A Presentation On

Gaseous Emissions in the Fertilizer Industry and Their Impact on Specific Energy Consumption Per Tonne Of Product

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Objectives of the Study

- To analyze the trends of gaseous pollutant's emissions in :
  - Fertilizer Plants based on the Latest Process Technologies and
  - The Old Generation Fertilizer Plants

vis-à-vis its relation with specific energy consumption per Tonne of Product

and

- Impact on human beings, animals, plants and environment etc.

Current Study is confined to Urea and its intermediate product Ammonia only.

Specific Energy Consumption & Gaseous Emission trend in Ammonia and Urea Plants

Specific Energy Consumption:

- In 1960s, specific energy consumption in Ammonia Plants was around 20 GCal per tonne of Ammonia.
- 1990s Generation Plants consumed about 30% Less Energy as compared to 1960s Generation Plants.
- Energy consumption per tonne of Ammonia in new Plants based on natural gas is about 7.0 Gcal.
- Three decades ago, the specific energy consumption per tonne of Urea was about 12 Gcal.
- The up-gradation/modernization and implementation of certain energy saving schemes together with efficient operations of plants have reduced the specific energy consumption to about 6.0 GCal per tonne of Urea in old Plants.

- De-bottlenecking Schemes in existing Indian Fertilizer Plants include:
  - Implementation of energy saving measures
  - Enhancement of installed capacity by more than 10%
- Depending on the scheme, overall specific energy consumption reduction to the order of about 15% can be achieved by implementation of De-bottlenecking schemes.

Retrofits considered for the improvement of the energy efficiency of an existing Ammonia Plant

Retrofit	Potential Energy Savings per tonne of Ammonia Gcal
Feed Gas Saturator	0.24
Convection Coils	0.22
Boiler Feed Water Economizer	0.10
Low heat removal of Carbon dioxide	0.26
Ammonia Converter	0.25 to 0.40

- The feedstock used for manufacturing Ammonia/Urea plays an important role in respect of specific energy consumption per tonne of product together with gaseous emissions.
- From the energy saving and less gaseous emission point of view, the best feed stock is natural gas.

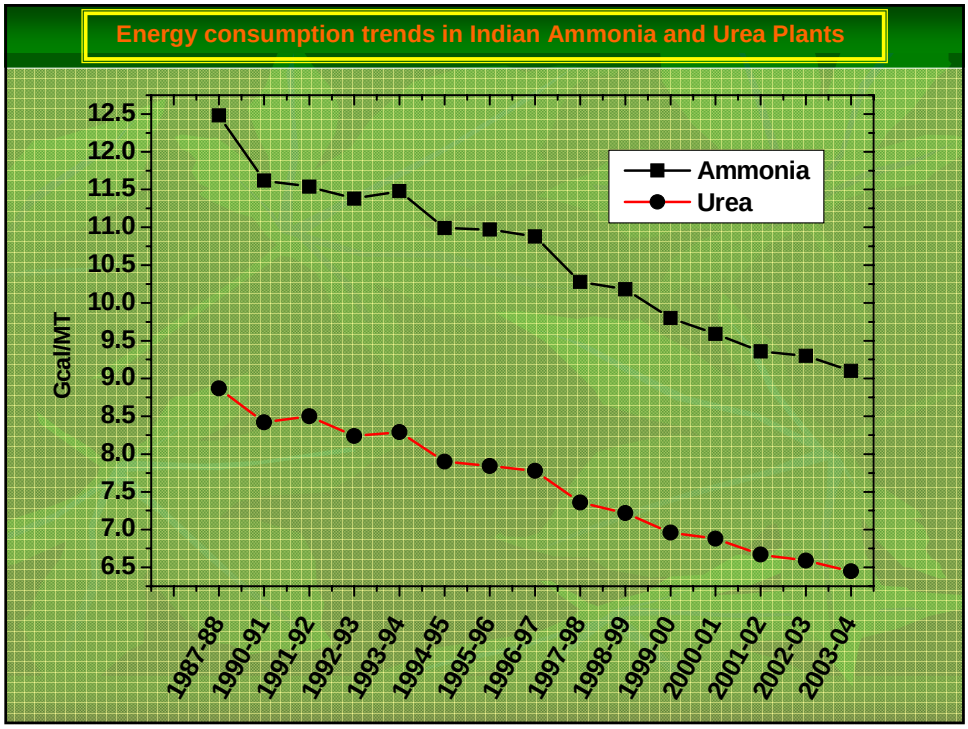
The comparative energy figures with respect to various feed-stocks are shown in the following table:

