EFFECT OF ULTRASONIC TREATMENT AND ALUMINIUM SULPHATE ON CHEMICAL WATER INDICATORS

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Abstract: The raw water treatment using coagulant and ultrasound indicates a faster decrease of turbidity. The main water indicators - pH dynamics and dissolved oxygen content are also presented and discussed. The dose of aluminum sulphate, actually the most widely used coagulant, decreases 8 times at the use of ultrasound waves, which represents an economy of chemicals for the water plants.

Keywords: ultrasound, generator, coagulant, aluminium sulphate, water, plant.

1. INTRODUCTION

The study of ultrasound effect on the water indicators is a topical area in the context of reducing water pollution by clean methods as well as the reduce the addition of chemicals needed in the various stages of water treatment.

Romanian scientists used the ultrasonic energy in order to obtain coagulation and settling effect for surface and waste water cleaning [1]. The conditions for coagulation efficiency at a lower working frequency than 25 kHz and about 10^3 Wcm^{-2} of acoustic intensity were established, as well as an efficiency of 30-65 % after one ultrasonic activation, and 95-100 % for repeated activation. Moreover, increasing the ultrasonic activation time does not lead to better results, therefore the operating principle for water settling consists in short consecutive activations for less than a minute.

Thus, following both presented considerations, in order to improve water quality an experimental installation with an ultrasound generator that tested the effect on raw water with coagulant added was used.

2. THE LABORATORY TECHNOLOGY FOR ULTRASOUND WATER TREATMENT

The experimental installation with the air-jet axial generator is working as follows: The air from the compressor 1 (Figure 1) at a pressure of 1-6 bar provides the flow rate and pressure required for the function of the axial generator [2]. The check valve V2 lets the air to reach to the pneumatic reducer 3, where the air pressure is adjusted at the demand pressure.

The working gas passes the axial generator 7 and produces both bubble aeration and ultrasound waves in the water volume. The testing water volume from the working tank 9 was of one liter. It was used water with the coagulator agent $Al_2(SO_4)_3$, which is the most commonly used nowadays in the water treatment plants [3]. The

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ultrasound generator is located inside a working tank with the water and it produces bubbling and ultrasound waves in the water mass.

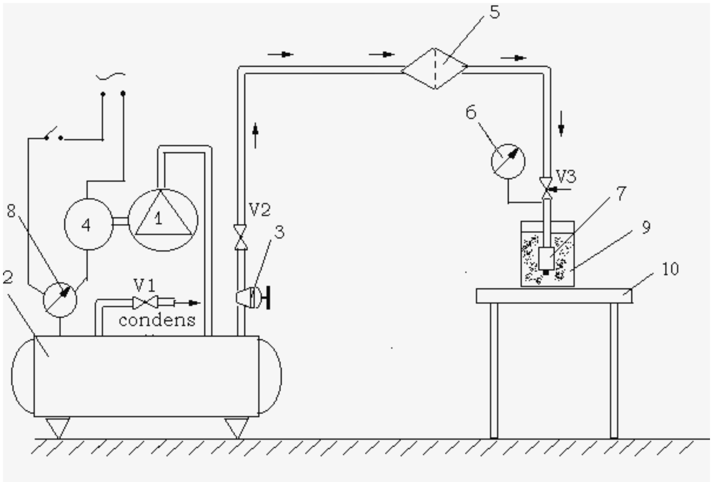


Fig. 1. The installation for sonic water treatment: 1-compressor; 2-air vessel; 3-pneumatic reducer; 4-gas cylinder; 5-air filter; 6-manometer; 7- air-jet axial generator; 8-electrocontact manometer; 9-working tank; 10-table; V1,V2,V3-check valves.

The air-jet generator [4] works as follows: the compressed air flow goes out of the nozzle and interacts with the resonator producing shock waves as in Figure 2.

