18. IMPACT OF FERTILIZERS ON THE ENVIRONMENT

Fertilizer is one of the major contributors to increased crop production. Recently, concern has been expressed that over-reliance on mineral fertilizers may cause unsustainable environmental penalties like eutrophication of surface water, nitrate (NO_3') pollution of groundwater, heavy metal pollution of soil, atmospheric pollution due to emission of nitrous oxide and ammonia, acid rain, etc. Though there are incidences of these problems in several parts of the world, very few of such problems in India can be linked to fertilizer use.

India has to produce 380 million tonnes against the present production of 206 million tonnes of food grain per annum in order to feed a population of 4 billion by 2025.. As there is no scope for horizontal expansion of our agricultural land additional amount of food grain has to be harnessed vertically in which fertilizer takes the lead role. Where there is no doubt on the yield propelling effect concerns have been expressed about the environmental impact of fertilizer use. There are some claims of dire consequences with fertilizer use and more particularly against N fertilizers. This makes some sense as fertilizer recovery efficiency of N " seldom exceeds 50 per cent. A major portion of the applied fertilizer is lost from soil-plant system by leaching, runoff, denitrification and volatilization and pollutes the soil, water and air; the vital resources of nature..

At present the country consumes about 17.8 million tones of fertilizer per annum and more than 65 per cent of it is nitrogenous fertilizer. The consumption of fertilizer has registered a spectacular growth during the last 3 decades and a very good correlation has been seen between food grain production and fertilizer consumption. Average consumption of fertilizer (N+P+K) in the country in 1999-2000 is about 106 kg ha" yr^{-1}. Though, this is much less in comparison to many other countries like China, Japan. United Kingdom, Korea, and Netherlands, where the consumption of N+P+K are 271, 295, 343, 459, and 50 kg ha-' yr^{-1}. respectively. Fertilizer consumption even in the neighbouring countries like Bangladesh and Pakistan are higher i.e., 154 and 129 kg ha-^{l} yr$^{\cdot l}$, respectively, than that of India. Moreover there is regional disparity in terms of fertilizer consumption. Farmers of Punjab use nearly 250 kg fertilizer ha" yr 1, whereas in North East Regions it is only 5-10 kg ha-^{l} yr'.

Environmental Consequences of NPK Fertilizer Use

Fertilizer N. P and K. after their application in soil undergo various transformation processes. A host of physical, chemical and biological processes are involved in such turn over. For example, dynamics of N in the soil-plant-atmosphere system includes the various soil processes like mineralization, immobilization, urea hydrolysis. nitrification, volatilization and, denitrification. Phosphorus after its application in soil is either removed by crop or gets converted into various insoluble forms (Fe and Al phosphate in acid soil and Ca-phosphate in alkaline soils) arid gets fixed in soil -clays or organic matter. The use efficiency *of* P does not exceed 20%. Significant amount of P is lost from the soil through surface runoff and erosion resulting in eutrophication of water bodies. Potassium is the most abundant plant nutrient in soil. It is more mobile than phosphate and is susceptible to loss by leaching, runoff and erosion. The use efficiency of fertilizer K is about 70%. Loss of K is a waste but carries no environmental concern.

Major environmental' consequences related to fertilizer use

Nitrate Pollution of Groundwater

Pollution of groundwater from fertilizer N is caused by leaching. The magnitude of loss depends upon soil conditions, agricultural practices, agro-climatic. conditions, and type of fertilizers and methods of application. The time taken by nitrate "to move from the root zone to the water table, therefore, varies considerably. In sandy soils with high water table and high rate of fertilizer application, it may reach the water table in matter of days whereas in heavy soils, low rainfall and low rate of application' with deep water table, it may take years.

Two main alleged health hazards are blue baby disease of young babies and cancer due to nitrate ingestion in food and water. World Health Organization (WHO) recommends that drinking water should not more than 10mg NO3-N L"l (50mg ,NO3]' Lot). However. nitrate is non-toxic, the concern is with its microbial reduction to nitrite. The nitrate is converted into nitrite in the intestine and then absorbed in the blood stream. Young babies cannot detoxify this nitrite, which combine with hemoglobin to form inactive form methaemoglobin thus reducing the capacity of blood to carry oxygen. When the conversion of nitrate to nitrite exceeds 10% blood is incapable of carrying oxygen and clinical symptoms such as gray or blue skin develop known as "methaemoglobinaemia" or "blue baby syndrome".

