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Environmental Impact of Fertilizer Production, its Use and Role of EIA in Sustainable Fertilizer and Agriculture Development

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Abstract

The paper presents a critical appraisal of the environmental pollution problems arising due to the production and use of nitrogenous and phosphatic fertilizers. The paper also highlights their impact on various components of environment and role of environmental impact assessment in sustainable fertilizer and agricultural development.

Introduction

India accounts for 2.25 % of the global land and 16 % of the world population. The population of India is estimated to reach billion marks by 2000 AD, which require larger and larger quantities of food grains (Khanna *et el.* 1989). Fertilizer industry has been playing a crucial role in ensuring sustained growth of agriculture production to meet the food grain requirement of 240 million tones by the end of 2000 AD. India is the largest manufacturer of fertilizers in the world. Installed capacity of nitrogenous fertilizers in India has increased from 0.085 million tone in 1950-51 to 9.3 million tone in 1995-96. The overall per hectare consumption has been rising steadily and is now reached a level of 70 kg from a mere 0.55 kg in 1950-51. Total consumption of fertilizer has increased from 0.069 million tone in 1950-51 to a level of 13.84 million tone in 1996 and has resulted in increase in the production of food grains from 55.9 million tone in 1949-50 to 190.0 million tone in 1995-96 (Narayan, 1990, India Fertilizer Industry 1995,India 1995, Aggarwal 1996). With sustained growth and systematic development of irrigation, irrigated potential has increased from 22.0 million hectare during pre plan period to about 81.2 million hectare at the end of 1991-92 (India 1995). Fertilizer consumption in India is about 70 kg per hectare against world average of 170 kg/hectare and 300 kg/hectare in developed countries (Awasthi 1997). Fertilizer consumption per capita per hectare is shown in Fig. 1.

The production of nitrogenous and phosphatic fertilizer in 1995-96 was 8.78 and 2.58 million tones respectively. By 2000 AD the estimated nitrogenous fertilizer requirement will be about 12.75 million tones and the estimated production will be 12.45 million tones with estimated demand supply gap of 0.3-1.9 million tones (Aggarwal 1996).

In view of the high yielding variety of seeds requiring abundant various nutrients, in the form of fertilizers, in order to realize their genetic potential during short vegetation period; fertilizer production and consumption in India has increased substantially. Fertilizer and agricultural development scenario in India is shown in Fig. 2.

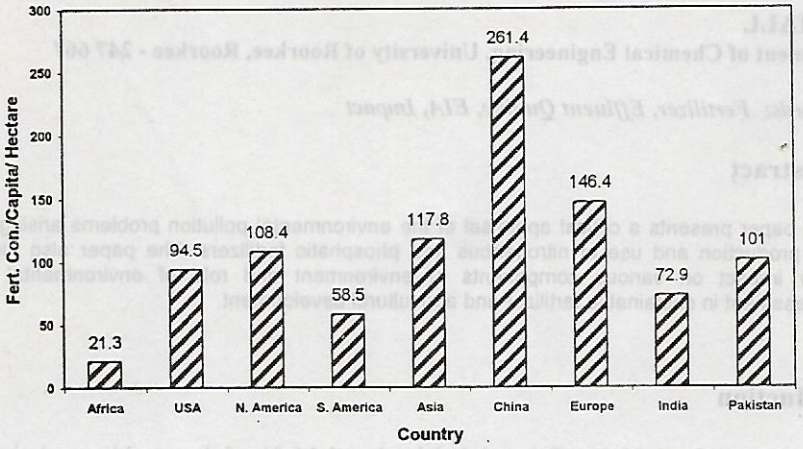

Fig. 1: Fertilizer consumption per capita per hectare land (in Kg)

