NEW POLYMERS WITH ENHANCED ACTIVITY FOR POTABLE WATER TREATMENT

Mihaela ARMEANU[1], Tiberiu CRISTEA[2], Cătălin ZAHARIA[3], Corneliu CINCU[4]

O caracteristică accentuată a apei din Târnava Mare este duritatea caracterizată de conținutul ridicat de ioni de calciu şi magneziu precum şi prezența ionilor de amoniu şi nitriți. În această lucrare, pe baza testelor de laborator, utilizând ape cu conținut similar, şi ținând seama de condițiile concrete din stație, se propune o instalație de dozare automată a sulfatului de aluminiu granulat şi o schemă optimă de tratare folosind agenți de coagulare (sulfat de aluminiu) şi floculare (poliacrilamida parțial hidrolizată A321). Rezultatele obținute în experimentul din stație, încadrează calitatea apei tratate în vederea potabilizării în normele legale europene în vigoare.

A major peculiarity of Târnava Mare water is its hardness characterised by a large amount of calcium and magnesium ions and by the presence of ammonium and nitrite ions. This paper presents an automatic dosage installation for granular aluminium sulphate and an optimum treatment scheme using coagulation agents (aluminium sulphate) and flocculation agents (partially hydrolysed polyacrylamide A321). This installation is proposed according to laboratory tests using waters with similar content and taking into account the station conditions. The results obtained within the station ensure the potable water quality accordingly to the actual European legislation.

Keywords: water purification, flocculation, coagulation, polyacrylamide

1. Introduction

Brief presentation of Albeşti-Sighişoara water plant

The Albeşti-Sighişoara water plant is placed on the river side of Târnava Mare. The crude water feed is directly from the river inlet so that the prevention or attenuation of turbidity shocks caused by the freshet could be hardly achieved.

[1] Eng., S.C. Kemwater Cristal S.R.L, Fundulea, ROMANIA
[2] Eng., S.C. Kemwater Cristal S.R.L, Fundulea, ROMANIA
[3] Eng., Department of Science and Engineering of Polymers, Faculty of Applied Chemistry and Materials Science, University POLITEHNICA of Bucharest, ROMANIA, email: zaharia.catalin@gmail.com
[4] Prof., Department of Science and Engineering of Polymers, University POLITEHNICA of Bucharest, ROMANIA, email: c_cincu@yahoo.com

To be more correct we have to say that, in the given conditions and in the absence of the turbidity sensors placed in the upstream flow in an optimum point, any perturbation affects directly the treating process. The solution for the operator to prevent these phenomena is the correction of the coagulant dosage [1].

In the absence of the information regarding the propagation of the perturbation in downstream flow, the physical time of the operator does not allow him to respond efficiently and therefore there is the risk of getting off the control to the process parameters.

Actually, the water treatment is done by using two decanters D1 and D2, figure 1 [2, 3].

During the experiment it was also used the pre-decanter D3 to show its efficiency and there were used coagulants and flocculants [1, 4, 5]. The dosage of aluminium sulphate that represents 80-85% of the total amount needed for water treatment was done at the entrance point of the station in the capture chamber. Before entering the pre-decanter of the water treated with aluminium sulphate, at a distance of 60 m from the aluminium sulphate dosage point, there was done the dosage of A321E polyelectrolyte (the total amount required). Then the treated water enters the pre-decanter. Before entering the decanters the rest of 15-20% of aluminium sulphate is also dosed. The treated water is sent to the filtration unit and is pumped in the distribution buffer tanks.

Pre-decanter was designed to solve or attenuate the turbidity shocks described above. The solution proved to be efficient, the pre-decanter having a high storage capacity in serial regime with Târnava Mare and the two decanters that work in parallel.

Characteristics of the crude water

Statistics show the fact that the frequency of the disturbing phenomena is higher within the autumn and spring. Even they are shorter as duration, the perturbations caused by short torrential rains, which do not lead to an increase of the flow of Târnava Mare River proved to be more aggressive by the carried loads with major implications in the treating process.

Any perturbation of the crude water quality, especially turbidity, but it is also valid for all the parameters characterising the crude water, propagates rapidly within the system leading to an imminent risk: all the parameters could move to the maximum limit of their values or even higher [6].