Consumption of feedstock and Energy for Ammonia Production

Feedstock and Fuel	Requirements per ton of Ammonia	Energy (Gcal)
Natural Gas	873 Nm^3	7.0
Naphtha	0.72 t	7.6
Fuel Oil	0.87 t	8.5
Coal	1.54 t	9.8

Energy consumption trends in Indian Ammonia and Urea Plants

Year	Ammonia - Gcal/MT	Urea - Gcal/MT
1987-88	12.48	8.87
1990-91	11.62	8.42
1991-92	11.54	8.50
1992-93	11.38	8.24
1993-94	11.48	8.29
1994-95	10.99	7.90
1995-96	10.97	7.84
1996-97	10.88	7.78
1997-98	10.28	7.36
1988-99	10.18	7.22
1999-00	9.80	6.96
2000-01	9.59	6.88
2001-02	9.36	6.67
2002-03	9.30	6.59
2003-04	9.10	6.45



Saving in Energy Consumption

Better feedstock, modern process technologies & instrumentation, together with improved operation and maintenance practices have resulted in significant saving in energy consumption. Modernization of plants of 60's and 70's vintage has helped the plants to reduce the energy consumption.

New plants are being designed energy – specific and environmental friendly for consumption of about 6.9 to 7.0 Gcal per tonne of Ammonia and 5.0 Gcal per tonne of Urea together with bare minimum gaseous emissions as pollutants.

Specific Energy Consumption & Gaseous Emission trend in Ammonia and Urea Plants

Gaseous Emissions

- Analysis of corresponding years actual gaseous emissions data of Indian Ammonia/Urea plants reveals that there is significant reduction in the emissions.
- This reduction has taken place due to:
  - Installation of various Pollution abatement facilities
  - Purge Gas recovery
  - De-Bottlenecking
  - Installation of CO_2 recovery Plants
  - Change of Feedstock
  - Adoption of environmental friendly Technologies
- Consequently, standard norms of gaseous emission have been brought down e.g. Urea dust emission to 50 mg/Nm^3 from 150/Nm^3.
- Specific analysis of actual Urea dust emission from Prilling towers of Indian Fertilizer Plants over a period of 12 years (1992-93 to 2004-05) reveals that the average reduction in Urea dust emission revolves around 30%.

Specific Energy Consumption & Gaseous Emission trend in Ammonia and Urea Plants

Vintage, Technology and Plant Configuration

- The Old Vintage Plants have:
  - Lower Installed Capacity
  - Higher Specific Consumption
  - Higher Gaseous Emissions
- First Generation Ammonia Plants of 200-450 MTPD Capacity were commissioned in 1960s using Reciprocating Compressors.
- Advent of Centrifugal compressors witnessed the installation of Ammonia plants with capacity of 600 MTPD or higher, which brought down the energy consumption of Ammonia production significantly.
- Next generation Ammonia plants were scaled upto 900-1000 MTPD and Latest generation plants are of 1350 MTPD/1520 MTPD and higher capacity upto 1800 – 2000 MTPD Ammonia, which gave even better energy consumption.
- The latest generation Plant will have specific energy consumption of about 5.0 Gcal per tonne of Urea.

Pollution Norms and Level of Emissions

- Problem of Environmental Management - a great concern Worldwide.
- India is a third largest chemical fertilizer industry after USA and China.
- India is more or less self - sufficient in respect of Urea Fertilizer production.
- Fertilizer industry in India ranks 7th out of 17 highly polluting industrial sectors.
- Gaseous Emissions in nitrogenous fertilizer Plants are Urea Dust, SPM, SOx, NOx, CO, CO_2, H_2S and NH_3.
- The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCB) under Ministry of Environment and Forest fix the norms for the pollutants in respect of gaseous emissions, liquid effluent, etc. for fertilizer industry. E.g. UPSCB norms for stack emission standards are:

  SOx : 100ppm , NOx : 100ppm , SPM : 40 mg/m^3 , NH_3 : 50ppm
- Analysis of gaseous emissions in fertilizer industry reveals that the actual emissions are lower than the prescribed levels.
- Ministry of Environment and Forests, Govt. of India gives directives to prepare comprehensive management plan together with Environmental Impact Assessment (EIA) to identify and evaluate pollution impact of the project on environmental system.

