ABSTRACT

The growth of the fertilizer industry in the country all these years has been guided by the necessity of increasing production. This has led to serious environmental degradation of water resources, soil and air around these plants. The air emissions include nitrogen oxides, sulphur oxides, green house gases, waste water stream contains effluents like suspended solids, phosphates, fluorides etc, solid waste majorly phosphogypsum, contains trace metals and radionuclides. Worldwide the focus of pollution control in the fertilizer industry has shifted from end of pipe treatment to avoiding pollution, clean technology and sustainable development. Hence, there is a necessity that environmental considerations play a substantive role in the future development of the industry. Despite the importance and urgency of the problem, not much comprehensive work has so far been done in India on the whole issue with a view to develop a national level policy guidelines for the industry from the environmental angle. But this is the need of the hour. Minimization of the environmental damage is possible by adoption and implementation of cleaner production processes, appropriate treatment technologies, bulk utilization of solid waste and following the standard emission guidelines. This study is an attempt to fill up the above gap by addressing the issues of process optimization and suggesting techniques for environmental management.

Keywords: Fertilizer Industry, Environmental degradation, Air emissions, Waste water stream, Solid waste, Cleaner production processes, Treatment, Process optimization, Environmental management

INTRODUCTION

Rapid industrialization in India after the post independent era has often been associated with large scale ecological damage largely due to unscientific and unsystematic disposal of industrial effluents. Globally, fertilizer consumption has over the past few decades increasingly shifted towards developing countries. The main force responsible for the shift are the introduction of environmental legislation restricting use of fertilizer in many developed countries and a significant growth in fertilizer demand in developing regions as a result of an unprecedented growth in population particularly in Asia. In India, the number of fertilizer plants has increased many folds in last few decades. This has caused serious environmental problems due to the release of toxic contaminants into air, water and soil.
The objective of this literature review is to assess best optimization processes in the fertilizer industry in relation to their potential to mitigate effects of air pollution including greenhouse gas emissions, waste water pollution, solid waste disposal, hazardous chemicals and noise pollution.

BACKGROUND

➢ FERTILIZER INDUSTRY IN INDIA

Indian Fertilizer Industry (2014-2015) is the second largest consumer of fertilizer in the World after China with 30 manufacturing units of urea with an installed capacity of 21.6 million tonnes and 12 units of DAP producing plants with a combined capacity of 8.3 million tonnes (Figure 1). India ranks 3rd in ammonia production and 2nd in urea in the world (Figure 2).

Fertilizers can be grouped into:

- Nitrogenous eg; urea, ammonium sulphate, ammonium nitrate, ammonium chloride
- Phosphatic eg; superphosphates
- Complex eg; ammonium phosphate and ammonium sulphate-phosphate
- Pota

![Figure 1. Consumption of Major Chemicals in India](image-url)
MANUFACTURING PROCESSES OF FERTILIZERS

➢ AMMONIA SYNTHESIS

Following process steps are proposed in the manufacturing of ammonia (Figure 3)

- Purification of Feedstock
- Primary, secondary and Heat Exchange Reforming
- Gas purification (Shift conversion and CO2 removal)
- Methanation and Syngas compression
- Ammonia Synthesis & Refrigeration
- Stripping of process Condensate

Figure 2. World Major Producing Countries of Fertilizers and Raw Materials (2013)
Urea production process involves the following steps (Figure 4):

- Urea synthesis and high pressure recovery
- Urea purification and low pressure recovery
- Urea concentration
- Urea prilling
- Process condensate treatment

Figure 3. Ammonia Synthesis Flowchart
Figure 4. Urea Synthesis Flowchart

- **PHOSPHORIC ACID SYNTHESIS**

Phosphate rock, or fluorapatite, is reacted with sulphuric acid to form phosphoric acid. An important byproduct of this step is hydrofluoric acid, HF. It combines with silica to form fluosilicic acid, H₂SiF₆. Another byproduct is calcium sulphate sludge, which is used to form ammonium sulphate.

- **AMMONIUM SULPHATE SYNTHESIS**

Reaction between ammonia and sulphuric acid gives ammonium sulphate. Alternatively, calcium sulphate sludge from phosphoric acid plant can be reacted with ammonium carbonate to produce ammonium sulphate and calcium carbonate, which can be used in the manufacture of cement.

