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Study Regarding the Process of Ammonia Ions Removal from Water Using the Ion Exchange

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Abstract: The paper presents the studies regarding the process of ammonium ions elimination from water using the method of ion exchange. The best conditions of the process are established, conditions that allow the achievement of a maximum separation degree of the ammonia ions, respectively the realization of a minimum residual concentration. Studies on the ion exchange process have as target the establishment of the chemical composition and the thermal influence. The target of the studies on ion exchange process is also to establish the retention degree.

Keywords: water treatment, ammonia removal, ion exchange process

1. Introduction

The purpose of this paper is to determine the retention degree of ammonia ions from synthetic water with a known content of ammonia using an ion exchange.

The ammonia is an indicator of drinking water pollution [1].

The ammonia result in water from incomplete degradation of organic substances that contain azotes or it can come from ground. The ammonia represents the first stage of the decomposition of organic substances with azotes in their molecules and this is the reason why it indicates a recent pollution (hours – days) and by consequence a very dangerous one.

The methods used to eliminate the ammonia from water are ion exchange, biological processes, chlorination, ozonizing, stripping.

The ion exchange method is successfully used for small concentrations of ammonium ions and it is recommended to be used for drinking water analysis [2, 3].

This paper shows the variation of the ammonium ion's concentration after advance separation using this method of ion exchange.

This procedure is based on the property of some naturals or synthetics materials to retain the ions present in a liquid (water), simultaneous with the yield of an equivalent quantity of ions that they posses.

In the paper is study the retention capacity of the ion exchange DOWEX type 50 WX 4 for ammonium ions from water.

2. Experimental

We used water samples with a known content of ammonium ions (50 mL with a 50 mg/L NH_4^+ concentration) in which we added different quantities of ion exchanger Dowex (0.1g, 0.2g, 0.3g, 0.4g, 0.5g). The samples were shake time of 5min, 10min, 15min and 20min, at different temperatures (15°C, 20°C, 25°C, 30°C, 35°C). For the stirring we used a shaker Bath type 609/A. After the stirring we have determinate the residual concentration of ammonium ions using the spectrophotometer method, at a wavelength equal to 440 nm with Nessler reagent [4, 5, 6].

For this analysis we used one UV-VIS spectrophotometer Varian Carry 50.

The ions exchanger DOWEX 50 WX 4 is a cation exchanger who is found in Na^+ or H^+ form. In this study we used exchanger DOWEX in Na^+ form and for the swollen of ion granules we used bidistillate water.

3. Results and discussion

3.1 The residual concentration of ammonium ions depending on the quantity of ion exchanger, stirring time and temperature

The experimental results regarding the residual concentration of ammonium ions depending on the quantity of ion exchanger and stirring time at a 15°C temperature are presented in Table 1 and Figure 1.

TABLE 1. Experimental data regarding the residual concentration of ammonium ions correlated with the quantity of ion exchanger and stirring time at 15°C temperature.

No.	Quantity of ion exchanger, g	Residual concentration of NH_4^+, mg NH_4^+/L			
		5 min	10 min	15 min	20 min
1	0.1	6.5	6.5	5.9	5.9
2	0.2	6.5	6.2	5.9	5.4
3	0.3	5.7	5.6	5.3	4.9
4	0.4	5.7	5.1	5	4.4
5	0.5	5.2	4.9	4.5	4.4

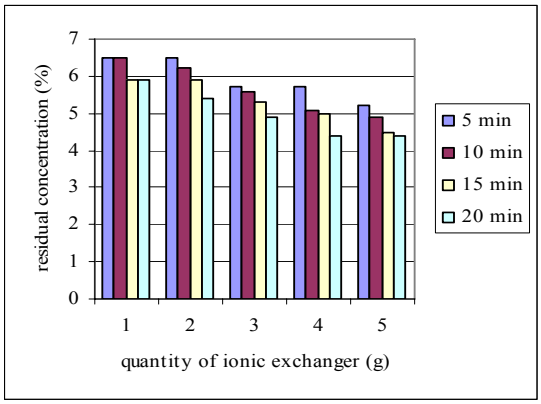

Figure 1. Correlation between residual concentration of ammonium ions and quantity of ion exchange and stirring time at 15°C temperature

It can be observe that once ion exchanger quantity and the time to stirring are rising, the residual concentration of ammonium ions is decreasing.

