Integrated Learning of Chemical Safety, Security and Sustainable Development for Planet Protection

A Curriculum Developed by

National Association for Chemical Security

in association with

CRDF Global

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National Association for Chemical Security (NACS), India

The NACS was founded in 2021. The founder members are associated with Indo-US Workshops on Chemical Security of Dual-use Chemicals supported by PNNL and CSP, State Department of USA, in India since 2016. Workshops became regular and were hosted by CSIR Labs and Universities in India. Since the workshops have been an annual event, it was proposed to establish an association at the national level in India, so that the propagation of awareness on Chemical Security in India can be undertaken effectively and interactions can be held both with the Academic and Industrial practitioners. NACS is regularly interacting with other organisations with similar objectives.

Civilian Research and Development Foundation (CRDF) Global

CRDF Global is an independent non-profit organization that promotes safety, security, and sustainability through science and innovation. CRDF Global was authorized by the U.S. Congress in 1992 under the FREEDOM Support Act and established in 1995 by the National Science Foundation. This unique public-private partnership promotes international scientific and technical collaboration through grants, technical resources, and training. CRDF Global was originally named the U.S. Civilian Research and Development Foundation for the Independent States of the Former Soviet Union (CRDF).

Acknowledgments

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Executive Summary

Chemistry plays a pivotal role in the human and environmental well-being, beside driving the modern economy. Chemicals are beneficial with regard to their use in various applications ranging from domestic to advanced research. Hence, their prudent management with reference to their safety and security ensuring sustainable development becomes an imperative endeavor globally, to maintain human and environmental health.

NACS committed to support advancing the knowledge of the academia as well as chemical industry on the integrated learning of chemical safety, security by promoting best practices, facilitating information sharing and collaboration, and advocating for policies & regulations that enhance the culture of safety and security towards sustainable development. Further, NACS aims to bring together stakeholders from industry, government, academia, and civil society to identify and address the most pressing challenges for the prudent chemical management and promote effective risk management strategies.

To propagate awareness and to bring intimate interactions between the stakeholders, NACS projected to develop a curriculum to fulfil the needs of the stakeholders and ensemble the gaps in the understanding on how to protect the Earth systems from further damage, thereby protecting ourselves and the environment.

The purpose of the curriculum is to persuade the audience from different domains to be cognizant of the significance of safety, security and sustainability to safeguard humankind, environment as well as the planet in its entirety, and create “Alert System” for all the practitioners, including the policy makers and civil society.

The CRDF Global joined hands with NACS and provided subject matter experts through their curriculum development mentorship program for the review and feedback on the content of the curriculum. The curriculum is made with special emphasis on students and young researchers to bring awareness about the chemicals and their impacts with a goal of thriving towards the sustainable development and betterment of the Earth Systems.

Integrated Learning of Chemical Safety, Security and Sustainable Development for Planet Protection

Genesis of the Curriculum

Objective:

To bring awareness and propagate the concepts of Chemical Safety, Chemical Security, and Ethics in Chemistry for Sustainable Development towards Planet Protection.

Purpose of awareness:

Chemicals are hazardous in nature and effect the human and environmental health, in turn the planet. So, awareness is essential for the planet protection.

Stakeholders:

Everyone who is associated with biological, chemical, environmental, engineering, and forensic sciences, Economists, policy makers and civil society.

Audience:

Students from colleges and universities, researchers, academicians, R&D organizations, industry, and the civil society.

Design of the Curriculum

The foundation of the present integrated curriculum is:

- The framework by the United Nations Security Council Resolution (UNSCR) 1540 (2004), and
- The United Nations Sustainable Development Goals (UN SDGs) (2015).

In resolution 1540 (2004), the Security Council decided that all States shall refrain from providing any form of support to non-State actors that attempt to develop, acquire, manufacture, possess, transport, transfer or use nuclear, chemical, or biological weapons and their means of delivery.

In 2015, the UN adopted 17 universal Sustainable Development Goals (SDGs) with the objective to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.

