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IMPROVEMENT METHODS OF THE DRINKABLE WATER QUALITY

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Abstract

The paper presents an analysis of substances that conduct at by-product formation of reaction at the water treatment. The organic substance concentration reduction from water before of disinfectant's application may conduct at concentration decrease of accrued by-product. It is presented the condition of coagulation's getting. The coagulants for the coagulation process are selected for a maximum global efficiency. The choice reagents and the work conditions of coagulants must be accurately established.

Key words: *coagulation, filtration, oxidation, pollutant, polymer*

Nomenclature

A	[mg/l $CaCO_3$]	alkalinity's brute water
A_m	[mg/l]	ammonium concentration
C_l	[mg/l]	chlorine concentration
i_h	[m/h]	decantation speed
k	[mS/cm]	conductivity
p	[bar]	pressure
Q	[m^3/h]	debit
t	[s]	time
T	[^{o}C]	temperature
T_b	[FNU]	turbidity
TOC	[mg C/dm^3]	total organic carbon concentration
α	[-]	temperature coefficient
v_f	[m/h]	seeming filtration speed

1. INTRODUCTION

Investigations on organic and inorganic water pollutants have had a significant impact on environmental sciences by providing reliable knowledge on inputs and environmental exposure in such a way that risk assessments can be performed. Especially important have been the development of chemical analytical techniques, which allow qualitative identifications and quantitative determinations of trace concentrations in aqueous and solid samples. A large number of environmental contaminants have been studied regarding their fate and behaviour in the environment, [3, 10].

Particles and sediments in aquatic systems are primarily not considered as pollutants per se. However, due to their character as reactive surfaces (particles) and their potential as sinks and archives (sediments) they play a crucial role within a 'cycling of polluting substances'.

The results of this paper will be applied for improving the situation regarding water pollutants in Romania by recognising critical points of chronic or acute contamination, [2].

Investigations should focus on environmental pollution by dangerous substances as defined by the European Water Directive, persistent organic pollutants including pesticides and heavy metals, petroleum and emerging contaminants such as pharmaceuticals, endocrine disruptors or biocide products, [4].

The paper describes the influence filtration methods about water's quality. It is distinguished the capacity of some polymer mixtures of different types to react on a lot of quality parameters of water. It is presented a comparison between the retaining efficiency of the organic substances and organic carbon after clarifying step, respectively of filtration on quartz sand stratum. It is analyzed the reduction efficiency of organic filling case usage of polymers mixture. The indicator's allowance depends of technology type used in the treatment process.

2. EXPERIMENTAL RESEARCHES

The experimental researches concerning the optimization of the coagulation - flocculation process allowance following problems, [5]:

1. The influence of the water quality on the reagent type of coagulation.

2. The regent type's influence concerning abeyances abstention efficiency and organic substances for different sources.

3. The improvement of the coagulation process with different coagulants (through polymers). The coagulation tests are effectuated in laboratory and pilot installations. The specific polymers for the drinkable water's treatment and the polymers obtained through irradiation with electrons and microwaves have been tested. Aluminium sulphate is used like polymer admixture.

4. The pH's influence on the coagulation process. The coagulation tests have used aluminium sulphate and ferric chloride, [6].

The coagulation process represents the fundamental step in treatment for drinkable water. The advanced coagulation represents the reduction process of the natural organic substances in the water's treatment channel.

In *table 1* are presented the reduction requirements of total organic carbon concentration *TOC* and the alkalinity's brute water *A* for the advanced coagulation.

The coagulation adjuvant is natural or synthesis substances used for the improvement of the coagulation process's performance, (getting of big flakes).The coagulation adjuvant doses may be established through coagulation - flocculation tests and tests on slush. The spell between the coagulant's injection and coagulation adjuvant's injection is very important. It is efficient as the polymers to be injected after what the micro-flocculation phase is fully. The water's composition and the temperature influence this spell. It is imperative to be established by experimental determinations for each case, [7].