Inter-Relationship between Pollutants' Emissions and Specific Energy Consumption

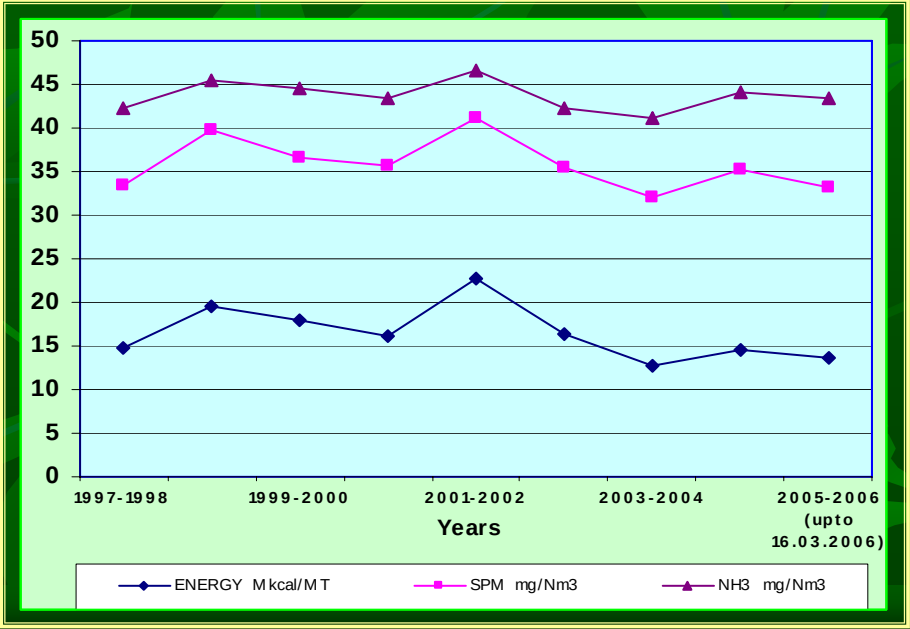
Analysis of Pollutants Emissions & Specific Energy Consumption carried out in 32 Indian fertilizer plants reveals a direct relationship between quantum of emissions of pollutants and specific energy consumption per tonne of product.

Following Tables represent two Gas based Plants
(Plant – A – Worst Energy Efficient, Plant – B – Most Energy Efficient)

Plant – A – (Worst Energy Efficient), Pre-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower- (Table-1)

YEAR	ENERGY Mkcal/MT	SPM mg/Nm^3	NH_3 mg/Nm^3
1997-1998	14.825	33.4	42.3
1998-1999	19.551	39.8	45.4
1999-2000	17.848	36.5	44.5
2000-2001	16.140	35.7	43.5
2001-2002	22.753	41.2	46.5
2002-2003	16.294	35.4	42.3
2003-2004	12.780	32.1	41.2
2004-2005	14.547	35.2	44.1
2005-2006 (upto 16.03.2006)	13.639	33.2	43.4

Plant – A – (Worst Energy Efficient), Pre-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower

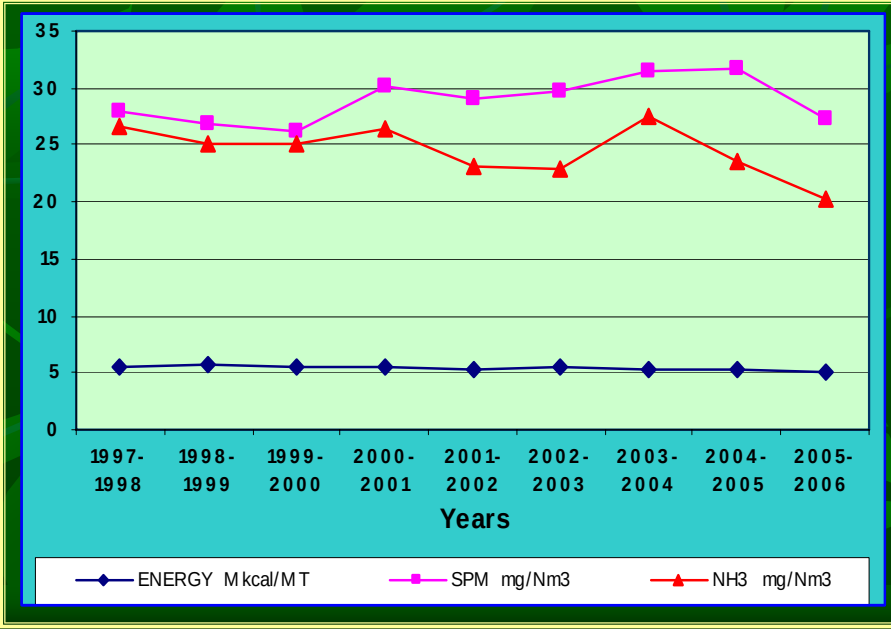


Plant – B – (Most Energy Efficient), Post-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower-(Table-2)