Experimental results regarding the correlation between residual concentrations of ammonium ions, the quantity of ion exchanger and the stirring time to 20°C temperature is show in table 2 and figure 2:

TABLE 2. Experimental results regarding the correlation between residual concentration of ammonium ions, quantity of ion exchanger and stirring time at 20°C temperature.

No.	Quantity of ion exchanger, g	Residual concentration of NH_4^+, mg NH_4^+/L			
		5 min	10 min	15 min	20 min
1	0.1	6.3	6.2	6.1	5.9
2	0.2	5.9	5.9	5.8	5.4
3	0.3	5.8	5.8	5.4	4.8
4	0.4	5.8	5.6	5.1	4.3
5	0.5	5.5	5.4	4.9	3.6

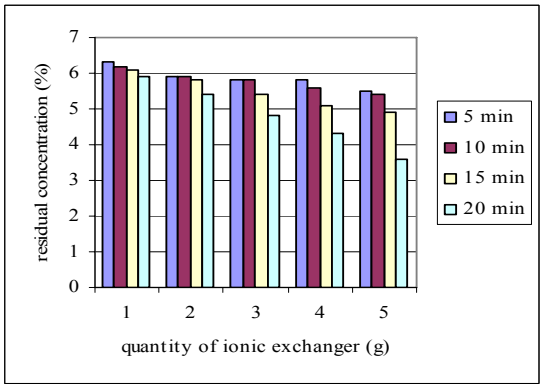

Figure 2. Correlation between residual concentration of ammonium ions and quantity of ion exchange and stirring time at 20°C temperature

We can observe that once the ion exchanger quantity and the stirring time are rising, the residual concentration of the ammonium ions are decreasing.

Experimental results regarding the correlation between residual concentrations of ammonium ions, the quantity of ion exchanger and the stirring time to 25°C temperature is show in Table 3 and Figure 3:

TABLE 3. Experimental results regarding the correlation between residual concentration of ammonium ions, quantity of ion exchanger and stirring time at 25°C temperature.

No.	Quantity of ion exchanger, g	Residual concentration of NH_4^+, mg NH_4^+/L			
		5 min	10 min	15 min	20 min
1	0.1	5.5	5.5	5.1	4.6
2	0.2	5.3	5.3	4.4	3.9
3	0.3	4.7	4.4	4.1	3.7
4	0.4	4.3	3.6	3.2	2.7
5	0.5	4.3	3.4	2.9	2.5

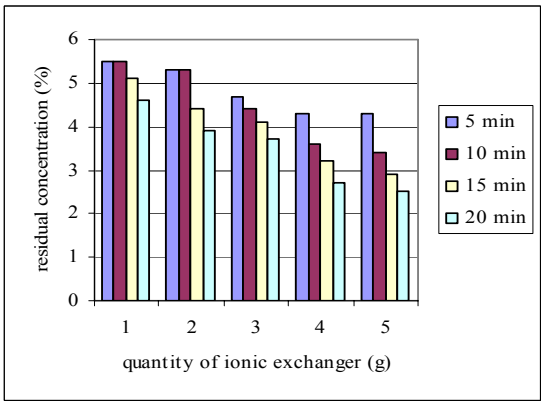

Figure 3. Correlation between residual concentration of ammonium ions and quantity of ion exchange and stirring time at 25°C temperature

It can be observe that once the ion exchanger quantity and the time stirring are rising, the residual concentration of ammonium ions are decreasing.

Experimental results regarding the correlation between residual concentrations of ammonium ions, the quantity of ion exchanger and the stirring time at 30°C temperature is show in Table 4 and Figure 4:

TABLE 4. Experimental results regarding the correlation between residual concentration of ammonium ions, quantity of ion exchanger and stirring time at 30°C temperature.