The experimental determinations are effectuated at Chirita Iasi water plant, (figure 1). The measures for the establishment of the optimum coagulation conditions are make obvious through

experimentation. Maximum efficiency of coagulation's achievement is determined by the substances and concentrations used. The powder active coal is necessary to dose correct in the optimization process of the coagulation – flocculation, because of the pesticides presence in water. It is obtaining the biologically steady water.

Table 1. Percentage reduction of total organic carbon concentration.

TOC [mg C/dm^3]	Alkalinity's brute water [mg/l $CaCO_3$]		
	0 - 60	60 – 120	> 120
2 – 4	35%	25%	15%
4 – 8	45%	35%	25%
> 8	50%	40%	30%

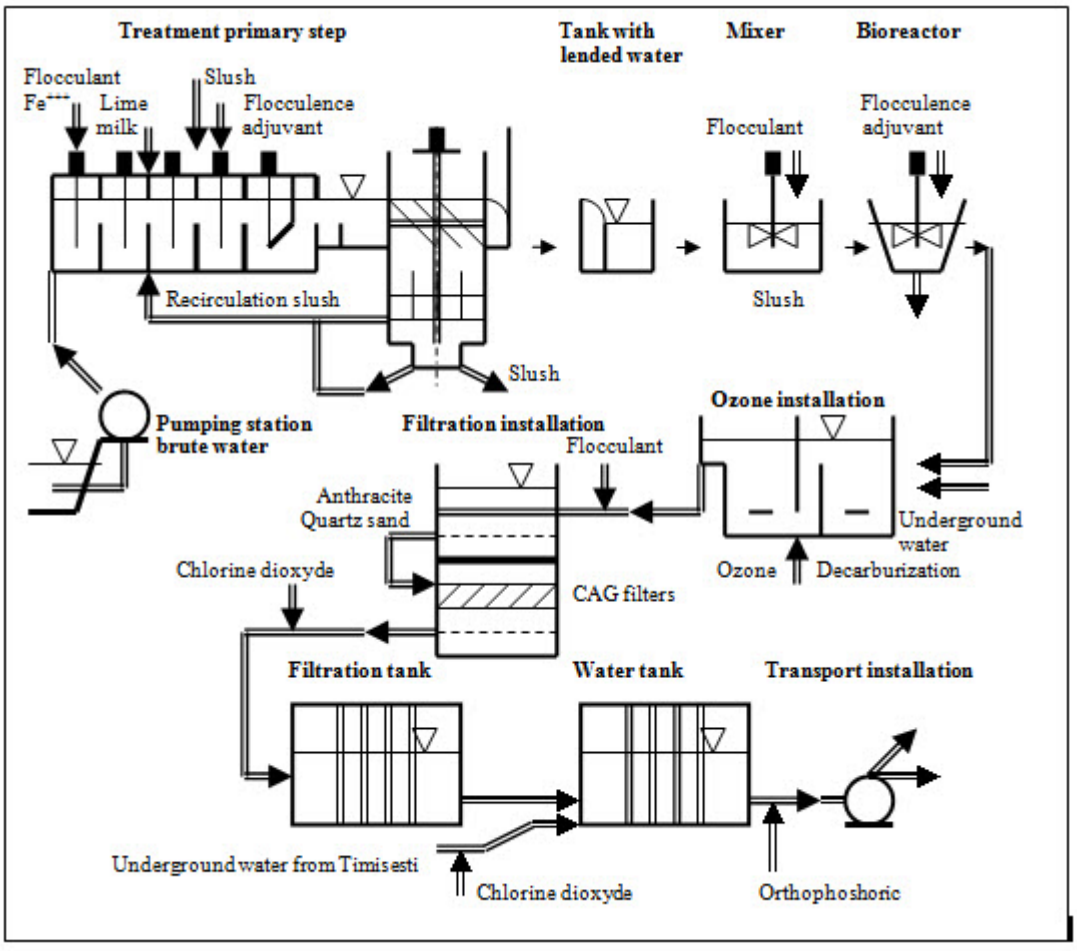

Fig. 1. Technological scheme from Chirita coagulation - flocculation plant.

