RESEARCH ON NATURAL POWDERED ZEOLITE INFLUENCE ON DRINKING WATER TREATMENT IN THE DRUSKININKAI III WATER WORKS

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Abstract

Aerated groundwater has been treated until now in open iron removal filters with crushed granite filter media at Druskininkai III drinking water works. The equipment was built in 1983. The existing groundwater's treatment equipment cannot ensure a very good quality of drinking water following the concentration of organic matter (permanganate index), iron and sometimes other matters in the water, from 2000 when the new hygiene norm HN24 : 1998 was accepted.

The removal of organic matter needs to be equipped to get a lesser concentration at the Druskininkai III water works before the iron removal treatment, for the aim of getting a good quality of drinking water. Data of the possibilities of the removal of organic matter and iron from groundwater without chemicals can be done only with aeration, by using the natural powdered zeolite (NPZ adsorbent) and filtration via quartz sand filter media technological processes that are presented in this article. Experimental research was carried out in an experimental pilot scale plant at the Druskininkai water treatment. Groundwater treated by conventional aeration, NPZ adsorbent dosage 80-100 mg/l, sedimentation equipment and filtration via pilot scale filters with 1.0-2.0 mm quartz sand filter media 5.0 m/h rate, content permanganate index to 1.75 mgO_2/l, iron concentration- 0.10 mg/l, Mn- 0.05 mg/l, ammonia-to 0.05 mg/l.

Introduction

Drinking water supplied to Druskininkai town from III (Latezerio) waterworks, which exploited two water horizons, i.e. agII-III Zemaitijos-Varduvos, water level that is situated at 40-50 m deep and with a highest chalk horizon, which is situated deeper at 89-103 m.

The waterworks started working in 1983. From its beginning the waterworks used approximately 6,000-7,000 m^3/d water. The water needs of Druskininkai town became lower from 1994 and only approximately 2,800 m^3/d were used in 2001: 2,400 m^3/d from Zemaitijos – Varduvos water horizon and 0,400 m^3/d from the highest chalk horizon.

The town everyday needs are approximately 3,000 m^3 of water and the future needs will be approximately 6,000 m^3/d. Hydro-geological investigation's data show that such a quantity of water can ensure only Zemaitijos –Varduvos water horizon alone or with highest chalk horizon water level.

Water resources of the highest chalk horizon are small, also the water horizons of Druskininkai are hydraulically connected and because of this if exploitation of highest chalk horizon will be more intensive, the water quality of one third of the waterworks can became lower.

The quality of different groundwater horizons is not the same. The quality of groundwater from Zemaitijos-Varduvos horizon following "Druskininku vandentiekis" data during 2000-2001 is: turbidity 0.25 - 1.52 mg/l, colour 10-70 mg/l Pt, total iron concentration –1.24-3.24 mg/l, manganese-0.06-0.15 mg/l, ammonia –0.3-2.24 mg/l, permanganate index–2.56-4.80mgO_2/l. Water quality from the highest chalk water horizon- turbidity 0.02-0.95 mg/l, colour -10-15 mg/l Pt, total iron concentration – 0.58-1.82 mg/l, manganese- 0.014-0.06 mg/l, ammonia –0.011-0.47 mg/l, permanganate index-2.24-5.44 mgO_2/l.