No.	Quantity of ion exchanger, g	Residual concentration of NH_4^+, mg NH_4^+/L			
		5 min	10 min	15 min	20 min
1	0.1	5.4	5.4	5.1	4.6
2	0.2	5.3	5.2	4.4	3.8
3	0.3	4.6	4.2	3.9	3.5
4	0.4	4.3	3.6	3.1	2.5
5	0.5	4.3	3.2	2.8	2.3

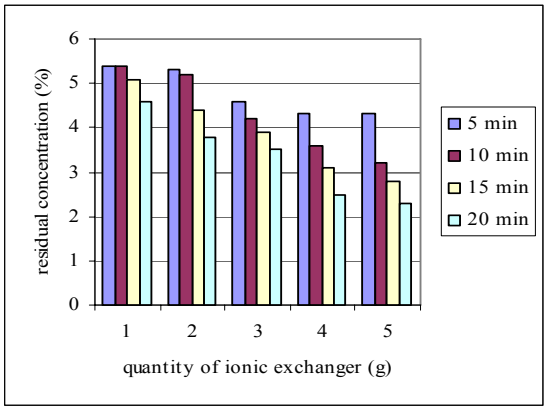

Figure 4. Correlation between residual concentration of ammonium ions and quantity of ion exchange and stirring time at 30°C temperature

It can be observed that once the ion exchange quantity and stirring time are rising, the residual concentration of the ammonium ions are decreasing.

Experimental results regarding the correlation between residual concentrations of ammonium ions, the quantity of ion exchanger and the stirring time to 35°C temperature is show in Table 5 and Figure 5:

TABLE 5. Experimental results regarding the correlation between residual concentration of ammonium ions, quantity of ion exchanger and stirring time at 35°C temperature.

No.	Quantity of ion exchanger, g	Residual concentration of NH_4^+, mg NH_4^+/L			
		5 min	10 min	15 min	20 min
1	0.1	4.62	4.59	3.89	2.24
2	0.2	4.43	4.35	3.35	2.83
3	0.3	4.37	4.31	3.08	2.52
4	0.4	4.13	3.41	2.83	2.04

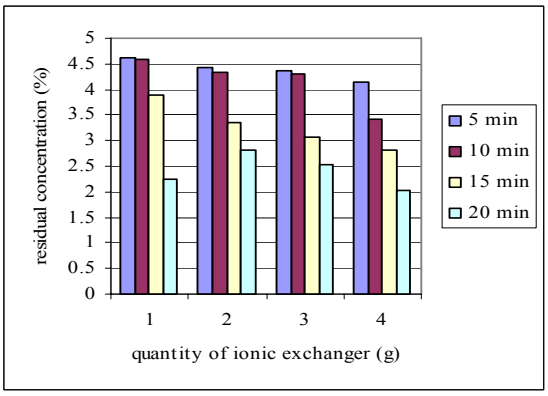

Figure 5. Correlation between the residual concentration of the ammonium ions and the quantity of ion exchanger, stirring time at 35°C temperature

It can be observed that once the ion exchanger quantity and the stirring time are rising, the residual concentration of the ammonium ions are decreasing.

Experimental results regarding the correlation between residual concentration of ammonium ions and temperature to the stirring time of 20 min and the quantity of ion exchanger 0.5 g are show in Table 6 and Figure 6:

TABLE 6. Experimental results regarding the correlation between residual concentration of ammonium ions and temperature at stirring time about 20 min and the quantity of ion exchanger 0.5g

Temperature °C	Residual concentration, mg NH_4^+/L	Stirring time, min	Quantity of ion exchanger, g
15°C	4.4	20 min	0.5 g
20°C	3.6		
25°C	2.5		
30°C	2.3		
35°C	1.84		

