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# THE ROLE OF CHEMISTRY IN ENVIRONMENTAL EDUCATION FOR SUSTAINABLE GROWTH AND DEVELOPMENT

**ADAGBOYI AMODU JOSEPH**
**DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY**
**IGNATIUS AJURU UNIVERSITY OF EDUCATION, RUMUOLUMENI, PORT HARCOURT, RIVERS STATE, NIGERIA**

**&**

**WOROKWU CHINDA**
**DEPARTMENT OF CHEMISTRY**
**FACULTY OF NATURAL AND APPLIED SCIENCES**
**IGNATIUS AJURU UNIVERSITY OF EDUCATION RUMUOLUMENI, PORT HARCOURT, RIVERS STATE, NIGERIA**

## ABSTRACT

*This study reviewed the role of Chemistry in Environmental Education for sustainable growth. Chemistry in Environmental Education plays a crucial role in understanding and solving contemporary environmental problems and by combining scientific knowledge with awareness and behavioral change strategies, this interdisciplinary approach equips individuals with the skills needed to protect and sustain the environment. The researcher reviewed the following sub-headings: Basic factors in Intersection of Chemistry and Environmental Education in Addressing Environmental Issues, Environmental Issues that could be addressed by Chemistry and Environmental Education, Chemistry Education and Climate Literacy, Key Aspects of the Intersection and Chemistry and Environmental Education. Based on the review, the researcher concludes that Integrating Chemistry with Environmental Education provides a powerful approach to addressing environmental issues. By implementing these recommendations, educational systems can equip students with the knowledge, skills, and attitudes needed to promote sustainable development and environmental protection. However, the researcher made the following suggestions: Curriculum planners should incorporate environmental topics such as pollution, waste management, climate change, Teachers should adopt laboratory experiments and field-based activities that demonstrate environmental chemistry concepts, Schools and institutions should promote the application of green chemistry principles to reduce hazardous substances and environmental pollution and students should be taught environmentally friendly chemical practices and Regular workshops and training programmes should be organized to equip teachers with the knowledge and skills needed to effectively integrate environmental education into chemistry teaching.*

**Keywords:** Chemistry, Environmental Education, Sustainable Development, Sustainable Growth



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## INTRODUCTION

Chemistry represents a vital area of study that equips learners with scientific knowledge and environmental awareness needed to address contemporary ecological challenges. Chemistry provides the foundational understanding of matter, chemical reactions, and processes, while environmental education focuses on developing attitudes, skills, and behaviors that promote environmental sustainability. Together, they foster a holistic approach to solving environmental problems (Danczak et al., 2020). At the core of this intersection is the application of chemical principles to understand environmental issues such as pollution, climate change, and resource depletion. For instance, concepts like Acid Rain, Greenhouse Effect, and Biogeochemical Cycles are rooted in chemistry but are essential topics in environmental education. Through these concepts, students learn how human activities influence the natural environment and how chemical processes can either harm or help ecological balance (Castro et al., 2019).

Furthermore, the integration promotes the development of environmentally responsible citizens. By understanding chemical pollutants and their effects, students become more conscious of issues such as water contamination, air pollution, and soil degradation. This knowledge encourages sustainable practices such as waste reduction, recycling, and the use of eco-friendly materials. For example, the study of Green Chemistry emphasizes designing chemical products and processes that minimize hazardous substances, thereby aligning scientific advancement with environmental protection (Chen & Liu, 2020).

In the educational context, combining chemistry with environmental education enhances teaching and learning by making scientific concepts more relevant and practical. Teachers can adopt experiential learning strategies such as laboratory experiments, fieldwork, and environmental monitoring activities. These approaches help students connect theoretical knowledge with real-world environmental challenges, thereby improving critical thinking and problem-solving skills (Chen & Liu, 2020).

Additionally, this intersection supports global sustainability efforts by aligning with educational goals that emphasize sustainable development. It prepares students for careers in environmental science, engineering, waste management, and related fields, contributing to national development and global environmental conservation (Clark et al., 2020). The intersection of chemistry and environmental education is essential for fostering scientific literacy and environmental stewardship. By integrating chemical knowledge with environmental awareness, education systems can empower learners to make informed decisions and actively participate in solving environmental problems, ultimately promoting a sustainable future.