Groundwater is supplied to the drinking water treatment system with iron removal equipment, after that the water is disinfected and supplied to the town networks. Iron removal plants were built following the typically old design with simple aeration of groundwater and filtration via gravitational filters with crushed gravel filter media (5-10 mm particle size and 2100 mm high) filter media technology. Iron concentration of filtered water is 0.2-0.3 mg/l and sometimes more. Permanganate index decreases a little. Druskininkai water from the water supply has a negative taste and colour. The reason for the negative taste and colour of the water from the water supply is the high quantity of organic matter in the groundwater, indicating a high level of permanganate index. Organoleptical problems are connected with disinfecting by using by chlorinating, during the highest dosage of Cl some chloramines can be produced and that can have some influence on the negative taste of the supplied water (2). The last conclusions made have a strong argument, because the high level of ammonia existing in the groundwater, which cannot be removed by iron removal filters, and after the chloral gas disinfecting can form chloramines. Druskininkai III water works and the existing water treatment equipment experience following the conclusions of hydrogeology specialists about the negative taste and odour of the drinking water after iron removal shows that the iron content in the groundwater is completely or partially in a complex organic matter form. Iron removal connected with organic matter needs to follow the organic matter removal process. Iron, ammonia, manganese and organic matter (permanganate index) concentrations need to be decreased if the quality of treated water should follow a very good quality classification (1). The problem with unacceptable colour, taste and odour can be solved in the same way. The existing water treatment at Druskininkai can be used only for the removal of iron and cannot be used for other needs (3, 4, 5).

Methods.

Two technologies (5, 6) can be proposed for the water works water treatment allowing for very good or good quality drinking water classification (1), except for membrane technologies, because it needs a lot of energy:

- ✓ Method with chemicals: using strong oxidants, coagulation and filtration;
- ▫ Method without chemicals: using of adsorbents and filtration.

Most common adsorbent material for the water treatment is activated carbon (powdered or filter media), but it is artificial material and can negatively influence the water's quality. Activated carbon is quite expensive compared with adsorption effectiveness. Some kinds of zeolites that are imported into Lithuania from the Ukraine can be used for the water treatment at Druskininkai III water works. The investigation's results have shown the effectiveness of zeolites to adsorb organic matter (6).

Aim of research – experimental investigation of water treatment technology without chemicals, when groundwater is treated by a natural adsorbent (powdered zeolite) and filtration is done with quartz sand filter media at the Druskininkai water works.

A pilot scale experimental plant was built at Druskininkai water works filters hall; the principal scheme is shown in Figure 1. Untreated groundwater from the main pipeline was supplied by a pump to the water supply's pipeline, connected to the reactor and pilot scale filters Nr.1 and Nr.2. The construction of the reactor lead regular contact time (by volume changing) depending on the technological needs. Powdered zeolite was added to the reactor. All contents of the reactor's volume were mixed by an air pump without the sedimentation of powdered zeolite. Water and powdered zeolite mixture from the reactor was supplied to the sedimentation equipment during the sedimentation process of the used zeolite. Sedimentation equipment was constructed from six DN50, 1500 mm lengths of plastic. Water after sedimentation was supplied to the pilot scale filter Nr.3 during the removal of iron and other matters. All pilot scale filter construction is the same. Layers high and the particle sizes were the same, but filter media were different. Filter media of pilot the scale filter Nr.2 was made from new quartz sand and filters Nr.1, Nr.3– made from used for iron and manganese removal quartz sand (new quartz sand is ready for iron removal after one week's treatment and for manganese removal– after 10–12 weeks). Experimental equipment lead compares treatment by adsorbent and untreated aerated filtration via quartz sand filter media filtration technology, when the same untreated water was supplied to the reactor and after aeration to the pilot scale filters Nr.1 and Nr.2. Pressure losses were metered with piezometers. The filter media was backwashed with untreated groundwater. Special taps regulated the experimental pilot scale plant; equipped in the untreated water supply pipelines and the filtrated water outlet pipeline and the water flow was metered by volume method.