The Curriculum on "Integrated Learning of Chemical Safety, Security and Sustainable Development for Planet Protection" composed of 7 modules.

Modules of the Curriculum

- Chemical Safety, Security and Ethics in Chemistry
- Best Practices of Chemical Safety and Security at Workplace
- Chemical Safety and Security – Risk Assessment and Management
- Chemical Safety and Security – Emergency Preparedness and Emergency Response
- Chemical Management Lifecycle and its Benefits
- Regulations, International Treaties and Conventions
- Sustainable Chemistry for Planet Protection

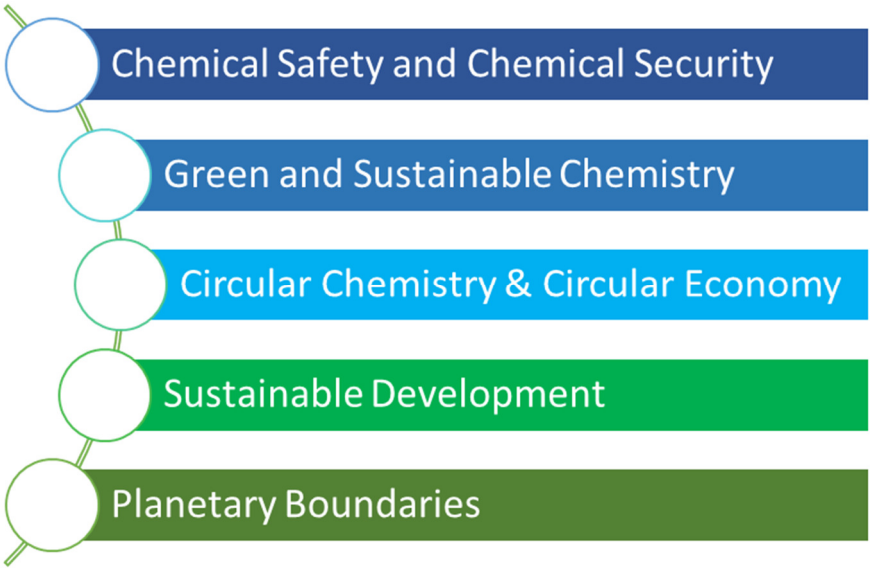
Main Ideas of the Curriculum

1. Chemistry plays an important role in the modern world, and it is the responsibility of the chemists to ensure that chemistry is being used in a safe and secure manner.
2. Safety and security are vital in the workplace. There are protocols and procedures to be followed to ensure and develop a culture of safety and security.
3. There are specific ways in which risks and hazards involved with handling dangerous chemicals can be appropriately assessed, characterized, and managed.
4. Places that deal with chemistry should always be prepared for emergencies and have protocols in place to respond in case of an emergency.
5. Managing chemicals is not just their procurement and disposal. The management of chemicals requires considerations to be made throughout the entire lifecycle of each chemical.
6. Many regulations, international treaties, and conventions for chemicals must be understood and followed to both improve chemical safety and security culture and to ensure that facilities are not in violation of any laws.
7. Sustainability considerations must be integrated into the practice of chemistry, along with safety and security for the goal of protection of the planet.