The intersection of Chemistry and Environmental Education plays a crucial role in understanding and solving contemporary environmental problems. By combining scientific knowledge with awareness and behavioral change strategies, this interdisciplinary approach equips individuals with the skills needed to protect and sustain the environment (Miranda et al., 2018). Chemistry provides a scientific understanding of environmental problems. Many environmental issues such as air pollution, water contamination, soil degradation, and climate change are rooted in chemical processes. Through concepts like Chemical Reactions, students learn how pollutants are formed, transformed, and degraded in the environment. Environmental education complements this by helping learners understand the real-world implications of these chemical processes and encouraging responsible behavior.

The integration promotes awareness of pollution sources and control measures. Chemistry explains the composition and effects of pollutants such as carbon monoxide, sulfur dioxide, and heavy metals. With knowledge of Green Chemistry, students are introduced to environmentally friendly practices such as reducing waste, recycling materials, and using safer chemicals (Manfra, 2019). Environmental education reinforces these ideas by instilling values and attitudes that support environmental conservation and sustainability.

Intersection enhances problem-solving and critical thinking skills. Students are encouraged to analyze environmental challenges and propose scientifically sound solutions. For example, understanding Water Purification methods such as filtration, distillation, and chlorination enables learners to address water pollution issues in their communities. Environmental education ensures that such knowledge is applied ethically and sustainably (Junior & Fernandez, 2016).

Furthermore, the integration fosters sustainable lifestyle practices. Chemistry helps individuals understand the impact of everyday activities, such as the use of plastics, fossil fuels, and household chemicals, on the environment. Environmental education then guides individuals toward adopting eco-friendly habits, such as waste segregation, energy conservation, and sustainable consumption (Junior & Fernandez, 2016). The intersection supports policy formulation and community engagement. Chemically informed citizens are better positioned to participate in environmental decision-making and advocate for policies that reduce pollution and promote sustainability. Environmental education empowers communities to take collective action based on scientific evidence.

This interdisciplinary approach contributes to achieving global sustainability targets, particularly those related to environmental protection, health, and sustainable development. By integrating chemistry knowledge with environmental awareness, learners become equipped to tackle environmental issues effectively. The intersection of chemistry and environmental education is essential for addressing environmental challenges. While chemistry provides the scientific foundation for understanding environmental processes, environmental education ensures that this knowledge translates into responsible actions and sustainable solutions (Hong & Talib, 2018). Together, they promote informed decision-making, environmental stewardship, and a healthier planet.

**Basic factors in Intersection of Chemistry and Environmental Education in Addressing Environmental Issues**

The intersection of Chemistry and Environmental Education plays a vital role in understanding and addressing environmental problems. The basic factors that define this intersection include:

**1.** Scientific Knowledge and Chemical Literacy: Understanding chemical principles such as reactions, compounds, and cycles (e.g., carbon and nitrogen cycles) helps explain environmental issues like pollution and climate change. Environmental education promotes chemical literacy, enabling individuals to make informed decisions about environmental sustainability (Ewais & Troyer, 2019).

**2.** Awareness of Environmental Pollution: Chemistry helps identify the sources, composition, and effects of pollutants in air, water, and soil and environmental education raises awareness about issues such as acid rain, ozone depletion, and water contamination.

**3.** Sustainable Use of Resources: The concept of green chemistry encourages the design of products and processes that reduce hazardous substances and environmental education emphasizes conservation, recycling, and efficient use of natural resources.

4. Health and Safety Considerations: Chemistry explains the toxic effects of chemicals on humans and ecosystems and Environmental education promotes safe practices and behaviors to minimize exposure to harmful substances (De Oliveira, et al., 2016).