The water treatment with elevated content of sulphide hydrogen requires an oxidation process for the transformation in colloidal sulphur; it is removed the sulphur through clarifying process, [11]. The experimentation is effectuated on ground water with ammonium and hydrogen sulphate content.

The oxidation is realized through the usage of sodium hypochlorite. It is analysed the possibility of removal of the sulphides and the hydrogen sulphate through oxidation and filtration with quartz sand, respectively hyper filtration. It is following the improvement of the oxidised water's clarifying process through coagulation process, [8].

It is analysed the water's quality from Prut river in the Chirita section. It is found the following properties:

- The water has big variations of turbulence and is feeble collared.
- pH is in the alkalescent domain (8,06 ÷ 8,16) pH units; the total alkalinity is (3 ÷ 3,5) mechiv/l.
- The mineralization indicators (fixed residue and conductivity) have values adequate to the mineralised average water; the mineralization is given by the bicarbonates and the calcium sulphates.
- The concentration of organic substances is established with potassium permanganate in the interval (10 ÷ 26) mg/l K Mn O_4. The concentration of organic substances is established with potassium bi-chromium in the interval (12 ÷ 15) mg/l O_2. These values may conduct at difficulties in the water's treatment.
- The pesticides concentration from water has excelled many times (5 ÷ 10) times the accepted concentration for drinkable water.

It is used a treatment channel with following processes:

- Oxidation with ClO_2 and ozone.
- Advanced coagulation with ferric chlorides (14,5 mg/l) and brute water acidifying with 2,5 % HCl solution, (18,5 mg/l).
- Clarifying in clarifying tank with concentrated dynamical stratum at hydraulic attempts i_h = 4 m/h.
- Castigation pH with lime water, (dozes of 28 mg/l).
- Quick filtration on quartz sand stratum. The seeming filtration speed is v_f = 6 m/h
- Post – oxidation with ozone (1 mg O_3/l) after quick filtration on sand.
- Filtration on granular active coal with seeming filtration speed v_f =5 m/h and time t = 8 min.
- Final disinfection with sodium hypochlorite, (dozes chlorine 1 mg/l).

The table 2 present the physical and chemical indicators for brute water from treatment station Chirita in year 2008, (a – average; m - maximum).

Table 2. Physical and chemical indicators for brute water from treatment station Chirita in year 2008, (a – average; m - maximum)

Indicator		Org. subst.	Suspensions	Chloride	Nitrate	NH_3	pH
Month	Value	mg/l	mg/l	mg/l	mg/l	mg/l	-
January	a	12,5	8,0	35,5	0,022	0,058	8,35
	m	13,4	10,0	39,0	0,031	0,088	8,40
February	a	13,9	11,5	38,0	0,034	0,100	8,34
	m	16,1	13,0	40,0	0,047	0,167	8,40
June	a	28,2	9,0	28,0	0,040	0,040	8,25
	m	45,9	9,0	30,0	0,042	0,078	8,30
July	a	43,3	19,0	28,5	0,020	0,022	7,74
	m	77,1	19,0	30,0	0,021	0,020	8,10
August	a	24,7	11,5	29,0	0,050	0,040	8,12
	m	39,8	15,0	32,0	0,054	0,058	8,30
September	a	12,0	12,0	29,0	0,050	0,090	8,13
	m	14,0	18,0	31,0	0,048	0,093	8,25
October	a	12,4	14,0	30,5	0,030	0,050	8,10
	m	13,6	20,0	32,0	0,046	0,100	8,20
November	a	12,6	12,5	33,0	0,020	0,040	8,16
	m	13,9	17,0	34,0	0,024	0,088	8,31

The results of chemical analysis are shown in table 3 for filtered water on quartz sand stratum (fq), on granular active coal and disinfection with sodium hypochlorite (csh).

It is tested water sources with aluminium sulphate and ferrous chloride at (6 ÷ 6,5) pH. It is ascertained the reduction of turbulence and organic substances' oxidation.