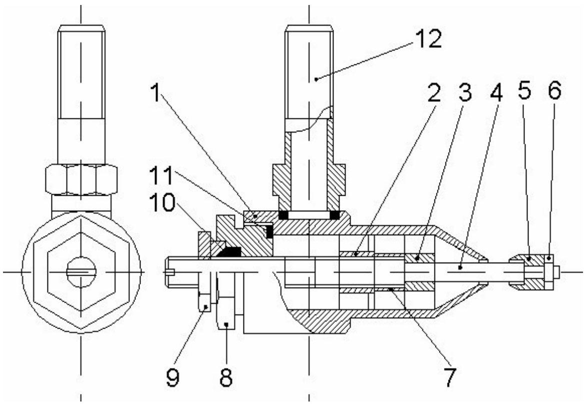


Fig. 2. The air-jet ultrasound generator design: 1-air nozzle; 2,3-cross support; 4-rod; 5-resonator; 6-screw-nut M2.5; 7-sleeve; 8-cover; 9-locking nut; 10-gasket; 11- ring; 12-fitting.

The laboratory technology consisted in using a raw water sample of one litter, a treating time in the range of 5÷40 seconds and a working generator's pressure of 0.4 MPa with the corresponding frequency of 27.2 KHz and acoustic intensity level of 131.0 dB [5].

It was studied the influence of the coagulant dose and the sonic treatment duration on the water indicators. The water parameters were determined according to the current Romanian standards [6-8].

3. RESULTS AND DISCUSSION

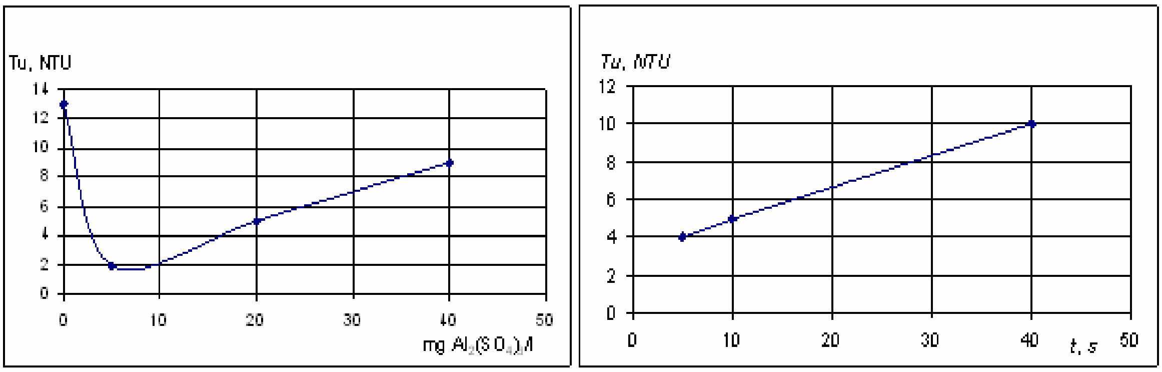
3.1. The water turbidity

In order to determine the minimum dose of coagulant for which the effect is observed, we studied the influence of coagulant concentration on turbidity at a treatment time of 10 seconds and a working pressure of the air-jet ultrasound generator of 0.4 MPa, corresponding to the frequency L= 131.0 dB and the sound intensity level ν=27.2 kHz [5].

As shown in Figure 3-a, the sudden reduction in turbidity is observed already at a dose of 5 mg/l $Al_2(SO_4)_3$ after the curve is rising. The maximum of turbidity is observed at the dose of 40 mg/l $Al_2(SO_4)_3$, which means that starting with dose of 10 mg/l $Al_2(SO_4)_3$, the turbidity increases once with the coagulant dose.

The dose registered for the minimal turbidity (Tu=2 NTU) is the one of 5 mg/l $Al_2(SO_4)_3$, which is eight times lower than the minimal dose of 40 mg/l $Al_2(SO_4)_3$ used in water treatment plants. The practical effect of sonic treatment is the simultaneous reduction of water turbidity of seven times as well as the coagulant dose of eight times.

