iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** X **Month of publication:** October 2022

DOI: https://doi.org/10.22214/ijraset.2022.45946

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue X Oct 2022- Available at www.ijraset.com

Ammonia Removal from Wastewater of Different Sources and Recent Development in Ammonia Stripping

Rushikesh Undalkar
Chemical Engineering Department, Vishwakarma institute of Technology, Pune

Abstract: Industrial wastewater contains organic impurities such as nitrogen compounds and many more. There is a limit to each compound in wastewater before discharging it into the ecosystem. It is maximum 2000-4000 g N/m3. It also depends upon different countries' environmental conservation laws. As nitrogen is harmful for aquatic life in low concentrations as well, it is needed to be treated before discharging and also before reuse in other applications. the removal of ammonia can be accomplished by steam stripping as well as by air stripping i.e. absorption and desorption. the conventional method of removal of ammonia is packed tower which has many issues in operation. Presently there are many advancements in removal of ammonia and research are going on in this paper we will discuss development in ammonia stripping and application with different sources of waste water from different industries.

Keywords: Ammonia stripping, Absorption, desorption, Packed tower, packing, wastewater treatment.

I. INTRODUCTION

In many developing countries there is problem of pollution which may be from industrial or agricultural or other human activities. Industrial waste water is also and big issue which needed to be solved with efficient technologies. The ammonia content in waste water is hazardous for aquatic life as well as for our ecosystem. In many industries ammonia content wastewater is generated and is also treated with different method depending upon its concentration. Most effective method to remove is ammonia stripping using air as an absorbent. This method is widely used due to its high advantages such as low cost, simple process, less manpower to handle. Other than this there are also many technologies like ion exchange, biological treatment, chemical treatment, etc. In many industries the recovered ammonia is reused in same process or it is sold to allied industries. So, ammonia recover is important in terms of economics as well as environment.

Many immerging technologies in ammonia stripping tells about the need of cost-effective process to remove ammonia from wastewater. Many researches are going on to develop most effective method to recover ammonia and other component which are useful in industries from waste generated from different sources.

Ammonia in water sources can take the form of ammonium ions (NH^{+}_{4}), dissolved ammonia (NH3), or a combination of both. In wastewater, ammonium ions coexist with ammonia and hydrogen ions.

$$NH3 + H2O \leftrightarrow NH4+ + OH- \leftrightarrow NH4OH \leftrightarrow NH3 + H2O$$

The undissociated ammonia can be removed using stripping and the amount depend upon the temperature and PH of the wastewater used in process. If the pH of liquid crosses 7 then equilibrium changes. According to Farrell If the pH is in range pf 10-11 the excess of hydroxyl ions are converts the NH4+ to NH4OH and liberates NH3 on contact with air.

II. AMMONIA STRIPPING

Ammonia stripping process is based on principal of mass transfer [1]. Basically, it is the advancement of aeration process used in wastewater treatment to remove impurities. Depending upon may researches, studies and comparison this method has been chosen as most effective for removal of ammonia from wastewater. In this process ammonia is removed by contacting wastewater with air. As seen before ammonia is found in two forms i.e. ions and in gaseous form which depends upon the temperature and pH.

As pH value plays an important role in the stripping process higher the pH higher the separation of ammonia so to increase the pH of the water other solvent are used such as lime which helps to shift the chemical equilibrium to right.

Temperature has been shown to have a significant impact on ammonia stripper performance [1]. This is due to Henry's law, which governs the solubility of ammonia in water. The constant of gas in Henry's law is dependent on solute, solvent, and temperature [1]. For example, Campos et al. discovered that removing ammonia from landfill leachate at 60°C was more significant over a 7-hour period than at 25°C [1]. In general, higher temperatures result in more efficient ammonia removal.

Apart from pH and temperature one more factor that affect the ammonia stripping i.e. water air ratio. Many studies have shown that optimum flow rate of both ammonia and water are needed for efficient separation. Lei et al. gave study about stripping efficiency of effluent influenced by air/water ratios. The study showed that higher ammonia removal rate was obtained after 12 h at an airflow rate of 10 L/min, in comparative to airflow rates at 3 L/min and 5 L/min [1].