The usage of the ferrous chloride reduces organic loading, particularly at oxidable hard organic substances. The coagulation - flocculation tests make obvious the water's aggressiveness growth through treatment, [9]. The castigations with lime water eliminate the aggressiveness effect of water. Also grow up the total organic carbon quantity with (30 ÷ 40) %. After organic substance' removal may be corrected pH. It is necessary lime dozes between (8 ÷ 10) mg CaO/l.

Figure 2 present the concentration's variation of total organic carbon depending on pH for lime water treatment from Chirita treatment station.

The polymers conduct at different efficiency all over: turbulence and organic loading. It is used polymers mixtures for coagulation – flocculation treatment in laboratory. The best behaviour has been the mixture *c*. Polymer optimum dose is 0,2 mg/l, (figure 3).

Table 3. Results of chemical analysis for filtered water on quartz sand stratum (fq), on granular active coal and disinfection with sodium hypochlorite (csh)

Indicator	UM	fq	csh
pH	-	7,16	7,23
Turbulence	TNU	0,70	0,50
Color	Pt-Co	3	3
Conductivity	µ	524	475
Fixed residue	mg/l	308	279
Alkalinity	mechiv/l	2,84	2,84
Total toughness	°G	11,42	11,42
Temporal toughness	°G	7,95	7,95
Permanent toughness	°G	3,46	3,46
Calcium	mg/l	70,14	72,14
Magnesium	mg/l	19,25	18,94
Iron	mg/l	0,01	0,008
Bicarbonate	mg/l	112,24	173,24
Sulphate	mg/l	92	88
Nitrate	mg/l	6,50	6,50
Nitric	mg/l	0,009	0,009
Ammonia	mg/l	0,05	0,05
CCO-Mn	mg $KMnO_4$/l	11,42	5,74
CCO-Cr	mg O_2/l	7,90	1,90
Total organic carbon	mg C/l	6,76	1,58

The experimentation in laboratory has used simple polymers and polymers mixtures. Some polymers mixtures have acted simultaneous about several quality parameters of water.

The measure and control system of drinkable water's quality, of functional parameters of the pipes network from Chirita pumping station has been complete automized in August – December 2008 with performance installations by Endress Hauser concern, figure 4. All system has automized calculus program that permits of the dispatcher from S. C. APAVITAL S. A. Iasi industry to pursue the parameters' network in 17 demurrages from the supply system with drinkable water of Iasi town. The registering is permanent, 24 hours. The water samples are analyzed automatic at each 2 ÷ 5 minutes. Drinkable water is treated with ammonium and chlorine in accordance with the properties of the analyzed water.

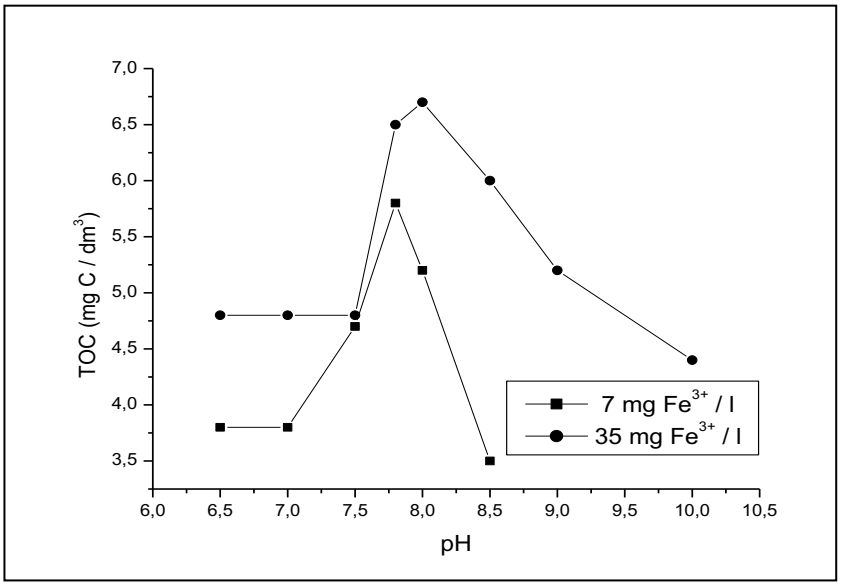

Fig. 2. Total organic carbon concentration variation *TOC* depending on *pH* for lime treatment from Chirita treatment station.