YEAR	ENERGY Mkcal/MT	SPM mg/Nm3	NH3 mg/Nm3
1997-1998	5.535	28.0	26.6
1998-1999	5.743	26.9	25.2
1999-2000	5.528	26.3	25.0
2000-2001	5.531	30.1	26.4
2001-2002	5.373	29.0	23.2
2002-2003	5.439	29.8	22.9
2003-2004	5.306	31.5	27.6
2004-2005	5.227	31.6	23.6
2005-2006	5.129	27.4	20.3

Wherever, the correlation is not depicted, there are certain abnormal operational reasons.

Plant – B – (Most Energy Efficient), Post-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower



Plant – A – (Worst Energy Efficient), Pre-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower- (Table-3)

YEAR	ENERGY Mkcal/MT	SPM mg/Nm^3
1997-1998	14.825	33.4
1998-1999	19.551	39.8
1999-2000	17.848	36.5
2000-2001	16.140	35.7
2001-2002	22.753	41.2
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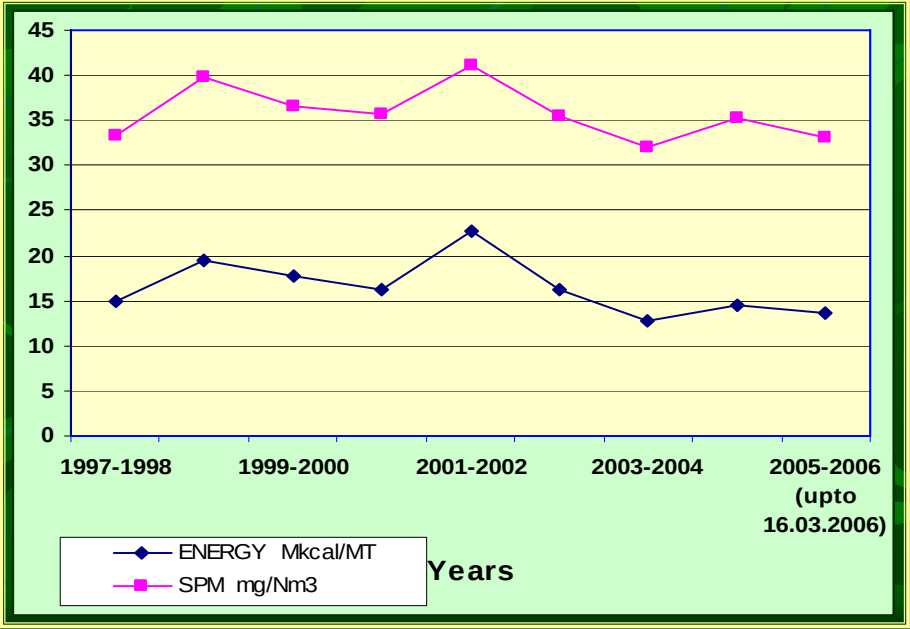
Plant – A – (Worst Energy Efficient), Pre-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower



Plant – B – (Most Energy Efficient), Post-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower-(Table-4)

