WATER CONDITIONING FOR FOOD INDUSTRY USES

RAISA NASTAS[1], V.RUSU[1], T.LUPASCU[1]
LUDMILA STARIS[1], MARIA SANDU[2]

ABSTRACT. – Water conditioning for food industry uses. Tap (drinking) water from many localities of Moldova doesn't always correspond to the "Sanitary standards for drinking water quality" or to the requirements of the "Regulation for non-alcoholic beverages", requiring the need for additional purification/ conditioning. This paper presents research regarding the removal/adsorption of the main pollutants in tap water (iron, manganese, aluminum, humic substances, trihalomethanes) on supports of local carbon adsorbents made from vegetable products (stones of peach and plum, walnut shells). Experiments were performed in dynamic conditions in columns of carbon adsorbents. As work solutions was used tap water where pollutants have been introduced in amounts equivalent to 3 maximum allowable concentrations. Carbonaceous adsorbents used for removal/adsorption of pollutants in dynamic conditions, reveal a capacity of up to 1:400 volumes adsorbent: solution before breakthrough. Combined filter, utilizing active carbons, was constructed and tested for conditioning of tap water for beverage and food production. The results demonstrated efficient remove of organic substances and heavy metals by filtering of about 700 volumes of water per volume of filter.

Keywords: drinking water quality, active carbons, absorption, organic substances, heavy metals.

1. INTRODUCTION

Analysis of the available data indicates the unsatisfactory situation concerning quality of potable water in many settlements in Moldova, as well as feed water for food and beverage production. The raw water for beverage and food production has to meet special toxicological, medical, and technological requirements and has to be of satisfactory taste and odor [1]. Usually, the water treatment and conditioning technologies in this area incorporate several methods that are characterized by the raw water composition and the requirements of the subsequent water use.

Chemical analysis of tap water in different zones of Republic of Moldova demonstrated that tap water from surface sources contains small amounts of organic substances and aluminum, but tap water from underground sources contains high level of iron [2].

[1] Institute of Chemistry, Academy of Sciences of Moldova, 3, Academiei str., MD-2028, Chisinau, Republic of Moldova, e-mail: nastasraisa@yahoo.com
[2] Institute of Ecology and Geografy, Academy of Sciences of Moldova, 3, Academiei str., MD-2028, Chisinau, Republic of Moldova

The conditioning of raw water for the use as feed for beverage and food production requires the correction of the concentrations of several constituents in water.

The purpose of this work was to test vegetal carbonaceous adsorbents, with a broad spectrum of physical-chemical characteristics, for removal of humic substances (HS), trihalomethanes (THM), aluminum, iron (III), and manganese (II) from water.

2. EXPERIMENTAL

A broad spectrum of vegetal carbonaceous adsorbents have been tested on adsorption of humic substances (HS), chloroform (THM) and metals (under static condition), to chose the more efficient adsorbents.

Structural parameters (obtained from sorption isotherms of nitrogen at 77 K) of active carbons and surface chemistry are presented in tables 1 and 2.

Table 1. ***Structural parameters of activated carbons obtained [3]***

Sample	Characteristics	S_{BET}, m^2/g	S_{me}, m^2/g	S_{micro}, m^2/g	V_s, cm^3/g	V_{micro}, cm^3/g	D, Å
CAP23	Obtained from peach stones	957	110	846	0,57	0,42	23,8
CAPrO36	Obtained from plum stones, oxidized with nitric acid	1199	128	1071	0,68	0,51	22,7

S_{BET} – BET surface area; S_{micro}, S_{me} – micropore and mesopore surface area, respectivelly; Vs – total pore volume; V_{micro} – micropore volume; D – average pore diameter.

Sorption processes for the more efficient adsorbents were performed also in dynamic conditions. The length of column was of 60 cm and diameter 1,5 cm, the speed of filtration was about 10 m^3/m^2h.