**5.** Problem-Solving and Critical Thinking Skills: Chemistry provides analytical tools for investigating environmental problems (e.g., laboratory analysis of pollutants). Environmental education develops the ability to evaluate environmental issues and propose practical solutions**.**

**Environmental Issues that could be addressed by Chemistry and Environmental Education**

Environmental issues are major global concerns that affect human health, ecosystems, and sustainable development. Both Chemistry and Environmental Education play critical roles in understanding, preventing, and solving these problems (Ramadhan et al., 2019). Below is a detailed discussion of key environmental issues that can be addressed through these disciplines:

1. Air Pollution: Air pollution arises from the release of harmful substances such as carbon monoxide, sulfur dioxide, nitrogen oxides, and particulate matter into the atmosphere. Air pollution is a major environmental and public health challenge, especially in rapidly urbanizing and industrial regions. Both Chemistry and Environmental Education play complementary roles in understanding, preventing, and controlling air pollution. Chemistry provides the scientific understanding and technological solutions needed to control air pollution, while Environmental Education promotes awareness, behavioral change, and community participation. Together, they offer a comprehensive approach to addressing air pollution and ensuring a healthier and more sustainable environment (Ramadhan et al., 2019).

a) Role of Chemistry: Chemistry helps identify the composition and sources of air pollutants, understand their reactions in the atmosphere (such as photochemical smog formation), and develop cleaner fuels and emission control technologies like catalytic converters.
b) Role of Environmental Education: It creates awareness about the causes and effects of air pollution and promotes environmentally friendly practices such as reducing vehicle use, adopting renewable energy, and proper waste burning practices.

2. Water Pollution: Water bodies are contaminated by industrial waste, agricultural runoff (fertilizers and pesticides), oil spills, and domestic sewage. Water pollution is a major environmental problem that affects human health, aquatic life, and sustainable development. Both Chemistry and Environmental Education play complementary roles in understanding, preventing, and controlling water pollution. Chemistry and Environmental Education play crucial roles in addressing water pollution by combining scientific knowledge with public awareness and responsible behavior. Their integration is essential for achieving sustainable environmental management and ensuring access to clean and safe water (Ramadhan et al., 2019).

a) Role of Chemistry: Chemistry is used to analyze water quality, detect contaminants, and develop purification methods such as filtration, chlorination, and desalination. It also helps in designing eco-friendly chemicals that reduce water contamination.
b) Role of Environmental Education: It encourages proper waste disposal, conservation of water resources, and public participation in protecting water bodies.

3. Soil Degradation and Pollution: Soil pollution results from excessive use of fertilizers, pesticides, industrial waste, and improper disposal of solid waste. Soil degradation and pollution are major environmental challenges, especially in regions affected by industrial activities, poor agricultural practices, and waste mismanagement. Integrating Chemistry and Environmental Education provides both scientific understanding and behavioral change needed to address these problems effectively. The combination of Chemistry and Environmental Education provides both scientific solutions and awareness needed to tackle soil degradation and pollution. While Chemistry offers tools for analysis, treatment, and restoration, Environmental Education promotes responsible behavior and sustainable practices. Together, they play a vital role in protecting soil resources and ensuring environmental sustainability (Santos et al., 2021).

a) Role of Chemistry: Chemistry helps in understanding soil composition, the effects of chemicals on soil fertility, and the development of organic fertilizers and bioremediation techniques to restore contaminated soils.
b) Role of Environmental Education: It educates farmers and communities on sustainable agricultural practices, such as crop rotation and reduced chemical usage.

4. Climate Change and Global Warming: This is caused by the accumulation of greenhouse gases such as carbon dioxide and methane in the atmosphere. Climate change and global warming are major environmental challenges driven largely by human activities such as fossil fuel combustion, deforestation, and industrial emissions. Both Chemistry and Environmental Education play crucial and complementary roles in understanding, mitigating, and adapting to these challenges. Addressing climate change and global warming requires both scientific innovation and public awareness. Chemistry provides the tools and technologies needed to reduce environmental impact, while Environmental Education equips individuals with the knowledge and attitudes necessary for sustainable living (Santos et al., 2021). Their combined efforts are essential for mitigating climate change and ensuring a healthier planet for future generations.

a) Role of Chemistry: Chemistry explains the greenhouse effect, monitors gas concentrations, and supports the development of alternative energy sources like solar, hydrogen, and biofuels.
b) Role of Environmental Education: It promotes climate-conscious behaviors such as energy conservation, tree planting, and reduced carbon footprint.