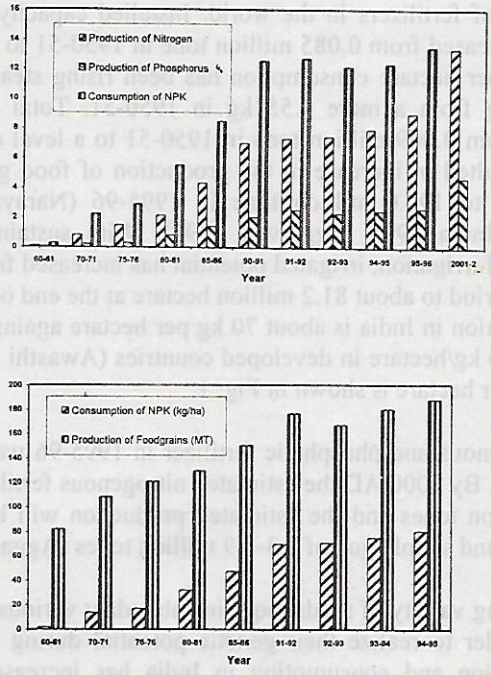

Fig. 2: Fertilizer and agriculture development scenario in India

Fertilizer industry consume wide variety of raw materials, like - natural gas, naphtha, coal, lignite, fuel oil, rock phosphate, gypsum, sulphur etc., for the production of wide spectrum of nitrogenous, phosphatic and mixed fertilizers. Utilisation of huge amount of natural resources and production of various grades of fertilizers raises a number of environmental issues and the fertilizer industry has been classified as one of the top highly polluting industries in India. Therefore, environmental impact assessment has been made mandatory.

About 40 million tones of P_2O_5 and 30 million tones of sulphur are used annually for the production of phosphatic fertilizer in the world (Landge and Ranade 1995). Consumption of rock phosphate, sulphur and imported phosphoric acid in India is about 2.1, 0.550 and 0.130 million tones respectively. In India production of phosphatic fertilizers has increased from 0.011 million tones in 1950-51 to 2.49 million tones in 1994-95 and consumption has increased from a level of 0.001 million tones to 2.95 million tones. There are about 80 units producing phosphatic fertilizers.

All activities, during extraction and storage of raw materials, manufacturing of the nitrogenous and phosphatic fertilizers and their use, contribute significantly to the pollution load on the environment by releasing huge amount pollutants like - ammonia, fluorine, fluorides, nitrate, phosphate, chromium, nickel, cadmium, arsenic, selenium, mercury, uranium, oil & grease, suspended solid, SOx, NOx, fly ash and other particulate matter etc. About 150 million tone of phosphogypsum is being produced annually, which is highly contaminating, and for that reason phosphatic fertilizer industries are posing serious environmental problems all over the world (Landge and Ranade 1995). Phosphogypsum to the tune of 4-5 million tones per annum is produced in India from phosphoric acid plants and an inventory of about 8-9 million tones is already available (CBRI Technology Profile 1993).

Thus, fertilizer industries have to play a crucial role for sustainable development that can be achieved through a sound environmental management plan, resource conservation, environmental equity, and maintenance of human health and Eco system structure. Fertilizer use efficiency has to be increased through better agronomic approaches. Present paper highlights the environmental issues related to fertilizer production and its use, their impact on various environmental components along with the steps required for sustainable fertilizer and agricultural development.

Environmental Pollution due to Fertilizer Production and Use

Environmental Impact Due to Off- Plant Activities

Nitrogenous and phosphatic fertilizer plant consumes wide variety of raw materials. Several thousand tones of natural resource are being consumed every year. Extraction of huge natural resource and subsequent stage of processing, transport of these raw materials raises number environmental issues. Extraction of oil and subsequent processing and mining of coal, lignite, limestone, rock phosphate results in solid wastes

(around 3-4 times of raw materials) during mining. Apart from this, the workers are also exposed to dust and suspended particulates. The mining of these materials also have an impact on the ecosystem.