Overall Learning Outcomes of the Curriculum

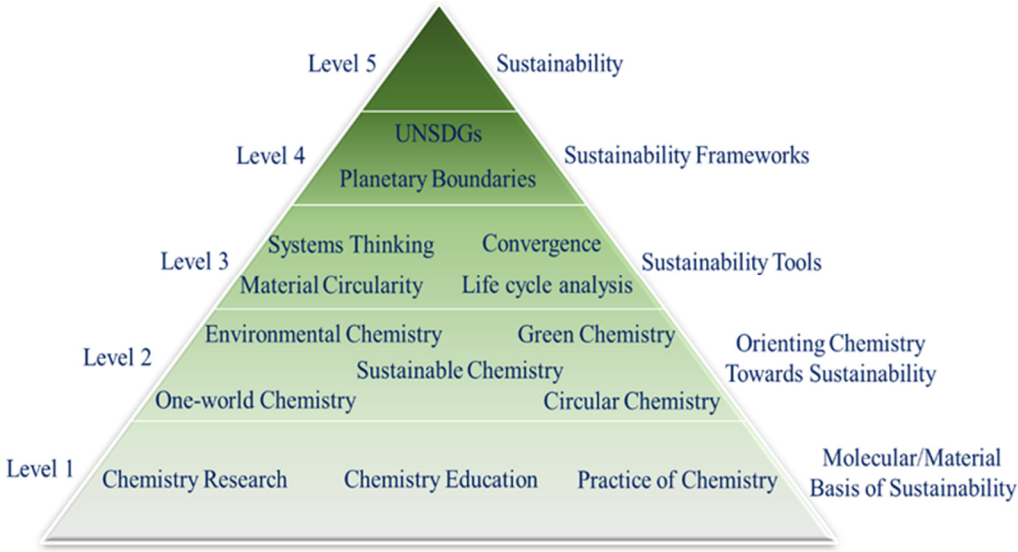
- Explain the vital role that chemistry plays in everyday living, and how it can be used for both beneficial and harmful purposes.
- Explain the importance of ethics in chemistry.
- Understand the differences between chemical safety and security.
- Describe best practices in chemical safety and security.
- Identify, characterize, and address chemical safety and security issues that arise when working with chemicals.
- Perform chemical risk assessments that consider all relevant health and environmental hazards.
- Prepare for and respond to chemical emergencies.
- Develop knowledge and skills for creating a culture of chemical safety and security in industrial and/or academic facilities.
- Create a plan for the management of chemicals that considers all aspects of their lifecycles.
- Summarize and follow the regulations, international treaties, and conventions in place to manage the use of chemicals on the international, national, and institutional levels.
- Integrate concepts of sustainability into the practice of chemistry.

Key Elements of the Curriculum



Framing Chemistry in the Sustainability Landscape

Systems approach to understand how chemistry is embedded in and can contribute at multiple levels toward the emergence of sustainability of the Earth system.



(ACS Sustainable Chem. Eng. 2022, 10, 39, 12933)

Level 1: Molecular/Material basis of Sustainability

As the science of transformation of matter, chemistry provides the material basis platform for working toward sustainability through the combined efforts of chemistry education, research, and practice.

Level 2: Orienting Chemistry Towards Sustainability

Orienting these efforts involved the development and incorporation of several complementary guiding principles and approaches e.g., Environmental Chemistry, 12 Principles of Green Chemistry, Sustainable Chemistry, One-world Chemistry, and Circular Chemistry incorporating Circular Economy concepts.

