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RESEARCH ARTICLE

Ammonia stripping using a continuous flow jet loop reactor: mass transfer of ammonia and effect on stripping performance of influent ammonia concentration, hydraulic retention time, temperature, and air flow rate

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Abstract

When wastewater containing ammonia is discharged into the receiving environment without any kind of treatment, it causes both environmental problems and negatively affects human health. In this study, the aim was to strip ammonia using air in a continuous flow jet loop reactor (JLR) and investigate the effects of ammonia concentration, hydraulic retention time (HRT), air flow rate, and temperature on ammonia removal within this scope. By changing the ammonia concentration in the influent, no significant change was observed in ammonia removal efficiency. With air flow rate 45 L min^{-1}, temperature 50 °C, pH 11, and HRT 7.5 h, mean 88.1% ammonia removal was achieved. Increasing the HRT, air flow rate, and temperature increased the ammonia removal efficiency. Later the ammonia stripping process in the continuous flow JLR was modeled and the volumetric mass transfer coefficient (K_La) for each parameter was calculated from the model equation. While the experimental parameters of air flow rate and temperature had a significant effect on the mass transfer coefficient, influent ammonia concentration and HRT were determined to have no effect.

Keywords Air stripping · Ammonia removal · Mass transfer · Ammonium · Modeling · Nitrogen

Introduction

One of the most important parameters that requires removal during domestic and industrial wastewater treatment is ammonia. Ammonia discharged into receiving environments (rivers, lakes, and seas) causes both environmental problems and negatively affects human health. Ammonia should be removed from wastewater due to toxic effects on sensitive biota in aquatic environments, reducing dissolved oxygen concentrations and causing eutrophication (Du et al. 2005). The main sources of ammonia pollution are landfill leachate, coke plant wastewater, digested swine wastewater, wastewater from the fertilizer industry, petrol refinery wastewater, metallurgic wastewater, and domestic wastewater (Tasdemir et al. 2020; Cao et al. 2019a). Increasing awareness of the harmful effects of ammonia released from wastewater treatment facilities into natural water systems has resulted in laws and regulations limiting ammonia discharge. As a result, many methods were developed to remove or recycle ammonia in water. Some of these methods include nitrification-denitrification (Bernet et al. 2000), chemical precipitation (Zhang et al. 2009), reverse osmosis (Bodalo et al. 2005), ion exchange and adsorption (Mohtar et al. 2020; Wu et al. 2019), and air stripping. The nitrification-denitrification process is the first process considered for ammonia removal from wastewater; however, it has disadvantages like long retention time, being affected by climatic conditions and high output ammonia concentration after treatment (Yuan et al. 2016a). Chemical precipitation is not suitable for commercial applications, is affected by the

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wastewater composition, and may create secondary pollutants (Yin et al. 2018). Reverse osmosis requires regular backwashing of the membrane due to membrane fouling (Huang et al. 2018). Finally, it is necessary to use a method that is easy and has an appropriate cost for operations to remove ammonia from wastewater.

There is an equilibrium between ammonium ions (NH_4^+) and un-ionized ammonia (NH_3) in water and wastewater. This equilibrium is affected by both the pH and temperature. In alkaline media, ammonium ions transform to non-ionized ammonia (Santos et al. 2020; Soetardji et al. 2015). The air stripping process brings a liquid mixture into contact with air and ensures the mass transfer of volatile components (ammonia, volatile organic components, etc.) from liquid form to gas form (Basakcilardan-Kabakci et al. 2007). Ammonia removal with the air stripping process is relatively cheap and has high ammonia removal efficiency (Hossini et al. 2016). With this method, the ammonia removal process uses simple equipment, and removal performance is not affected by wastewater fluctuations and toxic material (Yuan et al. 2016b). Air stripping in combination with absorption can be used to remove and recover ammonia from wastewater. Ammonia is transferred into the air bubble, then absorbed from the air bubble into a concentrated sulfuric acid solution, thereby generating an ammonium salt, which can be crystallized (Bonmatí and Flotats 2003). However, the mass transfer coefficient for ammonia from liquid phase to gas phase is low in a packed tower and long aeration durations are required due to blockage problems occurring during the process (Quan et al. 2009). Ammonia stripping performance is generally linked to temperature, pH, and air/water ratio (Provolo et al. 2017).