Table 2. ***Surface chemistry of activated carbons characterized by modified Boehm method [4]***

Sample	Quantity of the functional groups. Amount, meq/g				Character of the functional groups. Amount, meq/g			
	Titrant				Carboxylic		Phenolic	Basic
	0,05 N $NaHCO_3$	0,1 N Na_2CO_3	0,05 N NaOH	0,1 N HCl	Strong acidic	Weak acidic		
CAP23	0,10	0,29	0,58	0,59	0,10	0,19	0,29	0,59
CAPrO36	0,99	1,47	2,48	0,43	0,99	0,48	1,01	0,43

For simultaneous removal of HS, THM and heavy metals water samples were passed through two consecutive columns (with total working volume about 66 cm^3) with active carbon (CAP23) and oxidized active carbon (CAPrO36). In the effluents there has been determined the concentration of ingredients and pH values, chemical oxygen demand (COD), permanganate oxygen demand (MnOD), organic matter (OM) and hardness (HD).

The concentration of humic substances and chloroform have been determined by two procedures, wet-oxidation method and ultraviolet absorptin method (λ=254 nm and λ=280 nm) [5,6]. Metals ions have been determined by fotocolorimetric methods [6,7].

Working solutions, which consist of amounts equivalent to 2-3 maximum allowable concentration, have been modeled on natural waters of Republic Moldova (tap water from Chisinau, surface water from Ungheni, and from underground sources, Singerei).

The combined filter utilizing active carbon CAP23 (obtained from peach stones) and active carbon CAPrO36 (obtained from plum stones, oxidized with nitric acid) was constructed and tested for conditioning of tap water for beverage and food production.

3. RESULTS AND DISCUSSION

Chemical composition of tap water obtained from surface and underground sources in different zones of Moldova was determined. Parameters of quality for water samples are presented in table 3. Results demonstrated that tap water from surface sources contains appreciable amounts of organic substances, and tap water from underground sources contains high level of iron.

Previously results demonstrated that active carbon CAP23 (obtained from peach stones) posses highest sorption capacity for humic substances (HS) and chloroform (THM), and oxidized activated carbon CAPrO36 (obtained from plum stones, oxidized with nitric acid) – for metals (aluminum, iron, manganese) [8]. On this basis, the removal of Al^{3+}, Fe^{3+} and Mn^{2+} from individual solutions was performed in dynamic frontal method utilizing oxidized active carbon CAPrO36, obtained from plum stones. In this case, oxidized active carbon CAPrO36 works as an ion-exchanger (Fig. 1). The removal of humic substances (HS) and chloroform (THM) from individual solutions was performed using columns with carbonaceous adsorbent obtained from peach stones CAP23 (Fig. 2).

Removal efficiency of HS, THM and heavy metals from their mixture have been studied using two consecutive columns with active carbon (CAP23) and oxidized active carbon (CAPrO36). The output curves of adsorption of Al^{3+} ions from mixture and pH values of effluents (using the dynamic frontal method) are presented in figures 3A and 3B. Carbonaceous adsorbents used for removal of pollutants in dynamic conditions reveal a capacity of up to 1:400 volumes adsorbent: solution before breakthrough (Fig. 3A).

Table 3. ***Water quality for different locations of the Republic of Moldova***

Parameters of quality	Locations		
	Chisinau, r. Nistru	**Ungheni r. Prut**	**Singerei Ground water**
pH	7,2	7,3	7,2
Turbidity, mg/l	0,9	0,5	0,3
TDS, mg/l	330	277	964
Alcalinity,mgE/l	2,88	2,54	9,8
Oxidability, mgO/l	2,1	2,1	2,1
DOC, mgC/l	3,06	2,98	3,48
CDOC, mgC/l	2,28	2,33	2,48
Iron, mg/l	0,27	0,20	1,1
Mangan, mg/l	<0,01	<0,01	<0,01
Aluminium, mg/l	0,28	0,29	0,01

Adsorption (integral on effluents) of Al^{3+}, Fe^{3+}, Mn^{2+} ions and chloroform $CHCl_3$, and humic substances HS are presented in figures 4A and 4B.