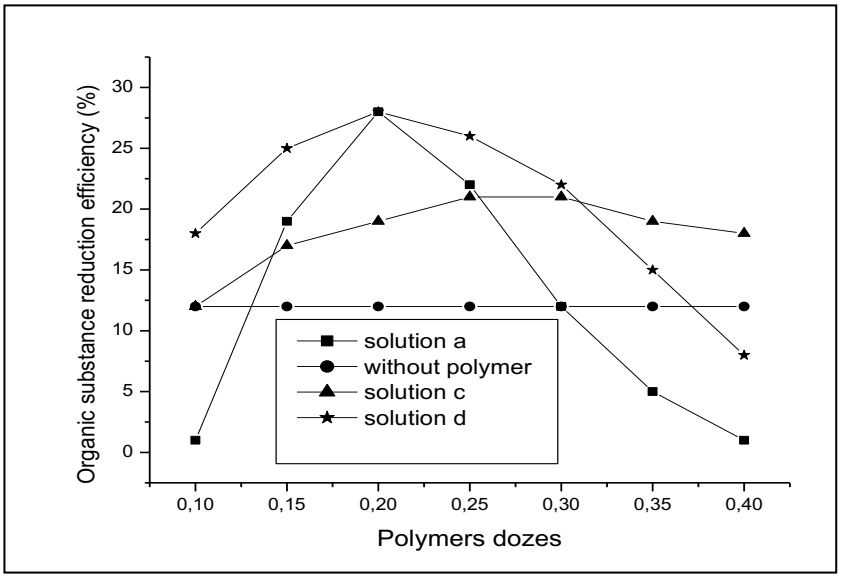

Fig. 3. Organic substance reduction efficiency depending on polymers dozes from Chirita treatment station.



Fig. 4. The pursuit installation of drinkable water network, TYPE 1.

The all measurement system of drinkable water's conductivity from pipes network supplied of Chirita Iasi pumping station includes the following elements: temperature integrated sensors inductive and conductive sensors.

The conductivity value k is measured depending on temperature coefficient α, on drinkable water's temperature T, on reference temperature T_o , accurately equation, [1]:

$$k(T) = k(T_o).\left[1+\alpha.(T-T_o)\right]. \quad (1)$$

The turbidity and the solid suspensions quantity *Tb* from drinkable water system are measured with the Liquisys M CUM 223/253 type system. The turbidity sensors are Turbimax W CUS 31 type.

The automized regulation system of chlorine and chlorine dioxide quantity from Chirita pumping station is Liquisys M CCM 223/253 type. The CSC 140/141 type sensors are used to visualize the automized measurement and processing of the Cl_2, HOCl, OCl^- concentrations, depending on the drinkable water pH.

The conductivity, chlorine and turbidity concentration variations are measured in same moments of 1.06.2009 day, (fig. 5) in Chirita pumping station.

The measurement system of ammonium quantity from drinkable water is Stamolys CA 71 AM type. The ammonium concentration variation in same time in 1.06.2009 day is presented in figure 6.

The digital transmission system of the pressure p and the debit Q from Chirita pumping station at the S. C. APAVITAL S. A. Iaşi dispatcher is Cerebar M HART, respectively Priline Promag 50 types. Figures 7 and 8 present la variation of pressure, respectively debit in same moment of 1.06.2009 day.