Following this result, we considered necessary to test the influence of treatment time at this minimal dose of 5 mg/l $Al_2(SO_4)_3$. In Figure 3-b is obvious that the turbidity increases with the treatment time, also the minimum treatment time of 5 seconds is necessary to achieve the turbidity decrease from 13 NTU corresponding to raw water (Figure 3-a) to 4 NTU (Figure 3-b) in treated water. Moreover, this result shows that the combination of minimal coagulant dose, ultrasound waves and a treatment time variation over 5 seconds does not qualify for lower values of turbidity but for increasing values which is not desirable for water treatment systems.

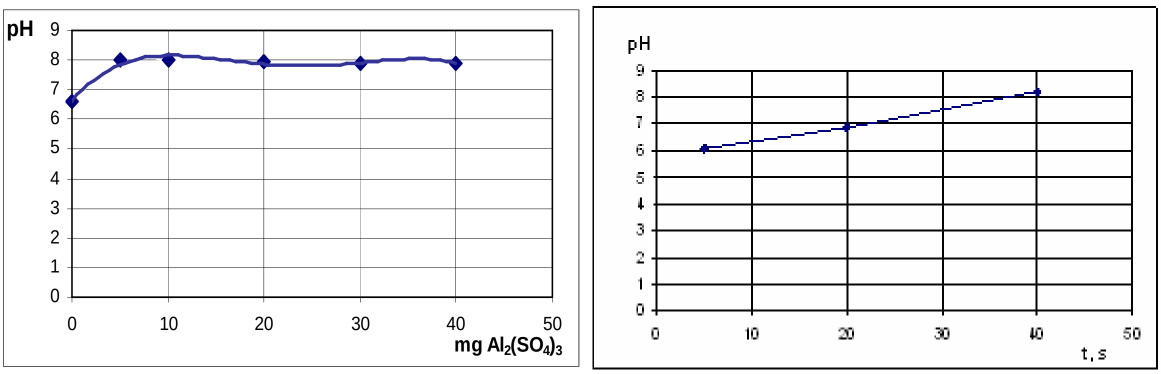


a) b)

Fig. 3. The water turbidity variation depending on the dose of coagulant $Al_2(SO_4)_3$ (a), respectively on the treatment time at the dose of 5 mg/l $Al_2(SO_4)_3$ (b).

3.2 The pH dynamics

It is observed the increase of pH regarding the difference of about 1.4 units between the raw water value and the water with the lower coagulant dose. After that, we can consider the coagulant dose does not influence the pH value, because the variation range is of pH=7.8÷8, as shown in Figure 4-a:



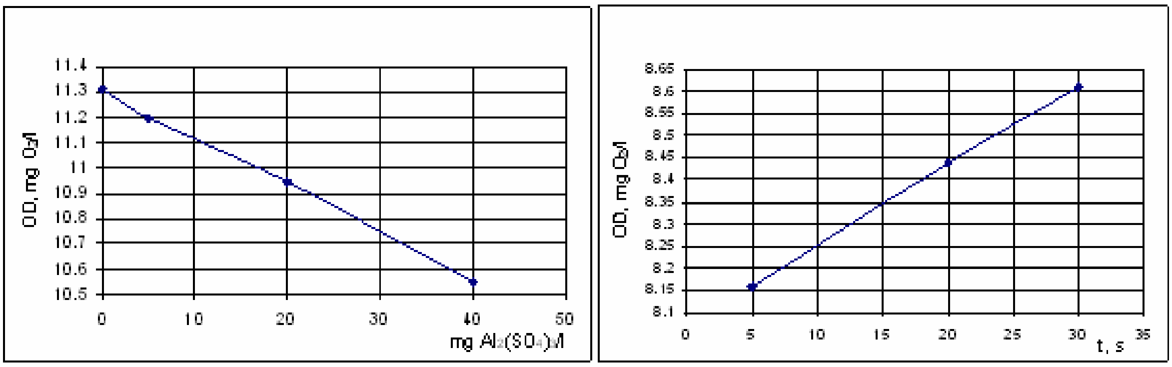
a) b)

Fig. 4. The pH variation depending on the dose of coagulant $Al_2(SO_4)_3$ (a), respectively on the treatment time at the dose of 5 mg/l $Al_2(SO_4)_3$ (b).

