International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-4, April 2019

Comparison of carbon dioxide removal methods from ground waters

Olga V. Sidorenko, Anna A. Shkileva, Elena S. Smirnova

***Abstract*: The article includes the researches of the comparison of carbon dioxide removal effects from ground water with simplified aeration method or ejector-vacuum method. The researches were made in conditions of Borovskaya iron removal stations.**

***Index Terms*: Spring ground water, carbon dioxide content, carbon dioxide removal methods.**

I. INTRODUCTION

The most of the towns in Tyumen region (i. e. more than 70 %) use ground waters as a central water-supply source because of them availability and safety in terms of sanitary-hygienic standards.
The specific characteristic of ground waters of West Siberia is high concentration of iron. This is due to high concentration of iron-containing minerals in the geological section. Processes of iron removal depend on base water chemistry i. e. of carbon dioxide content [1].
According SanPiN that controls the water indexes for consumers [2], the content of iron should not be higher than 0,3 mg/dm3.The SanPiN doesn't include index of dissolved carbon dioxide (i.e. the CO2), that why it is ignored at the most of iron removal stations.
Several public water supply abstractions facilities of Tyumen region have a high carbon dioxide level (from 100 mg/dm3 and higher) [3]. While as simplified aeration method recommended for less than 40 mg/dm3 dioxide level [4]. Necessity of control in field of the full carbon dioxide was regulated with removal operating and maintenance rules of public water supply, drainage and sewage [5].

II. SUBJECTS AND METHOD

Main objective of the research is measuring effectiveness of Borovskaya iron removal stations in Tyumen region.
There are several methods of dissolved gases removal from water. The research includes the comparison in efficiency of carbon dioxide removal with simplified aeration method or ejector vacuum method.

Manuscript published on 30 April 2019.
* Correspondence Author (s)
Olga V. Sidorenko, Industrial University of Tyumen, Tyumen, Russia.
Anna A. Shkileva, Industrial University of Tyumen, Tyumen, Russia.
Elena S. Smirnova, Industrial University of Tyumen, Tyumen, Russia.

The simplified aeration method is an inert method that includes aerification process and dissolved carbon dioxide removal process at the same time. This increasing processes of iron burning and hydrolysis with forming of ferrum hydroxide. The simplified free-flow aeration method can be realized with water outflow at low altitude to pipeline water pocket or central water channel of gravity filters.
The simplified free-flow aeration method is often used due to its simple and efficiency. But it is not useful in conditions of high carbon dioxide concentration due to it is not completely removes iron from underground water. The simplified aeration method usually shows equal 40 % of carbon dioxide removal efficiency.
Ejector-vacuum method is an active degassing method that based on ejector for air leak in the water flow. Water pumped through the jet nozzle that located on top of the plant and then falls down the pipes.
Low pressure in pipes formed the air leak that goes through the ports in pipes. This has led to the formation of water-to-air emulsion. The medium formed the intensive carbon dioxide desorption. Oxygen separation process has taken place in prefabricated basin or under filter load. Carbon dioxide removal efficiency of this method is 80 % [6].
Borovskoy town uses the underground waters of Kyrtymsky aquifer as a main water-supply source. It based at Borovskoe field. The underground waters can be characterizing as water with increased color, turbidity, permanganate value, high iron and manganese content that due to natural or man-made admixtures. The characteristics of base water set in Table 1.

Table 1. The characteristics of base water and purified water

Indexes	Units of measurement	Standards (MPC), not more then	PAO «Pticefabrika Borovskaya»,battery farm	
			Base water	Purified water
Smell	point	to 2	3	1
Flavor	point	to 2	3	1
Color	color degree	20	45,00	33,4
Turbidity	mg/dm^3	1,5	3,48	1,4
Total hardness	mg-eq/dm^3	7	5,26	5,2
Oxidizability	mgO_2/ dm^3	5	8,44	6,8
pH		6-9	6,95	7,4
Alkalinity	mg-eq/dm^3	10,0	4,9	4,6

Total iron	mg/dm^3	0,3	5,0	0,11
Ammonium (NH_4)	mg/dm^3	2	3,1	2,18
Nitrite (NO_2)	mg/dm^3	3	0,036	0,05
Nitrate (NO_3)	mg/dm^3	45	0,558	1,39
Sulfates (SO_4)	mg/dm^3	500	2,0	5,0
Solid residue	mg/dm^3	1000	342	347
Oil products	mg/dm^3	0,1	0,012	0,012
Manganese	mg/dm^3	0,1	0,63	0,39

But despite of the ground water quality, the purified water has an almost corresponds to the requirements of SanPiN [2], except of the color, manganese content and oxidizability.
The water quality had not had a sea changes within a year. Stations also had not had water control measures in field of dissolved carbon dioxide.
The following steps describe the water purification flow chart:
- ejection preaeration (process of water oxygenation with dissolved gases removal)
- free-flow iron removal with rapid filters
- water disinfection.