YEAR	ENERGY Mkcal/MT	SPM mg/Nm3
1997-1998	5.535	28.0
1998-1999	5.743	26.9
1999-2000	5.528	26.3
2000-2001	5.531	30.1
2001-2002	5.373	29.0
2002-2003	5.439	29.8
2003-2004	5.306	31.5
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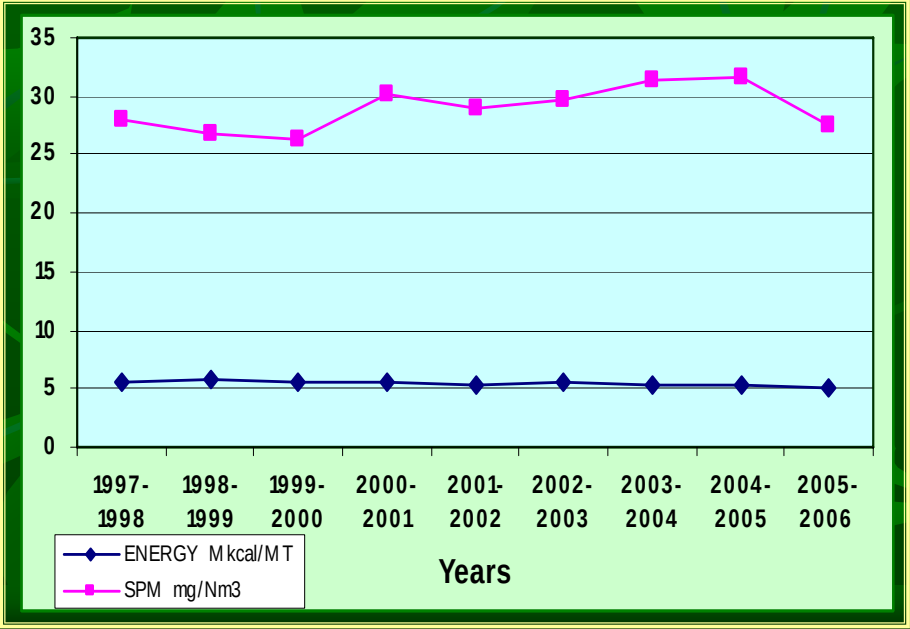
2005-2006	5.129	27.4

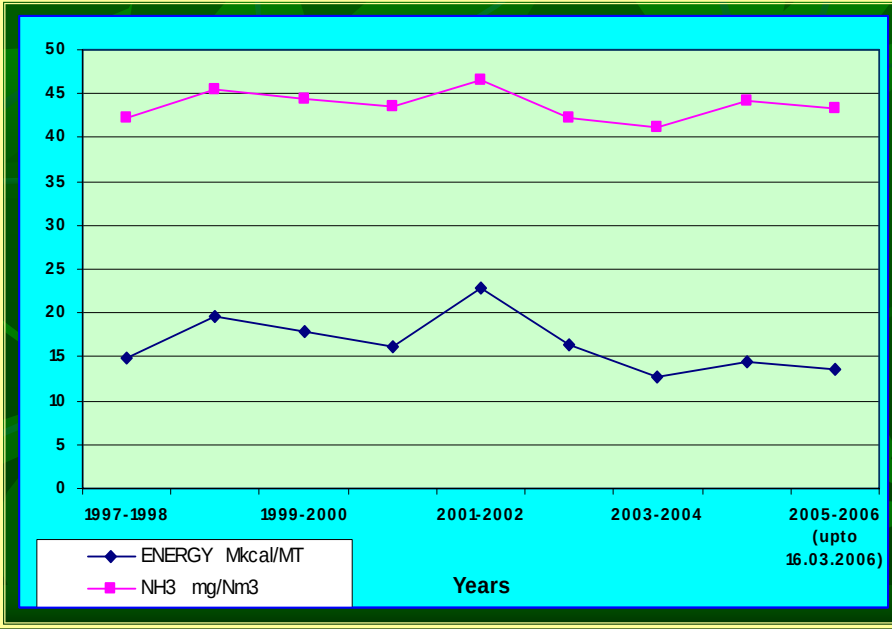
Plant – B – (Most Energy Efficient), Post-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower



Plant – A – (Worst Energy Efficient), Pre-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower- (Table-5)

YEAR	ENERGY Mkcal/MT	NH_3 mg/Nm^3
1997-1998	14.825	42.3
1998-1999	19.551	45.4
1999-2000	17.848	44.5
2000-2001	16.140	43.5
2001-2002	22.753	46.5
2002-2003	16.294	42.3
2003-2004	12.780	41.2
2004-2005	14.547	44.1
2005-2006 (upto 16.03.2006)	13.639	43.4