In recent years, unpacked gas-liquid contactors with high mass transfer rate have been used for the ammonia stripping process (Tasdemir et al. 2020; Liu et al. 2015; Quan et al. 2009). Due to better mixing features than classical reactors, jet loop reactors (JLR), with increasing potential for use in industrial wastewater treatment, may be used for ammonia removal with air stripping (Degermenci et al. 2012). Compared with classic reactors, JLR have many advantages like simple construction, better circulation with the same energy input compared to classic reactors, low investment and operating costs, better levels of gas dispersion, high heat and mass transfer, providing very homogeneous concentration and thermal profiles, no moving pieces within the reactor, and easy transition from the lab and pilot-scale equipment to industrial-scale equipment (Petruccioli et al. 2002; Farizoglu et al. 2004; Fadavi and Chisti 2005; Degermenci et al. 2016; Barlak et al. 2020). Due to these advantages, a continuous flow JLR was used with the aim of air stripping ammonia. The parameters most affecting ammonia removal include air flow rate, temperature, influent ammonia concentration, and hydraulic retention time, so the effect of these parameters was studied by using synthetically prepared wastewater containing ammonia. Additionally, a mathematical model was used to calculate the volumetric mass transfer coefficient for the ammonia stripping process.

Materials and methods

Experimental setup

The removal of ammonia by air stripping in the JLR used an experimental system with the schematic representation given in Fig. 1. The JLR was created by using two plexiglass cylindrical tubes, one inside the other. The reactor or outer tube had 100-mm external diameter and 4-mm wall thickness, while the draft tube or inner tube had 40-mm external diameter and 3-mm wall thickness. The large division at the top of the reactor is called the degassing tank. The degassing tank has a 180-mm diameter and 4-mm wall thickness. The lengths of the reactor, draft tube, and degassing tank were 85 cm, 65 cm, and 30 cm, respectively. The draft tube was placed radially in the center of the reactor. The reactor created using three cylindrical tubes had a total height of 105 cm. The liquid containing ammonia pumped by the circulation pump and the air coming from a separate line are passed through a jet nozzle and sprayed into the draft tube. The two-phase stream, which passes through the draft tube, strikes the impact plate directly below the reactor and changes direction from the sides to move upwards. Some amount of the liquid that reaches the level of the draft tube and contains air bubbles is pulled into the draft tube again due to pressure drop and the cycle continues. The liquid sprayed from the jet nozzle must be strong enough to push the air sent into the JLR under the draft tube. Thus, the liquid circulation rate in the JLR was chosen as 50 L min^{-1} to guarantee circulation around the draft tube. The jet nozzle shown in Fig. 1 comprises two tubes with a common center. The internal diameter of the external cylinder where liquid flows is 15.7 mm, while the internal diameter of the inner cylinder where air flows are 4 mm, with a wall thickness of 1.2 mm. The air and liquid flow rates are controlled by valves and flowmeters on the relevant pipelines. During the experiment, air entering the reactor is provided by an air compressor (ABAC). In order to remove the excessive heat produced by the degassing tank circulation pump, it was equipped with a stainless steel serpentine cooler. The reactor temperature was set by changing the flow rate of fluid passing through the serpentine cooler. The liquid volume of the JLR was 9 L and it was filled with deionized water at the start of the experiment. Later, the reactor was fed with synthetic wastewater prepared with NH_4Cl with a fixed influent flow rate. To ensure wastewater input and output in the system, a Cole Parmer brand Masterflex L/S model peristaltic pump was used. With

