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Fertiliser Industry on Sustainable Path

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The fertiliser industry has completed more than one hundred years of its operation. The first plant of single super phosphate (SSP) came into existence in 1906 at Ranipet, followed by ammonium sulphate with a modest production. Production of major fertilisers such as urea, DAP and complex fertilisers started from 1959, 1967 and 1968, respectively. Production of fertiliser products at the initiation of First Five Year Plan (1951 - 52) was mere 0.2 million metric tonnes (million MT), which increased to 52.0 million MT in 2025-26. The fertiliser sector depends on finite mineral resources for production of intermediates and fertiliser products. The import has reached to the extent of 78% in case of natural gas, 90% in case of rock phosphate, 70% in case of ammonia for production of complex fertilisers, in addition to about 50% for sulphur. Production of fertilisers involves chemical reactions and generate gases, waste water and solid wastes, which have concentration of elements in excess of permissible limits. The industry is proactive and plants have incorporated pollution control devices/schemes to contain the concentrations of these elements within the stipulated standards prescribed by the central and state regulatory bodies.

The industry has been undergoing a transformative journey towards sustainability. Regarding environmental stewardship, the industry has adopted a comprehensive set of initiatives that address energy efficiency, water conservation, emission reduction, biodiversity protection, and pathways for sustainable production of fertilisers. These efforts are closely aligned with the United Nations Sustainable Development Goals (SDGs), ensuring that the sector contributes meaningfully to global sustainability targets. By enhancing energy efficiency, the industry contributes directly to Affordable and Clean Energy (SDG 7) and Responsible Consumption and Production (SDG 12). Urea production is one of the most energy-intensive processes in the fertiliser sector, primarily due to the synthesis of ammonia, which is based on fossil fuel feedstock. Companies have been investing in advanced process technologies, implementing energy saving schemes, waste heat recovery systems, using catalysts with better conversion efficiencies, and adopting advanced process control systems for optimization of process parameters. Modernisation of pumps, compressors and turbines or replacement of them with the efficient one, have contributed to relatively higher energy efficiency. There has been substantial reduction in carbon dioxide emissions by switching over of naphtha and fuel oil-based feedstock to natural gas. The plants based on coal as fuel for steam and power converted to natural gas-based cogeneration plants for substituting major part of steam and power requirement. It is also worth making a mention that the plants are exploring use of artificial intelligence and machine learning for efficient operation, maintenance and internal benchmarking of processes for predictive and corrective action for optimum operation of the plants. These measures would further help plants to conserve resources. As a result of concerted efforts, the energy consumption of ammonia-urea plants over 3.5 decades have improved over 36% while carbon dioxide emission reduced by 47%. Complex fertiliser plants have also adopted measures to utilise waste heat from sulphuric acid production, and biomass resources for heating purposes, thereby reducing fossil fuel consumption. Sulphuric acid plants have been adopting improved catalysts for higher conversion and better utilisation of heat from the intermediate steps for enhanced efficiency. The losses of ammonia and phosphate from complex fertiliser production by use of efficient recovery system, from emissions and effluents results, in savings of finite resources and improving environment.

Water is a vital resource in fertiliser manufacturing, particularly in cooling and process operations. The industry has achieved significant progress in reducing water consumption, with weighted average consumption has reduced by more than 60% in urea and complex fertiliser units. There has been considerable reduction on waste water consumption. Key initiatives include recycling and reuse of process water and rainwater harvesting. Plants are opting for reverse osmosis for treatment of industrial effluents and modifying sewage treatment plant with membrane bio-reactor (MBR)

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technology such that the treated effluent is reused for cooling and process requirement. Advanced water treatment technologies have been helping in improving cycle of concentration of cooling tower, thereby reducing fresh water consumption. These efforts support Clean Water and Sanitation (SDG 6), ensuring that industrial growth does not compromise water availability for communities and ecosystems.

Environmental compliance remains central focus for fertiliser producers. Plants have installed continuous monitoring systems and data is linked to central and respective state pollution control boards. Adoption of cleaner technologies have led to substantial reduction in emissions and effluents. Modification in scrubbing system, effluent treatment plants, and emission control devices have been carried out by almost all plants. These measures reduce pollutants such as ammonia, NOx, SOx, and particulate matter, thereby improving air quality and safeguarding public health. The industry's commitment to emission reduction aligns with Climate Action (SDG 13) and Good Health and Well-Being (SDG 3). The solid wastes generated from the industrial processes are being managed as per the stipulated regulations. Efforts are in place for recycle and recovery of resources from spent catalysts, waste oil, chemical sludges, etc. wherever feasible. The industry has been ensuring that for the plastic packaging materials, equivalent quantities are being recycled. The phosphogypsum generated from production of phosphoric acid is an important resource and utilized for cement manufacturing, agricultural purposes, road construction and construction materials. Innovative uses of phosphogypsum are under development including production of sulphuric acid from phosphogypsum. These are the steps towards circular economy. Further, policy support for giving impetus to utilisation of phosphogypsum in road construction and cement industries would help in utilisation of legacy stock.

Beyond industrial operations, fertiliser companies are actively engaged in initiatives, which include afforestation projects, green belt development in and around plant sites, Miyawaki afforestation, rejuvenation of ponds, ecological restoration of degraded areas and preservation of wetland ecosystem, flora and fauna. Corporate Social Responsibility (CSR) programs often extend to community-led projects such as human and soil health, education, skill and infrastructure development in rural areas, women empowerment, etc. These actions contribute to Life on Land (SDG 15), reinforcing the industry's role in protecting ecosystems and promoting sustainable land use.

The fertiliser industry has been engaged in exploring innovative pathways to achieve long-term sustainability such as renewable energy integration in the production processes. Solar and wind power are increasingly used to meet operational energy needs without affecting the continuous operation of the plant. Energy storage solution using battery and pump hydro- system solutions are being explored to balance continuous demand and intermittent supply of renewable energy. Such initiatives help in reducing reliance on fossil fuels. Overcoming infrastructural and technical limitations in adoption of green hydrogen and green ammonia in medium to long-term will require a detailed and careful study. Commercial viability of these projects will also need conducive policy support. The pathways align with industry, innovation and Infrastructure (SDG 9) and Partnerships for the Goals (SDG 17), highlighting the industry's commitment to innovation and collaboration.

The fertiliser industry has been demonstrating leadership in sustainability by embracing energy efficiency, conserving water, reducing emissions, protecting biodiversity, and exploring renewable pathways. These initiatives are essential for ensuring long-term resilience and sustainable agricultural growth. By aligning with the UN Sustainable Development Goals, the industry reinforces its commitment to global sustainability and positions itself as a responsible partner in achieving a green future. This special issue of technology is devoted to such sustainability initiatives of the fertiliser industry. Eight articles published in the current Issue provide detailed efforts of the industry in the areas of efficient operation, decarbonization, water conservation, biodiversity management, and sustainable pathways. ■