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Sakunthala. Y. Ekanayake *is a Professor in the Department of Education in the Faculty of Arts at the University of Peradeniya, Sri Lanka. She received her Ph.D. from the Graduate School of Education, the University of Bristol, the UK in 2011. She is also the Head of the Department of Information Technology of the Faculty of Arts, University of Peradeniya. She is the vice president of the Indian Ocean Comparative Education Society and a member of the editorial team of the Global Comparative Education, Journal of the WCCES. She has published more than 40 papers in journals and conferences, authored three books, and also co-authored six books. She was conferred with a commonwealth fellowship at the University of Bristol in 2016. Her current research interest focuses on the use of mobile phones for teaching and learning, Pedagogy, E-Learning, Science Education, and Comparative Education.*

Themed Collection

Sustainable Development Goals and the Role of Chemists and Chemical Sciences

N. M. S. Hettigedara

President, Institute of Chemistry Ceylon

Background

One of the most important and remarkable events in the 70-year history of the United Nations (UN) was the declaration of 17 Sustainable Development Goals (SDGs) on 25 September 2015. Through this declaration, 193 member states of the United Nations which includes Sri Lanka also, agreed on a collective global mission to transform the planet to achieve a sustainable future by with a target year of 2030. Progress towards the SDGs will be measured against 169 specific indicators. While the Millennium Development Goals declared by the UN in 2000 focused on specific problems of the world's poor and shaped the development aid policies of the richest countries, the new SDGs envisage a global vision of development for all, based on the principle of sustainability. The responsibility is shared by all the countries. At its heart are the 17 Sustainable Development Goals (SDGs), 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 induce economic growth while tackling climate change and working to preserve our oceans and forests.

Generally, awareness of the SDGs, and their central importance is inadequate among the majority of practicing chemists or their professional bodies. The probable reason is that, the chemists too often busy themselves with short-term problems and research interests and do not see the broad picture. The International Organization for Chemical Sciences in Development (IOCD) with a deep concern for the future of both the planet and the chemical sciences, have issued a call to all their chemists to adopt the SDGs, as done by their governments and use this platform to reposition chemistry in a broader context and to ensure that chemistry plays its specific role as the central science.

Importance of Chemistry in achieving sustainable development goals

The knowledge and products contributed by chemistry such as providing sources of energy; a host of materials including polymers, plastics, semiconductors and solid-state display devices, agents for crop protection and plant growth, pharmaceuticals and

many more have been a major factor in the advances in human wealth, health and well-being over the past two centuries and justify chemistry's claim to be the 'quality of-life' science than any other discipline. It is the source of innovative new products and processes, including smart materials for better lifestyles, catalytic processes for light harvesting towards hydrogen production and carbon dioxide fixation, new vaccines and drugs for currently incurable diseases, and sensors for disease diagnosis *etc*.

We are also aware that, agriculture, irrigation/ drinking water, food, medicines, textiles, surgical equipment, soap, toiletries, detergents, washing powder, building materials and equipment used in detecting diseases are all based on chemicals and chemistry itself is the Central Science. It plays an important role in day-to-day life as well as in high technology products crossing all the sectors. If we just look into our food and nutrition aspects, we need to develop agriculture to produce food and to achieve this we should provide organic/chemical fertilizer. Especially, we should provide NPK and micronutrients in the form of chemicals or organic material. The plants absorb what they need. If that is so, we should produce standard fertilizer and ensure the quality. Similarly, we should introduce environmentally friendly weedicides. Inadequate human resources and advanced technology, tractors, machines, suitable seed and fertilizer etc are the constraints affecting agriculture.

By the year 2050, food should be provided to a population of an estimated 9.4 billion. Therefore, action should be taken not only for increasing food production but prevention of wastage of foods to 100% and ensure food security. Chemicals that are not harmful will be required for this purpose. With a view to maintain the quality standards, the services of professional chemists are required.

We know that there is no good attitude towards CHEMICALS in our country as well as in the world. Chemistry must also accept responsibility as one of the sources of many processes and products that have inadvertently contributed to a range of emerging global problems. The changes to earth's air, land and sea environment due to human activity have accelerated in the past 200 years resulting in global warming, damage to the protective ozone layer and depletion of natural resources. Increasing energy consumption, industrial activity, population growth and urbanization add pressure to the planetary system and it is clear that major changes are now needed if multiple crises (relating to food, water, climate and energy) are to be avoided and humanity is to move to a path of sustainability.