- **DIAMMONIUM PHOSPHATE (DAP) SYNTHESIS**

Phosphoric acid is neutralized with ammonia and the ammonium phosphate slurry so formed is granulated, or ammonium sulphate is added to the slurry before granulation to get ammonium sulphate phosphate.
Fertilizer plants contribute to atmospheric emission, effluent and solid waste generation. These environmental problems have repercussions at the local as well as global levels. Over the last 25 years considerable developments in technology has taken place in order to minimize the adverse environmental impacts. Even with the latest technology it has not been possible to fully ward off the ill effects arising out of the thermodynamic inefficiencies of the available systems and equipment. The environmental impact of a fertilizer plant depends on a wide variety of circumstances, including the nature of the plant, its design integrity, vintage, the processes and raw materials or feedstock which it uses, the location of the site, the nature of its surroundings, the regulations to which it must conform and the expertise of its operation and management network.

Table 1. Solid, Liquid and Gaseous Emissions from plants in Fertilizer Industry

<table>
<thead>
<tr>
<th>PLANT</th>
<th>SOLID WASTE</th>
<th>LIQUID EFFLUENT</th>
<th>GASEOUS EMISSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>Spent catalysts</td>
<td>Process condensate</td>
<td>Ammonia</td>
</tr>
<tr>
<td></td>
<td>Sludge from equipment</td>
<td>C02 removal solutions</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td></td>
<td>Insulation debris</td>
<td>Cooling tower blowdown</td>
<td>Furnace flue gas</td>
</tr>
<tr>
<td></td>
<td>Construction debris</td>
<td>Boiler blowdown</td>
<td>Vent gas</td>
</tr>
<tr>
<td></td>
<td>Oil sludge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td>Nil</td>
<td>Process condensate</td>
<td>Prilling tower dust</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gland leakages from pumps</td>
<td>Ammonia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wash floorings</td>
<td></td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>Sulphur sludge</td>
<td>Water treatment effluents</td>
<td>Acid mists</td>
</tr>
<tr>
<td></td>
<td>Spent catalysts</td>
<td></td>
<td>SO2/SO3 in stack</td>
</tr>
<tr>
<td></td>
<td>Packing etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphoric Acid</td>
<td>Gypsum</td>
<td>Plant washing</td>
<td>Fluorine</td>
</tr>
<tr>
<td></td>
<td>Sludges</td>
<td>Gypsum pond water</td>
<td>Particulate matter</td>
</tr>
<tr>
<td></td>
<td>Radioactivity</td>
<td>Acid leaks</td>
<td></td>
</tr>
<tr>
<td>Nitric Acid</td>
<td>Spent catalysts</td>
<td>Plant washing</td>
<td>Nitrogen oxides</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ammonia</td>
</tr>
<tr>
<td>Complex</td>
<td>Spillages</td>
<td>Plant washing</td>
<td>Particulate matter</td>
</tr>
<tr>
<td></td>
<td>Slurry from drainage/washing</td>
<td></td>
<td>Ammonia fumes</td>
</tr>
<tr>
<td>Ammonium Sulphate</td>
<td>Spillages</td>
<td>Plant washing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chalk slurry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power generation</td>
<td>Oil sludge</td>
<td>Water treatment effluents</td>
<td>Sulphur dioxide in flue gas</td>
</tr>
<tr>
<td>Water treatment</td>
<td>Used resins</td>
<td>Regeneration effluents</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>Sludge from equipment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OPTIMIZATION OF PROCESSES

AIR POLLUTION: GASEOUS EMISSIONS AND CONTROL SUGGESTIONS

AMMONIA PLANT

Emissions from ammonia plants comprise of light hydrocarbons from storages, hydrogen, carbon dioxide, sulphur dioxide, ammonia, carbon monoxide and gaseous leak from flanges, stuffing boxes and dust and particulate matter from catalyst handling operations. Plant start-up may involve the flaring of synthesis gas, and some oxides of nitrogen emissions may also come. Typical ammonia process based on steam reforming generates around 2.2 tonne of carbon dioxide, and less than one kilogram of nitrogen oxides and 0.2 kilogram of sulphur dioxide per tonne of ammonia produced. In the partial oxidation process 2.7-2.8 tonnes of carbon dioxide, 1.8 kilogram of nitrogen oxides and 3 kilogram of sulphur dioxide are produced per tonne of ammonia.

