The properties of water from a concrete plant to be used in cement composites

L Klus\textsuperscript{1,2}, V Vaclavik\textsuperscript{1,2}, T Dvorsky\textsuperscript{1}, J Svoboda\textsuperscript{1,2} and R Papesch\textsuperscript{1}

\textsuperscript{1} Institute of Environmental Engineering, Faculty of Mining and Geology, VSB-Technical University of Ostrava, Czech Republic,
\textsuperscript{2} Institute of Clean Technologies for Mining and Utilization of Raw Materials for Energy Use Faculty of Mining and Geology, VSB-Technical University of Ostrava, Czech Republic

Abstract: This article presents the requirements for concrete mixing water and evaluates the possibilities of using recycled waste sludge water generated in a concrete plant from rinsing water of the concrete plant agitating centre and agitation trucks. The production of concrete mix requires large amount of water and for this reason, it is necessary to use this resource in an economic way. For further use of these waters, it is vital to know their detailed properties in order to maximize their potential in the design of concrete formulations for the purpose of replacing pure mixing water with recycled sludge water so as to preserve or improve the physical and mechanical properties of fresh concrete mix or hardened concrete. The results of the wastewater tests from the concrete plant confirm compliance with the limit concentrations according to CSN EN 1008. The attention should be paid to the limit of concentration of sulphates.

1. Introduction
In order to maximize the potential utilization of mixing and recycled water, it is necessary to establish the chemical properties and their reactivity with other substances to facilitate their more efficient use in the design of concrete formulations. Nowadays, many research projects show the use of recycled concrete water, for example, to save fine particles such as fly ashes [1]. The problem of most of the waste and recycled waters in concrete plants is their content of acid substances and sulphate concentration. These waters must be chemically treated or diluted by adding pure mixing water for the optimum concrete mix [2-3]. Even the preparation of the so-called “gray water” (water containing a larger proportion of dissolved cement), which is added during concrete placing, can help to achieve higher initial strengths, i.e. acceleration of the setting and hardening of the concrete mix. This procedure does not have absolute validity, because the higher proportion of fine particles requires more water for proper hydration, as evidenced by many tests whose results are described in [4]. By modifying the mixing water, the exceptional physico-mechanical properties of the resulting concrete mix can be obtained. By applying the knowledge of chemical interactions, the desired properties of the concrete composites can be achieved [5-7]. This advantage is currently used in the design of new concrete formulations in civil engineering, since it is required by modern civil engineering so as to reach the required construction quality [8]. The aim of the presented research results is the possibility of using waste water from the concrete plant as the mixing water in the production of cement composites.

2. Materials and methods
This experimental study has examined water from natural sources (small water reservoirs) and recycled water (rinsing water from agitation trucks) for the use in the production of concrete. Based on the requirements of the European standards CSN EN 1008 [9], CSN EN 196-1 [10], EN 1015-3 [11],...
EN 196-3 + A1 [12], the properties of these waters have been examined by means of laboratory methods such as: detailed chemical analysis and mineralogical analysis of dissolved particles.

2.1 Mixing water
Mixing water serves as the basic activator of chemical reactions in the production of concrete, causing the formation of new crystalline structures in concrete. The properties of mixing water can influence the character of the concrete mix, whether it will be used, for example, for concrete with reinforcement, without reinforcement or for aggressive environment. Water and its components change the resulting character of the concrete mix, influence the process of crystallization of minerals and, according to the present components (sulphates, chlorides, alkalis, nitrates and others), form the binding elements and create strong bonds. These bonds influence the final physico-mechanical properties of the hardened concrete.

2.2 Water sampling
Sampling of pure and recycled sludge waters took place in concrete plants in the Moravian-Silesian Region and their exclusive water resources. The used mixing water sources are almost identical, and the additives used in concrete are identical in the concrete plants where the samples of recycled sludge water were taken. The results of the sample tests were compared to find out their properties.

2.3 Testing methodology of water samples
The samples of pure mixing water and recycled waste water from the concrete plant were tested in order to determine the properties of the mixing water according to CSN EN 1008 [9] and the requirements of the concrete mix production technology.

2.3.1 Determination of the pH value, temperature and conductivity
The pH values of the samples of sludge water and pure mixing water were measured potentiometrically by means of an electrochemical analytical method based on the measurement of the equilibrium cell voltage, which is composed of indicative and reference electrode. The temperature and conductivity determination was performed using Merci pH/Cond 3401 instrument during each sampling.

2.4 Determination of the mineralogical composition of the sludge
The determination of the mineralogical composition of the sludge sample from the concrete plant waste water was carried out using Bruker Advance D8 powder diffractometer equipped with Lynx Eye linear semiconductor detector and SOL-XE energy dispersion detector.

2.5 Determination of the chloride concentration
A methodology in accordance with CSN ISO 9297 [13] was used to determine the concentration of chlorides in the samples of sludge water and pure mixing water.

2.6 Determination of the sulphate concentration
A methodology in accordance with CSN 75 7477 [14] was used to determine the concentration of sulphates in the samples of sludge water and pure mixing water.

2.7 Determination of the nitrate concentration
A methodology in accordance with CSN ISO 7890-3 [15] was used to determine the concentration of nitrates in the samples of sludge water and pure mixing water.

2.8 Alkali analysis
The tested samples were filtered to obtain filtrate which was used to determine its chemical composition by means of atomic absorption spectrophotometry (AAS), VARIAN AA 280FS instrument. AAS measurement takes advantage of the analytical absorption property of the radiation of free atoms of the observed element.
2.9 **Disolving substances (RL) and Insolable substances (NL) analysis**

The determination of all suspended solids was carried out according to the methodical guidance of CSN EN 872 [16], where the given sample volume is filtered through a filter and subsequently dried in order to determine the amount of Insolable substances (NL) in g/l. The determination of the quantity of all dissolved substances was carried out according to the methodical guidance of CSN 75 7346 [17].

