1. Introduction

For producing nitrogenous fertilizers a variety of feed stocks may be used such as – lignite, coke, coke oven gas, electrolysis of water, natural gas, associated gas, naphtha, fuel oil etc. Nomally fertilizer plants are located at the point nearest to the feed stocks considering the variety of the resources [1]. Pollution control of fertilizer industry is a very complex problem. Industries are following the three pronged approach of pollution abatement at source, recycle/reuse and treatment of effluents in dealing with problem [2]. The central board for prevention and control of water pollution has laid down minimal national standards, (MINAS) and industries follow these standards [1, 2].

Like any other chemical industry, fertilizer industry produces some gaseous/liquid/solid effluents depending on the technology adopted, feed stock used and location of the industry etc (Table 1). The two major effluent streams are from ammonia production and phosphoric acid production plants. Effluent from ammonia production is highly alkaline and contains excess ammonia from gas scrubbing and gas cleaning operations. The phosphoric acid effluent is acidic and contains high amount of phosphates and suspended solids. The characteristics are different for different effluents according to their feed stocks.

Table 1 Effluent components in fertilizer industry

Air Emissions	**Liquid Effluents**	**Solid Wastes**
Oxides of sulphur (SO_X) • Sulphur dioxide (SO_2 • Sulphur trioxide (SO_3) • Hydrogen sulphide (H_2S)	Ammonical nitrogen • Free ammonia • Ammonium salts	Carbon sludge
Oxides of nitrogen (NOx) • Nitrogen dioxide (NO_2) • Nitric oxide (NO)	Oxidized nitrogen • Nitrite nitrogen • Nitrate nitrogen	Hard coke
Ammonia	Organic nitrogen • Urea • Arsenic • Methanol • Oil and grease • Chromate • Phosphate • Sulphide	Lime sludge
Fluoride compounds		Arsenic sludge
Acid mist		Gypsum

The impacts of discharge of these wastes to the environment causes varied adverse conditions which mainly depend on the nature and the quantum of discharge of pollutants. Due to discharge of effluent the pollution level increases and the increased pollution levels both in atmosphere and in water causes serious environmental problems. When excessive amount of ammonia is being emitted to the atmosphere or discharged with wastewater effluent streams, it is considered as one of those harmful pollutant constituents that damage seriously the environment. Due to its high solubility in water and to its chemical reactivity, ammonia is considered cause for eutrophication of surface water (i.e. the enrichment of water by nutrients causing an accelerated growth of algae for example). Due to this algal boom, whole stretch of water becomes choked, plants rot, all oxygen used up and fish die [3]. As active chemical species, ammonia in atmosphere oxidizes and when it is washed out by rains, it forms nitric acid. As a consequence, acidic rains increase acidification problem in soil and ground water. A decayed alga imparts disagreeable odors and tastes to water [4, 5]. Ammonia in free-state is an irritant and highly toxic to fish. Oily wastewater generated by various industries and subsequently discharged into the natural environment not only creates a major ecological problem but also wastes water resources throughout the world, particularly in arid and semi-arid countries [6].

There are many methods of treatment of effluents to control the pollutants. Unlike other industrial effluents, fertilizer effluent stream should be segregated and treated separately and combined together for final disposal. Wastes utilization programme basically involves three phases namely reduction of pollution at source, recycling /reuse/recovery and waste treatment and ultimate disposal.

The key focus of this study is to prevent pollution and sustain industrial development by removing ammonia from wastewater. Removal of ammonia from liquid effluent by advanced methods of membrane distillation or pervaporation is considered. The effects of different operating parameters on ammonia removal from aqueous solutions have been investigated. Experimental results compared with simulated results of ammonia removal by steam stripping method using PRO II for same ammonia feed composition.

2. Methodologies

In the present work ammonia bearing effluent was collected in a pit. The wastewater specification used for the present work considered on the basis of average data of a local industry, as in Table 1. The pilot plant (Permionics India Ltd., Baroda, India) pervaporation set up was used in this experiment for removing ammonia from wastewater (shown elsewhere). A circular flat sheet membrane was used in the flat plate module of the experimental setup. The effect of feed temperature exposure on the removal efficiency of ammonia was investigated. The effect of downstream pressure on ammonia removal efficiency was observed by varying the down stream pressure in the range of 63 mbar to 103 mbar. The feed pressure, feed temperature and pH maintained constant. The thermodynamic experiments were studied over a temperature range of 49 – 55 °C at pH 9. Permeate samples were collected at one hour interval.

A steam stripper was simulated using PRO/II simulation software and the flow conditions like feed temperature, feed pressure, steam flow rate etc. optimized to acquire target ammonia concentrations (25 ppm) in bottom of stripper.

Table 1 Feed and steam specifications

Feed specifications		Steam specifications	
Feed flow rate	10 m^3/h	Steam temperature	148 ºC
NH_3	3000 ppm	Steam pressure	4.5 kg/cm^2
H_2O	Remaining		

3. Results and discussions

Ammoniacal wastewater containing ammonia and water with flow rate 10 m^3/hr, having ammonia composition 3000 ppm was treated by pervaporation method to obtain less than 25 ppm ammonia in treated water. Experiments were performed at 49 °C and 55 °C to investigate the effect of temperature of the feed solution on ammonia removal. Fig.1. showed that the ammonia removal was affected by temperature. Higher feed temperature resulted in higher ammonia removal efficiencies.