5. Waste Management Issues: Improper disposal of solid waste, plastics, and hazardous materials leads to environmental pollution. Waste management is a major environmental challenge, especially in rapidly growing urban and rural communities. The integration of Chemistry and Environmental Education provides practical and sustainable solutions for managing waste effectively by combining scientific knowledge with awareness and behavioral change. The combination of Chemistry and Environmental Education provides a comprehensive approach to addressing waste management issues. While chemistry offers scientific solutions for waste treatment and recycling, environmental education promotes

awareness and responsible behavior. Together, they contribute significantly to sustainable waste management, environmental protection, and improved public health (Santos & Royer, 2020).

a) Role of Chemistry: Chemistry contributes to waste recycling, development of biodegradable materials, and safe disposal methods for hazardous waste.
b) Role of Environmental Education: It encourages waste reduction strategies such as the 3Rs (Reduce, Reuse, Recycle) and proper sanitation practices.

**Chemistry Education and Climate Literacy**

Combining chemistry with environmental education fosters critical thinking on issues like climate change and pollution, transforming theoretical science into actionable sustainability solutions. Integrating green chemistry principles into curricula teaches students to design, reduce, or eliminate hazardous substances, empowering them to tackle real-world environmental challenges, improve scientific literacy, and drive innovation (Soeharto et al., 2019). Climate change remains one of the most pressing global challenges of the 21st century. Its impacts - ranging from rising temperatures and sea levels to extreme weather events and biodiversity loss - pose existential threats to ecosystems and human societies (IPCC, 2021). Developing countries such as Nigeria are particularly vulnerable due to their dependence on climate-sensitive sectors like agriculture, weak infrastructure, and limited adaptive capacity (Susilawati et al., 2019). Cross River State, located in south-south Nigeria, exemplifies this vulnerability while also serving as an ecological hotspot with vast tropical rainforests and coastal zones.

Education, and specifically science education, has been recognized globally as a critical tool for promoting sustainable development and climate resilience (UNESCO, 2017). Science equips learners with the knowledge, skills, and values needed to understand environmental issues and to act responsibly. Within science, chemistry holds particular promise for climate change education. As the science of matter and its transformations, chemistry provides insights into greenhouse gases, energy resources, pollution, and sustainable technologies. When taught in context, Chemistry can move beyond abstract formulas to demonstrate its relevance for addressing real-world climate challenges (Sutiani et al., 2021).

Yet, in Nigeria, the teaching of chemistry remains largely exam-oriented and disconnected from sustainability issues. Students often perceive the subject as abstract and difficult, with little application to their daily lives. Meanwhile, environmental degradation, deforestation, and climate risks continue to intensify in Cross River State. This disconnect underscores the need to reimagine chemistry education as a vehicle for climate literacy and sustainable development (Teksoz et al., 2020). Chemistry is uniquely positioned to contribute to climate literacy. Concepts such as combustion, photosynthesis, acid rain, and ozone depletion are directly linked to climate change. Chemistry also underpins renewable energy technologies, waste management, and sustainable materials, all of which are central to the SDGs.

Globally, research shows that contextualized and inquiry-based chemistry teaching improves both learning outcomes and environmental awareness. For example, integrating green chemistry principles into curricula encourages students to consider the environmental impact of chemical processes and to explore sustainable alternatives (Wajdi et al., 2022).

In Nigeria, however, chemistry education remains largely theoretical. Teachers often focus on preparing students for national examinations such as the West African Examinations Council (WAEC) assessments. Climate-related topics, when included, are treated superficially without linking them to local issues such as deforestation, flooding, or energy consumption. This contributes to low student motivation and poor academic performance in chemistry.