2.10 **Determination of carbohydrates, humus substances and Fe**

The determination of carbohydrates was performed using a GlucoLab s 25 fast test. A 30 ml sample of humus substances was taken and treated with 3% sodium hydroxide according to CSN EN ISO 1008 standard [9] in order to determine the amount of the humus substances. The iron concentration was determined using an Eisen test set and colorimetric, ferospectral 1.14759 test method.

3. **Results and discussion**

Table 1 shows the average values of the test results of pure mixing water and recycled waste water from the concrete plant carried out in 2017 year (Stage I) and 2018 year (Stage II), as well.

| Tested properties | Pure mixing water from a concrete plant | Waste water from a concrete plant | Limit concentration according to CSN EN 1008 |
|-------------------|----------------------------------------|----------------------------------|--------------------------------------------|
| pH                | 1st stage 6.77 2nd stage 9.10          | 1st stage 12.56 2nd stage 12.40  | > 4                                        |
| Temperature [°C]  |                                        |                                  |                                             |
| Conductivity [µS/cm] |                                      |                                  |                                             |
| Humus substances  | acceptable                              | acceptable                       | Palerthan yellow-brown                      |
| Chlorides [mg/L]  | 14.20                                   | 53.00                            | < 600 (2000 < 4500)                        |
| Sulphates [mg/L]  | 40.30                                   | 95.0                             | < 2000                                     |
| Nitrates [mg/L]   | 47.00                                   | 90.00                            | < 500                                      |
| CHSKCr [mg/L]     | 5.980                                   | 5.236                            |                                             |
| Na [mg/L]         | 13.20                                   | 15.10                            | < 1000                                     |
| Pb [mg/L]         | 0                                       | 0.1105                           | < 100                                      |
| Zn [mg/L]         | 0.058                                   | 0.061                            | < 100                                      |
| Ca [mg/L]         | 32.68                                   | 24.90                            | 1610.00                                    |
| Glucose = sucrose [mg/L] | < 100 + < | < 100 + < | < 100 + < | < 100 + < |
| Fe [mg/L]         | < 0.10 (immeasurab | 0.10 (immeasurable) | 0.10 (immeasurable) | 0.10 (immeasurable) |
| BSK5 [mg/L]       | 2.930                                   | 3.235                            | 20.328                                     |
| K [mg/L]          | 8.83                                    | 9.81                             | 77.10                                      |
| Mg [mg/L]         | 3.85                                    | 4.67                             | < 100                                      |
| NL [mg/L]         | 0.004                                   | 0.004                            | < 1000                                     |
| RL [mg/L]         | 0.008                                   | 0.009                            | < 1000                                     |

Table 1 shows that, when the measured values of the monitored analytes in the 2nd and 1st stages of testing of the properties of pure and recycled waste water from the concrete plant are compared, the values of sulphates were considerably higher by 1 197.8 mg/l (41.3%), of chlorides by 156 mg/l (38%)
and of nitrates by 54 mg/l (23.1%). For clear specification the limit concentration of chlorides in reinforced concrete is 600 mg/L and for plain concrete is concentration to 4500 mg/L of chlorides. This can be explained by the fact that cast anhydrite screeds were prepared in the concrete plant prior to the sampling performed for testing the properties of pure and waste water, which confirms a significant increase of sulphates in the tested waste water samples. The results showed in table 1 clearly indicate that when using recycled waste water from the concrete plant, it is always necessary to take into account the different properties that could affect the properties of fresh concrete mix and hardened concrete. The other test values did not show significant difference when comparing the values from the 2nd and 1st stage of the property testing.

A mineralogical analysis presents the results of the represented minerals in the dry matter of the samples measured in the 1st and 2nd stage, resulting from the filtration of the individual samples of recycled sludge water. The highest amounts in the first stage included quartz (SiO2), bassanite (CaSO4·0.5H2O) and limestone (CaCO3). Three new minerals were found in the second stage, namely thaumasite (Ca3Si(OH)6(CO3)(SO4)·12H2O), gypsum (CaSO4·2H2O) and oligoclase An16 (Ca, Na) (Al, Si)2O8. An overview of the amount of the individual minerals is presented in figures 1 and 2.

![Figure 1. Mineralogical composition of waste water sludge from a concrete plant (1st stage) [%].](image1)

![Figure 2. Mineralogical composition of waste water sludge from a concrete plant (2nd stage) [%].](image2)

4. Conclusion
This article presents the results of a research dealing with the testing of the properties of pure mixing water in the concrete plant and waste recycled water generated in the concrete plant. The aim of the subsequent research is to replace the mixing water with recycled waste water from the concrete plant in the amount of 25, 50, 75 and 100 in the production of cement composites. Prior to the start of the production of cement test specimens, it is necessary to know the properties of mixing water and to compare whether they comply with the standard values according to CSN EN 1008. During the research, the samples of pure mixing water and waste water from the concrete plant were taken in two stages. The 1st stage presents the average values from 2017 year and the 2nd stages the values from 2018 year. The results of the tests of the required properties according to CSN EN 1008 are presented in table 1. It is obvious that the different values of the examined analytes have to be taken into account, when testing the individual water samples, and they can affect the properties of fresh mix
used for the production of cement composites. The properties of recycled waste water are directly proportional to the type of concrete produced in the concrete plant. Further research will be focused on the testing of the properties of fresh mix for the production of specimens of cement composites and the physico-mechanical properties of the produced test specimens based on waste recycled water from the concrete plant from the 2nd stage of research.

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