Instead, shows interest the pH variation (Figure 4-b) depending on the water treatment time with 5 mg/l $Al_2(SO_4)_3$ at the working pressure of p = 0.4 MPa, which indicates a pH increase with 2 units.

3.3. Dissolved Oxygen content in water

As shown in Figure 5-a, by increasing the coagulant dose, the dissolved oxygen content decreases from 11.2 to 10.55 mg O_2 /l. Thus the dose of aluminum sulfate influenced the dissolved oxygen content in an undesirable way because the dissolved oxygen is the only water parameter that needs to increase instead of decrease as desirable for the others water indicators. However the decrease is not severe, but should be considered as a negative aspect of using both aluminium sulphate and ultrasound waves in water treatment.



a) b)

Fig. 5. The dissolved oxygen content variation depending on the dose of coagulant $Al_2(SO_4)_3$ (a), respectively on the treatment time at the dose of 5 mg/l $Al_2(SO_4)_3$ (b).

The variation of dissolved oxygen on the water sonic treatment time at the minimal dose of 5 mg /l $Al_2(SO_4)_3$, shows that by increasing the treatment time (Figure 5-b), the concentration of oxygen in water increases from 8.16 to 8.61 mg/l O_2. This result underline the possibility of using lower coagulant doses both with ultrasound waves and time variation in order to obtain an optimal value of dissolved oxygen for the treated water.

Therefore, it is preferable to choose the minimum time for treatment in this case in order to achieve optimal results, which acknowledge other perspectives for the use of sonic technologies [9].

4. CONCLUSIONS

The increasing the dose (5-40 mg/l) of aluminum sulphate ($Al_2(SO_4)_3$) in ultrasound treatment (the generator working pressure 0.4 MPa, the sound intensity level L = 131.0 dB and the frequency ν = 27.2 kHz) with less treatment time (t = 10 s) showed that:
- the best value for water turbidity (Tu = 2 NTU) was for the dose of 5 mg/l $Al_2(SO_4)_3$, then the turbidity increases with the coagulant dose, which is not desired, preferably is the downward variation;
- the water pH is influenced by the coagulant presence only for the lowest dose of 5 mg/l $Al_2(SO_4)_3$, then the pH value varies in the range of pH=7.8÷8 with increasing coagulant dose;
- the oxygen content in water decreases from 11.2 to 10.55 mg O_2/l, therefore the minimal dose used is recommended to achieve the optimal result because the dissolved oxygen in water should not be descendent.

Further, it was studied the influence of sonic treatment time (5-40 seconds) on physical-chemical parameters of water with low coagulant dose (5 mg/l $Al_2(SO_4)_3$) and the generator working pressure of 0.4 MPa, (acoustic intensity level L = 131.0 dB, the frequency ν = 27.2 kHz) that highlighted the following:
- turbidity is minimally at 5 seconds of sonic treatment, then is growing about 2.5 times, so in order to achieve a significant descend of turbidity is recommended the minimal treatment time;
- pH increases two units, but is preferably to choose the treatment time in order to obtain neutral or alkaline values of pH;
- the oxygen content of water increases with sonic treatment time from 8.16 to 8.61 mg O_2/l allowing for the treatment time of 30 seconds as the best value for the dissolved oxygen content.

The results allow the dose coagulant reduction of 8 times, which is a real economy for any water treatment plant, which are high chemical consumers considering their permanent regime of working. Also, the results proved the applicability of the sonic technology studied on the water treatment in order to obtain a high quality of treated water with reduced consumption of chemicals.

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