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Investigation on Magnetic Field Usage for Urban Water Treatment †

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Abstract: The aim of this work was to investigate magnetic field (MF) usage for urban water treatment. Currently, the popular method of ground water purification includes water aeration and filtration, which are expensive and energy intensive. MF is not used for drinking water treatment but mostly for boiler and cooling water at industrial water plants or in farming for plant growth. The authors decided to test it at a small water treatment station in Poland. An MF generator was placed on the pipe between raw water intake and aeration. The results proved higher efficiency in water treatment, especially in hardness, turbidity, Fe, Mn and NH_4 removal.

Keywords: water treatment; water hardness; magnetic field

1. Introduction

Currently used water purification solutions for the needs of small towns are mainly based on physical processes, i.e., filtration and aeration. The realization of these processes is time consuming and energy consuming. This is why it is important to develop new methods of water treatment, especially in the local context, where small cities do not have the funds to build expensive infrastructure and have problems with providing access to drinking water for their residents. Even today, in many cities, there are treatment plants that were built in the 1960s and 1970s. [1] They are not modernized due to a lack of resources. Considering the economic calculation, solutions for small municipalities can be proposed using existing infrastructure requiring only maintenance or modernization. Moreover, it must be taken into account that filters represent pressure equipment subject to technical supervision. Old devices are often out of use, which is associated with the shutdown of the entire technological system. Therefore, the opportunities offered by the use of the electromagnetic field in the water treatment process are the future of this industry. When water passes through an appropriately shaped strong magnetic field (MF) created by permanent magnets, the dipole moment of ions and water particles changes. This leads to the fact that during crystallization of the salt, the polarization of the ionization zones is reduced. As a result, the crystal is split into thin layers and the ions are arranged according to one magnetic axis [2]. The use of MF is commonly used in boiler water treatment plants, but not in drinking water [3]. Therefore, research was undertaken into the possibilities of using the electromagnetic field in the process of drinking water treatment.

2. Material and Methods

The research was carried out at a water treatment plant in a town of about 200 inhabitants located in one of the poorer areas in North Poland, in Central Europe. Water treatment includes processes such as pre-filtration in the filter pipes of deep wells, aeration, 1st degree filtration and 2nd degree filtration. The capacity of the station was 40 m^3/h. In order to improve the quality of the processed water, the application of a magnetic field was proposed to the existing water treatment system. The device generating the electromagnetic field was installed. It was placed on the pipeline supplying the station before the aerator. The magnetic field was generated by the flow of an electric current through the electromagnetic coil. The studied water treatment plant was fed with underground water taken from two deep wells. Table 1 shows the averaged composition of the raw water intake.

Table 1. Raw and purified water composition.

Parameter [unit]	Raw Water	Purified Water without MF	Purified Water with MF	Deviation	Limits for Drinking Water
Colour mg/L	5	9	0	±1	<5
Turbidity NTU	19	1	0	±21	<0.2
pH	7.3	7.8	7.3	±0.7	6.5–9
Smell	acceptable	no smell	no smell	-	acceptable
Taste	acceptable	no taste	no taste	-	acceptable
Conductivity μS/L	1340	920	730	±270	2500
Ammonia nitrogen mg/L	0.41	0.35	0.18	±0.16	0.5
Total Manganese mg/L	0.115	0.02	0.001	±0.022	0.05
Total Iron mg/L	0.551	0.2	0.05	±0.225	0.2
Total hardness mg $CaCO_3$/L	480	450	316	±80	60–500
Chlorides mg/L	15	41	37	±5	250
Nitrate Nitrogen (V) mg/L	1.05	18.5	7.2	±0.1	50
Nitrate Nitrogen (III) mg/L	0.05	0.01	0.01	±0.005	0.5

Source: own investigation.

Analytical tests included measurements in both raw and purified water of such parameters as: color, turbidity, pH, smell, taste, ammonium nitrogen, manganese, iron, chlorides, nitrate (III) and nitrate (V).

3. Results and Discussion

The obtained results of tested parameters included in Table 1 allow us to observe that the content of elements such as iron and manganese in raw water significantly exceeds the acceptable standards for drinking water. This may have a significant impact on water quality and its safety for individual consumers. Moreover, raw water from wells is disqualified for direct consumption due to exceeding such parameters as high turbidity, ammonium nitrogen and nitrate nitrogen (V). High hardness of the raw water was also noted. The water treatment system at the analyzed treatment plant included I- and II-stage aeration and filtration. The process of water magnetization was additionally applied there as part of our own research. Table 1 shows the obtained results of the tests of treated water at the station before and after the electro-magnetizer installation.

The process of water magnetization completely changes the technological approach to the application of the existing water softening stations using the ion exchanger method [4]. MF technology has great possibilities of application when the water is hard. It could be used in installations where Ca and Mg deposits are precipitated, which was complained about by the water recipients in the analyzed town. The device supports the reaction without using additional chemical precipitation: $Ca(HCO_3)_2 + MF \Rightarrow CaCO_3 + CO_2 + H_2O$ [5].

It was observed that the device solved the problem of iron deposit collation in the line supplying the filters after the aerator. It is a sensitive place at the stations [6]. As a result of intensive iron oxidation in the aerator, a dense deposit precipitated—which usually must stop only in the filters [7]. Often, it covers the walls of water pipes behind the aerator, causing clogging. After the installation of the electromagnetic device, it was not necessary to clean this section of the pipe. Moreover, the use of MF allowed us to significantly reduce the concentration of Fe, Mn and NH_4 in the treated water [8]. Compared to a system without MF, the electromagnetic conductivity was also much lower. According to the available literature, it is estimated that the described phenomena are related to the fact that the applied technology generates pulsed MF and allows us to produce CO_2 and causes electrophoresis. This leads to the creation of a protective layer on the walls of pipes and devices in which water is in contact with. In this way, it protects the water purification devices from damage resulting from excessive Fe and the oxygen introduced during the aeration. At the same time, it allows us to precipitate $Mg(OH)_3$ flocs and adsorb the precipitated Fe, Mn, turbidity and hardness and NH_4 in them [9].

4. Conclusions

The obtained data allow us to prove that the magnetic field influences the water treatment process. Water treated at a station equipped with a magnetizer shows lower hardness, turbidity and lower concentration of iron and manganese, which gives it features that are very demanded by consumers. It was also pointed out that thanks to the applied solution, it was possible to significantly simplify the water treatment technology by eliminating II stage filtration. Moreover, MF allows us to reduce the costs of water production in existing technological systems.

Author Contributions: P.P. and I.S. conceived and designed the experiments; P.P. performed the experiments; I.S. analyzed the data; P.P. contributed materials and analysis tools; P.P. and I.S. wrote the paper. All authors have read and agreed to the published version of the manuscript.

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