We use fossil fuel but they are running out and causing global climate change. Precious elements which are in short supply, in a linear use-and-discard economy, causes resource depletion. The only way out is using renewable resources. We must use them in a circular economy in which everything is used for longer, reused, repaired and eventually fully recycled. Then only the generations could enjoy the diverse and beautiful world which will be good to inhabit. This important transformation, which is now urgent, will have new chemistry and chemical engineering processes at the forefront which must be implemented quickly. Application of circular economy concept, could be started even from the home set up. Achieving almost all of this requires major inputs from chemists and chemical engineers. We should do whatever possible to contribute towards achieving these goals.

It is very convenient to combine **green chemistry** and 12 principles of sustainable chemistry and green food analysis principles to achieve 17 **Sustainable Development Goals**. Similarly, in the chemical analysis of food it could be done according the **concept of green food analysis**.

17 Sustainable Development Goals (SDGs)

1. No Poverty: End poverty in all its forms everywhere.
2. Zero Hunger: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Good Health and well-being: Ensure healthy lives and promote wellbeing for all at all ages.
4. Quality education: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. Gender equality: Achieve gender equality and empower all women and girls.
6. Clean water and sanitation: Ensure availability and sustainable management of water and sanitation

for all.

7. Affordable and Clean energy: Ensure access to affordable, reliable sustainable and modern energy for all.
8. Decent work and economic growth: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
9. Industry, innovation and infrastructure: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
10. Reduced inequalities: Reduce inequality within and among countries.
11. Sustainable cities and communities: Make cities and human settlements inclusive, safe, resilient and sustainable.
12. Responsible consumption and production.: Ensure sustainable consumption and production patterns.
13. Climate action: Take urgent action to combat climatic change and its impacts.
14. Life below water: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
15. Life on land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
16. Peace, justice and Strong Institutions: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and effective, accountable and inclusive institutions at all levels.
17. Partnership for the Goals: Strengthen the means of implementation and revitalize the Global Partnership for sustainable development

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges faced by the people, including those related to poverty, inequality, climate change, environmental degradation, peace and justice. The 17 Goals are all interconnected, and in order to leave no one behind, it is important that we achieve them all by 2030. (https://www.un.org/sustainabledevelopment/sustainable-development-goals;).

Role of Chemistry in achieving SDGs

The importance and relationship of Chemistry as a Central Science and SDGs are reviewed below based on a literature review carried by us. The relevant SDG's are taken together to facilitate discussion.

Zero Hunger: End hunger, achieve food security and improved nutrition and promote sustainable agriculture (SDG2)

It has been observed that Agrochemicals (fertilizers, weed-killers and pesticides) can enhance crop production by up to 50 %. Since we produce approximately the amount of food needed to feed the world's population, although some people have too little and others too much, it follows that around 2–3 billion extra people are able to be fed because of the positive effect of agrochemicals. Agrochemicals must be highly active (only small amounts used), highly specific (only having the required effect and only in the desired place) and non-toxic (if they enter the food chain, they must be benign). Many chemicals with all these properties are available, but some are threatened with a ban without a full risk–benefit analysis being carried out and on the assumption that they are affecting the health or environment. The recent attempts to ban the use of glyphosate in some countries including Sri Lanka falls into this category.

Promotion of preserving agricultural products for the use during lean periods, food technology, chemical technology and traditional methods to prevent post harvest losses and longer storage, proper supply chain management, reduction of waste during transport, getting maximum price by maintaining good quality are important in achieving this goal. Use of traditional foods such as kos, del, manihot etc as substitutes for rice, should be promoted. Use of products such as coconut water and coconut scrapings after obtaining its milk should be promoted.

Good Health and welfare: Ensure healthy lives and promote wellbeing for all at all ages (SDG3)

Tackling antibiotic-resistant organisms, ameliorating (make something better) diseases of ageing (dementia, Parkinson's disease, many cancers) and lifestyle diseases (obesity, diabetes, drug and alcohol abuse) will require many new kinds of medicines. These will be made by chemists and commercialized by chemical engineers. Economically prepared balanced diets will provide essential macronutrients, carbohydrates and fats along with vitamins, minerals and water.

