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Assessing Chemistry Teachers' Knowledge of Atmospheric Chemistry Associated with Environmental Chemical Literacy

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ABSTRACT

Environmental chemical literacy (ECL) is part of environmental literacy which is one of the most abilities of a citizen for sustainable development. The data for this study were collected using a cross-sectional survey technique for high school chemistry teachers. The data was obtained through online test in atmospheric chemistry, which is consists of 4 topic, i.e. particulate matter (PM) 2.5, green house gasses correlated to global warming, ozone depletion and acid decomposition. Based on the study, it showed that two thirds of respondents have moderate ability in atmospheric chemistry associated with ECL.

Keyword: *environmental chemical literacy, atmospheric chemistry*

1. INTRODUCTION

Environmental chemical literacy, abbreviated as ECL, is part of environmental literacy which is one of the most abilities of a citizen for sustainable development. Environmental literacy was defined as a basic understanding of the concepts and knowledge of the issues and information relevant to the health and sustainability of the environment as well as environmental issues related to human health (Rowe, 2002). The term of ECL is a combination of chemical literacy and environmental literacy. An individual's ECL can be interpreted as an individual's ability to understand and use chemical concepts through scientific processes that are environmentally responsible and provide solutions to current and future related problems. The components of ECL were synthesized and adapted from environmental literacy frameworks (Simmons, 1995; Hollweg, et al, 2011) and aspects of chemical literacy (Shwartz, Ben-Zvi, & Hofstein (2006)), i.e.:

- Chemistry knowledge, which is the understanding related to the basic concepts of chemistry, including particles, chemical reactions, chemical laws and theories, and chemical applications in everyday life.
- Environmental competency, which is the understanding or ability to identify, analyze and evaluate problems and issues related to the environment, including the quality of water, air and soil, as well as the use and management of environmental components for humans and the sustainability of living things in the future.
- Environmental awareness, namely the attitude of being responsible for the environment and the motivation to actively participate in the improvement and protection of the environment, including making decisions and judgments about environmental issues in accordance with one's own morality.

A chemistry teacher must have good mastery of chemical content and literacy to solve problems in the surrounding environment. This is because chemistry is a branch of science that is closely related to everyday life. However, some people find it difficult to learn this subject matter (Treagust, Nieswandt & Duit, 2000). This difficulty occurs because some chemical concepts tend to be complex and abstract, requiring more effort and intellectual intelligence to understand them (Nakhleh, 1992; Cardellini, 2012; Adesoji, Omilani & Dada, 2017).

As a part of environmental chemistry, atmospheric chemistry spans from the fundamental understanding of chemical reactions to accurately measuring reaction rate and photochemical data for gas-phase processes (Ravishankara, 2003). Moreover, the scientific atmospheric measurements of chemicals and their abundances are important for understanding how we live (Prather, Holmes & Hsu, 2012). The atmosphere is influenced by both human activities and natural processes, causing the release of carbon dioxide, sulfur, nitrogen, ammonia, dust, and various other compounds (Pye, et al, 2020). The release of these pollutans can result in different consequences, such as the greenhouse effect, ozone depletion, acid deposition, and so on. The presence of acidic substances in the air, such as particles and droplets, has a significant impact on various processes related to the atmosphere and its interaction with different parts of the Earth system (like watersheds, marine and terrestrial ecosystems). The acidity levels in aerosols (also known as particulate matter, PM) and cloud droplets across the atmosphere vary significantly. Certain emissions caused by human activity, such as sulfur dioxide, nitrogen oxides, and organic acids, contribute to the increase in acidity levels. On the other hand, emissions like ammonia, nonvolatile cations (NVCs), and amines have the opposite effect and actually decrease acidity.

2. RESEARCH METHOD

The data for this study were collected using a cross-sectional survey technique for high school chemistry teachers who had previously studied at Universitas Negeri Yogyakarta. The survey was conducted in April 2022 with 57 chemistry teachers as respondents. The characteristics of the respondents are shown in Table 1.

Table 1. The characteristics of survey respondents

Gender (%)		High School Category (%)	
Male	Female	Public	Private
31,58	68,42	59,65	40,35

The data was obtained through online test of ECL, specifically in atmospheric chemistry. There were 20 statements about atmospheric chemistry, then the respondent determines whether the question is true, false or does not know. The topics studied in atmospheric chemistry such as particulate matter (PM) 2.5, green house gasses correlated to global warming, ozone depletion and acid decomposition. The examples of the statements are follows.