During the experiment, the turbidity variation (T) was between 90 and 870 °SiO_2 (fig. 2), and the content of organic substances was between 25 and 51 mg/l $KMnO_4$.

2. Experimental

Experience of various treatment units from our country showed that in the case of turbidity shocks provoked by freshets, supplementary investments are needed by using upstream accumulation basins capable of feeding the treatment units for a period equivalent to the critical freshet period. We have proposed and realized a pre-decanter at the entrance of the treatment unit.

Based on the industrially experiment, we could finally present arguments in the economic efficiency plan correlated with the performances of the final treated water within the quality indicators from European Union [7].

Points of reagents injection

Injection of aluminium sulphate

Based on literature and industrial practice, the optimum time to ensure the correct conditions for coagulant homogenisation within the volume of treated water and to ensure the hydrolysis conditions lies between 1-3 minutes [7, 9].

A smaller period of time than the minimum limit of the interval implies the existence of design adjustments and adequate equipment (mixture chamber, reaction chamber) that significantly increase the cost price of potable water.

In the experiment we have injected the aluminium sulphate at the entrance of crude water in the capture chamber and then the water is pumped in the pre-decanter (figure 1).

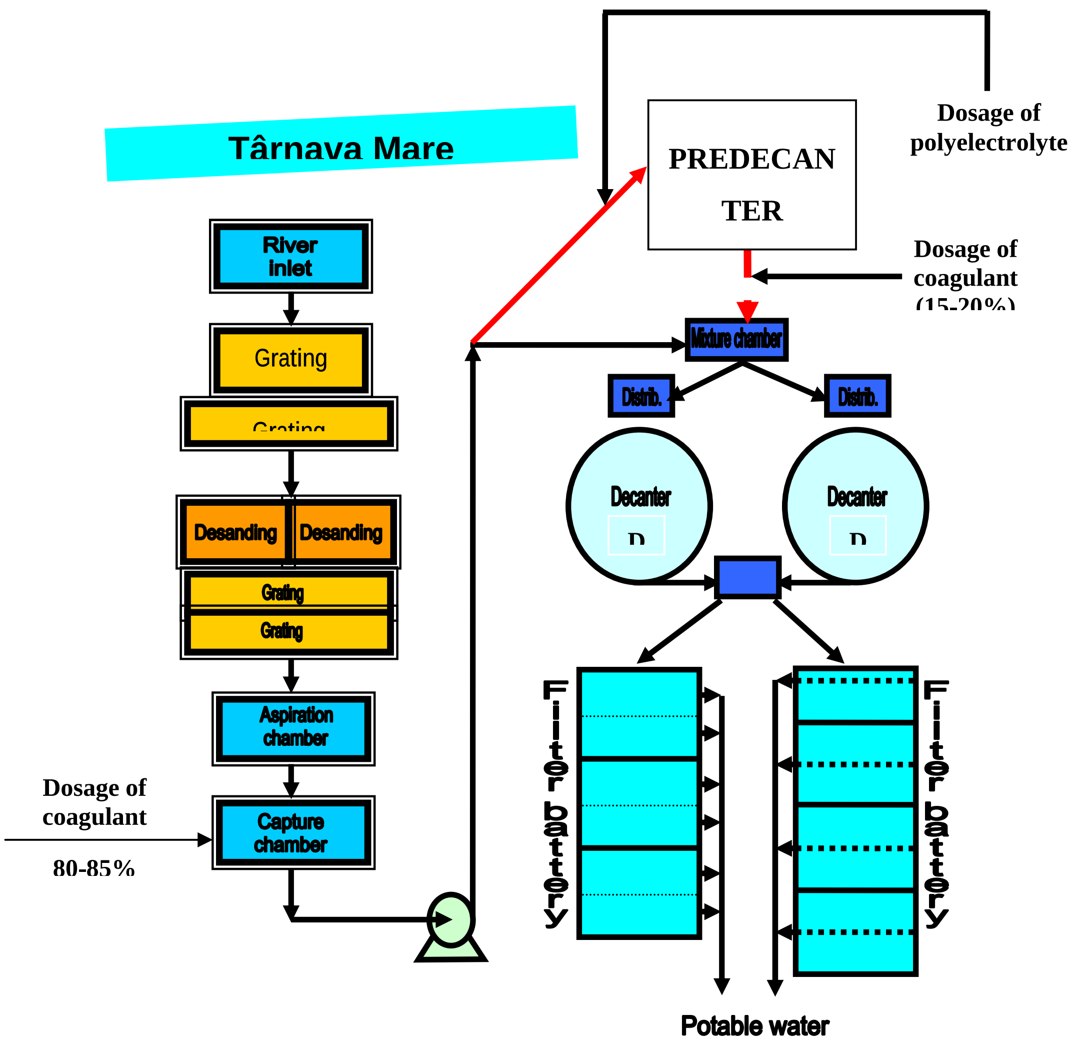
The choice of this point of injection is motivated by that fact that the time between the injection and the admission of crude water in the pre-decanter ensures a good mixing of aluminium sulphate and crude water flow and a proper time for hydrolysis-precipitation reaction of the germs of aluminium hydroxide.