Polyphenols, flavones, anti-oxidants are naturally available chemicals. Consumption of them in correct portions at correct age will prevent NCDs while protecting health. During certain seasons there will be food shortage and therefore, chemists should identify proper chemicals and technology to preserve the foods for future (*e.g.* dehydration of food) the quality which will be same as their natural products. When foods such as "Yahaposha" are provided, people will not be satisfied to take them as a main meal. When fresh fruits are not available dehydrated fruits can be consumed. Availability of adequate food of good quality will certainly lead to a healthy population. This will enable to build up immunity of the population. Necessary action should be taken for awareness building. At the same time measures for consumer protection can play an important role.

Quality Education: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (SDG 4)

Chemical education throughout the world is generally of very high quality at school and secondary and tertiary levels. The skills of a chemistry graduate are in high demand not only for employment in chemistry but in many sectors in which analytical thinking is required. However, one area which accords little attention in chemical education is ethics. The European Chemical Society (EuChemS), through Jan Mehlich, has developed the online course Good chemistry—methodological, ethical, and social dimensions consisting videos with quizzes, case studies, assignments and assessments. Such a course should be a prerequisite for working in any chemical or other scientific environment. It is also important to start capacity development even during the childhood and up to adults level. Application of Green chemistry, synthesis as well as technology and analysis are important in achieving the SDGs. Communication materials should be developed and workshops, seminars, exhibitions and teacher education should be conducted.

SDG 5. Gender equality: Achieve gender equality and empower all women and girls (SDG5)

Surveys in many countries show that although almost equal numbers of men and women take chemistry undergraduate programmes, only about 30% of the workforce in the chemical industry are women. In academia, the situation is worse with only 9%of chemistry professors being women. There is even poorer involvement of women in chemical engineering. We are losing a huge talent pool and therefore, we must change the culture, the working hours, childcare and the handling of maternity leave so as to make our wonderful subject attractive and accessible to all.

Committee on Women Chemists has been established by the American Chemical Society (ACS) in 1927 as the Women's Service Committee to encourage women chemists to take an active interest in Society activities. The Committee serves as a forum for women in chemistry and related professions; develop recommendations regarding issues of interest to women chemists; provide a means of increasing and improving participation of women in the chemical sciences and the Society; promote the recognition of women chemists; and inform the Council and other appropriate Society bodies of the Committee's activities. The Institute of Chemistry Ceylon as the professional body of Chemists in Sri Lanka has established a Women Chemists Committee.

Clean water and sanitation: Ensure availability and sustainable management of water and sanitation for all (SDG6)

It has been estimated that about 2,000 babies and children under the age of 5 die each day because they do not have access to clean water. In many countries, having ready access to cheap chlorine allows for safe

purification of water. The dual use of chemicals is a serious problem so the development of new water purification processes that can be carried out in remote places is essential. Sophisticated processes such as using photoexcitation of TiO_2 with sunlight to generate hydroxide radicals that destroy pollutants will have their place, but many other possibilities urgently await attention of chemists. On the other hand, the process of reusing water has to be started from household level. Using and reusing of water in industry and labs without wasting it is of utmost importance.

Affordable and Clean Energy and Climate Action (SDG 7& 13)

The provision of clean energy and climate action are closely associated with each other. Sun light is the only source of energy coming into the earth which must be harnessed more effectively than we do at present.

Biomass, wind, wave, hydro are all methods of converting solar energy to electricity, and more recently we have introduced photovoltaics. These must all be expanded and the conversion made more efficient by the chemists and chemical engineers who should lead the process.

Hydrogen could be an ideal fuel. It burns only to make water and it can be produced from water by electrolysis or perhaps direct photolysis using sunlight. Direct photolysis has been rather inefficient, but a system based on earth-abundant elements has achieved 4.7% conversion efficiency but more work is required before its commercialization. Handling and storing of hydrogen would be another challenge, whether it be stored through physical adsorption or reversible chemical complexation. Therefore, further progress is required in this area. "Town gas" had been in use in stoves for heating and cooking which is still used in some countries. Town gas contains 50% hydrogen and it was stored in gasometers and distributed through pipes. Despite its explosive nature, its distribution and safe use is well known.

Governments should promote setting up of smaller solar panels at household level as well as in other small establishments. Production of bio gas using wastes from agriculture and animal husbandry and use of solar power will save much needed foreign exchange. Some people in urban areas as well as in rural areas started using burned coconut shells in specially prepared hearths for cooking of their food during the shortage of fuel and LP gas in Sri Lanka recently.