1. Burning biomass will produce carbon dioxide gas in the form of black smoke.
2. Methane gas (CH_4) is a greenhouse gas which is polar and it has a tetrahedral molecular shape.
3. UV radiation from the sun will release chlorine atoms in chlorofluorocarbon compounds (CFCs) which break the O-O bonds in the ozone molecule.
4. Traffic jams on the highway contribute significantly to CO_2 emissions which cause acid rain.

The data obtained was analyzed descriptively to determine the ability of ECL of chemistry teachers, especially in atmospheric chemistry.

3. RESULTS AND DISCUSSION

The data was obtained in the period of April – May 2022. The respondents filled out an online questionnaire about atmospheric chemistry, consists of particulate matter (PM) 2.5, green house gasses correlated to global warming, ozone depletion and acid decomposition. Based on the data, the chemistry teachers' knowledge of atmospheric chemistry associated with ECL is shown in Figure 1.

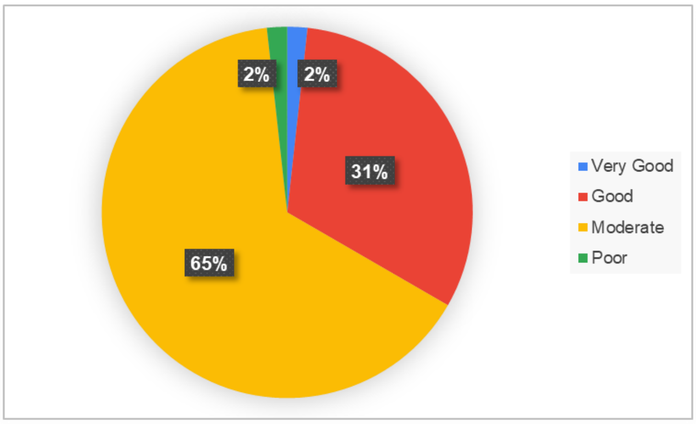

Figure 1. The chemistry teachers' knowledge of atmospheric chemistry associated with ECL

Based on the Figure 1, a two third of the chemistry teachers' knowledge of atmospheric chemistry is moderate. It means that the chemistry teachers' understanding in atmospheric chemistry is mediocre and they need to learn a lot about atmospheric chemistry which can later be conveyed to their students.

Atmospheric chemistry is the branch of atmospheric science focused on chemical processes within Earth's atmosphere. Enhancing knowledge in this field is extremely important for a better comprehension of climate influencing factors, air quality, and the interconnections between the atmosphere and biosphere. This field is thus situated at the intersection of chemistry with physics and biology, and includes processes acting on time and spatial scales below seconds and mm to those that occur on regional and global scales (Pryor, Crippa & Sullivan, 2015). This makes chemistry teachers have difficulty understanding atmospheric chemistry. For example, when there is a statement that burning biomass will produce carbon dioxide gas in the form of black smoke, there is a misconception among most teachers. Black smoke is an aerosol in which carbon dust particles, mostly, are dispersed in a gaseous medium. Misconceptions occur when the chemistry teachers always think that burning organic materials will produce carbon dioxide gas and water vapor, even though carbon dioxide gas is a gas that is colorless and odorless.

Based on the atmospheric chemistry topics, the chemistry teachers' knowledge of atmospheric chemistry associated with ECL is shown in Table 2.

Table 2. The chemistry teachers' knowledge of atmospheric chemistry associated with ECL for each topic

Particulate Matter (PM)2.5	Green House Gasses Correlated to Global Warming	Ozone Depletion	Acid Deposition
Good	Moderate	Good	Moderate

Table 2 shows that the chemistry teacher has difficulties in green house gasses correlated to global warming and acid deposition topics. Based on the analysis, the chemistry teacher's knowledge of atmospheric chemistry is related to the many misconceptions that teachers have. Chemical misconceptions are erroneous perceptions on chemistry understanding (Kay & Yiin, 2010). One of the most common misconceptions in atmospheric chemistry that is correlated with greenhouse gases is that low CO_2 concentrations in the atmosphere have no significant effect on Earth's surface temperature. Based on experiment conducted by Eunice Newton Foote in 1856, it showed that a carbon dioxide-filled cylinder placed in the sun retained more heat and remained warmer for longer than an air-filled cylinder (Ortiz & Jackson, 2022). These laboratory and atmospheric experiments have been repeated numerous times by scientists to demonstrate carbon dioxide's greenhouse effect.

