# Arguments for the Need to Modernize Water Treatment Technology in Small Towns and Cities, Based on the Example of the Municipality of Puńsk [†]

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**Abstract:** The goal of the research was to assess the pollution level of water in the existing real water treatment station in Pelele in the municipality of Punsk. The station needed to be rebuilt because the equipment in operation there had not been changed for years. As part of the research efforts, a new water purification system was designed. The technology of the station is based on a two-stage water treatment system. Water picked up directly from the intake (raw water) as well as purified water at the old and new stations were analyzed. Then, the results obtained from water tests before and after modernization of the station were compared. There were such parameters analyzed as: color, turbidity, pH, iron (Fe), and Manganese (Mn). Through the conducted research and the results of pollution parameters received, the levels of Fe and Mn in raw as well as treated water were revealed. Their concentrations have proven that water coming from the new station continues not to be appropriate for human consumption just after the modernization process.

**Keywords:** water treatment; iron; manganese; filtration

## 1. Introduction

Groundwater intake for tap water is a solution of inorganic and organic substances occurring on the Earth which are of natural or anthropogenic origin. The appropriate treatment for the quality of drinking water affects human health and domestic purposes [1–3]. The aim of the study was to optimize the process of water treatment at small-scale stations located in micro-agglomerations. Currently, in water treatment technology, there are applied physical processes such as filtration of water by special mineral deposits and chemical processes, such as aeration or the use of catalytic beds [4,5]. However, in real objects, the equipment used is not always properly fitted and calculated. The equipment is outdated and largely clogged and overgrown with biological film [2,6].

## 2. Material and Methods

As part of the research carried out, the analysis undertaken covered the water treatment plant in Pelele in the municipality of Punsk. The station needed to be modernized because the equipment, which had not been changed for 30 years, was still in operation there. There was an old mechanical mesh filter, a Venturi type aerator, and a quartz sand filter. The apparatus was supplemented by a hydrophore. After a full quality inspection of the station, it turned out that the mechanical filter was damaged. The screen, which was used as the first stage of cleaning, was cracked in many places. The

Venturi operator did not aerate the water effectively, due to the significant irregularity of the flows. At low flows, there was no suction of air, and the raw water flowed to the filter without enriching it with the oxygen necessary for reactions with iron. The last device sand filter was largely clogged with iron sediments. Biofilm developed on the sludge, causing an intrusive reduction of iron compounds and the formation of unpleasant odors.

The station absolutely required modernization. As part of the research efforts, a new water purification system was designed. The technology of the station is based on a two-stage water treatment system. Raw water directly from the intake is fed to a closed aerator, where it is accurately oxygenated. Next, it reaches the first stage of treatment, which is filters filled with quartz sand beds of various fractions, on which filtration, mainly of iron compounds, precipitated during aeration takes place. Then, the water reaches the second treatment stage, where pressure filters are filled with brauchtin and pyrolusite deposits, also called active mass of G-1 or catalytic mass of manganese dioxide, which is aimed at reducing manganese concentration.

Raw water samples taken directly from deep wells at the water treatment plant were the starting material for the study. Water picked up directly from the intake (raw water) as well as purified water at the old and new stations were analyzed. Then, the results obtained from water tests before and after modernization of the station were compared. The following parameters were analyzed: color, turbidity, pH, iron (Fe), Manganese (Mn), and pH. The tests were carried out in accredited laboratories in accordance with Polish standards, and the samples taken were accredited.

## 3. Results and Discussion

The Table 1 summarizes the results of raw water and water from the station before and after modernization.

**Table 1.** Results of the water test at the water treatment plant in Pelele in the municipality of Punsk.

| No. | Parameter | Unit | Raw Water | Treated Water before Modernization | Treated Water after Modernization | Max. Level of Concentration. (Dz. U. 2017 r. poz.2294) |
|---|---|---|---|---|---|---|
| 1 | Color | mg/L Pt | 30.00 | 9.00 | 8.00 | up to 15 mg/L Pt |
| 2 | Turbidity | NTU | 28.00 | 10.50 | 1.40 | up to 1 NTU |
| 3 | pH | ~ | 7.40 | 7.50 | 7.50 | 6.5–9.6 |
| 4 | Manganese (Mn) | µg/L | 498.00 | 18.00 | 9.00 | 50 |
| 5 | Iron (Fe) | µg/L | 4033.00 | 50.00 | <50 | 200 |

Source: Authors elaboration.

According to the manufacturer, the designed height of the catalytic bed should reduce the content of Fe and Mn to normative values that contain a maximum of 0.2 mg Fe/L and 0.05 mg Mn/L for filtration rates up to 20 m/h and pH above 7.5.

However, it took time to get the correct concentration of Mn during the start-up of the station, and the filtration bed had to be activated. The iron content in the raw water was 4033.00 µg/L. This is a high concentration, which resulted in overwork of both stages of plant treatment, i.e., filtration of I and II degree, making full use of their filtration capacity. This caused the level of manganese to oscillate over the limit of the acceptable standard for consumption. According to the demand of the city, the station was designed for a sufficiency of $Q = 40$ m$^3$/h. In order to enable proper operation of the filter beds, it was necessary to reduce the station's productivity to $Q = 35$ m$^3$/h for a period of over 30 days. This did not ensure adequate water supply to the inhabitants. After modifications to the automation settings and station set-ups, the planned capacity was achieved. The amount of catalytic bed in the second-degree filtration was increased, and the aeration efficiency was increased. Thanks to this, iron was precipitated on the first-degree filtration, which enabled proper removal of manganese on the second-degree filtration.

## 4. Conclusions

1.  The water treatment processes used in the analyzed plant before modernization were not enough for water purification. Extra processes, i.e., second filtration and proper aeration, should be added to water system.
2.  Through the conducted research and the results of pollution parameters received, the levels of Fe and Mn in raw as well as treated water were revealed. Their concentrations have proven that water coming from the new station continues not to be appropriate for human consumption just after the modernization process.

**Author Contributions:** P.P. conceived and designed the experiments; P.P. performed the experiments; I.S. analyzed the data; P.P. contributed materials; I.S. wrote the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

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