RESEARCH ARTICLE

European Journal of Education and Pedagogy
www.ej-edu.org

Air Pollution in High School Syllabus over Most Polluted Country: Assessment and Expert Opinion

Arindam Roy

ABSTRACT

India is one of the most vulnerable countries due to air pollution and it kills 1.67 million people every year in India. Although the air pollution issue in the country is well known, there is a gap of knowledge between assessment of the syllabus in terms of the topic "Air Pollution" in the school syllabus. In the present work, various topics related to air pollution in school textbooks have been evaluated for class V-XII and air quality experts' interview was conducted to identify the gap area in the syllabus. It was found that the present school syllabus does not adequately represent the present state of knowledge on air pollution. The syllabus highlighted the air pollution issues in the late 90s where gaseous pollutants and acid rain were the primary concern. Important issues in the last two decades such as Air Quality Index (AQI), Particulate Matter (PM), the inequity in pollution exposures, occupational health hazards, and adaptation procedures are either not included or described very briefly. Overall, the syllabus on air pollution is very much information-oriented and is not concept-oriented. The recommendations from the experts were included in the study which clearly calls for a substantial modification of the syllabus.

Keywords: air pollution education, environmental education, Indian school, syllabus assessment.

Published Online: November 28, 2022

ISSN: 2736-4534

DOI :10.24018/ejedu.2022.3.6.501

A. Roy*
École Polytechnique Fédérale de Lausanne, Switzerland.
(e-mail: arindam.roy@ epfl.ch)

****Corresponding Author***

I. Introduction

It is well known that air pollution education is an absolute necessary precondition for a proper air quality management program (Auerbach & Flieger, 1967; Teksoz, 2011). Integrating air pollution in the syllabus could effectively improve environmental literacy among the citizens (Teksoz, 2011). Air pollution is trans-disciplinary as it has components from both natural sciences and social sciences; and therefore, the practice of teaching about air pollution can be facilitate through chemical reactions, performing arts and social surveys (Huo *et al*., 2020). In developed countries, the high school syllabus includes trans-disciplinary topics such as economics of pollution control, public health and active transport (Education, 2009). Hands on air pollution education has already mainstreamed in developed countries where school students are equipped with air pollution sensors (Kaduwela *et al*., 2019; Al-Abadleh *et al*., 2022).

The global Burden of Disease study concluded that the death from the air pollution over India is 1.67 million for a single year which is 18% of the total deaths (Pandey *et al*., 2021). Among world's 20 most polluted cities, India has 10 (Kumari *et al*., 2020). During winter period, in some parts of India, government compelled to close schools due to air pollution (Chatterjee, 2019). Being such a polluted country, does the school syllabus over India, significantly reflect the present scenario? That was the primary question of the present reperch article.

The current research in air pollution is not always reflected in the syllabus. Scientists stated in a conference in early 2000 have questioned why the educators were still teaching about Sulfur di Oxide and acid rain, whereas Nitrogen created a lot bigger problem (Cunningham & Stubbs, 2003). In the late 70s, scientists and teachers in USA co-created acid rain and air pollution syllabus through workshops, laboratory, and classroom visits (Anderson, 1993). The field of air pollution has evolved a lot in the last two decades, and therefore it sometimes became difficult for the educators/syllabus creator to follow the same. In this study, I focus on the air pollution school syllabus over one of the most polluted countries in the present time.

The objective of the study is to evaluate the present status of air pollution as a topic in textbooks of Indian school. Air quality researchers over India were interviewed during the study regarding the syllabus to find out if the syllabus represents the recent advancement on air quality research in India adequately. I have followed National Council of Educational Research and Training (NCERT) books from class V-XII. NCERT books are the textbooks for Central Board of Secondary Education (CBSE) boards students, which is established by Government of India, and it is most popular and biggest education board in India (More than 27,000 schools affiliated). The NCERT textbooks are also popular among the students of other boards as well.

There are very few literatures available where environmental science syllabus over India has been evaluated (Gopal & Anand, 2006; Thrivikramji *et al*., 2021). To the best of my knowledge, none of them has evaluated

air pollution syllabus and study material on class to class basic and consult air quality experts to validate the syllabus.