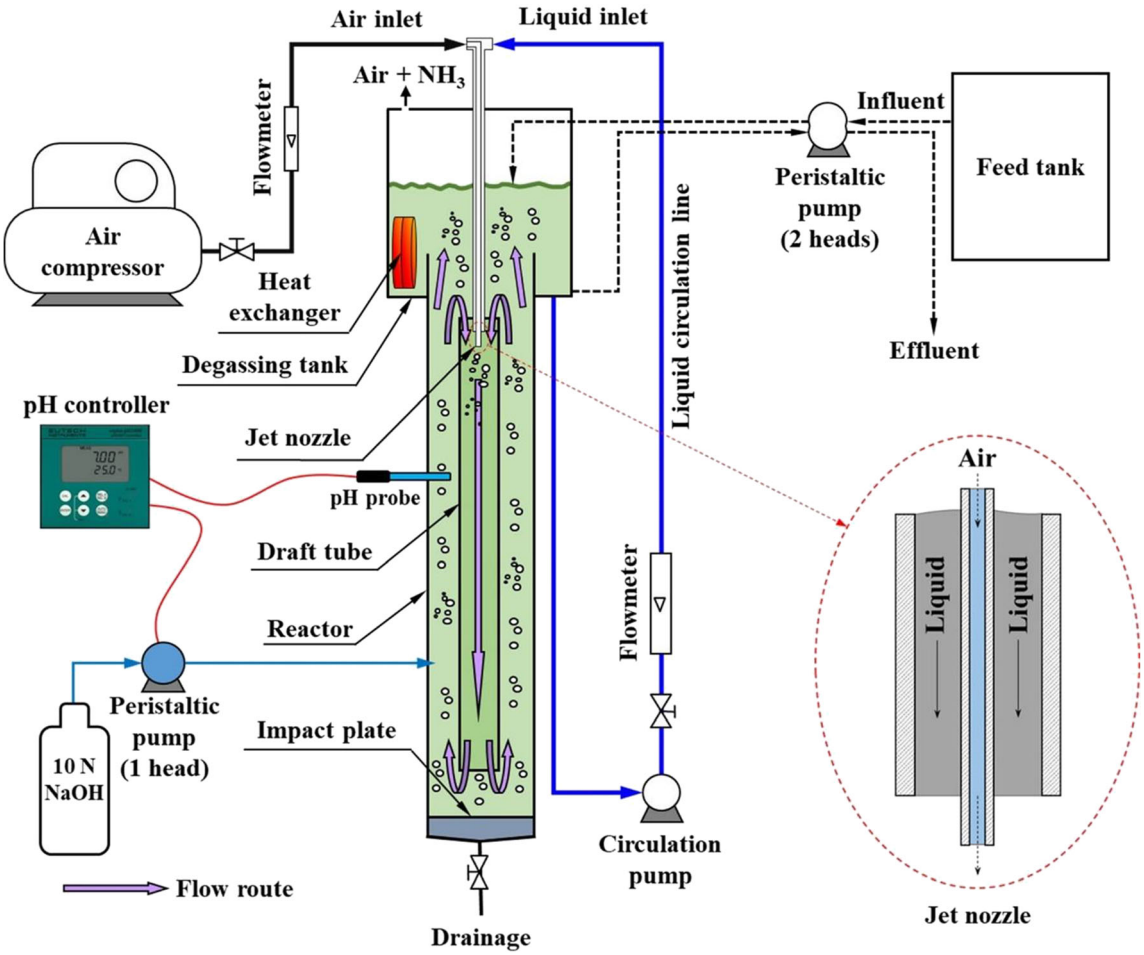

Fig. 1 Schematic view of the JLR system for stripping ammonia

the removal of NH_3 from the JLR, the pH falls over time. In all experiments, 10 N NaOH was used to keep the pH fixed at 11. In order to keep the pH value in the JLR at a constant value, a pH control system (Alpha pH 1000, Eutech) consisting of a MasterFlex peristaltic pump operated as on-off control was used. Ammonia concentration in the samples was measured using an ion-selective electrode which was attached to an Orion Portable pH and ISE Meter-290A+ (Thermo-Scientific).

Determination of mass transfer coefficient and ammonia removal efficiency

The mathematical mass equation for the continuous feed JLR may be written as in Eq. (1):

$$V_L\frac{dC_L}{dt}+\varepsilon_G V_L\frac{dC_G}{dt}=Q_L C_{L,\text{in}}-Q_L C_{L,\text{out}} + Q_G C_{G,\text{in}}-Q_G C_{G,\text{out}} \quad (1)$$

where Q_G is the volumetric air flow rate (L min^{-1}), $C_{G,\text{in}}$ and $C_{G,\text{out}}$ are the ammonia concentrations in the air entering and leaving the JLR (mg L^{-1}), V_L is the liquid volume in the JLR (L), $C_{L,\text{in}}$ and $C_{L,\text{out}}$ are the ammonia concentrations in the liquid phase entering and leaving the JLR (mg L^{-1}), and ε_G is the gas (air) holdup or the volume fraction of the air bubbles entrained in the liquid (dimensionless).