Environmental Impact of In-plant Activities

Significant quantities of liquid, gaseous and solid wastes are generated during the manufacturing of various grades of fertilizers. Other factors causing environmental deterioration within plant are thermal stresses and noise pollution. Waste water, air pollutants, solid waste generated in a fertilizer complex and their impact on environment are given in Fig. 3, 4 and 5 (Gomma and Lablanc 1985, Mahajan 1985, Barnes *et al.* 1987).

Water Environment

During the manufacture of various types of fertilizers related chemicals and intermediates, wastewater of varying qualities and quantities are generated depending upon the sections of the plant. It may be seen that almost all components present in the wastewater can have direct or indirect impact on the receiving water stream. The contaminants are well above the tolerance limits prescribed by MINAS in many cases. Main constituents in the wastewater from nitrogenous and phosphatic fertilizer plants are carbon particles, oil, sulphur compounds, arsenic, nickel, ammonia, cyanide, phenol, phosphates, fluorides etc. These pollutants have severe impact both on the surface and ground water.

Air Environment

Major gaseous pollutants from fertilizer plants are ammonia, sulphur bearing compounds, oxides of nitrogen, CO, acid mists, particulates at various stages of operation, fluorine, SOx, NOx and CO from power plants. Significant amount of NOx is emitted from nitric acid units in many nitrogenous fertilizer plants. Some of the parameters which increases tail gas NOx emissions in nitric acid plants are insufficient air supply resulting in incomplete oxidation, low pressure in absorber, high temperature in cooler, condenser and absorber, production of excessively high strength acid and operation at high throughput. The air quality deterioration may affect health and well-beings of people residing in the plant vicinity. This may also cause damage to the crop and vegetation in the surrounding agricultural areas.

During the transient conditions (start up condition, process upset conditions due to tripping, shut down condition) in ammonia and urea plant gases containing CH_4, CO, CO_2, H_2 and traces of ammonia from various sections are let out to atmosphere in appreciable quantities. Accidental leakages from ammonia storage and supply sections may be due to failure of couplings and hoses, leaks from pipes, gasket and appurtenances and rupture of lines, due to move of tank cars & trucks carrying ammonia. Phosphatic fertilizer also produces large-scale air pollution due to emission of dust and toxic gases at various stages of operation. Fluorine emission is one of the