**Chemistry and Environmental Education**

Environmental sciences are emerging as a new interdisciplinary scientific "discipline" and even beyond, within a process of distancing from specialized, compartmentalized, and disciplinary, into multidimensional, cross-boundary endeavor in the science-technology-environment society (STES) interfaces. This poses new challenges with respect to the intrinsic science and technology organization and to the way the relevant knowledge and processes will be put into action, guided by the superordinate idea[l]s ofsocial responsibility and sustainability. Thus, the "battle cry" for sustainable development, worldwide, turns the latter into a major driving force in the rethinking and redesigning processes of STES-oriented science, technology and environmental education courses, programs, and assessment (Bilgin, 2019).

The essence of the current reform in science/chemical education, worldwide, is a paradigm shift from algorithmic/imparting knowledge-type teaching to higher-ordercognitive skills (HOCS) learning.In the context of Education in Environmental Chemistry (EEC), the ultimate target is the STES-literate graduate, capable of evaluative thinking, decision making, problem solving, and taking a responsible action accordingly (Barke et al., 2018).The issue is how to translate this goal into effective, implementable courses, teaching strategies and assessment methodologies, which are consonant with this goal of 'HOCS learning'. Accordingly, the main recommendations of an International Workshop[1] – "Environmental Chemistry Education in Europe: Setting the Agenda" – were:

1. Environmental literacy requires the integration of environmental sciences into core chemical courses as well as the development and implementation of HOCS-promoting teaching strategies and assessment methodologies in chemical education.
2. The development of students' HOCS for transfer, followed by assessment of 'HOCS performance'; is the task ahead for meaningful EEC.

These require a change in emphasis in the way environmental chemistry is taught, – from a narrowly-focused applied analytical/ecotoxicological, or environmental engineering chemistry, to an interdisciplinary/multidisciplinary approach (Bilgin, 2019). The essence of these challenges involves the dealing with uncontrolled complex global systems and the practicing of science, technology, research and education from social responsibility and open-ended culture perspectives. The main contemporary relevant paradigms shift have been identified and presented in the Table below (Bedin et al., 2020).

## Conclusion

Integrating Chemistry with Environmental Education provides a powerful approach to addressing environmental issues. By implementing these suggestions, educational systems can equip students with the knowledge, skills, and attitudes needed to promote sustainable development and environmental protection.

## Suggestions

Based on the review, the following recommendations are proposed:

**1.** Integrate Environmental Concepts into Chemistry Curriculum**:** Curriculum planners should incorporate environmental topics such as pollution, waste management, climate change, and green chemistry into chemistry courses and lessons should emphasize real-life environmental problems and their chemical basis to make learning more relevant and practical.

**2.** Promote Practical and Inquiry-Based Learning**:** Teachers should adopt laboratory experiments and field-based activities that demonstrate environmental chemistry concepts and inquiry-based learning should be encouraged to help students investigate environmental problems and propose solutions.

**3.** Encourage the Use of Green Chemistry Principles: Schools and institutions should promote the application of green chemistry principles to reduce hazardous substances and environmental pollution and students should be taught environmentally friendly chemical practices, including waste minimization and safe disposal of chemicals.

**4.** Strengthen Teacher Training and Capacity Building**:** Regular workshops and training programmes should be organized to equip teachers with the knowledge and skills needed to effectively integrate environmental education into chemistry teaching and teachers should be exposed to modern teaching strategies and environmental issues relevant to their local context.

**5.** Foster Environmental Awareness and Responsibility**:** Schools should organize seminars, campaigns, and environmental clubs to raise awareness about environmental challenges and students should be encouraged to adopt environmentally responsible behaviors such as recycling, conservation, and pollution prevention.

## REFERENCES

Barke, H. D., Hazari, A., & Yitbarek, S. (2018). *Misconceptions in chemistry: Addressing perceptions in chemical education*. Springer Berlin Heidelberg.

Bedin, F. C., Costa, F. R. S., Júnior, A. L., &Kiouranis, N. M. M. (2020). Methodological trends in chemistry teaching research in the journal *Química Nova na Escola* (1995–2017). *Revista Pesquisa Qualitativa, 8*(17), 256–277.