As the ammonia accumulation in air bubbles is insignificant and there is no ammonia in influent air, the second term in Eq. (1) and $C_{G,\text{in}}$ is zero. As a result, Eq. (1) can be restated in the form given in Eq. (2).

$$V_L\frac{dC_L}{dt}=Q_L C_{L,\text{in}}-Q_L C_{L,\text{out}}-Q_G C_{G,\text{out}} \quad (2)$$

To solve Eq. (2), the ammonia concentrations in air and liquid exiting the reactor are needed. The equilibrium equation between air and liquid for any gas is given by Henry's law equation (Eq. (3)):

$$C_{G,\text{out}}=K_H C_L^* \quad (3)$$

where K_H is the dimensionless Henry constant and C_L^* is the concentration of ammonia in the liquid phase in equilibrium with air bubbles.

Combining Eqs. (2) and (3) gives Eq. (4).

$$\frac{dC_L}{dt} = \frac{Q_L}{V_L}\left(C_{L,\text{in}} - C_{L,\text{out}}\right) - \frac{Q_G K_H}{V_L} C_L^* \quad (4)$$

Ammonia stripping with air can be explained with the aid of a mathematical model based on two-film theory. With this aim, Matter-Muller et al. developed a model for gas transfer with air bubbles (Matter-Muller et al. 1981). In this model, when volume and pressure changes in air bubbles are ignored, the concentration of matter (ammonia) in equilibrium with the gas phase concentration is given by Eq. (5):

$$C_L^* = C_{L,\text{out}}\left[1 - \exp\left(-\frac{K_L a V_L}{K_H Q_G}\right)\right] \quad (5)$$

where K_L represents the total mass transfer coefficient and a is the interface area per unit liquid volume ($K_L a$, volumetric mass transfer coefficient). By combining Eqs. (4) and (5), they can be rewritten as Eq. (6).

$$\frac{dC_L}{dt} = \frac{Q_L}{V_L}\left(C_{L,\text{in}} - C_{L,\text{out}}\right) - \frac{Q_G K_H}{V_L}\left[1 - \exp\left(-\frac{K_L a V_L}{K_H Q_G}\right)\right] C_{L,\text{out}} \quad (6)$$

Due to the very short retention time of the stripping gas in the JLR, the output stripping gas is probably not close to saturation, so $(K_L a V_L)/(K_H Q_G) << 1$. Therefore, Matter-Muller et al. stated that the volumetric mass transfer coefficient can be calculated (Matter-Muller et al. 1981). In this situation, Eq. (6) transforms into Eq. (7).

$$\frac{dC_L}{dt} = \frac{Q_L}{V_L}\left(C_{L,\text{in}} - C_{L,\text{out}}\right) - K_L a C_{L,\text{out}} \quad (7)$$

Equation (7) is called the ordinary differential equation and was solved using the Runge-Kutta-4 integration method in the Berkeley Madonna program and the time-linked variation in ammonia concentration was calculated. The "curve fit" feature of the Berkeley Madonna program was used to minimize the standard deviation between the coefficients calculated with the model and the experimental data.

The efficiency of ammonia removal by air stripping was calculated by the following equation:

$$\text{Ammonia removal } (\%) = \left(1 - C_{L,\text{out}}/C_{L,\text{in}}\right) \times 100 \quad (8)$$

where $C_{L,\text{in}}$ is the influent ammonia concentration and $C_{L,\text{out}}$ is the effluent ammonia concentration.