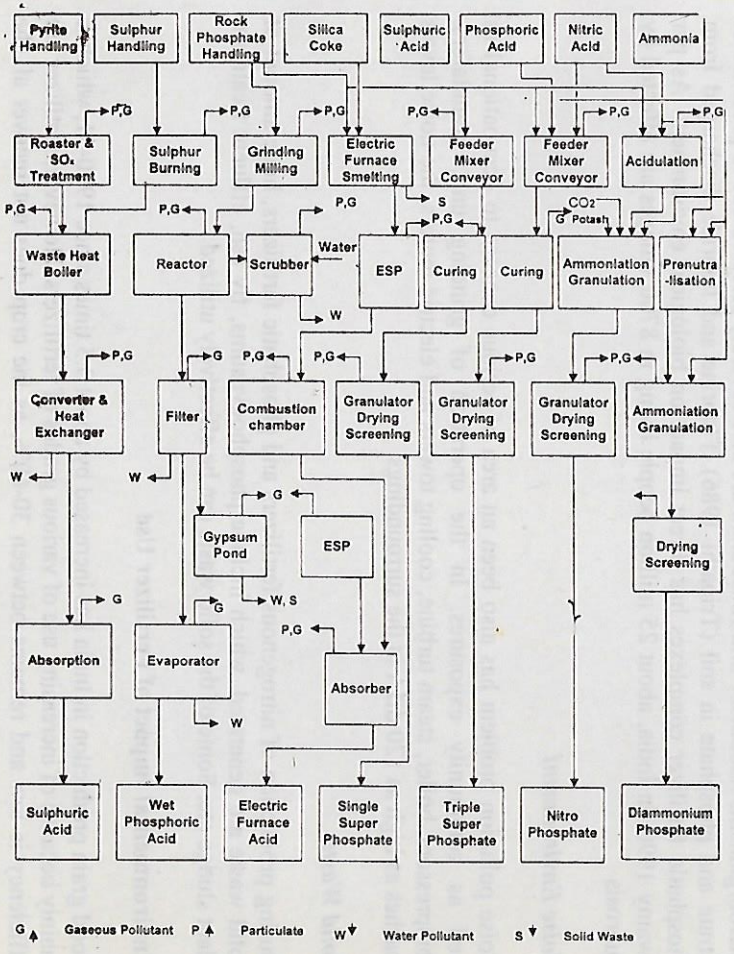

Fig 4: Waste emission and generation from phosphatic fertilizer plant

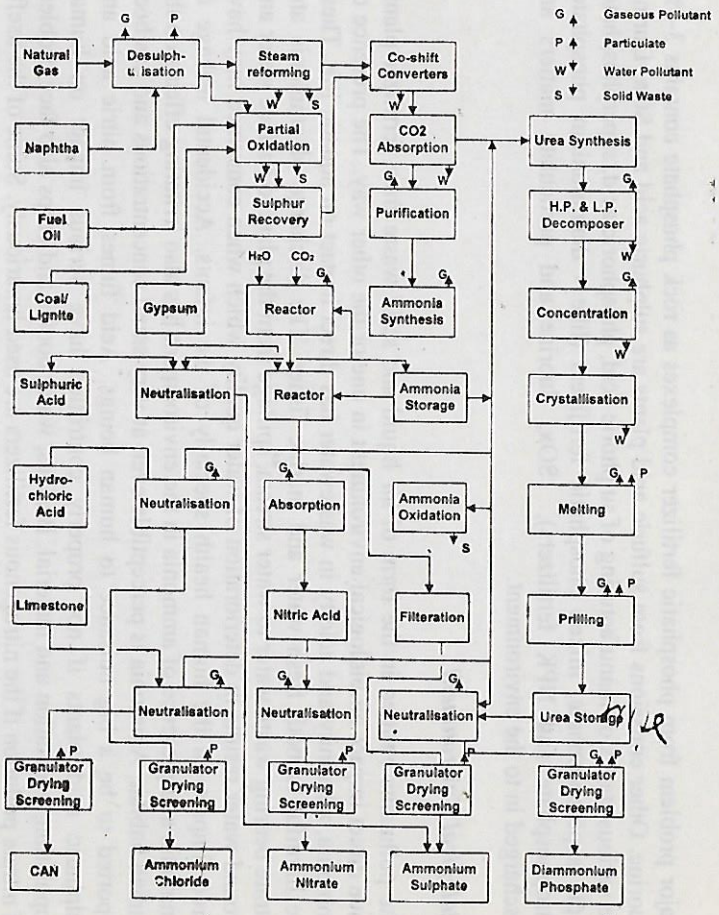

Fig. 3: Waste emission and generation in nitrogeneous fertilizer plant

major problem from phosphatic fertilizer complexes as rock phosphate contains 3-4% fluorine. Other emissions from sulfuric acid plants are sulphuric acid and SOx. During the various stages of manufacturing of sulphuric acid, phosphoric acid, superphosphate, triple superphosphate, mixed phosphatic fertilizers (like - diammonium phosphate, nitrophosphate and NPK fertilizers), SOx, fluorine and particulate matters are discharged in to the environment.