II. Evaluation of Present Syllabus

A. Occurrence of Air Pollution in Middle School Books

The present study has reviewed the NCERT books for class V-XII and identified the occurrence of the topic air pollution or air quality. The result is represented in Table I. In class V, air pollution was introduced indirectly through a story in an Environmental Studies book. Ashima, a kid who was sitting near the window, sneezed after a wind full of dusty air enter into the house. The correlation between dust and allergy has been well studied in air pollution research (Kim *et al*., 2013). Also, through conversation, it was mentioned that cars running on Compress Natural Gas (CNG) emit less smoke than petrol/diesel. Although, the abbreviation of CNG or any details were not provided. The conversation was created to explain depletion of natural resources. In class VII, explanation regarding dust and respiratory system are briefly described with a graphic. Also, it is stated that forest influences air quality, but no explanation regarding how it influences and whether positive or negative, was found.

In class VIII, there is an entire chapter dedicated to air and water pollution. Here different sources (Natural and anthropogenic) and types of air pollutants (Gas and particulates) such as SO_2, NO_2, Suspended Particulate Matter have been described briefly. The health impact of overall air pollutants has been stated with special reference to the smog formation. Case studies on Delhi CNG transformation and acidic precipitation from industrial emission have been discussed in detail. Activities such as counting cars in different regions (residential, commercial, industrial) and respiratory health survey in the neighborhoods have been suggested.

B. Occurrence of Air Pollution in Upper-Middle Class

Very few times air pollution is mentioned in high school textbooks for class IX and X. In class IX, fossil fuel combustion was discussed which does not add any further information or introduce any new concept as compared to class VIII. The health effects of air pollution, acidic gasses generation and smog were mentioned, but not described. In class X, only a handful of times air pollution was mentioned. Most of the time, the context of air pollution was drawn to introduce depletion of the natural resources and the necessity of transition to renewable energy.

C. Occurrence of Air Pollution in Higher Secondary Books

Air pollution has been described in detail in the class XI chemistry book. Chemistry of oxide of Sulphur and Nitrogen formation has been described with equation. Acidic rain chemistry has also been stated in detail. The health impact of each type of pollutants has been discussed in detail along with different air pollutant types; like Volatile Organic Compounds (VOCs), formaldehyde and peroxyacetyl nitrate (PAN). Tropospheric ozone and its role in smog formation has been introduced with chemical equations. Moreover, particulate matter (PM) and its increasing health impact with decreasing size has been discussed in detail. Smog control mechanisms such as catalytic converters and the role of plants in reducing particulate pollution has been described very briefly. In class XII also, multiple sections of a chapter on air pollution in Biology books. PM2.5 or particulate matter with diameter less than 2.5 micron, has been introduced. Air pollution removal techniques such as electrostatic precipitators and catalytic converters have been discussed thoroughly. Government mediated measures such as CNG cars in Delhi, setting and implementing emission standards for vehicles and different air pollution prevention acts have been discussed in detail.

TABLE I: Air Pollution Topics in Different Class

Class	Subject (Chapter)	Span	Topic
V	Environmental Studies (12)	Lines	Dusty air trigger sneezing, Smoke from vehicles and cooking
VI	Sciences (15,16)	Para	Burning garbage & cars produces harmful smoke & gasses
VII	Sciences (10)	Para, drawing	Dust in respiratory system
VIII	Sciences (18)	Chapter,	Source and types of pollutants, Delhi CNG & Taj Mahal case study, smog, health impact
IX	Sciences (14)	Section	Fossil fuel combustion, Lichen as bioindicator of pollution
X	Sciences (14)	Lines	Fossil fuel combustion, acid rain
XI	Chemistry (14)	Sections	Gas-phase and smog chemistry, rain chemistry, particulate, VOCs
XII	Biology (16)	Section	Pollution prevention acts, PM2.5, industrial pollution control, vehicular emission standards

D. Class Wise Comparison of Syllabus

The air pollution in the syllabus of different classes was discussed in the previous section. Overall, it can be observed that the detailed introduction of air pollution was made in middle school (Class VIII) and during higher secondary classes (XI and XII). Till class VII, the source and impacts of air pollution are not directly discussed. Only a few lines or a small paragraph were dedicated to providing statements related to the relation between dusty air and burning of any substances. These lines/paragraphs about air pollution are used to introduce other topics like waste or respiratory system. Air pollution was mainstreamed in Class VIII where an entire chapter was dedicated to explaining sources of air pollution. Although, the mitigation/adaptation approaches were not discussed in detail. Surprisingly, in class IX and X, air pollution was not discussed in an elaborate manner. No new information or concept was introduced and only a few lines or one paragraph was reserved for air pollution. One important observation from the assessment of the syllabus is that the topics are very much information oriented till class X. Some concepts were introduced in higher secondary classes but overall, the topics are mostly facts.