Bilgin, I. (2019). The effects of guided inquiry instruction incorporating a cooperative learning approach on university students' achievement of acid and bases concepts and attitude toward guided inquiry instruction. *Scientific Research and Essays, 4*(10), 132–144.

Castro, E. A., Paiva, F. M., & Silva, A. M. (2019). Chemistry learning: Challenges of basic education. *Revista Nova Paideia – Revista Interdisciplinarem Educação e Pesquisa, 1*(1), 73–88.

Chen, S. Y., & Liu, S. Y. (2020). Using augmented reality to experiment with elements in a chemistry course. *Computers in Human Behavior, 111*, 106.

Clark, J. S., Porath, S., Thiele, J., &Jobe, M. (2020). Action research. *New Prairie Press*.

Danczak, S. M., Thompson, C. D., & Overton, T. L. (2020). Development and validation of an instrument to measure undergraduate chemistry students' critical thinking skills. *Chemistry Education Research and Practice, 21*(1), 62–78.

De Oliveira, R., Cacuro, T. A., Fernandez, S., & Irazusta, S. P. (2016). Significant learning, environmental education and chemistry teaching: An experience held in a public school. *Revista Virtual de Química, 8*(3), 913–925.

Ewais, A., & Troyer, O. De. (2019). A usability and acceptance evaluation of the use of augmented reality for learning atoms and molecules reaction by primary school female students in Palestine. *Journal of Educational Computing Research, 57*(7), 1643–1670.

Hong, L. Y., & Talib, C. A. (2018). Scientific argumentation in chemistry education: Implications and suggestions. *Asian Social Science, 14*(11), 16–29.

IPCC, Intergovernmental Panel on Climate Chang. (2021). DOI: 10.59327/IPCC/AR6-9789291691647

Ismail, M. Z. (2021). The infusion of environmental education (EE) in chemistry teaching and students' awareness and attitudes towards environment in Malaysia. *Procedia – Social and Behavioral Sciences, 15*, 3404–3409.

Junior, L. P. C., & Fernandez, C. (2016). Environmental education in chemistry teacher training: A diagnostic study and social representations. *Química Nova, 39*(6), 748–756.

Manfra, M. M. (2019). Action research and systematic, intentional change in teaching practice. *Review of Research in Education, 43*(1), 163–196.

Miranda, J. L., Gomes, F., de Almeida, C. D., & Gerpe, R. (2018). The Anthropocene, environmental education, and teaching chemistry. *Revista Virtual de Química, 10*(6), 1990–2004.

Ramadhan, S., Sukma, E., & Indriyani, V. (2019). Environmental education and disaster mitigation through language learning. *IOP Conference Series: Earth and Environmental Science, 314*(1), 1–9.

Santos, A. T., Tamiasso-Martinhon, P., Sousa, C., & Rocha, A. S. (2021). Environmental education and chemistry instruction: Teaching report on pedagogical activities to address curriculum content. *Revista Virtual de Química, 13*(3), 595–607.

Soeharto, C. B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidkan, 8*(2), 247-266.

Susilawati, W. O., Widod, H., & Sumarno, .A. (2019). Strategy of teachers in supporting environmentally suitable development. *Journal of Education and Learning (EduLearn), 13*(2), 247-254.

Sutiani, A., Situmorang, M., & Silalahi, A. (2021). Implementation of an inquiry learning model with science literacy to improve student critical thinking skills. *International Journal of Instruction, 14*(2). 25-56.

Teksoz, G., Sahin, E., & Ertepinar, H. (2020). A new vision for chemistry education students: environmental education. *International Journal of Environmental Science Education, 5*(2), 131-149.

UNESCO (2017). Environmental and social sustainability frame work. https://unesdoc.unesco.org

Wajdi, M., Jamaluddin, A. B., Nurdiyanti, N., & Magfirah, N. (2022). The effectiveness of problem-based learning with environmental-based comic in enhancing students' environmental literacy. *International Journal of Evaluation and Research in Education, 11*(3), 1049-1057.