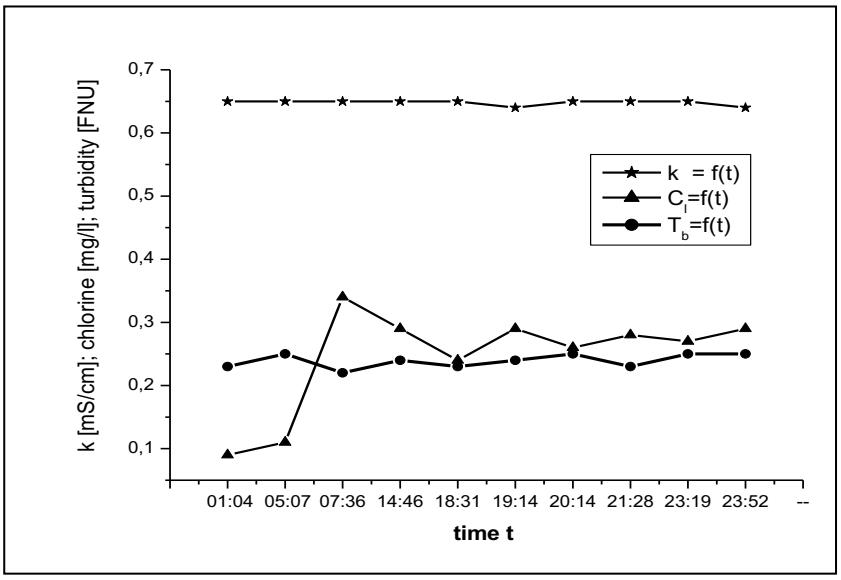

Fig. 5. Conductivity, chlorine concentration and turbidity variations depending on time in 1.06.2009 day.

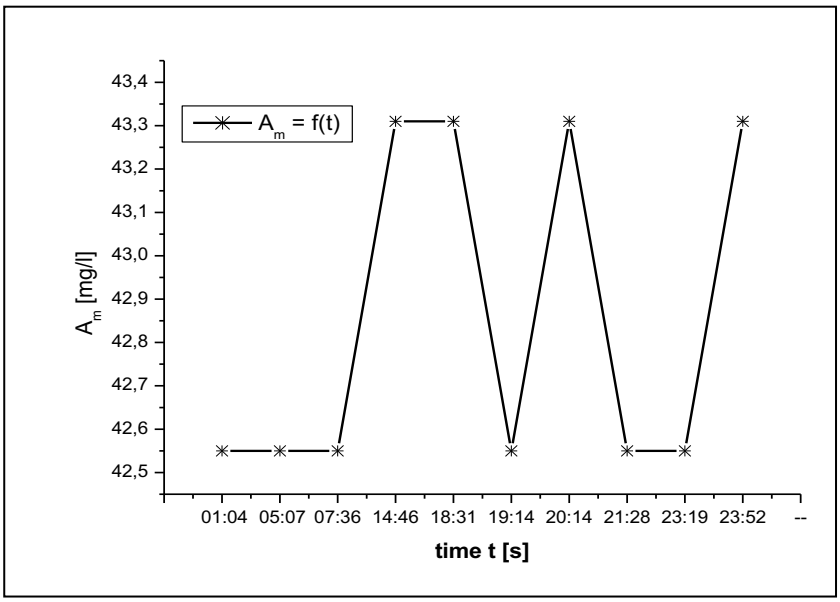

Fig. 6. Ammonium concentration variation depending on time in 1.06.2009 day.