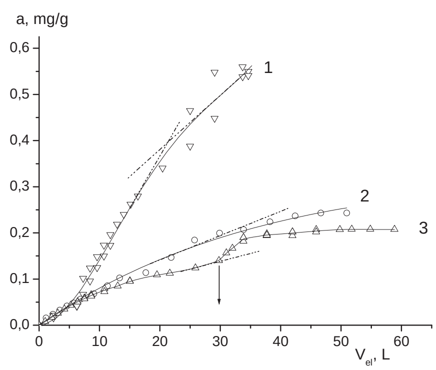

Fig. 1. ***Adsorption (integral on effluents) of Fe^{3+} ions (curve 1), Al^{3+} ions (curve 2) and Mn^{2+} ions (curve 3) on oxidized active carbon (CAPrO-36) in dynamic conditions.***

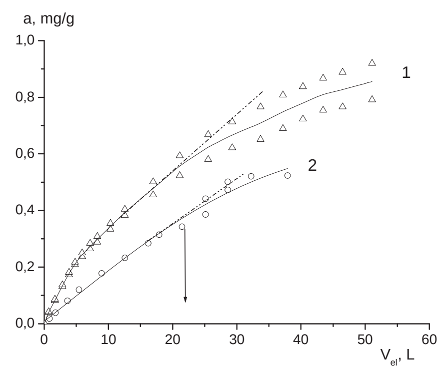

Fig. 2. ***Adsorption (integral on effluents) of humic substances (curve 1) and chloroform (curve 2) on active carbon (CAP-23) in dynamic conditions.***

Sorption processes of humic substances (HS), chloroform (THM) and metals (aluminum, iron and manganese), studied under dynamic conditions from solutions modeled on tap water, demonstrated that obtained adsorbents possess high sorption properties for organic and inorganic pollutants and may be utilized for tap water treatment.

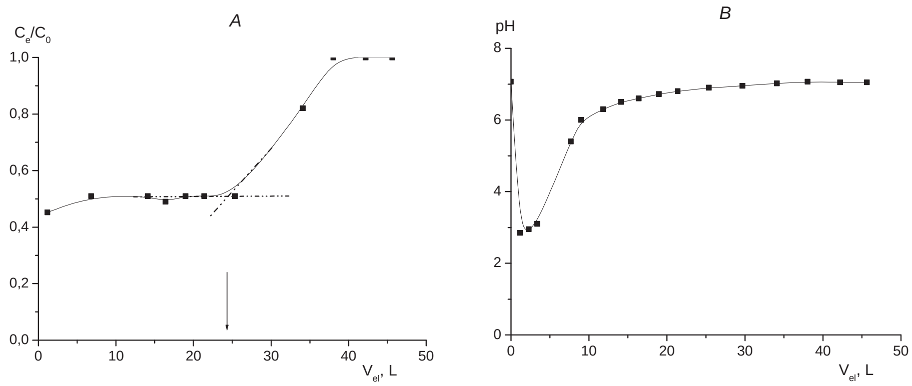

Fig. 3. ***The output curve of adsorption of Al^{3+} ions in dynamic conditions (A), and pH values of effluents (B). Model solution, containing Al^{3+}, Fe^{3+}, Mn^{2+} ions, chloroform $CHCl_3$ and humic substances HS.***

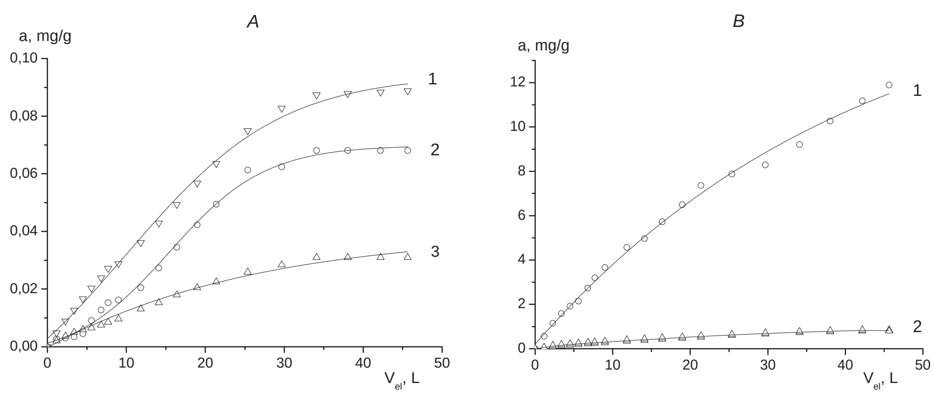

Fig. 4. ***Adsorption (integral on effluents) of Fe^{3+} ions (curve 1A), Al^{3+} ions (curve 2A) and Mn^{2+} ions (curve 3A), humic substances (curve 1B) and chloroform (curve 2B) in dynamic conditions from mixture.***