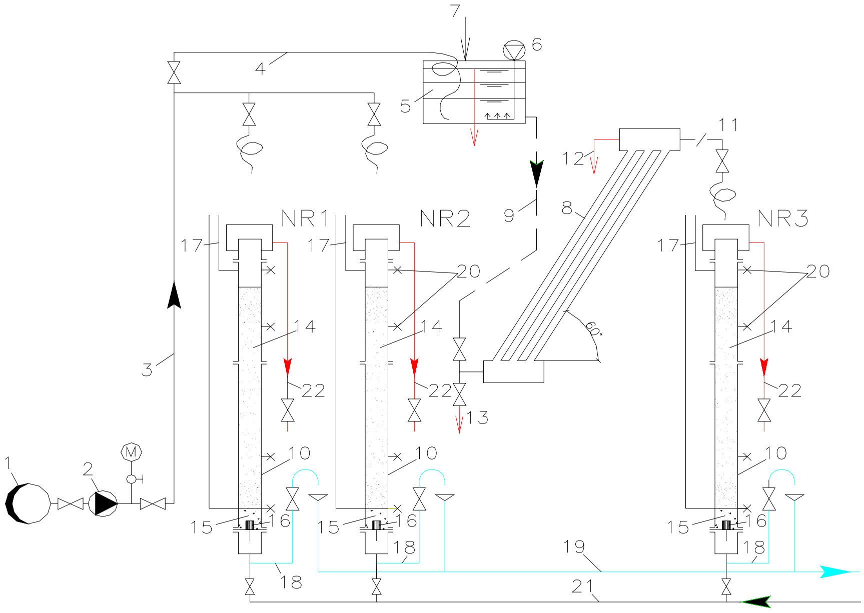

Figure 1. Pilot scale plant consists of:
1- main pipeline of water inlet; 2- pump; 3-pipline of water inlet to the pilot plant; 4-pipeline of water supply to the reactor; 5- 0,8 m^3 volume reactor; 6-air-pump; 7-dozage equipment for the adsorbent; 8-pilot scaled sedimentation equipment; 9- pipeline of the adsorbent treated water; 10-pilot scaled filters with diameter 150 mm; 11- pipeline for the water after sedimentation treatment; 12-emergency pipeline; 13- sediments discharge; 14- filter media (quartz sand); 15-fundamental layer; 16-drenage hood; 17-piezometers, 18- filtered water pipeline; 19- filtered water discharge pipeline; 20- taps for the water analyses taking; 21- backwash supply pipeline; 22- backwash discharge.

Merck systems Aqua-quant tests were used for the fast determination of iron, manganese and ammonia concentrations. The permanganate index, chemical oxygen demand, colour and turbidity were determinate by standard methods.

The dosage rate 60 mg/l was appropriated by investigation results from the laboratory's research before the experiment when the water and adsorbent contact time was 45 min. The water flow rate was 3,4 mm/s at sedimentation equipment (facilities of sedimentation equipment was approximately 12 m^3/m^2 h). Groundwater was supplied at the same time to the all-pilot scale filters (to Nr.3 – via a contact reactor and the sedimentation equipment). All pilot scale filters and filter media were backwashed properly with untreated water before every filter rate until the backwashing water seemed clear. The filter rate was established and filter pressure losses were registered before every start of the filtration rate. The filtration rate was controlled, filter media pressure losses were registered, and an analysis of the untreated water, water after sedimentation equipment and filtrated water were taken (depending on filter media layers) after 15 min filtration time (when the first filtrated water occurred). Untreated water analyses were taken twice during the filtration time and another analyses every 2-8 hours. Filter media pressure losses were registered all the time and the filter rate was controlled by the situation. The water supply was stopped when the filter media pressure losses were raised to 2 m w. t. and at the end the filtration rate was registered and the backwashing was started.

Results of the experimental investigation

The biggest part of the experiment was done with groundwater from the Varduvos- Zemaitijos horizon. Data of the experimental investigation was statistically calculated from the registered analyses and are presented in figures.

Filtrated water quality results of iron, ammonia and organic matter concentration following HN 24:1998 for very good quality of drinking water category resulted (1) if the filtration rate is 7 m/h and iron concentration, organic matter (permanganate index) and colour of untreated water are not high. Only the undetectable part of iron and manganese still found in filtrated water (manganese concentration in untreated water was up to 0.02 mg/l); and the permanganate index decrease to 1.75 mg/l O_2. The time of filtration rate was long, and pressure losses after 80 hours were only 1.64 m w. t., because the pilot scale filter media removed only a small part of the pollutants (little amount of iron and no manganese were in untreated water). The same quality water was filtered in the same conditions by pilot scale filter Nr.2 with unsatisfactory results. The reason for the unsatisfactory results is because the filter media of the pilot scale filter Nr. 2 was of new quartz sand and the filter media of the pilot scale filter Nr. 1was of used quartz sand.