Results and discussion

Effect of influent ammonia concentration

With the aim of determining the effect of influent ammonia concentration, synthetic wastewater containing 100 mg L^{-1}, 250 mg L^{-1}, and 500 mg L^{-1} ammonia was continuously fed into the JLR and the variation in effluent flow ammonia concentration was investigated linked to stripping duration. Air flow rate, hydraulic retention time, and temperature were fixed at 45 L min^{-1}, 7.5 h, and 50 °C, respectively. The results obtained are given in Fig. 2. With 10-h stripping duration, for 100 mg L^{-1}, 250 mg L^{-1}, and 500 mg L^{-1} influent ammonia concentration, the JLR effluent ammonia concentrations were 11.5 mg L^{-1}, 30.1 mg L^{-1}, and 60.9 mg L^{-1}, respectively. As understood from the results, the increase in influent ammonia concentration increased the effluent ammonia concentration. However, no significant variation was observed in ammonia removal efficiencies. For different influent ammonia concentrations, mean 88.1 ± 0.3% ammonia removal was obtained. With these results, ammonia removal efficiency can be said to be independent of influent ammonia concentrations. In other words, ammonia stripping efficiency for a system controlled by diffusion via a gas film theoretically is independent of ammonia concentration. For example, a study of ammonia stripping using a water-sparged aerocyclone (WSA) stated that efficiency was theoretically independent of volatile matter concentration (Quan et al. 2009). With the increase in concentration, the ammonia air stripping rate increased. The increased ammonia concentration increases the driving force for mass transfer and may cause higher ammonia removal rates.

The duration for effluent ammonia concentration to become steady in the JLR was determined with the aid of Fig. 2. With an influent ammonia concentration of 100 mg L^{-1}, the effluent ammonia concentration became stable in 2 h, while this value was 3 h for 250 mg L^{-1} and 4 h for 500 mg L^{-1}. The increase in influent ammonia concentration increased the duration required for the system to reach a steady state. The reason for this is that initially, the liquid in the reactor did not contain ammonia, so the increase in influent ammonia concentration increased the duration necessary for the effluent

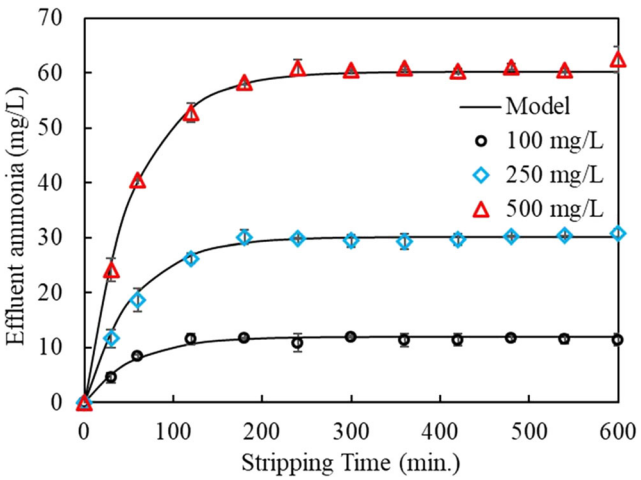

Fig. 2 Effect of influent ammonia concentration on air stripping of ammonia (pH = 11, Q_G = 45 L min^{-1}, HRT = 7.5 h, T = 50 °C)

ammonia concentration to become steady. Finally, the mass transfer coefficient was calculated from the mathematical model given in Eq. (7) and was found to be 1.0131 h^{-1}, 0.9756 h^{-1}, and 0.9613 h^{-1} for 100 mg L^{-1}, 250 mg L^{-1}, and 500 mg L^{-1}, respectively. The results show that ammonia concentration does not have a significant effect on mass transfer coefficients. Studies in different reactors reported K_La was not affected by input ammonia concentration (Ata et al. 2016; Quan et al. 2009).