Injection of polymer

The injection point of the polymer (partially hydrolysed polyacrylamide A321) is practically determined by all the specific conditions of a optimum. Based on the results from the laboratory we recommend a low time, 1-2 minutes, for the formation and cohesion of small sized flakes followed by decantation step.

For the above mentioned reasons the injection point of polyelectrolyte was established before the entrance of the water in pre-decanter.

From technological point of view, in the case of the use of polyelectrolytes as coagulation adjutants and flocculants it is important to have them injected in the system after coagulant injection (homogenisation of the coagulant with crude water after hydrolysis process, followed by formation and growth of germs).


Târnava Mare
River inlet
Grating
Desanding
Desanding
Grating
Grating
Aspiration chamber
Capture chamber
Dosage of coagulant
80-85%
PREDECAN
TER
Dosage of polyelectrolyte
Dosage of coagulant
Mixture chamber
Distrib.
Distrib.
Decanter
Decanter
Filter battery
Filter battery
Potable water

3. Results and discussions

In agreement with the team from the treating unit, we proposed one hour frequency of sampling and chemical analyses at the beginning of the experiment. In function of the results evolution and establishing a normal equilibrium of the station, the frequency could be modified.

Based on the obtained results we have drawn the diagrams that allow a qualitative and quantitative evolution of the obtained effects.

Figure 2 shows the evolution of turbidity of crude water during the whole experiment. It could be noticed a major perturbation of the water quality in the process in the interval 90-870°SiO_2 within few hours. The data within this diagram are a good example observed during the experiment, which confirm our findings concerning the difficulties appeared in the treating process of the shocks caused by the freshets specific for the water feed directly from the river inlet.

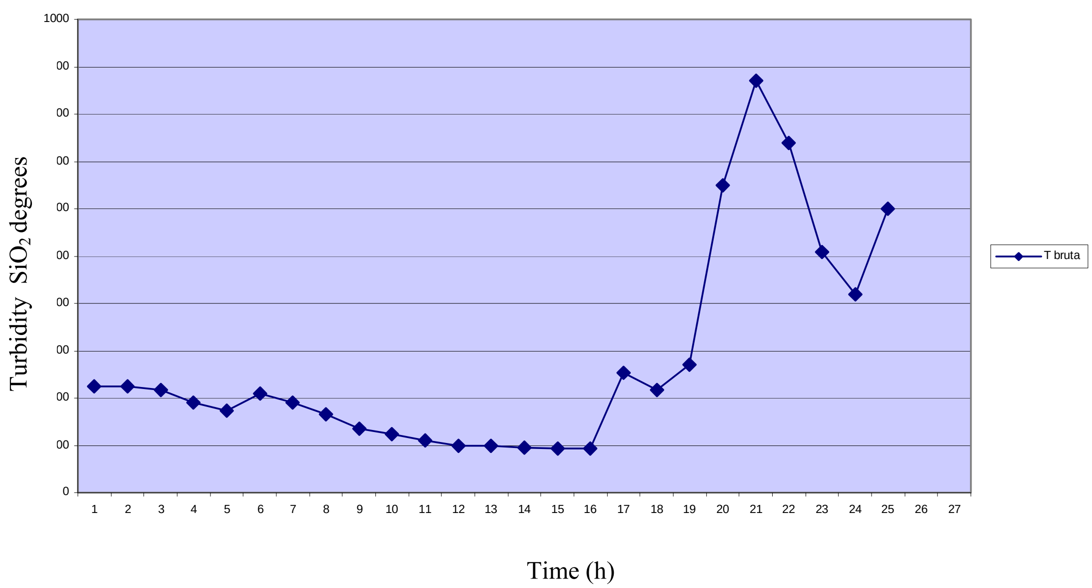


Fig. 2.Turbidity variation of crude water in Albeşti-Sighişoara (SiO_2 degress) in time (h)

Figure 3 shows the evolution of water turbidity at the entrance and exit of the pre-decanter. We can observe a significant decrease of the turbidity degree. The pre-decanter behaved positively so it proved one more time its performance.