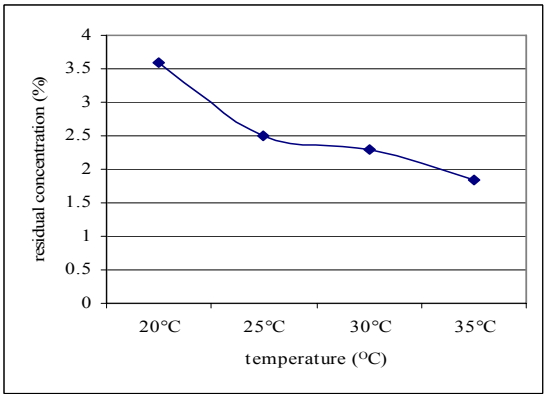

Figure 6. The dependence of the ammonium ions residual concentration function of temperature at 20 min stirring time and 0.5 ion exchanger quantity.

It can be observed once the ion exchanger quantity and the stirring time are rising, the residual concentration of ammonium ions are decreasing.

3.2. The degree of ammonium ions retention depending on the quantity of ion exchanger, stirring time and temperature

The experimental results regarding the degree of ammonium ions retention depending on the quantity of ion exchanger and the stirring time at 15°C temperature are show in Table 7 and Figure 7:

TABLE 7. Experimental dates regarding the correlation between ammonium ions retention degree and the quantity of ion exchanger by stirring time at 15°C temperature.

No.	Quantity of ion exchange	Retention degree η NH_4^+, %			
		5 min	10 min	15 min	20 min
1	0.1	0	0	9.23	9.23
2	0.2	0	4.61	9.23	16.92
3	0.3	12.3	13.84	18.46	24.61
4	0.4	12.3	21.53	23.07	32.3
5	0.5	20	24.61	30.76	32.3

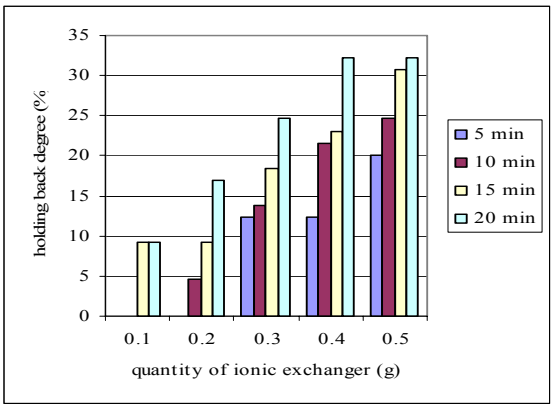

Figure 7. Correlation between the retention degree of the ammonium ions, the quantity of ion exchanger and stirring time at 15°C temperature

It can be observed that once the quantity of ion exchanger and stirring time are rising, the retention degree is rising too, at 15°C temperature.

The experimental results regarding the degree of ammonium ions retention depending on the quantity of ion exchanger and the time of stirring at 20°C temperature are show in Table 8 and Figure 8:

TABLE 8. Experimental dates regarding the correlation between retention degree of ammonium ions and the quantity of ion exchanger, stirring time at 20°C temperature.

No.	Quantity of ion exchange	Retention degree η NH_4^+, %			
		5 min	10 min	15 min	20 min
1	0.1	3.07	4.61	6.15	9.23
2	0.2	9.23	9.23	10.76	16.92
3	0.3	10.76	10.76	16.92	26.15
4	0.4	10.76	13.84	21.53	33.84
5	0.5	15.38	16.92	24.61	44.61

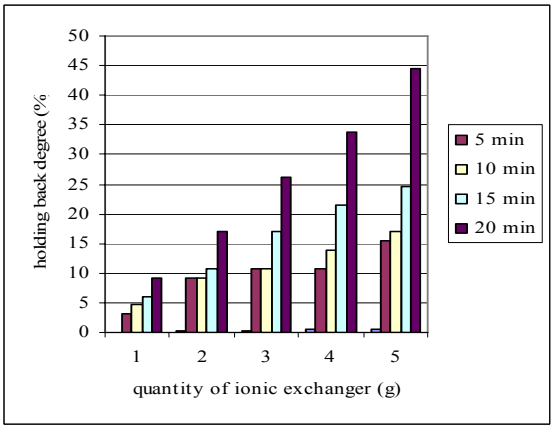

Figure 8. Correlation between the retention degree of the ammonium ions, the quantity of ion exchanger and stirring time at 20°C temperature

It can be observed that once the quantity of ion exchanger and stirring time are rising, the retention degree is rising too, at 20°C temperature.