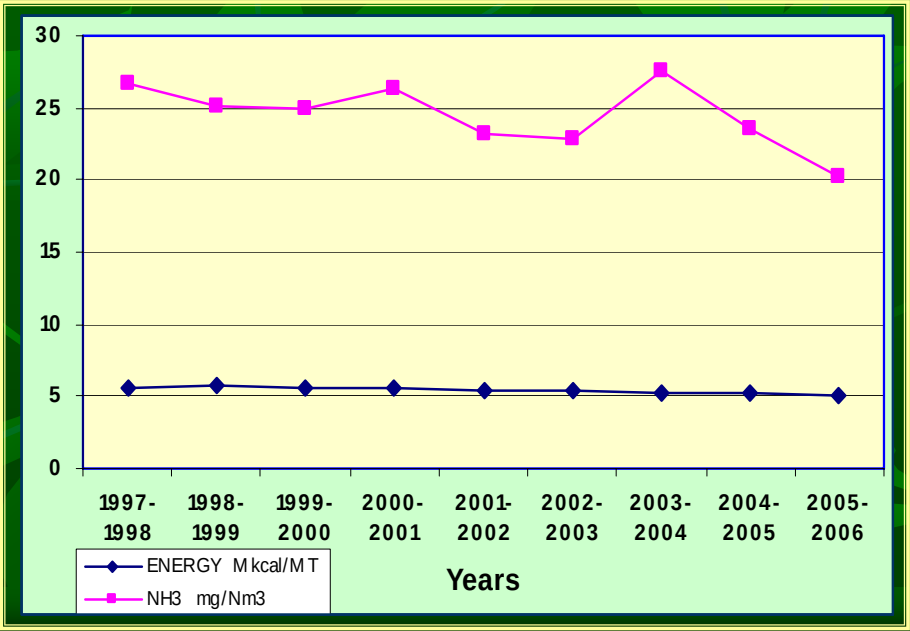
Plant – A – (Worst Energy Efficient), Pre-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower



Plant – B – (Most Energy Efficient), Post-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower-(Table-6)

YEAR	ENERGY Mkcal/MT	NH3 mg/Nm3
1997-1998	5.535	26.6
1998-1999	5.743	25.2
1999-2000	5.528	25.0
2000-2001	5.531	26.4
2001-2002	5.373	23.2
2002-2003	5.439	22.9
2003-2004	5.306	27.6
2004-2005	5.227	23.6
2005-2006	5.129	20.3

Plant – B – (Most Energy Efficient), Post-1992 – Gas based Urea Plant
Energy Consumption vis-à-vis Emission – Prilling Tower



Analysis

- During analysis, it was also observed in some of the cases that specific energy consumption is not directly proportional to gaseous emission wherever there were significant low percentage capacity utilization and frequent breakdowns in the plants as well as due to higher percent capacity utilization (above 100%) leading to less contact time and higher velocity of Prills in Prilling Tower.
- Analysis reveals that energy-efficient fertilizer plants are having lower level of emissions of pollutants .
- The latest fertilizer technologies are environmental-friendly having lower gaseous emissions and lower specific energy consumption per tonne of product.
- Gaseous emissions as pollutants cannot be eliminated totally in any chemical and fertilizer plant. However, it can be brought down to the bare minimum level by employing the latest and improved pollution abatement and energy saving schemes together with implementation of latest Research & Development in the field of Pollution abatement keeping in view the cost benefit analysis.

Impact on Health of Human beings, Animals and Plants	
Pollutants	**Effect on Health**
SOx	Increases human mucus flow, throat and eye irritation, causes bleaching of leaves and necrosis in leaves.
NOx	Eye and nasal irritation, cellular effects, changes in lung morphology, causes damages to the plants, decreases photosynthesis. Adverse effect on human being, particularly children and their mental retardation.
CO	Headache, dizziness, nausea, reduces oxygen carrying capacity of blood and forms carboxy haemoglobin, respiratory failure and death.
Ammonia	Irritation in eye and throat.
Fluorine/ Fluoride	Causes mottled teeth and bone damage at higher dose, Damages the plants.
Acid mist	Damages the plants, adverse effect on aquatic animals..
Urea Dust, SPM	Adverse effect on human being, adverse effect on flowers of plants.

Conclusion

- There is a direct relationship between emission of pollutants and specific energy consumption per tonne of product.
- The specific energy consumption in the new generation plants based on modern process technology is lower than the old generation plants.
- The level of gaseous emissions in the new generation plants based on modern process technology is lower than the old generation plants.
- The old plants which have been modernized/renovated or de-bottlenecking carried out, have significantly brought down the gaseous emissions and specific energy consumption.

Conclusion

- Plants having effective/efficient environmental and energy management system, achieve significantly lower level of gaseous emissions and specific energy consumption.
- Emissions of pollutants in fertilizer plants should be aimed to be controlled at source by implementing various pollution abatement schemes.
- Energy can be saved in any fertilizer plant by minimizing the gaseous emission levels by taking appropriate cost-effective measures.
- Apart from the Energy loss due to higher level of gaseous emissions, there is an adverse impact on the health of human beings, animals and plants etc. in and surrounding the fertilizer plants.