Ammonia stripping has many advantages over other methods of removal of ammonia which are as follows:

1) High removal rate
2) Simple operation
3) Low cost operation.
4) Helps to reduce air pollution, discharge gases with low concentration.
5) Low cost secondary treatment
6) Effective method for ammonia removal

III. RESEARCH AND DEVELOPMENT IN AMMONIA STRIPPING

Many researches have been done on lab scale to the industrial level by researchers to obtain maximum data to help to optimize the process in different perspectives. lot of studies showed than ammonia stripping can be done more effectively by packed tower with high ammonia removal rate and as more cost-effective method. Different studies with different parameters gave high removal rate depending upon concentration and other conditions

O'Farell et al. did a study on nitrogen removal by stripping in a municipal wastewater treatment plant's secondary effluent. Prior to stripping, lime is added to raise the pH of the effluent, and this is followed by a recarbonation process to neutralize it [2]. Aside from increasing the pH of the wastewater, calcium oxide (lime) produces calcium carbonate in the wastewater and acts as a coagulant for hard and particulate matter [1]. Furthermore, O'Farell et al. discovered that the ammonia stripping method could remove up to 90% of the ammonia from the secondary effluent [1].

Some other studies are tabulated in table 1 with their parameter and ammonia removal efficiencies found in researches.

Source of water	Level of study	Methodology Or equipment.	Operating parameters	Ammonia content	Ammonia recovery efficiency	Reference
Waste water	Lab	Counter current packed tower	For packing height of 1.5 & 2.5 ft and air water ratio 27ft3/gal	3.7-3.3 mg/gal	14.1 & 18%	[3]
Waste water plant	Lab	Crossflow packed tower, chlorination, recarbonation, high lime treatment	Air water ratio 280 ft3/gal	16.5 mg/liter	55%	[4]
Fertilizer effluent	Lab	Packed bed	Airflow rate: 420 $m^3 \cdot m^{-2} \cdot h^{-1}$ Temperature: 25oc pH:11	2000 mg/lit	99%	[5]
Landfill leachat	Lab	Packed bed	Airflow rate: 4500 $l.h^{-1}$ Temperature: 25oc pH:11	1213	88%	[6]
Wastewater	Lab	counter current packed column	Air-water ratio of 3600 ft^/gal Hydraulic loading of 1.4 gpm/ft.		95%	[7]

Wastewater	Pilot plant	Ammonia absorption unit	Air-water ratio of 510 fr/gal Hydraulic loading of 0.8 gpm/ft2.		95%	[8]
Petroleum refinery wastewater	Lab	Packed bed	Airflow rate: 8495.1 l of air/gal of wastewater pH: 10.5	100	85%	[9]
Ammonia-rich soda ash wastewater		Microwave assisted air stripping	Ph: 11; time: 5 mins microwave radiation power: 750 w	1350	96.3%	[10]
Sludge liquor from municipal wastewater treatment plants		Ion exchanger loop stripping	pH: 10.5	2300	84.6%	[11]
Swine wastewater	Lab	Microwave assisted air stripping	Ph: 11 microwave radiation: 700 w	2740	88.2%	[12]
Water treatment plant		Counter current stripping column packed with wood grid packing	Air-water ratio of 550 ft^/gal and a hydraulic loading of 7.5 gpm/ft2, Ph of 11.2	3 mg/litre	80%	[13]
Reclamation plant	Pilot and full scale	Counter current and crossflow unit by placement of baffles	Air-water ratio of 250-500 ft3 /gallon		50-90%	[14]
Reclamation plant	Pilot plant	Packed column air stripping	Packed tower (2 ft high), Air-water ratio of 600 ft3 /gallon and a liquid surface loading of 1.0 gpm/ft2.		95%	[15]
Raw manure digestate Mixer		Mixer	Temperature: 23°C, pH: 10	5000	88.7%	[16]

Table 1: Several studies on ammonia stripping process with varied types of industrial wastewater

From above studies two major problems encounter in ammonia stripping are fouling and sludge formation. During operation there is deposition of salts over the packing material which increases the fouling tendency of material and also helps in increasing pressure drop across the tower which directly affect the efficiency of tower. Scaling can reduce tower efficiency at lager percentage on regular operation which increases the maintenance cost of tower.

The sludge formation due to salts present in water also increase the maintenance cost but it can be recovered after operation. Different techniques are used to remove sludge automatically without process interception and helps in high performance.