Carbon dioxide (C02) is a greenhouse gas and contributes to global warming. The production of urea requires about 1.6 tonnes of CO2 per tonne of nitrogen. The fertilizer industry's share of the annual net addition of CO2 to the atmosphere resulting from human activities is estimated at 2%; and human activities account for only 7% of the quantity released annually by biological processes. Consequently, the share of fertilizer production in the total annual release of CO2 to the atmosphere is very small in the range of 0.1-0.2%. Nevertheless, the projected growth of fertilizer use makes it all the more desirable that the industry should keep CO2 emissions as low as possible. The fixation of by-product carbon dioxide as urea reduces the total carbon dioxide emissions considerably. Hence ammonia plants are most often associate with equivalent capacity urea plants also. Emissions also depend on the process and raw materials used as well as on the standards of operation and maintenance.

Steam injection and use of low NOx burners are control mechanisms adopted to reduce formation of nitrogen oxides. Usually the furnace is operated with excess air and hence the chances of formation of carbon monoxide (CO), usually a product of incomplete combustion, are remote.

Sulphur, an impurity invariably present in all petroleum fractions, gets converted to its compounds that are major sources of pollution during the manufacturing process. Natural gas, unlike other petroleum feedstock, contains only very small quantities of sulphur (up to 5 mg/lNm3) and is entirely removed by hydrogenation. In the case of naphtha the sulphur content in the range of 1000-1500 parts per million (ppm) and is usually gas or light hydrocarbons sulphur emissions are negligible. However, larger amounts of sulphur are present in heavy oils and coal. Partial oxidation processes extract up to 95% of sulphur in the elemental form in a Claus sulphur recovery unit. Depending on recovery equipment, up to 3 kilogram sulphur dioxide per tonne of ammonia could be emitted from coal and fuel oil based plants, compared with less than 0.01 kilogram in gas-based plants. Plants employing steam-reforming technology have lower emissions compared to partial oxidation processes. Removed by hydrofining or hydrodesulphurization process prior to reforming. There shall be no ammonia emission (odour concentration 18-35 mg/lNm3) from plants unless there is a leak or so.
All ammonia-bearing streams such as high-pressure loop purge gas from the synthesis unit etc. are scrubbed with water, ammonia is recovered and the rest is used as fuel in the reformer furnace. During plant start up and shutdown when nickel catalyst temperatures are in the range of 100-150°C, in presence of carbon monoxide, there is a chance of formation of poisonous Nickel Carbonyl (NiCO₄) in the reformer. This situation is avoided by careful manipulation of the operating temperatures. Modern developments in gasification and ammonia process technology such as excess air reforming and auto thermal reforming provide significant reductions in emissions. Auto thermal reforming also reduces total energy consumption by necessitating (increased) power import and decreasing net heat loss.

➢ UREA PLANT

Urea plant capacities are normally commensurate with that of ammonia and carbon dioxide that are available from associated ammonia plants. Atmospheric emissions from this plant are mainly ammonia and urea dust arise out of the prilling or granulation process. The ammonia emissions are from leaks in the plant and degradation of urea to form biuret in the prilling tower. Much of the dust from prilling towers and granulators is caused by condensation products of urea vapours. Particulate emissions occur from seeding dust, undersize prills or granules, broken prills and also due to attrition. Prilling towers with natural draft may have less attrition and, hence, less dust than those with forced draft. Prilling tower, emissions range from 0.5 to 1 kilogram ammonia and 0.5-1.5 kilogram urea dust per tonne of product. With granulation, the granulator exit gas is scrubbed and losses can thereby limited to 0.25-0.8 kilogram of ammonia and 0.25-0.4 kilogram of urea dust per tonne. Without scrubbing, dust emission from granulators would be in the range of 5-30 kilogram per tonne or more, depending on granulation efficiency. In older plants, ammonia emitted from vents are typically be maintained within a range of 0.2-0.75 kilogram per tonne of urea, depending on the process and its operating efficiency, but in new plants this is reduced to as low as 0.06 kilogram per tonne.

➢ NITRIC ACID PLANT

The main atmospheric emissions from nitric acid plants are oxides of nitrogen (NOₓ)-nitrous oxide (N2O), nitrogen peroxide (N2O3) and nitric oxide (NO). The concentration of these gases vary between 75 and 2000 ppmv depending on final acid concentration, pressure of the process, cooling temperatures, and degree of tail gas treatment available. Reduction in nitrogen oxides is usually achieved by absorption in cold dilute 25 to 30% nitric acid followed by stripping desorption and recycling the gas back to the process, acid or alkaline chemical absorption, adsorption on molecular sieves, catalytic reduction with natural gas or other hydrocarbon fuel or selective catalytic reduction with ammonia.