To ensure that global warming can be controlled, it is probably not sufficient just to stop using fossil fuels, especially with the disparity in per capita energy use. It is necessary to extract CO_2 from the air and use or store it safely. This will be a major undertaking with CO_2 present at only 400 ppm; too much for the climate but very dilute for extraction. Although the overall atmospheric concentration is low, the amount of CO_2 that will have to be removed is huge. Still, we do not really know about any methods that should be adopted. Therefore, more creative thinking is now necessary. However, clearing forests in large scale as seen in many countries without replanting schemes and devastation of large extents of forest areas due to fire will quickly make the problem even more urgent.

Methane is emitted from variety of anthropogenic and natural resources. It is more efficient at trapping heat than other gases. Methane has more than 80 times the warming power of CO_2 over the first 20 years after it reaches the atmosphere while it is responsible for around 30% of the current rise in global temperature. Australia has recently signed a global pledge to cut methane emissions by 30% by 2030 thus becoming the 122^{th} country that had already adopted the non binding pledge. Farming and food production should be more environmentally friendly. Animals should be fed with more nutritious feed.

The chemical sciences help to understand, mitigate, and adapt to climate change. A detailed understanding of pollutants and their chemistry in important in interpreting health effects, regulating emissions and developing pollution reducing technologies. Chemists can also be part of the effort to understand and address new problems such as potential effects of different chemicals that the people are exposed to.

Industrial Innovation and Infrastructure, Sustainable Cities and Communities and Responsible Consumption and Production (SDG 9, 11 and 12)

Our attitude towards the way we make and use consumer items need to change. At present we make

an item for consumer use and build in redundancy so that when one part breaks, for example the door of an oven, we think of buying a new machine and the old one is discarded or kept on the road side for the garbage truck to remove it. This is an example of the linear economy which consumes raw materials sometimes at an unsustainable rate and also it produces considerable amounts of waste.

Therefore, we will have to move very quickly towards the circular economy where we manufacture objects to last, we use them for longer, we replace or repair parts that breakdown, we reuse them in whole or in part. When the object has come to the end of its useful life, we recycle as many of the elements in it as possible thus the waste becomes a raw material and we move away from both element depletion and waste accumulation.

In the present economy some manufacturers are reluctant to produce long lasting equipment and machinery with a view to reducing the cost and meet the requirement of the ordinary people who have lesser purchasing power. Such items with a short span of life will be disposed without repairing and reusing. Certain equipment cannot be repaired due to high cost of spare parts. Manufacturers should be encouraged to produce durable items and contribute to circular economy.

The European Chemical Society (EuChemS) released a new version of the periodic table as a part of celebrating the International Year of Periodic Table (2019) which highlights element availability and vulnerability towards dispersion. It also highlights which elements can come from conflict minerals and 31 elements that are in smartphones. It is important to note that all the elements that can come from conflict minerals are in smartphones and six of the elements in smartphones are expected to be depleted within 100 years if we carry on as we are. Smartphones are the archetypal use and-discard technology, often being replaced every 2–3 years. It has been estimated that about 10 million smartphones are exchanged in Europe every month. Many of these phones are not traded in but kept in drawers or cupboards. The elements in these phones are beyond reach for recycling. In a recent survey the Royal Society of Chemistry (RSC) found that 51% of all homes in the UK have at least one unused piece of electronic equipment and 42% have more than five. For those phones that are handed in, there are not enough ethical recycling facilities available. Sri Lanka, with a population of 21.6 million use 38.9 million phones according to statistics.

Life below water: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. (SDG 14) and Life on land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. (SDG 15)

Fisheries development is an important source of food production and hence action should be taken to protect our territorial sea water from exploitation by other countries. Every measure should be taken for sustainable fish production which needs a common approach by the countries. Marine environment pollution should be minimized. Bilateral agreements, awareness creation and implementation of rules and regulations play a greater role. Life forms which are diverse depend on a clean and vibrant ecosystem. Our waste cannot be continued to dump into the land and the sea.

We grow plants, which we eat either directly or through animals that have eaten them. All the nutrients then end up in human bodies and mostly in human excrement which, after treatment, is flushed into water areas and ultimately into the sea. We then have to replenish the land using fertilizers—another example of the linear economy. There are considerable opportunities in recovering elements such as phosphorus from human excrement.