The combined filter utilizing active carbon CAP23 (obtained from peach stones) and active carbon CAPrO36 (obtained from plum stones) was constructed. This combined filter was tested under dynamic conditions for remove from tap water at high flow velocities of the impurities.

The results demonstrated efficient remove of organic substances and heavy metals by filtering of about 700 volumes of water per volume of filter (Tab. 4, Fig. 5).

Table 4. ***Quality characteristics* of water passed thorough combined filter with active carbon CAP23 (obtained from peach stones) and active carbon CAPrO36 (obtained from plum stones)***

V_l/V_s	*HD*	HCO_3^-	Cl^-	SO_4^{2-}	*pH*	*MnOD*	*Corg*	*OM*
0	3,7	226	48,6	84	7,70	1,93	2,94	5,89
200	1,5	110	44,2	55	6,45	0	0,08	0,16
300	2,2	104	43,8	68	6,50	0,08	0,05	0,10
400	2,5	122	44,8	63	6,55	0,28	0,13	0,26
500	3,3	134	43,7	68	6,55	0,30	0,15	0,30
600	3,5	163	44,7	63	6,95	0,90	0,35	0,70
700	3,4	177	41,8	65	7,05	1,00	0,36	0,72
800	3,7	183	41,8	66	7,10	1,60	0,74	1,48
900	3,7	169	43,7	72	7,15	1,70	1,32	2,64
1000	3,7	188	41,9	71	7,15	1,60	2,15	4,30
1100	3,7	183	42,4	78	7,20	1,90	2,60	5,20

**MnOD – permanganate oxygen demand, mg O_2/L, Corg, mg/L, Organic matter OM, mg/L, Hardness HD, meq/L, content of ions, mg/L. Filter volume 0,595 L, V_l/V_s is the water volumes: sorbent volume ratio passed thorough filter. Dynamic velocity of filtering 15 L/h. Initial water V_l/V_s = 0.*

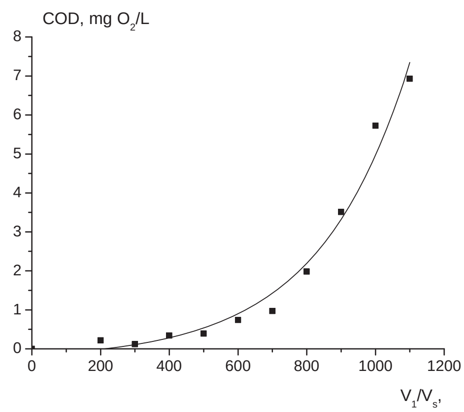

Fig. 5 ***Chemical oxygen demand (COD) of water passed thorough combined filter with active carbon CAP23 and oxidized active carbon CAPrO36.***

4. CONCLUSIONS

Sorption processes of humic substances (HS), chloroform (THM) and metals (aluminum, iron, manganese) were studied under dynamic conditions from solutions modeled on tap water. It was demonstrated that obtained adsorbents possess high sorption properties for organic and inorganic pollutants and may be utilized for tap water treatment.

Carbonaceous adsorbents used for removal of pollutants in dynamic conditions reveal a capacity of up to 1:400 volumes adsorbent: solution before breakthrough.

The combined filter utilizing active carbon CAP23 (obtained from peach stones) and active carbon CAPrO36 (obtained from plum stones) was constructed and tested for conditioning of tap water for beverage and food production. The results demonstrated efficient remove of organic substances and heavy metals by filtering 700 volumes of water per volume of filter.

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