➢ SO2 PLANT

Atmospheric emissions from sulphuric acid plants consist of sulphur dioxide, sulphur trioxide, particulate matter and acid mist. Both are released with the waste gas from the final absorber tower. Acid mist can be effectively eliminated by equipment such as Brink filters or irrigated...
Candle filters. Sulphur trioxide emission being as low as 0.15 kilogram per tonne of sulphuric acid in new double conversion and double absorption (DCDA) plants whereas it is usually around 0.6 kilogram per tonne in single contact plants. Sulphur dioxide emission is about 10-12 kilogram per tonne of sulphuric acid in single contact plants and only 2-3 kilogram per tonne in double contact plants (UNEP, 1998). In plants where sulphur is burnt to produce SO2 the only liquid effluent is generated from boiler blow-down and water treatment. In plants where SO2 is received from pyrites roasting, effluent from gas cleaning operations also arise.

**CONTROL DEVICES**

To control air emission, **electrostatic precipitators**, **scrubbers** for gaseous emissions, **cyclone dust collectors** can be installed and being operated efficiently. Adequate arrangement needs to be made for stack sampling and monitoring of pollutant level in flue gases. The stack emissions should always be well within the prescribed limits stipulated by State Pollution Control Board & MOEF. The ambient air quality monitoring stations should be installed at various locations in consultation with Pollution Control Board.

- **ELECTROSTATIC PRECIPITATORS**

The gas stream is passed between two electrodes, across which a high potential difference is maintained. Out of the two electrodes, one is the discharging and the other is the collecting electrode. Because of a high potential difference and the discharge system a powerful ionizing field is formed. Consequently, ionization creates an active glow zone (blue electric discharge), called the ‘corona’ or ‘corona glow’. ESP’s have high efficiency approaching 99%.

![Figure 5. Electrostatic Precipitator](image-url)
It is a structure without moving parts in which the velocity of an inlet gas stream is transformed into a confined vortex from which centrifugal forces tend to drive the suspended particles to the wall of the cyclone body. It consists of a vertically placed cylinder which has an inverted cone attached to its base. The particulate laden gas stream centers tangentially at the inlet point into the cylinder. The outlet pipe for the purified gas is a central cylindrical opening at the top. The dust particles are collected at the bottom in a storage hopper. The gas path follows a double-vortex. First, the gas spirals downwards at the outer periphery of the cylindrical portion continues through the conical portion and reaches the bottom. The gas stream then moves upward in a narrower inner spiral concentric with the first and leaves through the outlet pipe. Due to the rapid spiraling movement of the gas, the dispersoids are projected towards the wall by the centrifugal force and then they drop by gravity to the bottom of the body, where they are collected in the storage hopper. High efficiency cyclones have a smaller body diameter to create greater separating forces.

Figure 6. Cyclone

To reduce the emission of Ammonia & Particulate Matter, adequate scrubbing system can be been installed. The un-reacted ammonia fumes and water vapor from the Pre-neutralizer and Granulator are fed to Fumes Scrubber where ammonia in the gas stream is scrubbed with scrubber liquor and the liquor is recycled back to the Pre-neutralizer. While all the dust generated from Dryer and Cooler and various other Material Handling equipment like Elevators, Conveyors, Pulverizes etc. are collected and passed through respective high efficiency Cyclones to separate the dust particles and the resultant gas is fed to the respective
wet Scrubbers. The Fumes, Dust and Dryer scrubber are of venturi type followed by cyclonic type spray towers while cooler scrubber is only a spray tower. Each Scrubber is provided with a fan for creating the required draft. The scrubbed gasses are let out into the atmosphere through a common stack. Inclined venturi scrubber for granulator fumes and tail gas scrubber can be provided for additional scrubbing of Dryer and Fumes scrubber exhaust gases to achieve maximum recovery of ammonia and fertilizer dust before discharge to the stack.