All around us we use plastics which is a very popular material due to their unique properties. Polyethylene gas pipes and Perspex windows are just two examples. As people abuse the use of plastics through thoughtless, reckless linear economy the land and the seas become heavily polluted. Single-use plastics can be stopped, but there is a need to have good ways of dealing with end-of-use plastics. All plastic objects should be reusable and recyclable.

Some plastics are biodegradable, but they can do considerable damage to the environment during the period of biodegradation. Hence, they should not be

allowed into the wider biosphere. Some of the plastics used can be replaced by paper, wood, plant material, clothe and other bioderived materials, but still there is a considerable opportunity to design new polymers for specific tasks.

Partnership for the Goals: Strengthen the means of implementation and revitalize the Global Partnership for sustainable development (SDG 17)

Chemists and chemical engineers should play a key role for future sustainable world, but they must work with experts from other disciplines such as agriculture as well as sociology, psychology and politics and all the other branches of science and engineering. They should not limit risk assessment of everything that they plan to do in the lab but it is necessary to take a much wider view about the long term consequences of what they propose. They should discuss with other partners on their plans and get necessary advice on minimizing possible risks.

No Poverty, Decent work and economic growth, Reduced inequalities, Peace, justice and Strong Institutions: (SDG 1, 8,10 and 16)

The objectives of these goals are to end poverty in all its forms everywhere, promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all reduce inequality within and among countries and promote peaceful and inclusive societies for sustainable development, provide access to justice for all and effective, accountable and inclusive institutions at all levels.

The challenges mentioned above and their successful completion will provide considerable benefits to those who have been involved in the discoveries and their implementation will help in achieving the four goals of "no poverty", "decent work and economic growth", "reduced inequalities" and "peace and justice. The chemists and chemical engineers will play an indirect but important role in achieving these goals.

Establishment of a National Secretariat for the Professional Practice of Chemistry (NSPPC)

The Institute has taken steps to establish a National Secretariat for the Professional Practice of Chemistry (NSPPC) since June this year (2022), which covers the performance of services related to public interest, public safety, and legal or regulatory matters. The National Secretariat will be responsible for identifying special fields of importance for the practice of Chemistry, maintaining a Register of Chemists for each field, continuing professional development, implementation of the Code of Ethics for Chemists and overall administration. The National Secretariat will undertake programs for the implementation of Sustainable Development Goals (SDGs) and the International Year of Basic Science for Sustainable Development (IYBSSD 2022) in view of their relevance to the objectives of Institute of Chemistry Ceylon. The activities lined up for the Year are as follows:

1. Communication with UNESCO, IUPAC, OPCW and other relevant agencies regarding raising of funds.
2. Virtual official inauguration of IYBSSD 2022: Professional organizations, Institutes of Biology, Physics, Mathematics will be contacted for participation
3. Virtual IYBSSD 2022 exhibition and trade fair.
4. Seminars and workshops
   a. CPD : Professional Chemists
   b. SDG: 1. Individual, 2. Industry, 3. Policy makers, 4. Universities and schools
5. News releases and publication of articles and supplements
6. Publication of IYBSSD 2022 special issue: 'Chemistry in Sri Lanka'
7. Public Awareness programs / chemical magic shows/Inter university debates/cultural programs
8. Webinars: Seminars/Discussions (University/ Industry/IChemC) Identify Webinar topics.
9. Chemistry day in schools
10. Establishment of mobile laboratory units
11. Interschool chemistry quiz programs
12. 'Education for All'- BSc, Diploma in Laboratory Technology course and Chemistry Graduateship program etc: Strengthen the evaluation of quality of programs to achieve SDGs

13. Feeding of information to the Website /U tube/ Facebook
14. Publication of an IYBSSDC 2011 souvenir by the end of the year.
15. Launching of programs to achieve 12 Sustainable Development goals of Chemistry

Institutes and others to be involved

Based on the experience gained by the Institute of Chemistry Ceylon in the capacity of National Adhering Organization for International Year of Chemistry (IYC 2011), action has been already initiated to involve institutions such as UN, UNESCO, IUPAC, IUPAP, RSC, all the government ministries, relevant government statutory bodies, government academic institutes, chemists, scientists, academics, university students, school children, and private sector industries in the programmes that have been planned by the Institute. The industries will include the following.