III. Limitations of the Present Syllabus

In class XI and XII, the science stream, students were exposed to various technical details of air pollution. Gas-phase chemistry, rain-chemistry, and various workplace

TABLE II: AIR POLLUTION SUBJECT MATTER IN DIFFERENT CLASS

Class	Source	Adaptation/mitigation
V	Cooking, Vehicular	CNG produce less smoke as compared to petrol/diesel
VI	Vehicular, leaf and stubble burning	Wearing mask, Composting, and recycling
VII	Brick kilns	No information
VIII	Cars, Brick kilns, industrial, Cracker, Power plants, wood	Stop burning, Shift to renewable energy, non-Motorized transport
IX	Combustion	No information
X	Fossil fuel	Combustion efficiency
XI	Leaded petrol, car, industry, bio-aerosol, fly ash, coal, dust	Catalytic convertor, plantation
XII	Occupational sources, different industrial sources	Electrostatic precipitator, Catalytic convertor, Regulations, acts, and standards

sources like coal combustion, wood saw dust machine operation, fossil fuel combustions have been described. More importantly, in class XII, different controlling mechanisms of air pollution and differential health impact by different pollutant has been well represented in detail. However, the technical details of air pollution are described mostly in the science books of higher secondary class. Therefore, the students of other streams (arts and commerce) will not be able to know about this. PM2.5 is considered as the most potent air pollutant which kills 1.67 million people over India every year (Pandey *et al*., 2021). In general, the particulate air pollutants have significantly higher health impact than the gaseous counter parts (Fang *et al*., 2013). As particulate matter was described in higher secondary classes, a significant number of students who do not opt for science miss the details. Also, the classroom activities related to air pollution are found to be very limited. Direct measurement of air pollutants was not part of the activity curriculum. Other than the technical details, the topic air pollution is closely related to inequality, injustice, and gender aspects of social sciences. It was well observed that the higher air pollution exposer is linked with lower-income levels. However, the transdisciplinary approach to explain the inequal impact of air pollution was not observed while assessing the books.

IV. EXPERT OPINION ON THE PRESENT SYLLABUS

Fifteen researchers/scientists who are working on Indian air quality for at least five years were anonymously interviewed for this study. The semi-structured interview took place in a one-to-one session where at first, I asked what should be included in middle school, higher school, and higher secondary school syllabus. After that, I briefed them about the present NCERT syllabus and then asked some follow up questions regarding:

a) Do you think that Indian air quality scenario has been represented in the syllabus?

b) Global disease burden study has shown contribution from death from indoor and outdoor pollution are very much comparable (Pandey *et al*., 2021). Do you think, in the syllabus, indoor pollution should also be highlighted as outdoor one?

c) Delhi CNG and Taj Mahal are described as case studies. However, both of them happened almost two decades ago. Do you think new case studies from different parts of India should be included in syllabus?

d) The societal impact of air pollution is often uneven and unequal. Do you think that social issues related to air pollution should be included in the syllabus?

e) The syllabus needs to be updated. Do you agree with the statement?

The results from the interview have been presented in Table III.

TABLE III: RESULTS FROM THE EXPERTS INTERVIEW (N=15)

Questions	Response	Representative comment
Is the syllabus Indianized?	Y=3* N=12	Technically sound but does not have adequate Indian examples.
Should indoor pollution include?	Y=12* N=3	Not only cooking, but also mosquito coil, incense sticks
Is the new case study included?	Y=15** N=0	Stubble burning, Odd-even cars, Transport of pollutants
Should inequity in exposure be added?	Y=14** N=1	Yes, and it should be included before class 10.
Syllabus should be updated?	Y=15** N=0	Yes, why still
Middle school syllabus		Sources, PM2.5, inequality in exposure, indoor pollution, AQI
High school syllabus		SWAT analysis, case studies, distribution, controls
Higher secondary syllabus		Chemistry and physics of air pollution, plume model

*p-value<0.05, ***p-value<0.01.