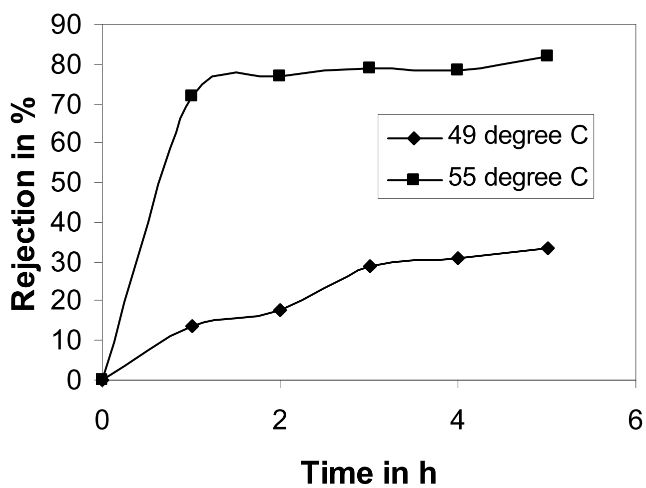

Fig.1. Plot of time vs. rejection on ammonia removal by pervaporation, influence of temperature. Operating parameters: Feed Pressure 1 kg/cm^2, pH 9, downstream pressure 63 mbar, feed concentration 3000 ppm

Experiments were conducted at 83 mbar to 103 mbar downstream pressure to find out the influence of downstream pressure on ammonia removal efficiency. Fig.2. showed that the ammonia removal was affected by downstream pressure.

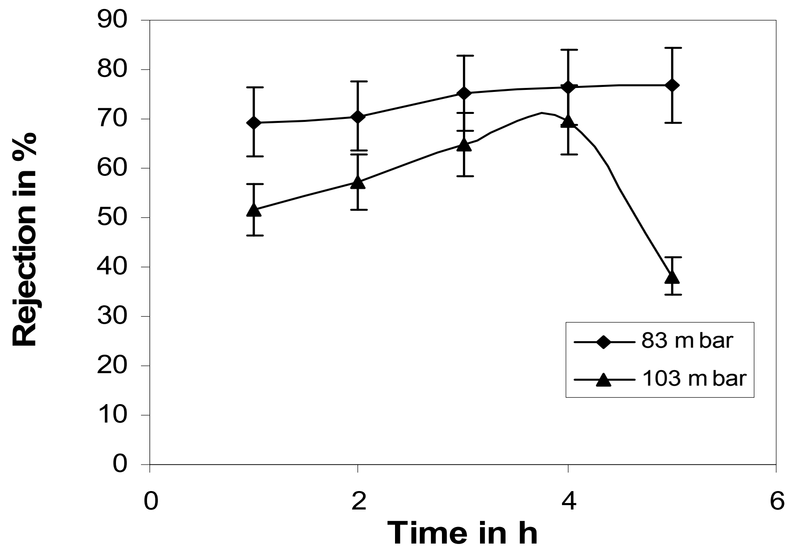

Fig.2. Plot of time vs. rejection on ammonia removal by pervaporation, Influence of downstream pressure. Operating parameters: Temperature 49 °C, pH 9, feed pressure, 1 kg/cm^2, feed concentration 3000 ppm

To compare removal of ammonia from wastewater by conventional steam stripper, theoretical simulation was performed at same feed and steam conditions. On increasing the temperature of the feed i.e. waste water stream at constant steam pressure, steam flow rate and steam temperature after simulation it was found that at 100ºC simulation converges. So 100ºC was assumed as optimum temperature. On increasing the steam pressure on top tray the removal efficiency of ammonia decreases at constant feed temperature, steam flow rate and steam temperature (Table 2). The steam flow rate affected the ammonia removal efficiency also. For same feed conditions and constant steam pressure and temperature, the ammonia removal efficiency increases with increasing steam flow rate (Table 3).

Table 2. Effect of pressure on ammonia concentration in the stripper bottom

Pressure(kg/cm^2)	Ammonia Concentration in bottom (ppm)
1	149.8
1.2	209.8
1.3	241.9
1.4	276.6
1.5	313.1

Table 3. Effect of Steam flow rate on ammonia concentration in the stripper bottom

Steam Flow Rate (kg/h)	Ammonia Concentration in Bottom (ppm)
500	1458.2
750	533.0
800	413.3
900	240.8
1000	137.4
1100	78.5
1200	45.4
1300	26.8
1325	23.6
1350	20.7

5. Conclusion

The effluents from fertilizer industry are treated by the above techniques according to their composition present in the effluent. At constant feed concentration, feed pressure, feed temperature and down stream pressure the concentration in permeate side decreases with increase in time. An experimental result shows that high feed temperature and low downstream pressures enhanced ammonia removal. From the simulation results it is concluded that 100^{o}C is the optimum temperature for ammonia removal from fertilizer waste water. On increasing the feed pressure or pressure at the top of the column the removal of ammonia decreases at fixed steam flow rate. It has been observed that as steam flow rate increases the ammonia concentration in bottom of the stripper decreases.

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