Effect of hydraulic retention time

The hydraulic retention time (HRT) is an important parameter directly affecting the design, cost, and energy requirements of wastewater treatment (Viero and Sant'Anna 2008). Generally, high HRT will lead to higher investment and operation costs. As a result, varying HRT has significant effects on ammonia removal. As a result of experiments in the JLR, the effect of HRT on effluent ammonia concentration linked to stripping duration is shown in Fig. 3. For 2.50 h, 3.75 h, and 7.50 h HRT, steady-state effluent ammonia concentrations were 141 mg L^{-1}, 107 mg L^{-1}, and 60.9 mg L^{-1}, respectively. Steady-state ammonia removal efficiencies were found to be 71.8%, 78.6%, and 87.8% for 2.50 h, 3.75 h, and 7.50 h HRT, respectively. The increase in HRT (reduction in feed flow rate with a constant volume) reduced the ammonia concentration in the effluent. A study with ammonia removal by air stripping using a rotating packed bed (RPB) reported similar results (Yuan et al. 2016b). Later, durations required for ammonia removal to reach a steady state were determined and were found to be 2 h, 3 h, and 4 h for 2.50 h, 3.75 h, and 7.50 h HRT, respectively. Lin et al. reported a similar trend for ammonia removal with microwave radiation (Lin et al. 2009). As understood from the results, the duration required for the JLR effluent ammonia concentration to reach a steady state increased with the increase in hydraulic retention time. With the reduction in the hydraulic retention time, in other words, increasing the feed flow rate, the ammonia load entering the system is increased. As a result, the duration for the system to reach a steady state reduces with the increase in input ammonia load. Later, the effect of HRT on the volumetric mass transfer coefficient was determined. K_La obtained from the mathematical model given in Eq. (7) were calculated as 0.9634 h^{-1}, 0.9575 h^{-1}, and 0.9613 h^{-1} for 2.50 h, 3.75 h, and 7.50 h HRT, respectively. Results clearly show that hydraulic retention time does not have an important effect on mass transfer coefficients.

Effect of air flow rate

Air flow rate is an important factor for the ammonia stripping process (Pi et al. 2009). With the aim of determining the effect of air flow rate on effluent ammonia concentration, experiments were performed with 20 L min^{-1}, 30 L min^{-1}, and 45 L min^{-1} air flow rate. Experiments fed synthetic wastewater containing 500 mg L^{-1} ammonia into the reactor at a 20 mL min^{-1} flow rate (HRT = 7.50 h). The reactor was set to pH 11 and temperature 50 °C and results are given in Fig. 4. At the end of the 10-h stripping duration (steady state), the JLR effluent ammonia concentrations were 144 mg L^{-1}, 101 mg L^{-1}, and 60.9 mg L^{-1} for 20 L min^{-1}, 30 L min^{-1}, and 45 L min^{-1} air flow rate, respectively. Hence, the increase in air flow rate caused a reduction in the effluent ammonia concentration. The steady-state ammonia removal efficiencies for 20 L min^{-1}, 30 L min^{-1}, and 45 L min^{-1} air flow rate were 71.2%, 79.8%, and 87.7%, respectively. A high air flow rate reduces the gas film layer thickness due to increased gas-liquid interface area and turbulence; as a result, ammonia removal efficiency and volumetric mass transfer coefficient increase (Degermenci et al. 2012). The volumetric mass transfer coefficients obtained from the mathematical model were calculated as 0.3055 h^{-1}, 0.5194 h^{-1}, and 0.9613 h^{-1} for 20 L min^{-1}, 30 L min^{-1}, and 45

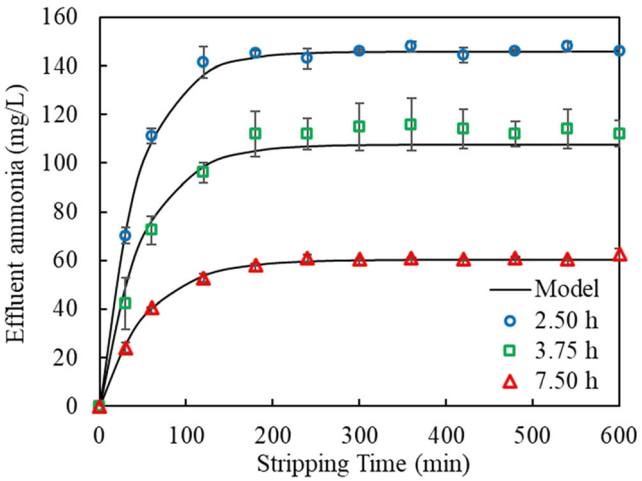

Fig. 3 Effect of HRT on effluent ammonia concentration (pH = 11, C_0 = 500 mg L^{-1}, Q_G = 45 L min^{-1}, T = 50 °C)