Tamil Nadu in the south, Orissa (Ganjam district) and Bihar in the cast and Gujarat on the west high average nitrate and high N fertilizer consumption. But there were several exceptions. For example, in West Bengal, where the average nitrate level was low inspite of high dosage of N fertilizers. There are very few cases of high nitrate content in groundwater in India that can be related to fertilizer use. We argue that the stray incidence of high nitrate levels in groundwater in certain pockets cannot be attributed to mineral fertilizer consumption but to dumping of animal wastes and extensive use of farmyard manure

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Eutrophication

Another major problem associated with excess fertilizer use is the eutrophication of surface water causing several diseases. Arable soils leak considerable amounts of nitrate, phosphate, potassium and other nutrients mainly through run-off and erosion, which enrich the water body in terms of nutrients leading to luxurious growth of algae and other organisms and resultant eutrophication problems in ponds

Ammonia Volatilization

Volatilization of NH3 is not only a major loss of N but also a cause of environmental pollution. From the atmosphere NH3, is washed out by clouds and redeposit' on the terrestrial ecosystem In the atmosphere it is oxidized to N2O, which acts as a greenhouse gas and is responsible for the destruction of ozone layer. It also forms salts with acidic gases and these salt particles can be transported long distances especially in the absence of clouds. The deposition close to the source is substantial, but hard to estimate due to interaction with other pollutants. In northern Europe, it has been estimated that 94% of the NH3, released from agricultural sources is redeposited into surrounding ecosystems

Acid Rain

The effect of acid rain on ecosystems is gradually being documented, particularly in temperate region Nitrogenous fertilizers contribute substantially towards emissions of ammonia, one of the agents causing acid rain. A high atmospheric concentration of ammonia can result in acidification of land and water surfaces, cause plant damage and reduce plant bio-diversity in natural systems. Excess of ammonia deposited causes eutrophication effect of N. Deposition of NH3 contributes to acidification of soils if nitrified.

Greenhouse Gases

Greenhouse gases (GHGs) are atmospheric compounds that store energy, thus influencing the climate. Each of the GHGs has a different global warming potential that takes into account the effectiveness of each gas in trapping heat radiation and its longevity in the atmosphere. For instance, one kilogram of methane (CH_4) is estimated to have the same warming potential as 21 kilograms of carbon dioxide (CO_2), and one kilogram of nitrous oxide (N_2O) has an equivalent impact to approximately 310 kilograms of CO_2.

According to the Organization for Economic Cooperation and Development (OECD), CO_2, CH_4 and N_2O emissions in agriculture at global level are estimated to account for 14 per cent of the total emission of GHGs. However, estimates of both absorption and emission of these three gases are subject to significant uncertainties.

Nitrogen Gas (N2)

Large amounts of nitrogen gas are emitted to the atmosphere via denitrification, including that of nitrogen fertilizers. Nitrogen gas constitutes 78 per cent of the atmosphere and it has no direct greenhouse effect. Release of N_2 reduces nitrogen (N) available to crops, but is not otherwise detrimental to the environment.

Nitrogen Oxides (NO and NO2)

Nitrogen oxides are not GHGs. Nitrogen fertilizer input accounts for only 0.5 per cent of NO emissions. Both nitric oxide (NO) and nitrogen dioxide (NO_2) react in sunlight with volatile organic compounds to form tropospheric ozone (O_3). Ozone is toxic to crops, even at low concentrations, and detrimental to the health of sensitive individuals.

Nitrous Oxide (N2O)

Nitrous oxide has a greenhouse effect and is considered to be detrimental to the ozone layer. According to experts of the Intergovernmental Panel on Climate Change (IPCC), N_2O is responsible for 7.5 per cent of the calculated greenhouse effect caused by human activity. The concentration in the atmosphere is increasing at a rate of about 0.2 per cent per year. Although nitrogen fertilizers can be a direct or indirect source, they account for only 0.8 per cent of the N_2O emissions. Moreover, new, more efficient nitrogen fertilizers coupled with site-specific fertilization practices reduce N_2O emissions.