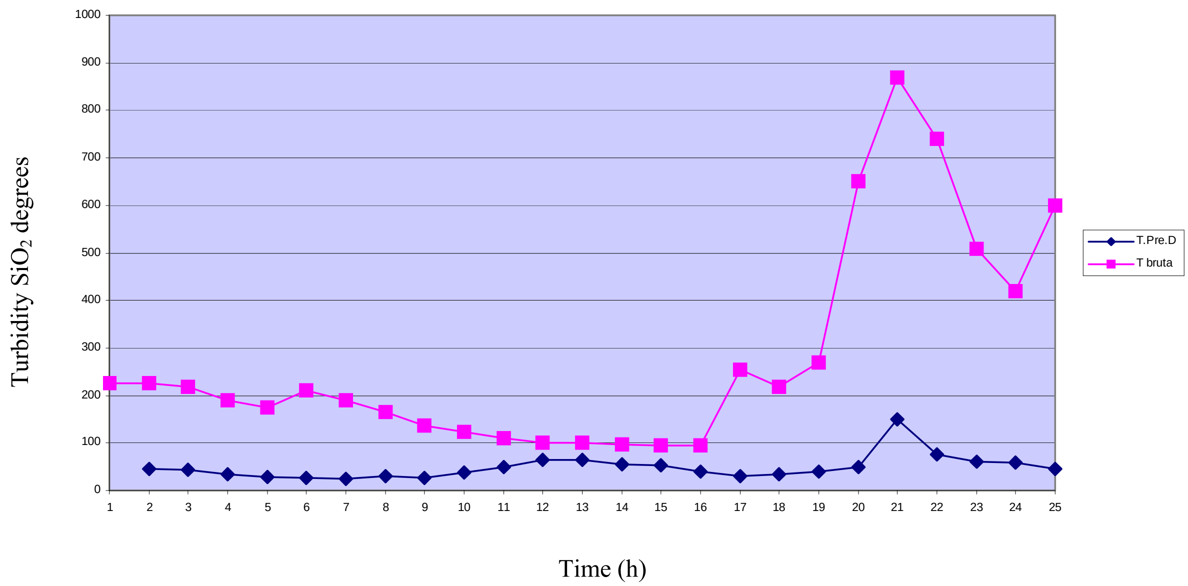


Fig. 3. Comparison between the turbidity of crude water and of the water at the exit of the pre-decanter

Figure 4 shows the variation of the turbidity of crude water, pre-decanted (exit of pre-decanter) and decanted (exit of D1 and D2 decanters). We can notice an increase of the water turbidity at the exit of pre-decanter with the increase of the turbidity of crude water, the shock being already present. At the exit of the decanters this phenomenon is not present anymore. This fact is due to the use of the pre-decanter that support all the shocks of the parameters at the entrance and if the process is ran correctly in the decanted and filtered water these parameters do not have fluctuations anymore.