I have got very interesting answers from the air pollution experts regarding the syllabus. All of them agreed on the fact that there is a gap between the present scientific advancement and the syllabus regarding the topic air pollution. Several experts have mentioned that air pollution should be taught in a gradual manner, rather than concentrating it in class VIII and Class XI-XII. Also, the students should learn about important topics on air pollution such as Air Quality Index (AQI), PM2.5, primary and secondary sources in their middle school classes. Inequality in air pollutants exposures should also be included before class X, as after that students choose Arts, Science and Commerce stream. Also, strategic management techniques like SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis can be introduced to improve the analytical power regarding the air pollution management in higher classes (9-10). Overall, majority of the experts agreed on the fact that the information and case studies should be updated and more recent case studies such as pollution capping in Surat (Greenstone *et al*., 2019), odd-even car strategy in Delhi (Kumar *et al*., 2017) and stubble burning in Indo-Gangetic Plain (Abdurrahman et al., 2020) should be included as case studies. Indoor pollutions sources such as solid fuel combustion for cooking, mosquito repellents, incense sticks etc. should be included in middle schools. One expert has mentioned that in middle schools, the kids are still taught by the parents. Information on indoor and occupational pollution sources and their impact might make aware the parents as well to change their behavior. Also, all the respondents agreed on using more hands-on low-cost instruments to visualize the data regarding distribution of air pollution.

V. RECOMMENDATION

The syllabus on air pollution is required to be updated for every class. The present syllabus focuses on issues in the early 2000s. The present syllabus on air pollution is concentrated in Class VIII and Class XI-XII. However, it is recommended that it should follow a gradual learning curve. The syllabus also focused primarily on gaseous air pollutants rather the particulate matter, which is one of the primary reasons behind premature mortality over India. PM2.5 and PM10 should be introduced and the concept of AQI needs to be incorporated in middle schools' classes. The experts have mentioned several new Indian case studies which are very contemporary. These case studies should be incorporated into the syllabus. Also, the air pollution syllabus is very much information oriented. The scope of critical thinking and analysis is limited. Conceptual topics regarding occupational hazards, polluters' pay, exposure inequalities, vulnerable communities need to be included (Florig *et al*., 1995; Hajat *et al*., 2015). The social aspect of air pollution should be discussed in early classes where all the students follow a similar syllabus. The experts also suggested to include activity-based learning (Nwosu *et al*., 2022) and information regarding adaptations measures in personal life such as improved ventilation, behavioral modifications, and usage of clean cooking fuel in early classes (Gunnarsen & Fanger, 1992; Liao *et al*., 2021).

Low-cost sensors for air quality measurements are quite available and being used in educational purposes in several countries. Also, pollution catchers and Ozone detection experiments are really simple and can be performed using household materials (Hartz & Carlson, 2003; Zimmermann *et al*., 2018). These tools can be introduced in school level for educating students about air pollution. Finally, air pollution research in India made significant progression in last two decades. Sophisticated instrumentations, large computational facilities and thousands of the researchers dedicatedly working on air pollution over India. Syllabus makers and scientists need to sit together to modify the present syllabus on air pollution.

ACKNOWLEDGMENT

I would like to thank LAPI (Laboratory of atmospheric processes and their impacts) for hosting me and Clean Air Project India by Swiss Agency for Development and Cooperation (SDC) for my postdoctoral fellowship.

FUNDING

No funding was required to conduct the study.

REFERENCES

Abdurrahman, M. I., Chaki, S., & Saini, G. (2020). Stubble burning: Effects on health & environment, regulations, and management practices. *Environmental Advances*, 2, 100011.

Al-Abadleh, H. A., Khalaf, Y., Salama, C., & Kurorwaho, B. (2022). Air quality education in public schools. *Science*, 376(6593), 589–589.

Anderson, N. D. (1993). SCI-LINK: An innovative project linking research scientists and science teachers. *Journal of Science Teacher Education*, 4(2), 44–50.

Auerbach, I. L., & Flieger, K. (1967). The importance of public education in air pollution control. *Journal of the air pollution control association*, 17(2), 102–104.

Chatterjee, P. (2019). Indian air pollution: loaded dice. *The Lancet Planetary Health*, 3(12), e500–e501.

Cunningham, W. P., & Stubbs, H. S. (2003). Information needs related to teaching about air quality. *Environment international*, 29(2-3), 331–336.

Education, E. (2009). *Scope and sequence of expectations*. The Ontario Curriculum, 2009 Edition.

Fang, Y., Mauzerall, D. L., Liu, J., Fiore, A. M., & Horowitz, L. W. (2013). Impacts of 21st century climate change on global air pollution-related premature mortality. *Climatic Change*, 121(2), 239–253.