1. Production of Chemicals (Raw)
2. Food Industry
3. Packaging Industry
4. Pharmaceuticals/Medical drugs Industry
5. Medical Diagnostics products industry
6. Cosmetic Industry
7. Plastics Industry
8. Rubber Industry
9. Cement & cement products Industry
10. Agrochemicals Industry
11. Petroleum industry
12. Paint Industry
13. Paints Industry
14. Textiles & Apparels industry
15. Herbal products Industry
16. Ayurvedic products
17. Medical devises Industry
18. Veterinary products / foods / pharmaceuticals industry
19. Ceramics Industry
20. Steel Industry
21. Mineral Industry
22. Printing industry
23. Water technology
24. Environmental products industry
25. Pulp & paper industry
26. Printing industry
27. Computer industry

Summary

The theme of the Institute of Chemistry for the Year 2022/2023 is "Role of Chemists in Achieving Sustainable Development Goals". Chemistry can help to meet all of the SDGs to varying degrees. In particular, the chemical sciences are central to (i) the development of clean and sustainable forms of energy, for example, through efficient capture of solar energy, clean fuel cells and carbon capture, storage and reuse; (ii) the application of green chemistry principles and processes to manufacturing and for material substitution; (iii) ensuring the efficient and affordable recycling of resources in short supply including 'endangered elements' and natural products; and (iv) developing new analytical techniques needed for more effective monitoring of the environment. Orientation of chemistry and chemical research towards sustainable topics is the main gateway to attain SDGs in the society. Careful interaction with chemistry and chemical compounds leads to sustainable life. As the leading professional body of chemists in Sri Lanka, the Institute will take action to contribute to the achievement of SDGs through a series of programs with the participation of chemists, chemical industries and government agencies as well as international organizations. Already several programs have been initiated. The Institute will also take the lead in IYBSSD 2022 based on its experience gained in the successful implementation of IYC 2011as its Adhering organization in Sri Lanka.

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Mr. N M S Hettigedara *graduated from the Institute of Chemistry Ceylon. He is a Senior Nutritionist and Dietitian at the Sri Lanka Police Hospital, Colombo having the rank of Senior Superintendent of Police (SSP). He obtained a BPharm (Honours) degree, MSc in Food Science and Nutrition and currently reading for his PhD. He is a Chartered Chemist. He is a Fellow of Institute of Chemistry and a Fellow of Dietitian's Association of Sri Lanka. He is also a registered pharmacist and a member for life of Pharmaceutical Society of Sri Lanka and Nutritional Society. Member of the American Society of Nephrology.*

Themed Collection

Science Education in Sri Lanka: Current Status and Challenges Ahead

Sumedha Madawala

Chairperson, Board of Study in Science Education, Postgraduate Institute of Science, University of Peradeniya

The recent pandemic and the following economic turmoil have challenged all sectors including the education. The Covid – 19 outbreak numbs entire nations across the world, affecting both teachers and students alike. Of all major areas, Science Education seems to be the worst affected as Science is best taught in face-to-face mode. Once the teaching-learning process was switched to online mode overnight, the teachers struggled to convey important scientific concepts to their charges through these digital modalities that are new to them as well as for their charges. In comparison to western countries, developing countries like Sri Lanka faced even worst consequences due to lack of resources and infrastructure facilities to adjust to this new mode of teaching-learning process. Despite all these consequences of the pandemic, the importance of science literacy has never been highlighted as much as it was during the Covid era. Science literacy helped people to better understand the Covid-19, its origin and mutations, its spread, long-term health consequences, the significance of the vaccination program etc. For example, the health authorities managed to get rid of the peoples' fear of the vaccination drive through awareness programs, where people with strong scientific literacy were able to grasp the importance quickly that prompted the rest to follow. Furthermore, this understanding also helped authorities to make people conscious of preventive measures to control further spreading. The preventive measures of Covid-19 such as social distancing, personal hygiene such as hand washing, wearing masks etc. and their importance were effectively conveyed to the general public with the help of their sound knowledge in science.

As the pandemic is creeping away from our horizon, the country is facing now the worst economic turmoil since the independence in 1948. Corruption, long-term mismanagement of public funds, unsustainable developmental projects, and ill-conceived policies are some of the contributory factors for the present debacle. To make things worse, the economic crisis is bringing new challenges to the education sector. In order to bring the national economy back on tracks, some short- and long-term progressive measures should be taken. Science Education has long being recognized as