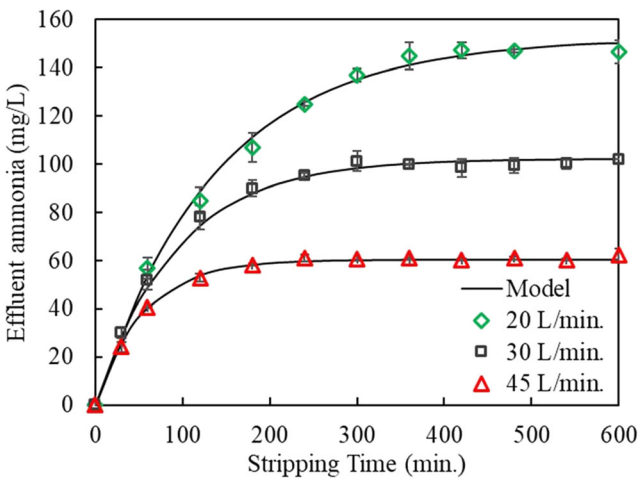

Fig. 4 Effect of air flow rate on effluent ammonia concentration (pH = 11, C_0 = 500 mg L^{-1}, HRT = 7.50 h, T = 50 °C)

L min^{-1} air flow rates. Due to the high solubility of ammonia in liquid, all mass transfer resistance in the ammonia stripping process is basically on the gas film side (Zhu et al. 2017). The mass transfer resistance in the gas film may be reduced by increasing the air flow rate; hence, increasing the air flow rate encourages stripping of ammonia from wastewater (Quan et al. 2009). Using the experimental results, the durations required for the effluent ammonia concentration to reach a steady state were determined. For 20 L min^{-1}, 30 L min^{-1}, and 45 L min^{-1} air flow rate, the durations were 6 h, 5 h, and 4 h, respectively. The increase in air flow rate causes a reduction in the duration required for the system to reach a steady state. In this situation, lower air flow rates will reduce ammonia removal and as there is no ammonia in the liquid within the reactor initially, the duration for the system to reach a steady state will increase.

Effect of liquid phase temperature

Wastewater temperature is an important factor in the ammonia stripping process. With the aim of determining the effect of temperature on effluent ammonia concentration, experiments were performed at 20 °C, 30 °C, and 50 °C. Experiments used synthetic wastewater containing 500 mg L^{-1} ammonia. The hydraulic retention time for the synthetic wastewater in the JLR was 7.50 h and the air flow rate was 45 L min^{-1}. As shown in Fig. 5, the effluent ammonia concentrations reduced with increasing temperature and steady-state ammonia concentrations were measured as 193 mg L^{-1}, 126 mg L^{-1}, and 60.9 mg L^{-1} at 20 °C, 30 °C, and 50 °C, respectively. In conclusion, a higher medium temperature ensured higher ammonia removal. Later, the mass transfer coefficients were calculated from the mathematical model and values were 0.1895 h^{-1}, 0.3741 h^{-1}, and 0.9613 h^{-1} at 20 °C, 30 °C, and 50 °C, respectively. The increase in temperature supports molecular diffusion in the ammonia gas film causing an increase in all mass transfer coefficients. Liu et al. found similar results using a stripping tower (Liu et al. 2015).

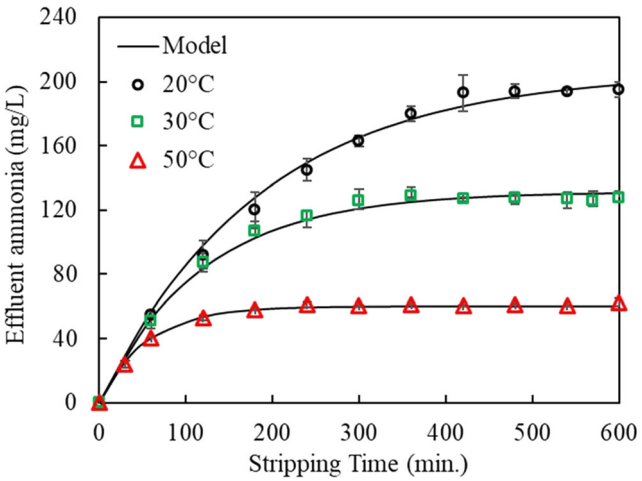

Fig. 5 Effect of temperature on effluent ammonia concentration (pH = 11, C_0 = 500 mg L^{-1}, Q_G = 45 L min^{-1}, HRT = 7.50 h)