IV. AMMONIA RECOVERY FROM ML OF DYES PRODUCTION

In many dyes production plants effluent has many hazardous chemicals which are harmful for ecosystem. In anthraquinone dyes production ammonia is used in reaction which is carried throughout process and lastly it is removed in filtration. The ML is collected has some percentages of ammonia which can be recovered using stripping and reuse in same process which improves the productivity of plant.

The ammonia in the mother liquor is near about 5- 10% which is recovered using steam stripping process

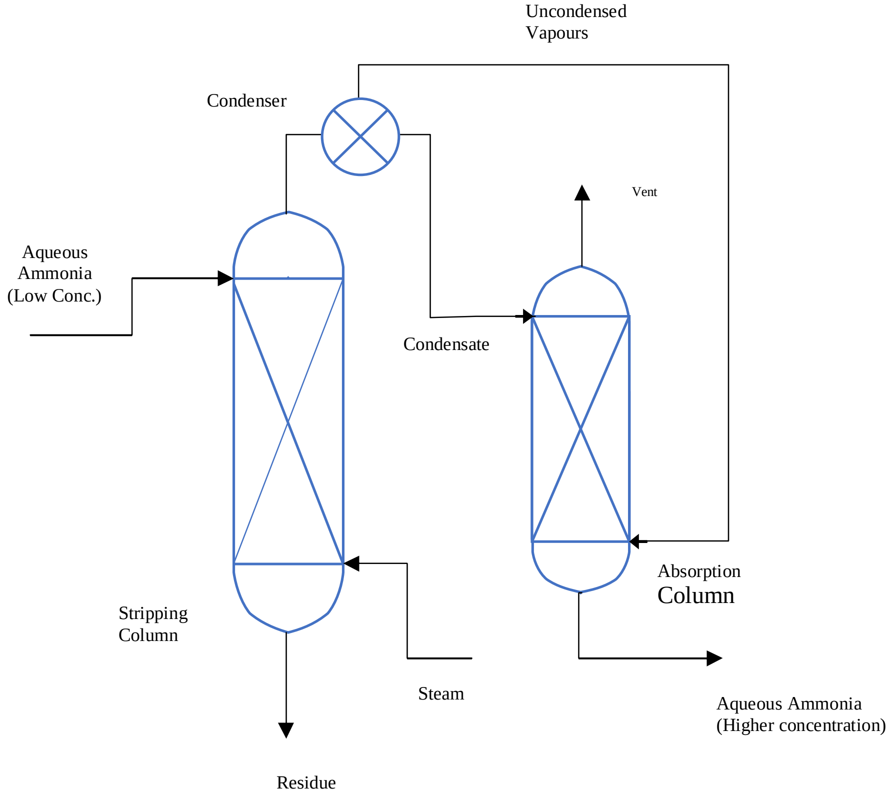

Figure 1: Ammonia recovery system

Property	Values
Temperature	25°C
Pressure	1 bar
Equipment	Packed tower
Packing	Pal Ring

Aqueous ammonia is feed to the stripping column at 500kg/hr and steam (LPS) is used for heating of solution up to 85°C (top temp.). Ammonia vapours are condensed and collected into storage vessel and uncondensed vapours are feed to absorption column from bottom of column and condensate is used as absorbent in absorption column which helps to attain required concentration of aqueous ammonia and can be used in reaction of same process.

At the bottom of absorption column, the aqueous ammonia with required concentration is obtained and is stored in tank farm for future batches. This technique helps to recover ammonia from effluent and reuse it in reaction of same process. Residue of stripping column has very less amount of ammonia concentration less than 2000ppm.

V. DEVELOPMENT IN AMMONIA STRIPPING

In recent decades many new technologies introduced in market to enhance the productivity of industries and treat hazardous effluent. Following are some advance equipment to remove ammonia from waste water:

Development in ammonia stripping:

In recent decades many new technologies introduced in market to enhance the productivity of industries and treat hazardous effluent.