The experimental results regarding the degree of ammonium ions retention depending on the quantity of ion exchanger and the time of stirring at 25°C temperature are show in Table 9 and Figure 9:

TABLE 9. Experimental dates regarding the correlation between retention degree of ammonium ions and the quantity of ion exchanger, stirring time at 25°C temperature.

No.	Quantity of ion exchange	Retention degree η NH_4^+, %			
		5 min	10 min	15 min	20 min
1	0.1	8.3	8.3	15	23.33
2	0.2	11.66	11.66	26.66	35
3	0.3	21.66	26.66	31.66	38.33
4	0.4	28.33	40	46.66	55
5	0.5	28.33	43.33	51.66	58.33

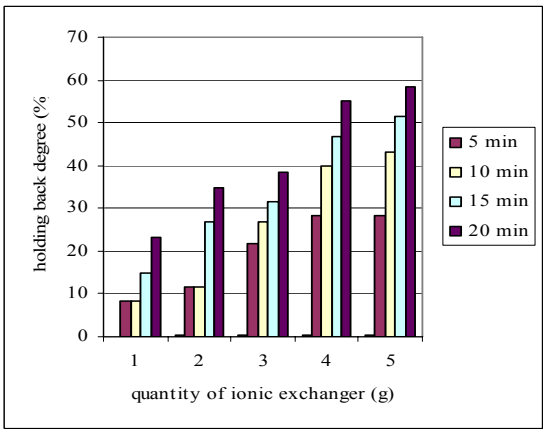

Figure 9. Correlation between the retention degree of the ammonium ions, the quantity of ion exchanger and stirring time at 25°C temperature

It can be observed that once the quantity of ion exchanger and time of stirring are rising, the retention degree is rising too, at 25°C temperature.

The experimental results regarding the ammonium ions retention degree depending on the quantity of ion exchanger and the time of stirring at 30°C temperature are show in Table 10 and Figure 10:

TABLE 10. Experimental dates regarding the correlation between ammonium ions retention degree and the quantity of ion exchanger, stirring time at 30°C temperature.

No.	Quantity of ion exchange	Retention degree η NH_4^+, %			
		5 min	10 min	15 min	20 min
1	0.1	6.66	6.66	15	23.33
2	0.2	11.66	13.33	26.66	36.66
3	0.3	23.33	30	35	41.66
4	0.4	28.33	40	48.33	58.33
5	0.5	28.33	46.66	53.33	61.66

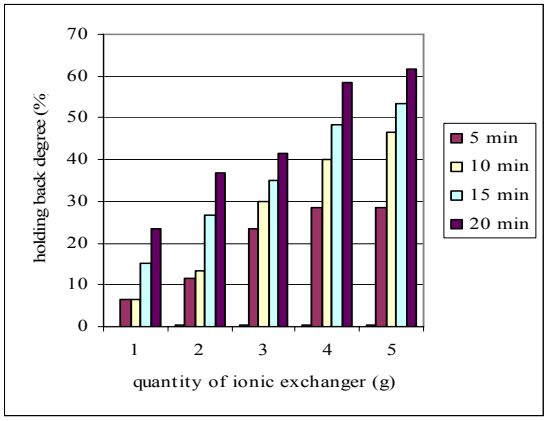

Figure 10. Correlation between the retention degree of the ammonium ions, the quantity of ion exchanger and stirring time at 30°C temperature

It can be observed that once the quantity of ion exchanger and stirring time are rising, the retention degree is rising too, at 30°C temperature.