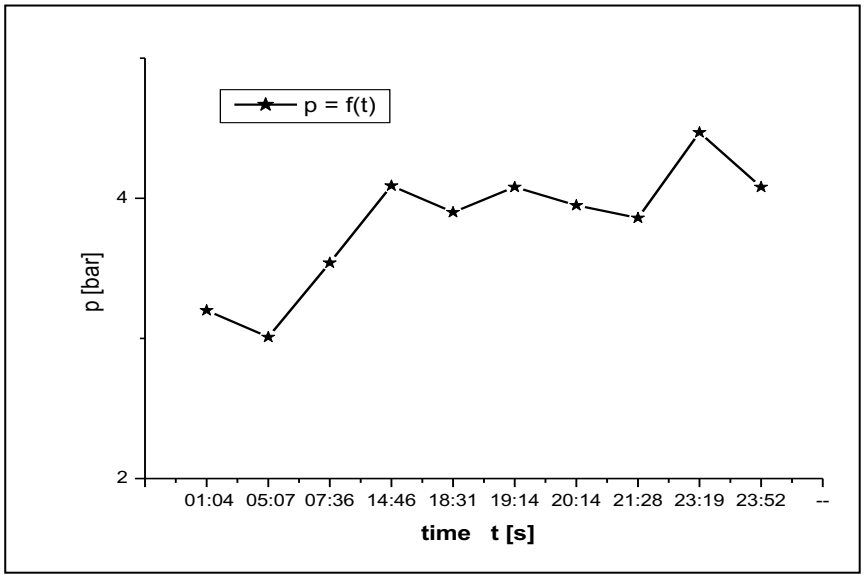

Fig.7. Pressure variation depending on time in 1.06.2009 day, Chirita pumping station.

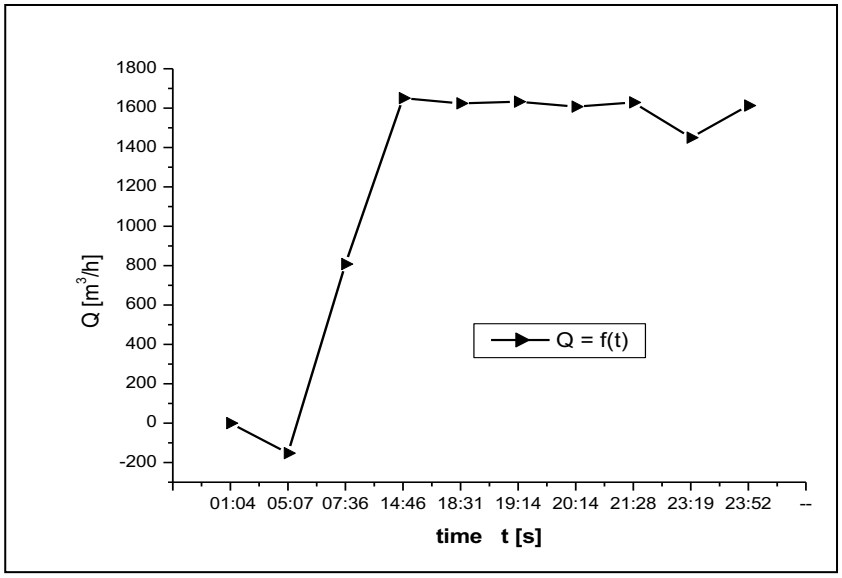

Fig.8. Debit variation depending on time in 1.06.2009 day, Chirita pumping station.

3. CONCLUSIONS

The studies concerning the water's treatment in Chirita treatment station make obvious the following conclusions:

- Te water source present treatment difficulties because of elevated concentration of organic substances; concentration of total organic carbon is (10 ÷ 18) mg C/l.
- Removal maximum efficiency of the organic loading through advanced coagulation is obtained with ferric chloride (5 ÷ 7) mg Fe^{3+}/l and reduced pH (6 ÷ 6,5). It is necessary to use powder active coal for the coagulation - flocculation optimum process.
- The water's treatment with ozone and granular active coal establish good qualities, in the limit imposed by the standard.
- Sulphide hydrogen may be eliminated with 100 % efficiency using filtration and oxidation with chloride.
- The filtration process on sand has not good efficiency; it is not drinkable water. It is necessary the coagulation - flocculation and clarifying process. It is recommended the clarifying tank with (4 ÷ 5) m/h and sedimentation time of 1 h.
- The nitrogen may be eliminated through treatment with chlorine.
- The filtered water on diaphragm has the standard qualities.
- It comes out that chlorine and ammonium concentrations grow up in the maximum consumption period of network: C_l = (0,1 ÷ 0,35) [mg/l] and A_m = (42,55 ÷ 43,31) [mg/l]. In the same time, pressure and debit grow up because to the increase of the active consumers number in the network: p = (3,01 ÷ 4,09) [bar] and Q = (0 ÷ 1650,74) [m^3/h].

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