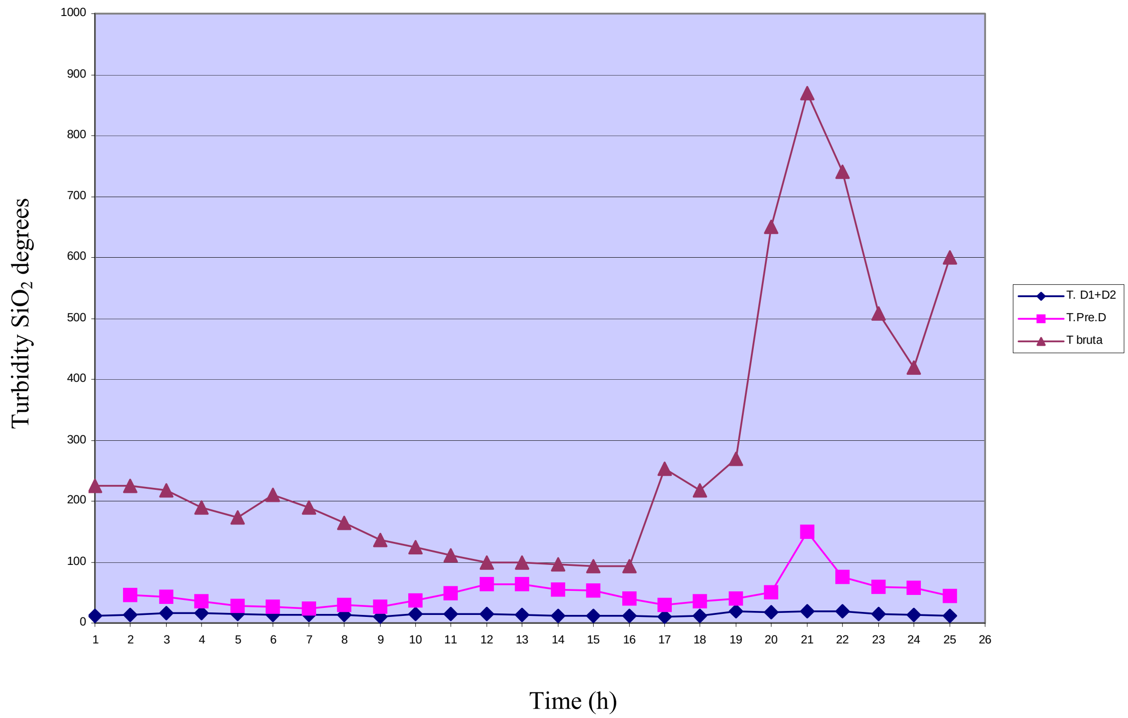


Fig. 4. Variation of the turbidity of crude water, exit of pre-decanter at exit of D1 and D2 decanters

This method of controlling the shocks is based on the simultaneously use of the automated dosing equipment of the coagulant and flocculants; this dosage is done with a high precision of $\pm 1 \cdot 10^{-2}$ mg/L. The coagulant dose (aluminium sulphate) and flocculant dose (partially hydrolysed polyacrylamide A321) are very low (0.06-0.1 mg/L) and vary with the turbidity of the crude water.

The presented results show one more time the ability of the adjutants to ameliorate the clearing process through coagulation, flocculation and sedimentation.

A special concern must be taking into account when analyzing the quality indicators of the finite water for the general use.

Figure 5 shows the values for a major indicator of the quality of finite water, which is content of organic substances expressed in mg/L potassium permanganate ($KMNO_4$). We can notice that only after the pre-decanting step when the system is in equilibrium, the values of this parameter decrease with 70% as compared to the value of the crude water. The low content of the organic substances after D1 and D2 decanters is also a confirmation of the improvement of water quality after coagulation-flocculation process.