The experimental results regarding the ammonium ions retention degree depending on the quantity of ion exchanger and the time of stirring at 35°C temperature are show in Table 11 and Figure 11:

TABLE 11. Experimental dates regarding the correlation between retention degree of ammonium ions and the quantity of ion exchanger, stirring time at 35°C temperature.

No.	Quantity of ion exchange	Retention degree η NH_4^+, %			
		5 min	10 min	15 min	20 min
1	0.1	23	23.5	35.16	46
2	0.2	26.16	27.5	44.16	52.83
3	0.3	27.16	28.16	48.66	58
4	0.4	31.16	43.16	52.83	66
5	0.5	43	48.16	57.83	69.33

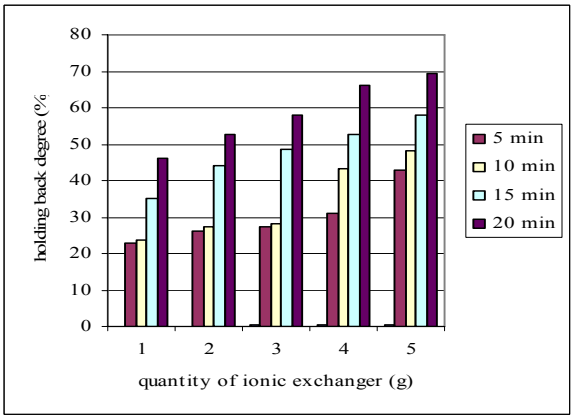

Figure 11. Correlation between the retention degree of the ammonium ions, the quantity of ion exchanger and stirring time at 35°C temperature

It can be observed that once the quantity of ion exchanger and time of stirring are rising, the retention degree is rising too, at 35°C temperature.

The experimental results regarding the correlation between the degree of ammonium ions retention and the temperature at stirring time about 20 min and quantity of ion exchanger 0.5 g are show in Table 12 and Figure 12:

TABLE 12. Experimental dates regarding correlation between the retention degree of the ammonium ions , temperature at stirring time about 20 min and quantity of ion exchanger about 0.5 g.

Temperature, °C	Retention degree, %	Stirring time, min	Quantity of ion exchange, g
15°C	32.3	20	0.5
20°C	44.61		
25°C	58.33		
30°C	61.66		
35°C	69.33		

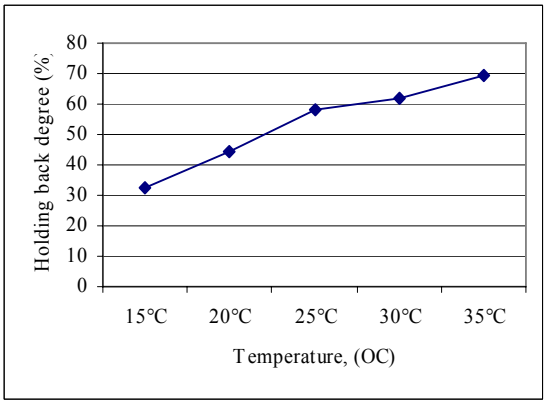

Figure 12. Correlation between retention degree of the ammonium ions, temperature to the stirring time 20min and quantity of ion exchange 0.5 g.

It can be observed that once the temperature is rising, the retention degree of the ammonium ions is rising too.

4. Conclusions

The purpose of this paper was to show the retention of ammonium ions from water using an ion exchanger DOWEX. The water used had a quantity of ammoniums ions well know.

The conclusions are:

- ✓ The residual concentration of ammonium ions decrease with the rising of the quantity of ion exchanger use;
- ✓ The residual concentration of ammonium ions increase with the rising of the stirring time;
- ✓ The residual concentration of ammonium ions decrease with the rising of the temperature;
- ✓ The ammonium ions retention degree on ion exchanger rise with the rising of the quantity of ion exchanger use;
- ✓ The ammonium ions retention degree on ion exchanger rise with the rising of the time of stirring;
- ✓ The ammonium ions retention degree on ion exchanger rise with the rising of the temperature.

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