DAP/NPK Plant - Scrubbing Section

Figure 7. Scrubbing Section for DAP/NPK Plant

➢ WATER POLLUTION: EFFLUENTS AND CONTROL SUUGESTIONS

Sources of waste water streams are
- Process water, final products
- Process intermediaries
- Oil bearing wastes from compressor house and boiler house
- Wash water from gas scrubbing towers
- Regeneration and rinse waters from demineralization plant
- Cooling tower and boiler blowdowns
- Phenols and cyanides, if ammonia is extracted from ammonical liquor of coke ovens
Table 2. AVERAGE COMPOSITION OF WASTE WATER STREAM

<table>
<thead>
<tr>
<th>S.NO</th>
<th>ITEM OF ANALYSIS</th>
<th>VALUES (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>7.5-9.5</td>
</tr>
<tr>
<td>2</td>
<td>Total Solids</td>
<td>5400</td>
</tr>
<tr>
<td>3</td>
<td>Ammonia Nitrogen</td>
<td>700</td>
</tr>
<tr>
<td>4</td>
<td>Urea Nitrogen</td>
<td>600</td>
</tr>
<tr>
<td>5</td>
<td>Phosphates</td>
<td>75</td>
</tr>
<tr>
<td>6</td>
<td>Fluorides</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>Arsenic</td>
<td>1.5</td>
</tr>
</tbody>
</table>

The levels of pollutants present in effluent can be reduced to acceptable level by adopting the following wastewater treatment schemes:

- Effluent treatment Plant
- Neutralization of waste water
- Sewage treatment plant.

➢ AMMONIA PLANT

Process condensate, from excess steam put to the primary reformer, is produced upon cooling the converted gas upstream of carbon dioxide removal unit and is a source of liquid effluent from the plant. Usually around one cubic metre of condensate per tonne of ammonia is generated and it contains up to 1000 ppm each of ammonia and methanol as pollutants. Most of this condensate can be recovered as steam and recycled by stripping with process steam feed to the primary reformer. The stripped condensate that contains not more than 50 ppm each of these pollutants can be further purified by ion exchange method and then used as boiler feed water. Similarly, ammonia from purge and flash gases from the synthesis loop are recovered by absorption in water followed by distillation in a closed loop. The lean gases from the stripper and purge recovery system are routed along with other off gases to the furnace.

➢ UREA PLANT

Blowdown from boilers, cooling tower and regeneration effluents from water conditioning plants also contribute to generation of wastewater. In addition to the above in the non-catalytic partial oxidation process, water containing suspended and dissolved impurities, soot and slag are produced, which necessitates treatment using mechanical, chemical and biological means.
Waste water from urea plants include the process condensate from the vacuum concentration stages (around 0.5 tonne per tonne urea) and the steam and turbine condensate (0.4 and 0.2 tonne per tonne urea respectively) and small quantities of oily water from equipment. The process condensate is normally treated and reused as boiler feed. Low-pressure steam so generated is used for process heating, in turbines, or exported to other plants. The waste-water normally contains about 2% ammonia, 4% carbon dioxide, and 1% urea by weight and must therefore be treated in a thermal Hydrolyser-Stripper. The recovered gases are recycled to the synthesis section and the effluents now contain only around 0.0025 kg ammonia and 0.0005 kg urea per tonne of product. Alternatively the ammonia bearing effluents are also biologically treated, initially oxidizing to nitrate and then by de-nitrifying to nitrogen gas.

WAYS FOR EFFICIENT TREATMENT OF WASTE WATER STREAM

1. Efforts to reduce the consumption of water such as reuse of treated domestic sewage water in the area, rain water recharging well in the township with a storage pond to conserve rain water helps in reducing the salinity in the underground water table in the township and its neighboring areas. All the liquid effluents generated due to stoppage of plants, plant floor & equipment draining, washings etc if collected in a sump, can be recycled back to the process as it contains nutrients. Further, domestic sewage water generated in the factory premises can also be reused after treatment in domestic sewage treatment plant having facilities for secondary and tertiary treatment. All the solid wastes can be reclaimed and reused which includes sludge from sump and plant drain as it contains nutrients.

2. For efficient treatment, it is necessary to segregate the various waste streams and to treat them separately before they are mixed together for final treatment eg; carbon slurry waste which is generated during gasification of naphtha by the steam reforming process, gas scrubber wastes containing monoethanolamine (MEA), arsenic, potassium carbonate and caustic, urea, ammonia and ammonium sulphate and phosphate bearing wastes, acid spillages, acidic and alkaline wastes from demineralization plant, oily wastes from equipments and cooling water and domestic sewage. These streams require individual treatment. The oily wastes should be passed through an oil water separator. Acidic wastes should be stored separately and mixed with the remaining wastes after ammonia removal. Wastes containing phosphates and fluorides should be separated from each other and should get treatment for reduction of phosphates and fluorides by lime and coagulant. Chemical precipitation reduces phosphates to 5mg/l and fluorides to 20 mg/l. Further biological treatment may take the form of trickling filter, activated sludge and its modifications, aerated lagoons and stabilization ponds.