Biological Environment

The pollutants emitted in the form of air liquid and solid waste from fertilizer plants have direct impact on biological environment in one or the other way. The presence of ammonia, alkalinity and acidity in wastewater has direct impact on aquatic life. These are harmful to both fresh water and marine fishes. The discharge of ammonia and nitrate bearing waste water to water stream, spillage from the plant to surface water and ground water results in deterioration of water quality which when consumed may have direct impact on the human health specially of the infants. Accidental leakage of ammonia and presence of ammonia in the environment has also irritating effects on the human habitat. Ammonia is perceptible even at very small concentrations and has been reported to be a big nuisance to human beings. Acid fumes from nitric acid and sulphuric acid plants if not properly controlled have serious impact on human population, vegetation and material. Besides, water bodies and crops also face problem of nitrate pollution if the nitrogenous fertilizers are used luxuriously. Some of the useful microorganisms *Azobactor and Rhizobium* are also severely affected due to presence of nitrate and phosphate in soil (Tripathi 1986). Fluorine and fluoride discharged from phosphatic fertilizer complexes has direct impact on biological environment. As per Swamy 1990, in India, about 25 million people living in 8700 villages are affected by fluorosis

Noise Environment

Noise pollution problem has also been an area of serious concern to occupational as well as community exposures. In the operation of grinding unit, granulators, compressors, boiler, steam turbine, cooling towers and electric motors, the noise levels reaches as high as 120 dBA in the surroundings.

Solid Waste

During production of nitrogenous fertilizers and phosphatic fertilizers, huge amount of solid waste are generated, which include phosphogypsums, fly ash, effluent treatment plant sludge etc. Some of the solid waste can be effectively utilized.

Environmental Impact of Fertilizer Use

Food grain production in India has increased by about 3.5 times since 1950-51, which is mainly because of increasing use of various grades of fertilizers. However, fertilizer use efficiency is low and remains between 30-60%, as the crop does not recover all the

nitrogen applied to the field. With proper irrigation facilities, better water management and proper fertilizer selection; the fertilizer use efficiency has increased during recent years. However, it is still at a lower level. Important environmental issues related to the use of nitrogenous and phosphatic fertilizer are the increase in phosphate, nitrate, heavy metal content of surface and ground water. The increasing use of nitrogenous and phosphatic fertilizers has resulted in serious impact on environment by increased nitrate contents in surface and ground water, which has been a cause of major concern in both developed and developing countries. Tames and Lee rivers of USA are living example of nitrate pollution where nitrate content was below 4 mg/1 in 1940 and was reciirded more than 17 mg/1 in 1986. Similarly, high nitrate problem is noticed in many other parts of USA, UK and India (Tripathi 1986). Nitrate level in some parts of Haryana and Punjab is at alarming level due to excessive use of fertilizers. A Summary of some of the investigations made by previous authors on nitrate, phosphate and fluoride contents of ground water in some of the states is given in Table 1. Plants take a part of the fertilizer directly or by hydrolysis of urea to amine, a part by denitrification and leaching ultimately loses rest.

Excessive nitrate concentration in drinking water poses an immediate and serious health threat to infants less than six months. The nitrate ions react with blood hemoglobin, reduces blood's oxygen carrying capacity, this produces a disease called blue baby or methamoglobinemia. A further potential health hazard may be the formation of carcinogenic nitrosoamines in human digestive system by conversion of nitrate and subsequent reactions with amino acid.

Phosphate is strongly adsorbed onto the soil complex and immobile in the soil water environment. However, some factors that result in mobility of phosphate in ground water may be sandy nature of strata, presence of organic matter, occurrence of high water table and excessive addition of phosphatic fertilizer (Handa 1983). The fertilizer use efficiency of phosphatic fertilizer is very low; therefore, chances of loss of phosphate through runoff are always there. Another important implication of phosphatic fertilizer use is the increase in the heavy metal content of soil, and which may go to surface water and ground water due to runoff, as significant quantity of heavy metals like mercury, cadmium, vanadium, uranium nickel etc are present in the rock phosphate.

Summary of Environmental Impact of Fertilizer Production and Use

Major environmental apprehensions from fertilizer manufacture are:

- Deterioration of environment due to off plant activity which includes oil processing for naphtha and natural gas, mining of coal, gypsum, rock phosphate, benification, resulting in solid waste, wastewater, particulates, heavy metals etc.
- Deterioration in air quality due to emission of fluorine, particulates, NOx, SOx, acid fumes etc.