During the highest chalk horizon groundwater treatment with aeration and filtration when the filtration rate is 7 m/h and the filter media is 1.0–2.0 mm fraction size, 1.6 m high quartz sand filter media, results of the drinking water's quality following the very good quality category. Other part of the investigation was done with a lesser quality Varduvos–Zemaitijos horizon groundwater treatment.

The following results during the aeration and filtration rate were: 7–9 m/h of untreated groundwater with iron concentration 1.50 mg/l, 0.18–0.20 mg/l of manganese, 0.70 mg/l of ammonia and permanganate index 3.89–4.12 mg/l O_2, via pilot scaled filters Nr.1 and Nr.2, iron removal was 80–86% (concentration in filtrated water was 0.20 mg/l), manganese removal was only 22–35% (concentration in filtrated water 0.13–0.15 mg/l). Removal of ammonia was small too (14–17%), and permanganate index stay without decreasing. Filtration rate time was 24–30 hours before pressure losses increased up to 2 m w. t.

The following results during the aeration, 40-45 min. adsorption with PNZ adsorbent and filtration rate were: 8 m/h via pilot scaled filter Nr.3 filter media of Varduvos-Zemaitijos groundwater, concentration of the ammonia decreased to 0.04–0.05 mg/l, permanganate index-to 1.60–1.70 mg/l O_2, manganese concentration-to 0.03–0.06 mg/l, colour- to 15 mg/l Pt. Iron concentration of the filtered water was more than 0.20 mg/l. Water quality increased during the groundwater treatment with NPZ adsorbent: iron concentration decrease 13% (from 1.50 to 1.30 mg/l), manganese – 50–60% (from 0.20–0.18 mg/l to 0.08–0.09 mg/l), permanganate index decrease 56% (from 3.89–4.12 to 1.70–1.86 mg/l O_2). Concentration of ammonia decreases a little– from 0.70 to 0.60 mg/l.The iron removal effectiveness was unsatisfactory following the accepted conditions and the water treatment parameters were changed: dosage of NPZ was increased up to 80–90 mg/l, filtration rate was decreased to 5 m/h. Concentrations of iron, ammonia and permanganate index decrease can be seen in the last filtration rate data showed in Figures 2, 3 and 4.

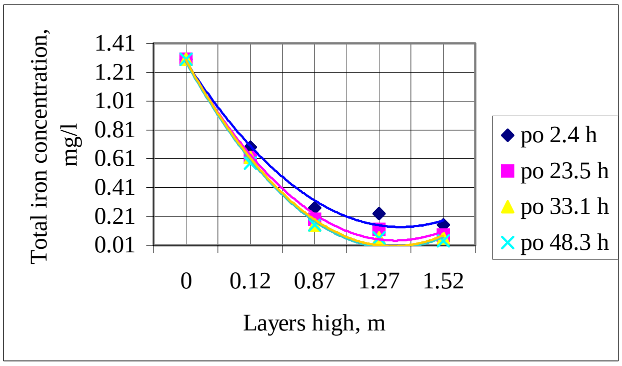

Figure 2. Iron removal from the PNZ treated (80 mg/l) Varduvos-Žemaitijos groundwater filtered 5 m/h filtration rate, when groundwater content Fe $_b$=1,50 mg/l, water after sedimentation Fe $_b$=1,30 mg/l (pilot scaled filter Nr.3)