The increase in temperature may cause an increase in molecular diffusion in both ammonia liquid and gas films (Ata et al. 2016). The Henry constant given in Eq. (3) increases due to the increase in temperature; hence, the solubility of ammonia gas in water reduces. Due to this effect, the mass transfer rate increased from the liquid phase to the gas phase. Stated differently, increasing temperature assists desorption of ammonia from the liquid. Many studies in the literature concluded that higher temperatures increased ammonia stripping efficiency (Yuan et al. 2016b; Cao et al. 2019b; Saracco and Genon 1994). As a result, for air stripping of ammonia, the process should be operated at a higher temperature if possible.

Comparison with other ammonia stripping reactors

The continuous flow JLR used with the aim of ammonia stripping was compared with a continuous flow rotating packed bed (RPB) and packed type stripping tower reactor (Table 1). Various parameters such as power consumption, treatment efficiencies and hydraulic retention times are needed to compare reactors. In reactors used in ammonia stripping, the air/water ratio varies between 30:1 and 6000:1. Studies show that ammonia stripping efficiencies do not increase much at 1500–2000:1 and above. Again, studies have shown that the air/water ratio is not as effective as pH (Gustin and Marinsek-Logar 2011). For this reason, in the comparisons in Table 1, attempts were made to use results with the same pH and temperature values. When Table 1 is examined, JLRs require longer hydraulic residence time in continuous feed experiments for different types of wastewater. As seen from Table 1, the amount of air introduced into the unit volume of the reactor is the lowest in JLR. However, the removal efficiency is as high as other applications. This situation is explained as a result of the turbulence in the reactor and the efficiency of mass transfer. In JLRs, reactor temperature increases due to circulation. This eliminates the need for an additional external heater. In addition, an important advantage in JLRs is that there are no moving parts in the reactor and it does not cause problems such as clogging due to scale formation in packed towers. As a result, a real comparison must be made considering the construction and operating costs of these reactors.

Conclusion

In this study, the continuous flow JLR displayed high removal efficiency for air stripping of ammonia. A notable variation in ammonia removal efficiency was not observed by changing the initial ammonia concentrations. However, increasing HRT, air flow rate, and temperature increased ammonia

Table 1 Comparison of JLR, RPB, and packed tower

Reactor type	pH	V_L (L)	Q_G (L min^{-1})	Q_L (L min^{-1})	T (°C)	Q_G/V_L (min^{-1})	Q_G/Q_L	Efficiency (%)	Reference
Jet loop reactor	11	9	45	0.02	50	5	2250	87.8	This work
	11	9	45	0.02	30	5	2250	74.8	
	11	9	45	0.02	20	5	2250	61.4	
Rotating packed bed	11	0.4	80	0.05	40	200	1600	81	Yuan et al. (2016b)
	11	0.4	80	0.05	30	200	1600	69	
	11	0.4	90	0.05	25	225	1800	64	
Packed tower	10.5	1000	25,000	7.44	15	25	3360	75	Li et al. (2006)
Packed tower	10.5	21.2	1600	0.8	50	75	2000	92.8	Gustin and Marinsek-Logar (2011)

removal efficiency. Maximum removal efficiency with different influent ammonia concentrations was obtained as 88.1 ± 0.3% with 45 L min^{-1} air flow rate, 50 °C temperature, pH 11, and HRT 7.5 h. Operating the ammonia stripping process at higher air flow rates and temperatures may significantly increase the ammonia removal efficiency. For effective removal with the air stripping process in JLR of a continuous flow of ammonia, firstly high medium temperature, then high air flow, and finally high HRT are required. For each parameter, the mass transfer coefficient was calculated in a model equation obtained by modeling the ammonia stripping process in continuous flow JLR. While air flow rate and temperature were identified to have a significant effect on mass transfer coefficient, initial concentration and HRT were determined not to have significant effects on K_La.

Availability of data and materials Not applicable.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by N.D. and E.Y. The first draft of the manuscript was written by N.D. and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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