The chemistry teachers' knowledge in acid deposition is moderate. Some of them have an inaccurate understanding of the causes of acid deposition and the effects of acid rain on soil fertility. The highest acid deposition is near the emission sources, for example coal-fired power plant. Wind-blown, alkaline soil dust is important in neutralizing the acidity of the emissions. The acid rain flows through the soil, which can leach aluminum from soil clay particles (Larssen, et al, 1999). Its probably caused elevated concentrations of toxic aluminum in soil water.

4. CONCLUSION

Based on the study, it showed that two thirds of respondents have moderate ability in atmospheric chemistry associated with ECL. More over, the chemistry teahers' knowledge in particulate matter (PM) 2.5 and ozone depletion topic is good. Even though, their knowledge in green house gasses correlated to global warming and acid decomposition topic is moderate.

REFERENCES

Adesoji, F. A., Omilani, N. A., & Dada, S. O. (2017). A comparison of perceived and actual; Students' learning difficulties in physical chemistry. *International Journal of Brain and Cognitive Sciences*, 6(1), 1-8. doi: http://doi.org/10.5923/j.ijbcs.20170601.01

Cardellini, L. (2012). Chemistry: why the subject is difficult? *Educación química*, 23, 305-310. Doi: https://doi.org/10.1016/S0187-893X(17)

Hollweg, K.S., Taylor, J.R., Bybee, R.W., Marcinkowski, T.J., McBeth, W.C., and Zoido, P. (2011). *Developing a framework for assessing environmental literacy*. Washington, DC: North American Association for Environmental Education

Kay, C. C. & Yiin, H. K. (2010). Misconceptions in The Teaching of Chemistry in Secondary Schools in Singapore & Malaysia. *Proceedings of the Sunway Academic Conference 2010/1*, 1-10.

Larssen, T., Seip, H. M., Semb, A., Mulder, J., Muniz, I. P., Vogt, R. D., ... & Eilertsen, O. (1999). Acid deposition and its effects in China: an overview. *Environmental Science & Policy*, 2(1), 9-24.

Nakhleh, M.B. (1992). Why some students don't learn chemistry: Chemical misconceptions. *Journal of Chemical Education*, 69(3), 191-196.

Ortiz, J. D., & Jackson, R. (2022). Understanding Eunice Foote's 1856 experiments: heat absorption by atmospheric gases. *Notes and Records*, 76(1), 67-84.

Prather, M. J., Holmes, C. D., & Hsu, J. (2012). Reactive greenhouse gas scenarios: Systematic exploration of uncertainties and the role of atmospheric chemistry. *Geophysical Research Letters*, 39(9).

Pryor, S. C., Crippa, P. & Sullivan, R. C. (2015) *Atmospheric Chemistry: Reference Module in Earth Systems and Environmental Sciences*. Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.09177-6

Pye, H. O. T., Nenes, A., Alexander, B., …, Zuend, A. (2020). The acidity of atmospheric particles and clouds. *Atmospheric Chemistry and Physics,* 20(8). https://doi.org/10.5194/acp-20-4809-2020

Ravishankara, A. R. (2003). Introduction: atmospheric chemistry long-term issues. *Chemical Reviews*, 103(12), 4505-4508.

Rowe, D. (2002). Environmental literacy and sustainability as core requirements: Success stories and models. *Teaching sustainability at universities*, 79-103.

Shwartz, Y., Ben-Zvi, R., & Hofstein, A. (2006). The use of scientific literacy taxonomy for assessing the development of chemical literacy among high-school students. *Chemistry education research and practice*, 7(4), 203-225.

Simmons, D. (1995). Developing a framework for national environmental education standards [Working paper]. In D. Simmons (Ed.), *The NAAEE standards project: Papers on the development of environmental education standards* (pp. 9-58). Troy, OH: North American Association for Environmental Education.

Treagust, D., Nieswandt, M., & Duit, R. (2000). Sources of students' difficulties in learning chemistry. *Educación química*, 11(2), 228-235.