Following are some advance equipment to remove ammonia from waste water:
1) Ion Exchange Loop Stripping
2) Microwave-Assisted Air Stripping
3) Membrane Distillation
4) Rotating Packed Bed Reactors
5) Jet Loop Reactor

Every equipment has its operation conditions for removal of ammonia from wastewater. But as compared to conventional packed tower these are more efficient with high removal rate and also has may other advantages such as
a) Low fouling tendency,
b) Low air consumption
c) Continuous operation in packed bed reactor
d) Removal of other impurities.
e) Higher tolerance to suspended solids

Among above membrane technologies are having prominent results in ammonia removal but it also has drawback same of in packed tower i.e. fouling. Microwave stripping also has high ammonia removal rate about 95% but it also has one disadvantage i.e. high-power consumption so, in both cases further researches are needed.

VI. CONCLUSION

Conventional method of ammonia stripping is widely used due to its some advantages, but more optimizations are needed in structure, operation and recovery. In recent development the technologies also have some drawback which need to be optimized. For high stripping efficiency with optimum operational cost technologies need to be developed in future. Ammonia stripping process is most convenient method of separation of ammonia from wastewater. As discussed most important factors that affect ammonia stripping are pH, air-water ratio and temperature so keeping this in mind process should be designed for ammonia removal. From recent technologies membrane distillation and microwave assisted air stripping are more efficient for ammonia removal. A cost analysis of advanced techniques is required to assess their economic viability for specific wastewater treatment.

REFERENCES

[1] L. Kinidi, I. A. W. Tan, N. B. Abdul Wahab, K. F. bin Tamrin, C. N. Hipolito, and S. F. Salleh, “Recent Development in Ammonia Stripping Process for Industrial Wastewater Treatment,” International Journal of Chemical Engineering, vol. 2018, 2018, doi: 10.1155/2018/3181087.
[2] A. Qarni, A. Balushi, M. Mahri, and M. A. Dwivedi, “Latest Trends on Ammonia Extraction: A Detailed Review of Ten Current Literatures,” International Journal of Students’ Research in Technology & Management, vol. 10, no. 2, pp. 10–22, 2022, doi: 10.18510/ijsrt.
[3] R. L. Mumford and J. L. Schnoor, “AWWA, Miami, Florida, 601,” 1982.
[4] van Vuuren, “JWPCF,” vol. 52, 4, 661, 1980.
[5] V. K. Minocha and A. V. S. P. Rao, “Ammonia removal and recovery from urea fertilizer plant waste,” Environmental Technology, vol. 9, no. 7, pp. 655–664, 1988.
[6] F. M. Ferraz, J. Povinelli, and E. M. Veira, “Ammonia removal from landfill leachate by air stripping and absorption,” Environmental Technology, vol. 34, no. 15, pp. 2317–2326, 2013.
[7] Trulsson and S.G., “JWPCF,” JWPCF, vol. 51, no. 10, p. 2513, 1979.
[8] Prettyman, R.W, and Kepple, “ASHRAE,” ASHRAE, vol. 41, 1976.
[9] B. V. Prather, “Wastewater aeration may be key to more efficient removal of impurities,” Oil and Gas Journal, vol. 57, pp. 78–89, 1959.
[10] J. C. Li Lin, “Removal of ammonia nitrogen in wastewater by microwave radiation: a pilot-scale study,” Journal of Hazardous Materials, vol. 168, no. 2–3, pp. 862–867, 2009.
[11] M. Ellersdorfer, “The ion-exchange-loop stripping process: ammonium recovery from sludge liquor using NACl-treated clinoptilolite and simultaneous air stripping,” Water Science and Technology, vol. 77, no. 3, pp. 695–705, 2017.
[12] J. H. La, T. Kim, J. K. Jang, and I. S. Change, “Ammonia nitrogen removal and recovery from swine wastewater by microwave radiation,” Environmental Engineering Research, vol. 19, no. 4, pp. 381–385, 2014.
[13] Short and C.S, “Water Services,” Water Services, vol. 3, no. 81, 1974.
[14] Wesner, G.M, Culp, R.L, J.G, and Gonzales, “JWPCF,” Public Works, vol. 5,6, no. 82, 1972.
[15] Slechta, A.F, Culp, and R.L, “JWPCF,” JWPCF, vol. 39, no. 5, p. 787, 1967.
[16] A. Limoli, M. Langone, and G. Andreottola, “Ammonia removal from raw manure digestate by means of a turbulent mixing stripping process,” Journal of Environmental Management, vol. 176, pp. 1–10, 2016.