3. Ammonia removal can be done by

- air stripping- it involves raising the ph of the waste to 11.5 when ammonia is liberated as a gas. Vigorous agitation is required at this stage either with compressed air or by stripping towers fitted with fans. Compressed air agitation done for 3 hours at elevated ph effected 90.5% removal. Upto 98% removal can take place by using stripping towers filled with redwood slats and filled with air, provided enough air is supplied and the tower height is about 7 meters.
• steam stripping- it is economical if the ammonia concentration is 3-4% but the steam requirement is very high, of the order of 240 tonnes per hour, so this method is not economical.
• lagooning after ph adjustment- Lagooning after raising ph to 11 for a day can reduce ammonia by 44-61%.
• nitrification and denitrification- this process can be combined with carbonaceous BOD removal in the activated sludge process. But fertilizer wastes being deficit in carbon, a source of carbon is required for the success of this process. Using a submerged fixed film reactor for nitrification of ammonia bearing waste water can be up to 4 times more efficient than the conventional trickling filter.


5. 1000 TPD unit produces ammonia and urea bearing waste-water of 10,000 m3 per day. Urea can be hydrolyzed to ammonia and carbon dioxide under high temperature and pressure, provided the waste water contains only urea and ammonia. Urea can be hydrolyzed under anaerobic conditions using a fixed film fixed bed (FFFBR) reactor. This can handle about 2 times more urea than a continuous flow stirred tank (CFSTR) reactor.

6. A plant unit with zero liquid effluent can be designed through use of process condensate stripper and condensate polisher unit for recycling of process condensate.

7. The total liquid effluent generated from the water treatment plant and other plants should be segregated into two categories i.e. strong effluent and weak effluent and collected into respective strong effluent tank and bulk effluent tank. After confirming the permissible limit set by the state pollution control board, part of bulk effluent can be utilized for gardening within the plant premises, balance quantity is used for irrigation purpose by farmers of nearby villages. The strong effluent can be pumped to solar evaporation lagoons if available in the premises. To avoid the seepage of effluent to underground water, lagoons should be laminated with two layers of 100 micron thick black polythene sheet spread on the 30 mm thick and 20 mm thick plaster layer of bentonite, cement and local soil respectively. Also inspection wells should be made nearer to the lagoons to monitor seepage of the effluent into underground water.

<table>
<thead>
<tr>
<th>CHARCATERISTIC</th>
<th>PHOSPHORIC ACID PLANT (mg/l) except ph</th>
<th>DI-AMMONIUM PHOSPHATE PLANT (mg/l) except ph</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: ANALYSIS OF WASTE WATER FROM PHOSPHATIC FERTILIZER PLANT
### WATER CONSERVATION MEASURES

The liquid effluents generated from the various plants can be treated through deep hydrolyser, distillation column, stripper and ETP based on steam stripping, disc oil separator, Reverse Osmosis plant, pH neutralization, guard pond, etc. to ensure that the treated water quality conforms to the specification laid down by the designated authority. Non-Chromate cooling water system can be adopted to eliminate the generation of chromium (hazardous heavy metals).

The conservation of water, being precious resource, has always been given importance and following schemes can be adopted since inception to optimize the utilization of water and the entire effluent generated in the factory is recycled / reused after adequate treatment in plant process and irrigation of farm lands:

1. **Treatment and reuse of process condensate and turbine condensate**

   In Ammonia Plant, process condensate is treated in the stripper for removal of its ammonical content. Further it can be allowed to pass through a polisher unit to remove all dissolved salts contained in the process condensate. The polished condensate if pumped to plant can be reused as boiler feed water. Similarly, the turbine condensate of Ammonia Plant can be sent to condensate polisher unit of D.M. Plant for polishing in Ion Exchange units. The treated water can thus be recycled and reused as boiler feed water for steam generation.

2. **Reuse of Steam Condensate from Urea Plant**

   The steam condensate from surface condensate of turbo driven CO2 compressor system and from process of Urea can be recycled to steam generation plant as a make up to boiler feed water.

3. **Treatment and Reuse of waste water of Urea Plant (Deep Urea Hydrolyser)**
In order to recover the valuable Urea and Ammonia from effluents and make the effluents reusable, the deep urea hydrolyser can be used.

(4) Treatment and reuse of Ammonical & Deoiled Effluent

Ammonical effluent and deoiled water from Ammonia and Urea Plant if treated in Ammonia stripper of effluent treatment plant, the treated effluent water can be recycled and reused in water softening plant.