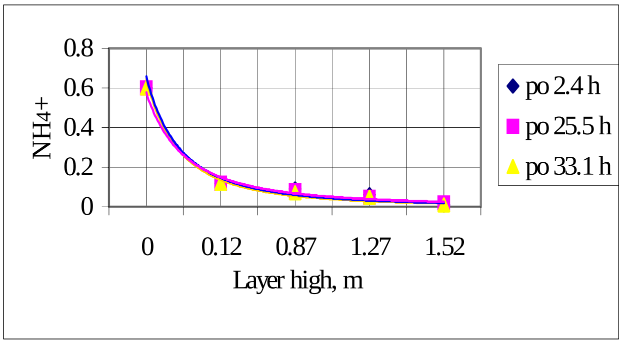

Fig 3. Ammonia removal from the PNZ treated (80 mg/l) Varduvos-Žemaitijos groundwater filtered 5 m/h filtration rate, when groundwater content was NH_4^+=0,65 mg/l, water after sedimentation-NH_4^+=0,60 mg/l (pilot scaled filter Nr.3)

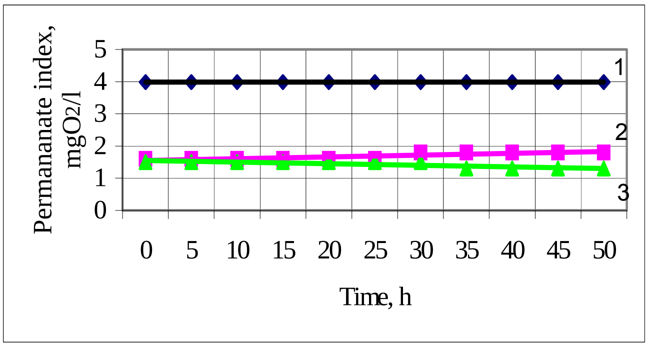

Figure 4. Changes of the permanganate index for the Varduvos- Žemaitijos groundwater when treated with PNZ (80 mg/l) and filtrated 5 m/h rate (pilot scaled filter Nr 3, 1-groundwater, 2-water after sedimentation treatment, 3-filtered water)

Discussion and Conclusions

1. When groundwater of highest chalk horizon at III water works was aerated and filtrated with a filtration rate of 7 m/h via 1–2 mm particle size filter media, 1.52 m high quartz sand, the filtered water was of a very good quality drinking water category (1).
2. Dosage of NPZ adsorbent into the aerated Varduvos–Zemaitijos horizon groundwater has positive influences on the treated water's quality. Dosage of 60–70 mg/l NPZ, when contact time is 45 min., after sedimentation treatment of the iron concentration of water decrease 13% (from 1.50 to 1.30 mg/l), manganese – 50–60% (from 0.20–0.18 to 0.08–0.09), permanganate index decrease 56% (from 3.89–4.12 to 1.70–1.86 mg/l O_2), ammonia concentration decreased a little – from 0.70 to 0.60 mg/l.
3. When groundwater of Varduvos- Zemaitijos horizon at III water works was aerated, treated with NPZ and filtrated with filtration rate 8 m/h via 1–2 mm particle size filter media, 1.52 m high quartz sand (used and new), filtered water iron concentration was 0.26–0.28 mg/l (untreated water 1.30 mg/l), manganese 0.03 mg/l, ammonia 0.05 mg/l. Permanganate index was the same after filtration. High iron concentration after treatment shows that iron is an in a stable organic matter complex and without adsorption or strong oxidants it cannot be removed (some removal with small adsorbent dosage is also ineffective).
4. When groundwater of Varduvos- Zemaitijos horizon at III water works was treated with adsorbent NPZ, organic matter decreased more than by half. Without treatment with adsorbent organic matter there is a negative influence on the water's taste and odour and interfere with disinfection's by Cl gas.
5. When the dosage of NPZ adsorbent was increased up to 80–90 mg/l and filtration rate decreased to 5 m/h, groundwater of Varduvos- Zemaitijos horizon at III water works was aerated, treated with NPZ adsorbent, using sedimentation equipment filtrated via 1–2 mm particle size filter media, 1.52 m high quartz sand), filtrated water iron concentration was approximately 0.10 mg/l, manganese concentration approximately 0.05 mg/l; all the water's quality was of a very good quality drinking water category (1).

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