- Deterioration in the surface and ground water quality due to presence of high nitrate, fluoride, suspended and dissolved solid, ammonia, oil & grease, heavy metals, cyanide etc.
- Environmental deterioration due to noise pollution at various stages like ammonia manufacture, urea manufacture, rock phosphate mining, grinding, granulator, boiler blow downs, boiler, turbine, compressors etc.
- Adverse impact on biological environment due to various toxic pollutants discharge in water and air during production and application of fertilizer.
- Adverse impact on the land environment due to various solid waste like over burden from mining and benification stages wastes, phosphogypsum, fly ash, effluent treatment plant sludge, chromium bearing sludge.
- Fertilizer use efficiency in India is low. Increasing use of fertilizers and over fertilization has resulted in deterioration of surface and ground water quality through loss of nutrient, immobilization or even fixation. Undesirable over supply in mobile form in the soil resulting in the presence of nitrates, phosphates, heavy metals and fluorine in the ground water. Concentration of these pollutants is well above the prescribed limits in ground water at many parts of the country.
- Socio-cultural disruption due to influx of labour force, migration from outside, movement of heavy machinery, additional traffic etc.

The basic resources which are likely to be affected due to location / expansion / modernization of the fertilizer manufacturing activities are:

- **Physical component:** Meteorology, air quality, surface water, ground water and hydrology, topography, geology.
- **Ecological Environment:** Fresh water ecology, terrestrial flora and fauna, natural vegetation, species diversity, bacterial population, eutrophication, plant productivity.
- **Human use value and socio-economic & cultural aspects:** Land use, transportation, water & power supply, medical & education facilities, industries and other occupation, fisheries, animal husbandry, gross economic yield etc.

Environmental impact identification and impact assessment network for nitrogenous and phosphatic fertilizer manufacture activities is shown in Fig. 5.

Role of Environmental Impact Assessment (EIA) on Sustainable Fertilizer and Agricultural Development

Green revolution to meet the fast growing demand of food grains need high yielding varieties of seeds, which rely heavily on irrigation, fertilizers, and pesticides. This is serious environmental problem and calls for sustainable agricultural development. Constitutional pre conditions, which must be satisfied while working for goal of sustainable development, are equity and social justice, economic efficiency, ecological harmony and endogenous choice (Khanna *et al.* 1989).

EIA is an activity designed to identify and predict the impact on the bio-geophysical environment and on man's health and well being of legislative proposal, policies, programme, projects and operation procedures and to interpret and communicate information about its impact. As per EIA notification 1994 by Ministry of Environment and Forest, EIA has been made mandatory

When we are looking towards 21st century and projection of population to about 1.2 billion by 2011. The fertilizer industry would need at least two times growth with about 20 million tones of nitrogenous, phosphatic and mixed fertilizers including the compensation for current gaps in meeting the food grain demand (Singh 1996). Increasing demand of both nitrogenous and phosphatic fertilizers will require huge amount of natural gas, naphtha, coal, fuel oil, rock phosphate, sulfur/ sulphuric acid etc. Therefore, fertilizer industry has to take effective environmental management plan in the following areas.

- Reducing emission of ammonia, at various levels of operation.
- Reducing the emission of fluorine at various stages of operation by scrubbing the fluorine laden gases and their subsequent utilization by use of computer base dual scrubbing system consisting of venturi scrubber combined with packed column.
- Reduction in the wastewater generation by more and more recycling and utilisation of zero discharge technologies.
- Reduction in the emission of SO_2 and acid mist through better controls of operating parameters during conversion and absorption stages by on-line control, as in many plants emissions are still at higher value.
- Use of molecular sieve absorber to recover trace quantities of toxic pollutants.
- Improvement in the acid mist eliminator.
- On line monitoring of pollutants.
- Proper utilisation of carbon, phosphogypsum, coal fly ash. Some of the applications of phosphogypsum may be in gypsum plaster, gypsum ceiling tiles, gypsum marble products, gypsum board and cement.

