. A literature review of national indoor air quality regulations relevant to laboratories was then conducted, and the parameters were selected according to the results of risk factor mapping in the laboratory.

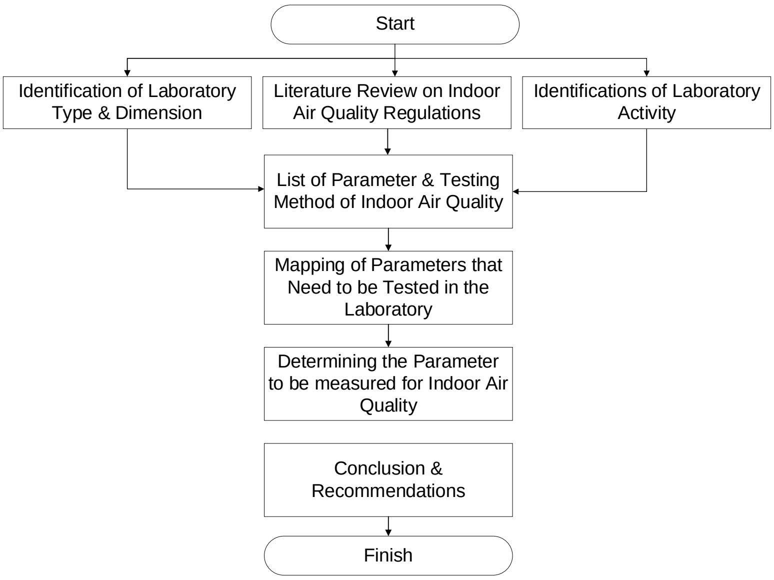

Fig. 1: Research Framework

This study initiated with the identification of laboratory types and dimensions to establish a comprehensive framework for subsequent procedures. The preliminary stage involved identifying laboratory activities based on the Environmental Engineering study program module. The selection of parameter criteria was focused on potential risk sources related to laboratory activities and conditions, regulations applicable at the time of the study, and quality standards explicitly defined in the form of ranges or permitted values. A literature review was conducted to compile a list of parameters and their potential sources, which were taken from previous studies. Subsequently, parameter mapping was carried out to ensure that all relevant factors requiring assessment in each laboratory were systematically considered. The research was conducted at the Environmental Chemistry Laboratory of the Environmental Engineering Study Program, Faculty of Engineering, President University. The laboratory room dimensions were measured using a laser meter.

3. Results and Discussion

Table 1 presents the identification of laboratory parameters, which was carried out by mapping the activities, equipment, and chemicals used in relation to potential emission scenarios. This identification process also considers laboratory dimensions, conditions of use, and environmental engineering laboratory modules as supporting references to ensure that all relevant factors contributing to indoor air quality risks are addressed systematically.

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Table 1: Laboratory Parameter Identification

Lab Dimension (W x L)	Activity	Machine/ Tools/ Chem.	Emission Scenario	Usage Condition	References
Environmental Chemistry Lab (10 m x 5,7 m)	Solids	Sample of solids, Furnace, Desiccator	Odor, particulate, dust.	Room condition: Using Exhaust Fan & AC Room occupied by 30 - 40 students	Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 109-111.
	Hardness	Tools: Heater (hot plate/steambath) Chemicals: hexamethylenetetramine, NH4Cl, Mg-EDTA, salt of ethylenediaminetetraacetic acid dihydrate, NH4OH, MgSO4, Eriochrome Black T, triethanolamine, Calmagite, inert salt, anhydrous CaCO3 powder, HCL, distilled water, NaOH.	Chemical vapor during dilution/sample measurement process		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 142-149.
	Chlorine Residual	Chemicals: Acetic acid, Potassium iodide, Na2S2O3, distilled water, potassium bi-iodate, CHCl3, sodium borate, mercuric iodide, K2Cr2O7, starch (potato, arrowroot or soluble), Standard iodine.	Chemical vapor during dilution and titration process, dust or particulate matter from using powdery chemical (ex: starch)		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 66-71.
	Acidity Testing	Tools: Dessicator, water heater (stove or waterbath) Chemical: Carbon dioxide-free water, methyl orange, Phenolphthalein solution, (COOH)2, NaOH, Hydrogen peroxide, Sodium thiosulfate, distilled water.	Vapor during dilution process		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 105-108.
	5-Day BOD Test	Tools: Chiller/refrigerator, air incubator or water bath. Chemicals: KH2PO4, Na2HPO4·7H2O, NH4Cl,distilled water, MgSO4·7H2O, CaCl2,FeCl3·6H2O, conc sulfuric acid, sodium hydroxide,Na2SO3, Nitrification inhibitor.	Vapor during dilution process, the use of chiller/refrigerator/air incubator.		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 60-65
	Ni & Pb by Atomic Absorption Spectrophotometer	Tools: Atomic absorption spectrometer, Burner, Readout, Hollow-cathode lamp or an electrodeless discharge lamp, Pressure-reducing valves, Vent. Chemicals: Air, Acetylene, Metal-free water, calcium carbonate, HCl diluted water, lanthanum oxide, Hydrogen peroxide, HNO3, 0.1000 g nickel metal, 0.1598 g lead nitrate.	Chemical vapor during dilution, dust or particulate matter from using powdery chemical (ex: nickel), lead, water vapor from boiling process.		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 67-76.
	NH3 Phenate Method	Chemicals: liquified phenol, v/v ethyl alcohol, sodium nitroprusside, deionized water, trisodium citrate, sodium hydroxide, Sodium hypochlorite, alkaline citrate solution, Ammonium chloride.	Odor from storing Sodium nitroprusside, chemical vapor during dilution/mixing/checking sample		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 77-78.