Water station has 8 rapid filters with the quartz sand and 107,5 m2 of total area. Filtration speed is sustained of 2,5 to 3 m/h, compared to the recommended of 5 to 7 m/h [4]. This due to the achievement of less than 0,3 mg/dm3 of iron in purified water.
Carbon dioxide concentration were measured in accordance with CV1.01.17-2004 [7] (measuring technique) directly at the sampling station.
Practical part of the research was made in conditions of Borovskaya battery farm iron removal stations.
Two types of filters were used in researches:
-First filter used for ejector method (hereafter referred to as filter #1)
-Second filter used for free-flow aeration method with water outflow at 1m altitude to pipeline water pocket (hereafter referred to as filter #2)
The researches includes the following steps:
1. Base water-testing in water wells and water analysis were made. Key water indexes: carbon dioxide, Fecommon, Fe2+, pH, temperature;
2. Aerated water-testing works in water pocket #1(after ejection) and #2 (after water outflow) filters were completed and water was tested to free carbon dioxide content, Fecommon, Fe2+.
3. Water-testing works of #1 and #2 filtered water and analysis of the above-mentioned water samples characteristics analysis.
4. All research stages were repeated after 24 and 48 hours.

III. RESULTS

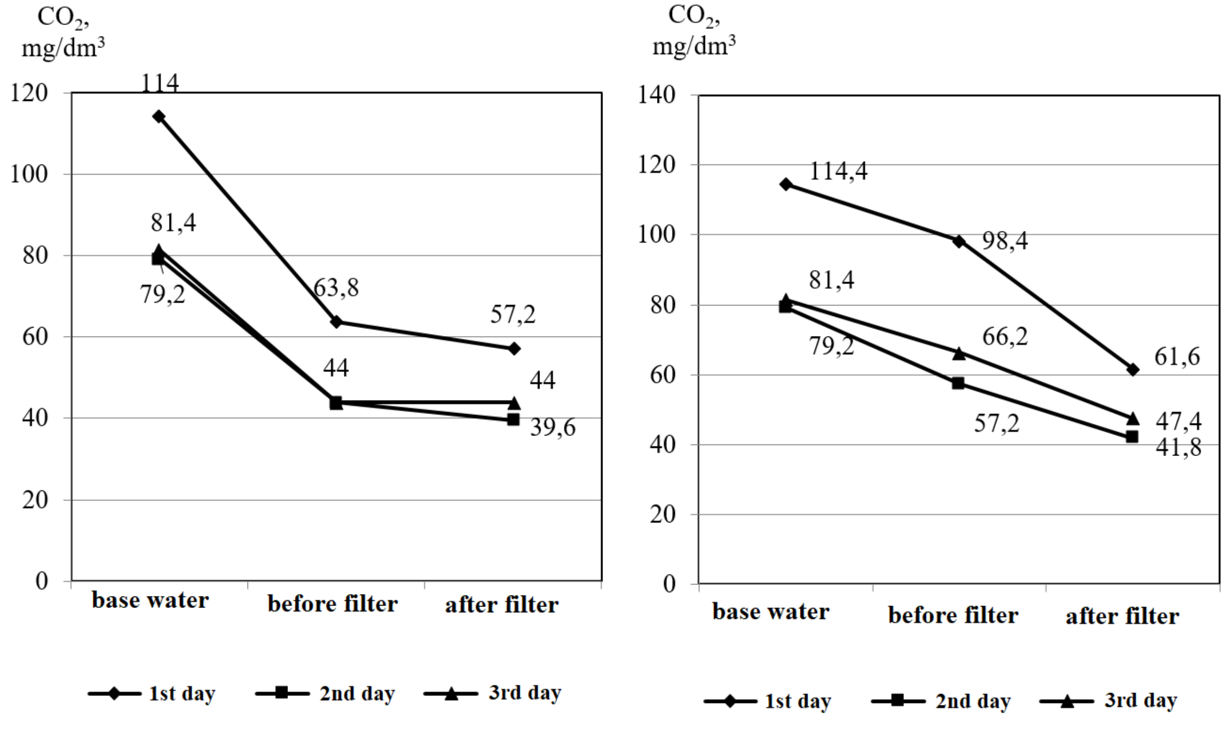
Research results set in Table 1. The average temperature range during sampling was 7-9°C.