Level 3: Sustainability Tools

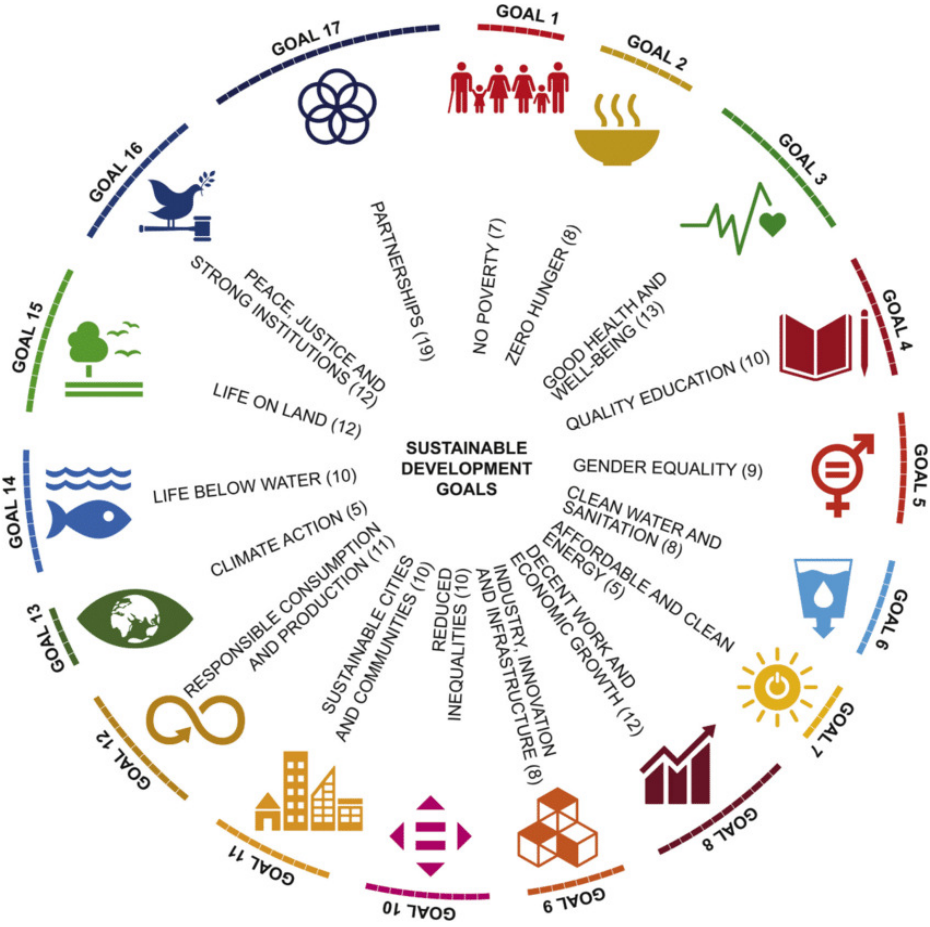
Approaching sustainability requires integrated consideration of factors related to the impacts of human activity on systems that include the economy, society, and the environment. Several tools such as Systems Thinking, Material Circularity, Convergence and Life Cycle Analysis are available to assist in understanding the interactions between chemistry and these Earth and societal systems and in operationalizing the sustainability principles.

Level 4: Sustainability Frameworks

Important frameworks have emerged that provide guidance on the pathways to sustainability. The UN Sustainable Development Goals (SDGs); and the Planetary Boundaries framework which provides assessments of the extent to which human activity, including transformations of matter, is within or exceeding safe operating limits, with many of the control variables for the nine boundaries being chemical entities.

UN Sustainable Development Goals (SDGs)

The UN SDGs provide a time-bound and specific set of goals and targets, mostly to be achieved by 2030 as milestones on the pathway to sustainable development. The 17 SDGs are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.



Important SDGs relevant for Green & Sustainable Chemistry are:

- SDG 2 [Agriculture & Food – Sustainable food production]
- SDG 3 [Health & Well-being – Safe medicines and vaccines]
- SDG 4 [Quality Education]
- SDG 6 [Clean Water & Sanitation]
- SDG 7 [Clean Energy research and technologies]
- SDG 9 [Reduce raw material use and waste generation]
- SDG 12 [Manufacturing, use of natural resources]
- SDG 13 [Climate Action], and
- SDG 16 [Chemistry for peaceful purposes]

Planetary Boundaries

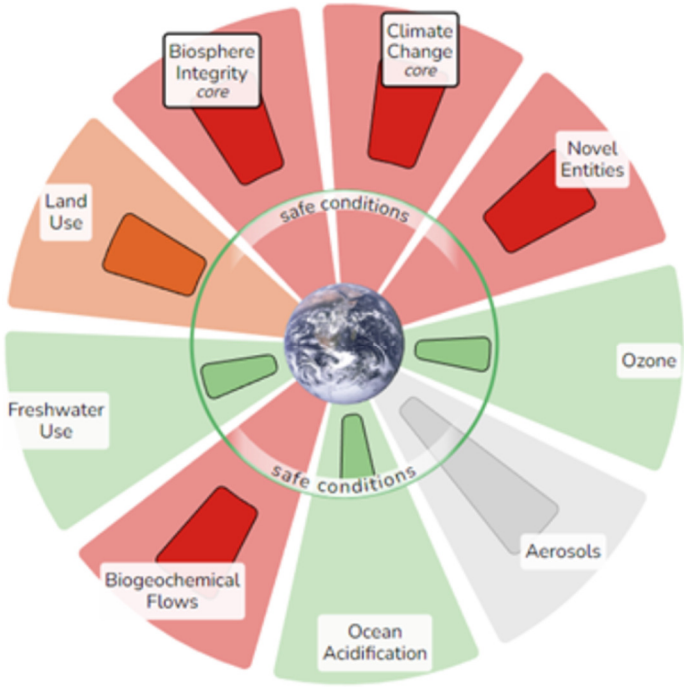
The Planetary Boundaries framework, first published by the Stockholm Resilience Centre in 2009, is a great example of using systems thinking to understand sustainability issues.