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Lab Dimension (W x L)	Activity	Machine/ Tools/ Chem.	Emission Scenario	Usage Condition	References
	NO3	Tools: Oven Chemicals: deionized water, Dry potassium nitrate, water, stock nitrate solution, CHCl3.	Heat, odor from chemical dilution storing, Chemical vapor during dilution process.		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 79-81.
	Pb wth Dithizone Method	Tools: Fume hood Chemicals: Pb(NO3)2, Pb(NO3)2, water, pure Pb metal, stock solution, Nitric acid, Ammonium hydroxide, ammonium citrate, anhydrous sodium sulfite, hydroxylamine hydrochloride, potassium cyanide, KCN, dithizone reagent, CHCl3, anhydrous Na2SO3, KI, resublimed iodine.	Exposure to poisoned chemical		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 82-85.
	Turbidity	Chemicals: Hydrazine sulfate, distilled water, hexamethylenetetramine	Vapor during dilution/sample measurement process/strong chemical solution		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 103-104.
	Alkalinity	Chemicals: Sodium carbonate solution, approximately 0.05 N, Standard sulfuric acid or hydrochloric acid, 0.1 N & 0.02 N, Bromcresol green indicator solution, Mixed bromcresol green-methyl red indicator solution.	Vapor during dilution/sample measurement process		Manual for Air, Solid Waste, Water and Wastewater Laboratory Page. 109-112.

Table 1 provides a comprehensive overview of the parameter identification process carried out at the Environmental Chemistry Laboratory. Mapping of activities, equipment, and chemicals shows that the majority of emission scenarios are closely related to the release of particulate matter. The formation of these particulates is mainly associated with two dominant sources, namely combustion processes such as furnace operation during solid analysis, which produces odors, dust, and fine particulates, and the handling of powdered chemicals in experimental procedures, including titration and sample preparation, which can release dust or particulates into the indoor environment. These results indicate that particulate matter is the most important pollutant in laboratories, not only because of its direct health impacts but also because of its persistence and tendency to accumulate in limited spaces if not adequately controlled. In addition to particulate emissions, this identification also highlights the presence of chemical vapors as another significant emission scenario. These vapors are produced during heating, dilution, or titration processes involving volatile reagents and acids. Although the specific characteristics of these vapors vary according to their activity, their contribution to the complexity of indoor air contaminants in laboratory environments is considerable, reinforcing the importance of effective ventilation systems and proper environmental monitoring.

Another important finding is the relatively high occupancy rate of laboratories, which typically accommodate around 30 to 40 students during experiment sessions. This density significantly contributes to the accumulation of carbon dioxide from respiration, which serves as an indicator of ventilation adequacy. High carbon dioxide concentrations not only reduce indoor air quality but also impair cognitive performance, concentration, and comfort, especially in academic environments. Additionally, the metabolic activity of occupants, along with the heat load from laboratory equipment such as furnaces and heaters, contributes to increased indoor temperatures, while humidity levels also tend to rise in such crowded conditions. The interaction of these factors can increase discomfort and affect the dispersion or chemical reactivity of pollutants. Based on a review of national regulations, the following are indoor air quality parameters that are relevant to laboratory work environments, the quality standard of which is regulated by national regulations.