Although increasing losses of nutrients is an unavoidable consequence of increased fertilization, however, fertilizer use efficiency can be improved to avoid agricultural drainage through proper agronomic approaches that includes.

- Use of proper size and type of fertilizer
- Avoidance of excessive use of fertilizer through balance fertilization based on soil test
- Split up of the fertilizer dose
- Avoidance of excessive use of irrigation water
- Effective control of weeds
- Ensuring proper plant spacing for optimum fertilizer use
- Proper control of pests and diseases
- Selecting most responsive and best suited crops and their varieties for the locality
- Proper scheduling of planting/ sowing

Introduction of leguminous crops in diverse rotational and inter cropping sequence.

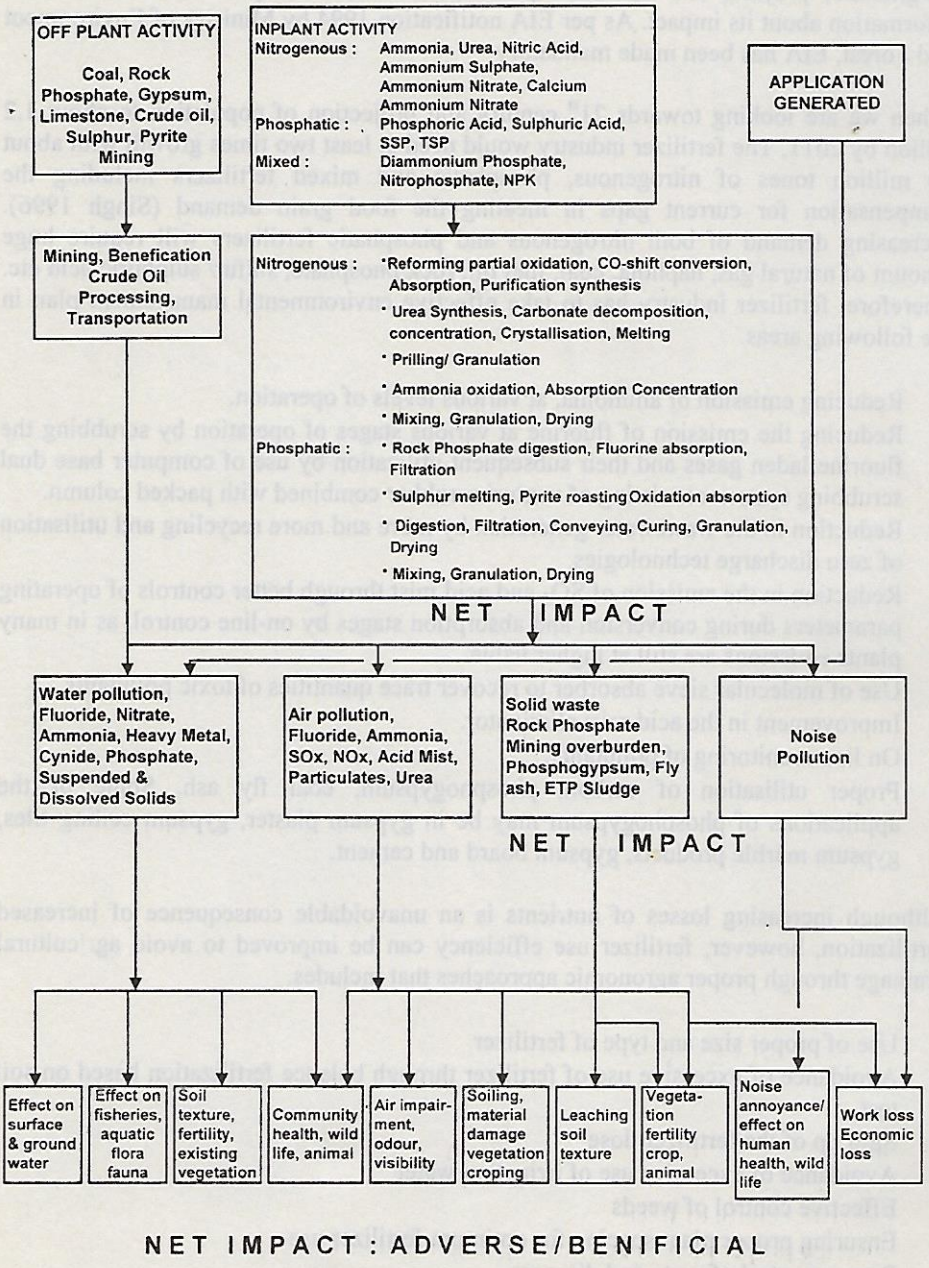

Fig. 5 Impact identification and assessment network for nitrogenous and phosphatic fertilizer

Table 1. Impact of fertilizer production and use on ground water

Reference	Findings
Kakkar 1981	High nitrate concentration in Ground water of Haryana
Handa 1985	Nitrate level in dug well 100 – 300 mg/L Potassium> 100 mg/L, PO_4 1.0 – 3.65 mg/L (Chhata, Mathura and Moradabad, U.P.) Dug well of Agra: Nitrate level -1302 mg/L Assam, West Bengal, Orissa, Kerala – 100 mg/L
Gupta 1991	Out of 1080 samples, average nitrate level was recorded to 271 mg/L. Fluoride was also on higher side.
Gupta *et al.* 1993	Fluride in ground water of 77 villages Minimum 2.28 mg/L Maximum – 22 mg/L
Andamuthu and Subbaram 1994	Out of 129 well water 36.45 % samples exceeded the limit of nitrate concentration. Average nitrate level was found to be 41.7 mg/L at Bhayani, Tamilnadu
Nawlakhe *et al.* 1994	Nitrate 0 – 246 mg/L, Fluoride 0.2 – 5.2 mg/L at Palamu, Bihar
Prasad *et al.* 1994	Nitrate 0.1 to 200 mg/L, Fluoride 0.3 to 1.8 mg/L in North Bihar