Methane (CH4)

Methane is a GHG. Within agriculture, CH_4 is emitted mostly by ruminant digestive process and from livestock wastes. Rice paddy fields are also a major source of CH_4 that is formed by the anaerobic decomposition of organic matter. The addition of readily decomposable organic matter significantly increases CH_4 emissions. The impact of mineral fertilizers on CH_4 emissions is not clear, but seems minor.

Fertilizers and Gas Emissions

The use of phosphate and potash fertilizers does not contribute directly to GHG emissions, but all forms of nitrogen fertilizers may lead to N_2O emissions. Since there is no significant uptake mechanism for N_2O in agricultural systems, mitigation focuses on emission reduction. In general, agricultural practices that increase nutrient use efficiency and diminish nitrogen leaching are also appropriate for minimizing N_2O emissions. Best management practices, which match the nitrogen supply to crop requirements and integrate animal manure and crop residue management into crop production, result in a net reduction in N_2O emissions. The proper balance of nutrients optimizes the efficiency of applied and residual soil nitrogen. Other agricultural practices that minimize nitrogen losses include the adoption of reduced tillage practices, the prevention of water-logging through improved drainage and the treatment of sodic soils.

Replacing plant nutrients removed during harvests, and minimizing nutrient losses to the environment are the goals of effective fertilization. This involves both efficient and balanced fertilization to ensure adequate plant nutrition while maintaining optimum soil fertility levels.

Trace Element and Heavy Metals Contamination

There is an increasing concern about the occurrence 'of trace elements in the environment in concentrations which can be harmful for animal health. Many fertilizers. phosphatic fertilizers in particular, contain varying amounts of trace elements such as F, As, Cd, Co, Cr, Hg. Mo, Ni and Pb (Table). The main issues concerning these potentially harmful elements are i)'soil accumulation and possibility of the long-term effects on crop yields and quality, ii) plant uptake and the content of the element in animal feed and human diet. iii) potentially damage to the soil micro flora. and iv) direct exposure to humans through contact and ingestion. The famous incidences of "itai-itai" and "minamata" diseases due to Cd and Hg toxicity. respectively are the examples of potential threat of heavy metal pollution. In Japan excessive use of sulphate containing fertilizers in paddy soils resulted in As toxicity, which was attributed to the displacement of arsenate ions from soil particles by sulphate ions. Such situations may be observed in the Deccan plateau of India, which are of volcanic origin.

Heavy metal contents (average) in fertilizers

Fertilizer	Heavy metal (mg kg" fertilizer)			
	Cu	Zn	Mn	Mo
Single super phosphate	26	115	150	3.3
Diammonium phosphate				109
Muriate of potash	3	3	8	0.2
Ca-ammonium nitrate	0.2	6	11	
Urea	0.4	0.5	0.5	0.2
Ammonium sulpha.te	0.5	0.5	70	0.1
Triple super phosphate	7	75	200	0.1
Ammonium 'phosphate	3	80	160	2
.Complex fertilizer	22	276		
Rock phosphate	100	200	0.5	--

Quality of Environment due to Fertilizer Use

While explaining the negative impacts of fertilizer application one should look into the benefits the world is harvesting from fertilizer use. Fertilizer is an indispensable input of intensive agriculture. The success of green revolution also goes to fertilizer use as **Dr. N.E. Borlaugh said, "If the high yielding varieties were the catalysts that ignited the green revolution, the chemical fertilizers were the fuel that powered its forward thrust".** It improves soil-health and the deteriorating health of soil due to excess mining of nutrients. Availability of organic manures would not be sufficient to replenish the whole of harvested nutrients. Even it were possible to supply the entire amount of N needed by organic sources, the" pollution problem would be greater. It is reported that

losses of N from organic sources were more than that of inorganic sources. Fertilizer also improves farming efficiency. The extensive-intensive type of farming would be impossible without fertilizers. Moreover, the mineral, protein and vitamin content of crops may be improved as judicious fertilization corrects the inadequate level of nutrient availability.

Fertilizer application also retards erosion as the better developed canopy and extensive root system of fertilized crop protects the soil against wind and water erosion, The residual effects of the greater organic production are significant in the improved soil aggregation imparted by the larger quantity of fresh organic return. It also conserves water because only well nourished crops use water efficiently thereby producing more yields per unit amount of water. Use of fertilizer promotes air purification by stimulating vegetative production absorbing more CO_2 from atmosphere and purifies the air. Fertilizer, by increasing productivity reduces the encroachment of farming onto marginal, erodible and forest land.