Table 2: National Indoor Air Quality Standards

No.	Parameter	Quality Standard	Unit	References
1.	Temperature	18-30	°C	Permenkes No.2/2023
		≤32		Permenaker No.5/2018
2.	Lighting	200-300	Lux	Permenaker No.5/2018
		≤ 60		Permenkes No.2/2023
3.	Humidity	40-60	% Rh	Permenkes No.2/2023
				Permenaker No.5/2018
4.	Wind Flow	0,15-0,25	m/s	Permenkes No.2/2023
		≤ 0,3		Permenaker No.5/2018
5.	Noise	≤ 60	dBA	Permenkes No.2/2023
6.	TSP	≤10	mg/m^3	Permenaker No.5/2018
7.	PM_{10}	≤ 70	$\mu g/m^3$	Permenkes No.2/2023
		≤ 180		Permenaker No.5/2018
8.	$PM_{2.5}$	≤ 25	$\mu g/m^3$	Permenkes No.2/2023
9.	Sulfur Dioxide	≤ 500	$\mu g/m^3$	Permenkes No.2/2023
10.	Nitrogen Dioxide	≤ 200	$\mu g/m^3$	Permenkes No.2/2023
		<150		Permenaker No.5/2018
11.	Ozon	≤ 100	$\mu g/m^3$	Permenkes No.2/2023
		≤ 120		Permenaker No.5/2018
12.	Carbon Monoxide	≤ 9	ppm	Permenkes No.2/2023
13.	Carbon Dioxide	≤ 1000	ppm	Permenkes No.2/2023
		≤ 1000		Permenaker No.5/2018
14.	Lead (Pb)	≤ 1,5	$\mu g/m^3$	Permenkes No.2/2023
15.	Asbestos	≤ 5	serat/ml	Permenkes No.2/2023
		≤ 0,1		Permenaker No.5/2018
16.	Radon	100-300	Bq/m^3	Permenkes No.2/2023
17.	CH_2O	≤ 0,1	ppm	Permenkes No.2/2023
18.	VOC as CH4	≤ 3	ppm	Permenkes No.2/2023
19.	Nicotine	1-10	$\mu g/m^3$	Permenkes No.2/2023
20	Mercury	≤ 1	$\mu g/m^3$	Permenkes No.2/2023

No.	Parameter	Quality Standard	Unit	References
21.	Germ Count	≤ 700	CFU/m^3	Permenkes No.2/2023
		≤500		Permenaker No.5/2018

In general, the mapping results show that there are several indoor air quality parameters that require attention in this laboratory, namely particulate matter, carbon dioxide, temperature, and humidity. Meanwhile, laboratories, which are work environments, are subject to physical parameters that are part of national work environment standards [8], [9] to ensure quality, such as noise and lighting parameters. These parameters reflect the dominant risks arising from experimental activities and occupancy patterns. Therefore, these parameters should be the primary focus for monitoring and management strategies, not only to ensure compliance with health and safety standards, but also to maintain an effective and safe learning environment that protects students and laboratory staff from potential exposure risks. From Laboratory Parameter Identification in **Table 1**, mapping was done to determine which parameters are applicable in this laboratory. The results led to the **Table 3** which consists of 9 critical parameters.

Table 3: Parameter Determination

No	Parameter	Source
1	Temperature	Experimental activities (solids practicum using furnace/oven, heater in hardness and acidity testing practicum), outdoor air/weather, human activity, poor ventilation system.
2	Humidity	Experimental activities (use of heater in harness test to heat liquid, waterbath in 5-Day BOD test, heating with stove in acidity testing, use of volatile chemical in each practicum), human respiration, humid outdoor air.
3	CO_2	Human respiration, outdoor air, poor ventilation system
4	$PM_{2.5}$	Experimental activities (Solids practicum using a furnace, use of powdery chemicals in each practicum), outdoor particles/dust/dirt.
5	PM_{10}	Experimental activities (Solids practicum using a furnace, use of powdery chemicals in each practicum), outdoor particles/dust/dirt.
6	Lighting	Crowded work area, dim lamp, poor natural lighting.
7	Noise	Experimental activities (use of fumehood in experiments involving acidic liquids such as practicum of water COD levels and residual chlorine, use of vacuum pumps in the filtration process of water samples), crowded human activities.
8	Wind Flow	Mechanical Ventilation
9	Total Suspended Particle	Experimental activities (solids practicum using a furnace, use of powdery chemicals in each practicum), outdoor particles/dust/dirt.

Table 3 is the result of determining the parameters through identification of laboratory activities and equipment as well as literature review [10] [11] [12] [13] [14] [15] of previous studies and national regulations related to indoor air quality. The selected parameters are considered crucial because they have a high potential risk to air quality and health based on practicum activities as relevant pollutant sources in this laboratory.

4. Conclusion

The results of this study provide a comprehensive overview of indoor air quality critical parameters in the laboratory, thereby forming the basis for the development of an appropriate Environmental Health and Safety (EHS) management system at President University's laboratory. Based on the identification of risk factors (activities, machine, chemical use) and relevant national regulatory frameworks, the key parameters identified as essential include temperature, humidity, CO2, PM2.5, PM10, lighting, noise, wind flow and TSP which serve as an important foundation for the development of EHS management system designed to the President University laboratory. Based on the results of this study, recommendations that can be made include regularly monitoring indoor air quality with an IAQ monitoring device, relocate furnaces to separate room with proper ventilation as potential source of particulates, and installing dehumidifiers to maintain humidity levels. These strategies are essential to ensure a learning environment that is not only healthy and comfortable, but also fully aligned with national health and safety standards.

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