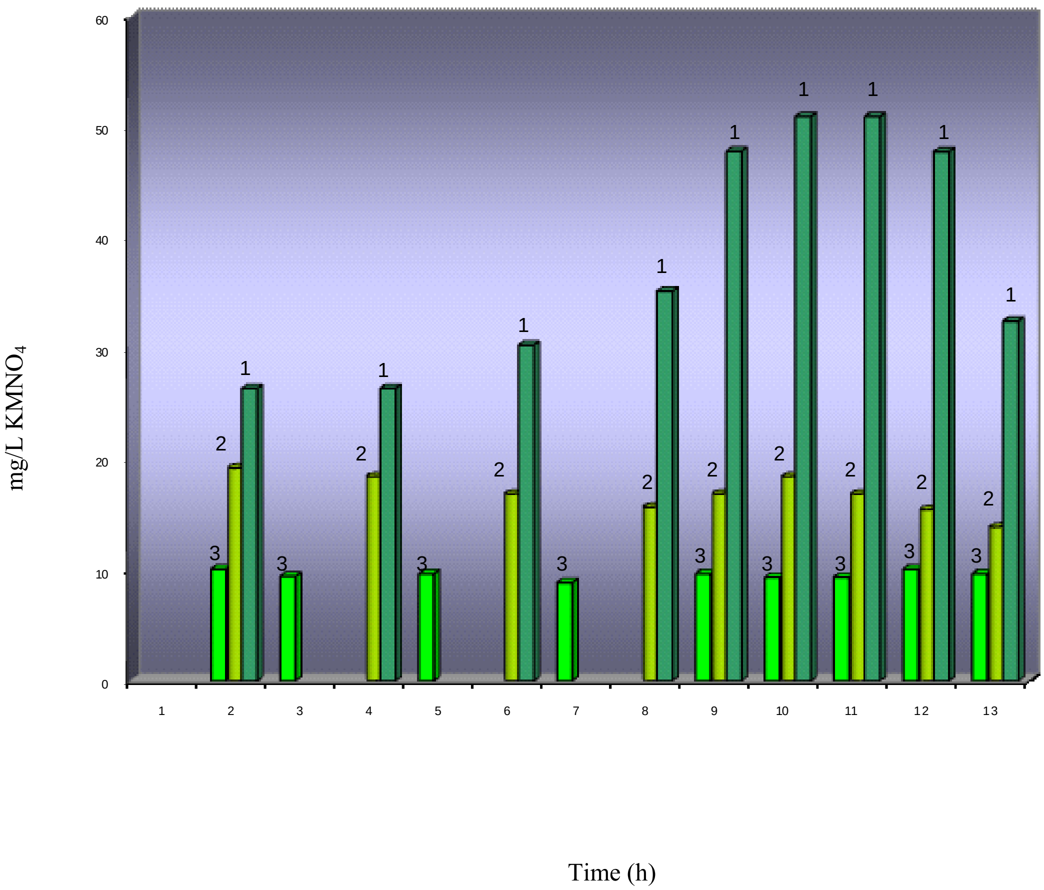


Fig. 5. Concentration of organic substances (mg/L) in crude water (1), exit of pre-decanter (2) and potable water (3)

We present some significant values of the parameters of crude water and pre-decanted water (exit of pre-decanter) (table 1).

Taking into account the obtained results presented also in table 1, we can say that by using pre-decanter D3 a significant decrease of the turbidity from 870-

508°SiO_2 to 60-45°SiO_2 and a decrease of the organic substances from 48-50 mg/L $KMnO_4$ to 17-14 mg/L $KMnO_4$.

Table 1

Turbidity and organic substances in crude and pre-decanted water

	Crude water	Water at the exit of the pre-decanter
Turbidity °SiO_2	870	60
	740	58
	508	45
Organic substances, mg/$KMnO_4$	47.85	16.9
	50.98	15.48
	50.98	13.9

From the exit of the pre-decanter to the exit of the treating unit, there are two more steps of the process, decantation and filtration and as a result the quality of potable water at the exit is superior taking into account the parameters at the exit of the pre-decanter (figures 3-5).

In the water treatment process the injection points of aluminium sulphate and polyelectrolyte must be chosen to favour the coagulation-flocculation process and to obtain better results both for water quality and for the reduction of reagents consumption. The dosage in the same point of both reagents (coagulant and flocculant) could not lead to any positive results as the polyelectrolyte could not be efficient without the flocculation germs created by the flocculant within the system. Therefore no good results could be achieved as we need a higher dose of coagulant (45-80 mg/L) than the optimum working dose when polyelectrolyte is used (25-60 mg/L).

The use of polymers in the conditions of turbidity variations (both for low turbidity and high turbidity) leads to an improvement of water purification that is finally quantified by:

- The decrease of turbidity in decanted water for lower doses of aluminium sulphate than the optimum doses of the flocculant (45-80 mg/L);

- Reduction of residual aluminium content in the decantation up to values inferior to the limit and accepted in the potable water;
- Reduction of the content of organic substances in the decantation;
- Reduction of specific consumption of aluminium sulphate.

4. Conclusions

1. The results obtained within this industrial with the D3 pre-decanter shows its efficiency in the process;
2. The use of an 80-85% dose of aluminium sulphate in the aspiration chamber of the flooding valve and the dosing of the polyelectrolyte before entering the pre-decanter determine a good behaviour of the decanters, especially the pre-decanter;
3. The proposed technological scheme and the use of the mixed system coagulant-flocculant allow the obtaining of potable water with quality indicators in good agreement with EU rules even if we have high turbidity variations of the crude water.

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