(5) Total recycle of effluent through Reverse Osmosis effluent treatment plant

An effluent treatment cum recycle plant based on Reverse Osmosis Technology can be installed to treat the industrial liquid effluent e.g. regeneration effluent of D.M. Plant, cooling water blow down and surplus effluent water. The treated water can be reused in process as cooling water make-up.

EFFICIENT SOLID WASTE DISPOSAL STRATEGIES

Solid Waste Management: Domestic garbage generated from canteen and other areas of the plant should be collected and segregated. The reject paper bags and polythene bags should be stored in scrap yard and sold to outside party.

AMMONIA PLANT

Spent catalysts and molecular sieves, used up resins, sludge from process vessels, packaging materials, insulation rejects etc., are sources of solid waste generated in modern ammonia plants. Usually eight or nine different catalysts are used in a steam-reforming based ammonia plant and most of these catalysts have an average useful life of around 2 to 6 years after which they are replaced. In the case of partial oxidation plants the number of catalysts used are only three or four. These catalysts contain heavy and toxic metals such as hexavalent chromium, nickel, zinc, iron, mineral supports etc., and hence cannot be disposed as landfills. Some of these spent catalysts are used for metal recovery. Additives used in the potassium carbonate solution used for absorption of carbon dioxide such as vanadium pentoxide, arsenic tri oxide, amines are also hazardous. Start up and shut downs cause majority of the process emissions from the ammonia plant. Reduction in start up time, recovery of vent gases as fuel and use of flare will reduce air pollution during start up and shut down. The economically achievable minimum emission levels vary among old and new plants. Assuming steady-state production, oxides of nitrogen can be limited to 0.45 kilogram nitrogen oxides per tonne of ammonia (75 ppmv or 150 mg/NmJ ) in new plants, and about twice this in olden plants. Ammonia in wastewater can be reduced to 0.1 kilograms per tonne of ammonia produced. Spent catalysts can be limited to about 0.2 kilogram per tonne of ammonia. Environmental investment and operating costs vary according to emission standards or targets to be achieved, process design, integration with other facilities, raw materials, revamping requirements etc. The modern ammonia plant is characterized by large capacities and involves the storage, transport and handling of several hazardous and toxic materials in huge quantities. These involve petroleum feedstock and fuel, carbon monoxide, hydrogen, ammonia etc. that are hazardous. Hence it is
necessary that a comprehensive safety and risk analysis be carried out to operate and maintain these plants safely.

- **UREA PLANT**
  
  There are no solid wastes from urea plants except spillages of product and mechanical refuse which can be fully retrieved.

- **NITRIC ACID PLANT**
  
  Spent catalysts and resins are major solid waste generated from nitric acid plants. The platinum/rhodium catalyst after use is usually returned to the manufacturer for recovery of precious metals. Spent resins are burned in kilns. Nitrous oxide (N2O) emissions can be minimized by various means such as extended absorption in water to achieve a concentration of 100 ppmv. Alkaline absorption by treating the tail gas with sodium hydroxide solution produces nitrite solutions, which can be treated and safely disposed or sold. In non-selective catalytic reduction hydrogen or a hydrocarbon fuel is burned along with the tail gas over a platinum, rhodium or palladium catalyst to reduce nitrous oxide to nitric oxide. Tail gases may need to be pre-heated, and the use of hydrocarbon fuel release carbon monoxide and hydrocarbons in the atmosphere. In selective catalytic reduction ammonia is used to reduce nitrogen oxides to nitrogen over a catalyst such as vanadium pentoxide, platinum, iron/chromium oxides or zeolites. If there is some ammonia leakage, depending on catalyst efficiency, the tail gas must be kept above 100°C after expansion. On the other hand with ammonia addition and with a high efficiency catalyst, nitrogen oxides can be reduced to about 100 parts per million by volume (ppmv). Extended absorption and selective catalytic reduction are appropriate treatment techniques depending on their technical and economic feasibility. A Selective Catalytic Reduction (SCR) unit costs less than a new absorption tower, but the latter would have much lower associated running costs. With the above systems it is possible to achieve a reduction of nitrogen oxides to at least 150 ppmv (1.6 kilogram per tonne of 100% nitric acid), whilst the economic target for existing plant should be 400 ppmv (4.2 kilogram per tonne), except in the case of low pressure plants, where a realistic target would be 1000 ppmv (10.4 kilogram per tonne).