Florig, H. K., Spofford Jr, W. O., & Xiaoying Ma, Z. M. (1995). China strives to make the polluter pay. *Environmental science & technology*, 29(6), 268A–273A.

Gopal, G. V., & Anand, V. V. (2006, December). Environmental education in school curriculum an overall perspective. In *Proceedings of Symposium on Environment Education & Ecosystem Conservation, Indian Institute of Science* (pp. 28–30).

Greenstone, M., Pande, R., Ryan, N., & Sudarshan, A. (2019). *The Surat Emissions Trading Scheme*. Energy Policy Institute at the University of Chicago. https://epic. uchicago. edu/research/the-surat-emissions-trading-scheme-a-first-look-at-the-worlds-first-particulate-trading-system.

Gunnarsen, L., & Fanger, P. O. (1992). Adaptation to indoor air pollution. *Environment International*, 18(1), 43–54.

Hajat, A., Hsia, C., & O'Neill, M. S. (2015). Socioeconomic disparities and air pollution exposure: a global review. *Current environmental health reports*, 2(4), 440–450.

Hartz, C., & Carlson, S. (2003). *Exploring your environment: Youth activity guide*. Level 1, Eco-wonders.

Huo, Y. J., Shih, K. T., & Lin, C. J. (2020, November). The study on integrating air pollution environmental education into the teaching personal and social responsibility model in physical education. In *IOP Conference Series: Earth and Environmental Science* (Vol. 576, No. 1, p. 012006). IOP Publishing.

Kaduwela, A. P., Kaduwela, A. P., Jrade, E., Brusseau, M., Morris, S., Morris, J., & Risk, V. (2019). Development of a low-cost air sensor package and indoor air quality monitoring in a California middle school: Detection of a distant wildfire. *Journal of the Air & Waste Management Association*, 69(9), 1015–1022.

Kim, K. H., Jahan, S. A., & Kabir, E. (2013). A review on human health perspective of air pollution with respect to allergies and asthma. *Environment international*, 59, 41–52.

Kumar, P., Gulia, S., Harrison, R. M., & Khare, M. (2017). The influence of odd-even car trial on fine and coarse particles in Delhi. *Environmental Pollution*, 225, 20–30.

Kumari, S., Lakhani, A., & Kumari, K. M. (2020). COVID-19 and air pollution in Indian cities: World's most polluted cities. *Aerosol and Air Quality Research*, 20(12), 2592–2603.

Liao, J., Kirby, M. A., Pillarisetti, A., Piedrahita, R., Balakrishnan, K., Sambandam, S., ... & Young, B. N. (2021). LPG stove and fuel intervention among pregnant women reduce fine particle air pollution exposures in three countries: Pilot results from the HAPIN trial. *Environmental Pollution*, 291, 118198.

Nwosu, S. N., Etiubon, R. U., & Ofem, I. B. (2022). Effect of the activity-based learning on basic science and technology students' non-cognitive skills in south-south Nigeria. *European Journal of Education and Pedagogy*, 3(5), 67–74.

Pandey, A., Brauer, M., Cropper, M. L., Balakrishnan, K., Mathur, P., Dey, S., ... & Dandona, L. (2021). Health and economic impact of air pollution in the states of India: The Global Burden of Disease Study 2019. *The Lancet Planetary Health*, 5(1), e25–e38.

Teksoz, G. T. (2011). Managing air pollution: How does education help. *The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources*, 1, 397–422.

Thrivikramji, K. P., Sajinkumar, K. S., & Rani, V. R. (2021). Climate change science in school curriculum: solution to ignorance of commons in developing countries. *Journal of Climate Change*, 7(4), 29–34.

Zimmermann, K., Young, L., & Woodard, K. (2018). Community-based undergraduate research: measurement of hazardous air pollutants with regard to environmental justice. In *Environmental Chemistry: Undergraduate and Graduate Classroom, Laboratory, and Local Community Learning Experiences* (pp. 21-47). American Chemical Society.

European Journal of Education and Pedagogy
www.ej-edu.org

Arindam Roy was born in India on Dec 6, 1990. He earned his doctorate from University of Calcutta where he studied climate change forcer over pristine environments over India, including Himalaya and Sundarban.

Arindam is presently working as a scientist at École Polytechnique Fédérale de Lausanne where he works on crowd sourcing of climate change information, citizen science and environmental policy. He also co-founded the first communication platform on climate Change in his native language Bengali.