Table 2. Iron removing researches results

Water sampling point	Period	Indexes				
		CO_2, mg/dm^3	CO_2 remove efficiency, %	Fe_{common}, mg/dm^3	Fe^{2+}, mg/dm^3	pH
Base water	1st day	114,4	-	4,93	2,98	6,45
	2nd day	79,2	-	5,19	2,98	6,38
	3rd day	81,4	-	4,67	2,98	6,38
Water pocket #1	1st day	63,8	44,23	4,93	0,44	6,96
	2nd day	44	44,44	5,19	0,25	6,89
	3rd day	44	45,95	4,41	0,64	6,94
Water pocket #2	1st day	98,4	13,99	4,93	0,6	-
	2nd day	57,2	27,78	5,19	0,64	6,48
	3rd day	66,2	18,67	5,19	0,68	6,43
Filtered wate r#1	1st day	57,2	50,00	0,052	0,012	6,97
	2nd day	39,6	50,00	0,08	0,02	6,93
	3rd day	44	45,95	0,08	0,04	6,92
Filtered water #2	1st day	61,6	46,15	0,042	0,016	-
	2nd day	41,8	47,22	0,09	0,024	6,55
	3rd day	47,4	41,77	0,12	0,052	6,58

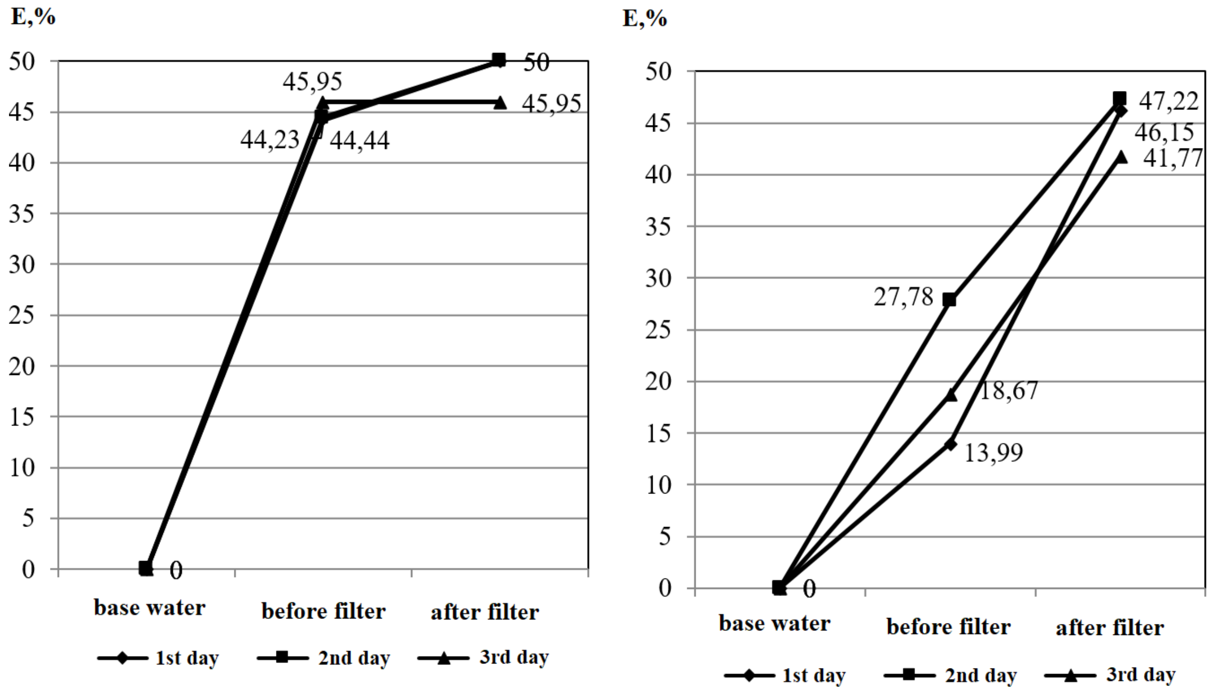
Graphs (Figure 1), that show reducing carbon dioxide content with simplified aeration method (for 1b figure) and ejector-vacuum method (for 1a figure) were based on Table 1.
Figure 2 shows the CO2 remove efficiency graphs, according to the degassing method applied.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)



a) b)