- **SULPHURIC ACID PLANT**
  
  Solid wastes from these plants are spent catalyst and sulphur muck. Spent catalyst is returned to the catalyst supplier for recycling. Otherwise, solid wastes are usually disposed of by landfilling, subject to screening for heavy metals.

- **HAZARDOUS CHEMICALS AND WASTE MANAGEMENT SUGGESTIONS**
  
  Following practices can be used for proper management of hazardous chemicals and wastes:
  
  - Filled containers with spent catalyst are taken to an isolated, covered designated area.
  - The spent catalyst is stored in sealed drums and sold out to authorized parties for recycling and reuse.
  - Proper training is being given and will continue to be provided to drivers for
transportation of hazardous chemicals, spill control and emergency actions.

- The storage conditions will be improved by taking necessary measures to reduce contamination.
- The personal protective equipment like hand gloves, PVC suit, safety goggles, dust mask and gumboots will be provided to the workers involved.

**NOISE LEVEL IN PLANT ATMOSPHERE AND ITS CONTROL**

Noise sources in fertilizer plants are furnaces and fired heaters, burners, blowers and fans, air coolers, pumps, compressors, cooling tower fans, steam venting and let down, grinders, crushers, centrifuges, compressed air, vibration of equipment and pipelines, moving machinery, conveyors etc.

Insulating the source from the operators console is usually adopted as the basic strategy to combat sound pollution. Special refractory linings for furnaces, insulation, low noise burners, installation of silencers for fans, blowers, vent stacks etc. special noise attenuation for ducting and pipe work, control valves with special trims to reduce noise, low air velocity and low fin tip air coolers, special protective enclosures for machinery such as pumps, turbines, compressors etc., are the available techniques by which the impact of sound pollution in plants are reduced to an acceptable level.

A proper routine and preventive maintenance procedure for all the noise generating equipment should be implemented and followed up in consultation with the respective units, which will help to minimize noise levels within the plant area. The noise levels in the work area shall be maintained within standard prescribed for the work area as per CPCB. Personal protective equipment like earplugs, earmuffs etc. shall also be provided to the operators, workers and other personnel within the plant. Proper maintenance of machinery will be ensured to reduce noise level.

**CONCLUSION**

Pollution of air, water and land caused by emissions and effluents containing oxides of nitrogen, sulphur, carbon, ammonia, hydrogen sulphide, fluorine, greenhouse gases, acid mist, dust and particulates, radiation, phosphogypsum, heavy metals, toxic chemical, used catalysts, resins, chemical residues and spillages and waste oil and lubricants, chlorofluorocarbons, laboratory wastes, redundant equipment, mechanical refuse, plastics etc., are the major environmental issues and concerns from the fertilizer industry. These concerns have been addressed in fertilizer production in such a way to keep the environmental impact of emissions and waste to a minimum by increasing the efficiency of production processes and adopting techniques of reducing pollution and through effective abatement. The extent of pollution and damage to the environment, arising out of the production processes varies with the different fertilizer materials and thus specific control strategies and optimization techniques have been suggested. With the currently available technologies, it is possible to control the impact of these concerns within an acceptable level.

This review suggests the following remedial measures:
1. Implementation of cleaner production processes
   Adoption of pollution prevention measures can yield both economic and environmental benefits. Gaseous emissions removal can be done by biohydrogenation and partial oxidation for sulphur removal, auto thermal reforming, adsorption for nitrogen oxides, double contact and double absorption process for sulphur oxide removal, segregation of various waste water streams, reduction, reuse and recycle of water, extended absorption and selective catalytic reduction for solid waste stabilization.

2. Treatment Technologies
   Gaseous emissions removal can be done by use of scrubbers, steam injection, NOx burners, cyclones, electrostatic precipitators, Brink filters and irrigated candle filters in sulphuric acid plant, ammonia removal by air stripping, steam stripping, lagooning after pH adjustment, nitrification and denitrification, noise control by use noise burners, installation of silencers for fans, blowers, special noise attenuation techniques etc.

3. Utilization of solid waste
   Opportunities to use phosphogypsum, the major kind of solid waste as a soil conditioner for alkali soil and soils deficient in sulphur should be explored. This will help in reducing volume of solid waste and save space for its disposal. Extended adsorption and selective catalytic reduction are appropriate techniques depending on their technical and economic feasibility.

4. Emission guidelines
   Well designed, well operated and well monitored pollution control systems help minimizing damages to the environment. The ideal air emission and effluent level should be achieved.

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