The framework describes nine Earth system processes that collectively quantitatively assess the state of the Earth system with respect to human development.

The changes over time to each Earth system process are monitored by one or more control variables that are thought to be representative of the processes of change in that Earth system process.

The framework also illustrates the interconnectedness of the Earth system, making it a valuable demonstration of and a learning resource for systems thinking. The changes over time of these control variables demonstrate how chemistry both describes and regulates important features of planetary health.

(https://sastice.com/kcvs-planetary-boundaries/)



The nine human-perturbed Earth system processes are:

- Biosphere integrity
- Climate change
- Novel entities
- Aerosols
- Stratospheric ozone
- Ocean acidification
- Freshwater use
- Land use
- Biogeochemical flows

The latest update (Azote for Stockholm Resilience Centre, based on analysis in Richardson et al, 2023) not only quantified all boundaries, but it also concludes that six of the nine boundaries have been transgressed.

The understanding of what is harmful or hazardous from a planetary perspective has thus expanded to include effects beyond toxicity as the current major focus of chemicals management.

Subject Matter Experts Reviews

Review:

The flow of matter and energy is at the heart of almost every aspect of modern society. And the profession of chemistry, through analysing, synthesizing, and transforming substances, is a central science in contributing to the well-being of both people and the planet – at present and into the future.

But the powerful tools of chemistry are not always used for beneficial purposes. Often, the unintended consequences of beneficial uses of chemistry are not anticipated, and sometimes chemistry is intentionally used to create harm. It is therefore of utmost importance to ensure that chemistry programs and the chemistry workplace pay careful attention to chemical safety, chemical security, and the role chemistry plays in the emergence of sustainability.

The National Association for Chemical Security, India, should be applauded for devoting such a substantial effort to creating educational materials for use in both university chemistry programs and chemical industry with the support of CRDF Global. These curriculum resources introduce, with examples, the necessity of integrating all three of these dimensions into the study and practice of chemistry. They provide a great starting point for universities and others to build on and adapt what is here to make sure that the next generation of chemists, and citizens who use chemistry, are aware of the importance of chemistry in our lives and the need to have a strong culture of responsible practice that emphasizes safety, security, and sustainability.

- Prof. Peter G. Mahaffy, The King's University, Canada

Review:

The curriculum developed by the NACS, India, is specifically designed for academic institutions and/or chemical users. The content of the curriculum aims to promote the culture of responsible chemical management in institutions to ensure the safety, security, and sustainability of our chemical activities.

The curriculum offers rules, best practices and tactics for integrated chemical management making it invaluable tool for academics, staff, students, researchers engaged in chemical-based activities.

Furthermore, the curriculum emphasizes the importance of encouraging sustainability in chemical management. It explores ways to minimize the production of chemical wastes, implement green chemistry techniques and reduce our environmental impact. Adopting sustainable practices that can help in creating a healthier planet serve as a model for future generations. For integrated chemical management initiatives to be successful, faculty, staff, students, and researchers must all play a part, according to institutional leadership.

Consider this curriculum as a manual to promote sustainability, chemical safety and security in our education setting. By implementing the ideas and methods described here into practices we can safeguard our neighbourhood, encourage responsible chemical management, and works towards more sustainable future.

- Prof. Ahmed Fahmy A. Youssef, Cairo University, Egypt

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