Fig. 1. Reducing of CO_2 from underground waters with a) ejector-vacuum method; b) simplified aeration method



a) б)

Fig. 2. CO_2 removing efficiency a) ejector-vacuum method; b) simplified aeration method

The above-mentioned graphs and tables show that efficiency of carbon dioxide removing with ejector-vacuum method is 17- 30 % higher (depending on initial concentration) than aeration method. But during water filtration processes it having less carbon dioxide content due to the massive contacting area of water and air and slow speed of water. Filtrated water has an almost equal CO2 remove efficiency for both methods, it is about 48% for ejector-vacuum method and 45 % for simplified aeration method.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

The ejector-vacuum method is a highly energy-intensive due to making of the high speed of water on nozzle-exit (not fewer than 2 m/s),
which takes a great loss of pressure in facility. Main disadvantage is that water pressure before nozzle should be 25-35 m, in addition height of ejector part of facility shouldn't be fewer than 2,5 m.
Simplified aeration method does not require additional energy. Water comes with well pumps and then flew in water pocket.
For CO_2 determination from ground waters with average temperature 5-8°C and conditions of full iron removal it is recommended to use approximation formula [8]

$$CO_2^{св} = 4,8 \cdot 10^{7+\sqrt{I}-pH} \quad (1)$$

,

I – is for ionic force of water.

Ionic force of fresh water and water with less than 1000 mg/dm^3 of salt content may be calculated by the formula

$$I = 0,000022 \cdot P \quad (2)$$

,

P – is for total salt content, mg/dm^3.

We've got the following formula, that based on Table 1 and Table 2: $I = 0,000022 \cdot 342 = 0,0075$;

$$CO_2^{св} = 4,8 \cdot 10^{7+\sqrt{0,0075}-6,4} = 23,3 mg/dm^3$$

According the above, amount of carbon dioxide for normal conditions of iron removing process after degassing should not be more than 23,3 mg/dm^3. According the SR (set of rules) 31.13330.2012 [4], amount of carbon dioxide should not be more than 40 mg/dm^3 in case of simplified aeration method.

IV. CONCLUSION

- efficiency of carbon dioxide removing with ejector-vacuum method is 17-30% higher than aeration method.
- ejector-vacuum filtered water has a higher dissolved carbon dioxide content than is necessary for regular iron removing reaction;
- ejector-vacuum method is a highly energy-intensive in comparison with simplified aeration method that makes it ineffective in conditions of high carbon dioxide content concentration (80-100 mg/dm^3).

REFERENCES

1. Kraynov, S.V. Hydrogeochemestry/ S. V. Kraynov, V. M. Schvec. – M.: Subsoil, 1992. – 463 p.
2. SanPiN 2.1.4.1074-01 «Potable water. Hygienic requirements for water quality of centralized potable water supply systems. Quality control".
3. Julin, A.G. Reducing of carbon dioxide from groundwater during its iron removing / A. G. Julin, O. V. Bolotova // News of higher educational institutions. Construction. – 2002. – # 4. – P. 89–92.
4. SR 31.13330.2012 Water supply. External supply line and facilities.
5. TLV 3-02-2001 Rules of technical operation of systems and facilities of public water supply and sewage.
6. Sharapov,V.I./ Decarbonizers of water purification system for heat supply systems / V.I. Sharapov, M.A. Sivukhina – M. : ACB p.h, 2000. – 200 p.
7. CV 1.01.17-2004 Water quality. Methods for measuring the content of free carbon dioxide in potable and natural water samples. Titrimetric method.
8. Stankevicius, V.I. Filtration of water with iron removing / V.I. Stankevicius. - Vilnius: Moxlas, 1978. - 120 p.