Rao *et al.* 1994	Fluoride 0 – 12.5 mg/L in ground water of Unnao (U.P.) and Shivpuri (M.P.)
Singh *et al.* 1994	NO_3 4 – 4400 mg/L In Rajgarh Tehsil, Churu District of Rajasthan)
Joshi *et al.* 1995	Nitrate level 1.2 – 164 mg/L in bore wells , 1.3 to 150 mg/L in dug wells. Rural area of Nagpur

Conclusions

With the increasing population the demand of fertilizers is bound to increase. According to working group on fertilizer for the Eight Plan the gap between demand and production will go up by 3.6 million tones by 2001-2002. More and more fertilizer projects are likely to be implemented in order to bridge the gap. Fertilizer industry has to play an important role in controlling the emission and discharges to safe limit and

save the mankind from environmental disaster. Unsound environmental management plan and non-judicious use of fertilizers are liable to affect the vital component of the environment namely water, air, soil and biological. Fertilizer use efficiency has to be increased to avoid the ground and surface water contamination with nitrate by proper agronomic and chemical approaches. Although implementation of new projects, expansion of existing plants are unavoidable, however, various environmental parameters which are likely to have impact on the environment are to be critically examined before setting up a new plant or going for expansion. Effective environmental management plan and post operation monitoring of various parameters are to be incorporated in case of new projects. Fertilizer industry and agronomist has to play an important role for sustainable agricultural development in achieving environmental equity both intergenerational and intersociety by sound environmental management plan and improved soil, crop and irrigation management policies.

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