The properties of waste water from a concrete plant

L Klus¹, V Václavík¹², T Dvorský¹, J Svoboda¹ and R Papesch¹

¹Institute of Environmental Engineering, Faculty of Mining and Geology, VSB-Technical University of Ostrava, Czech Republic
²Institute 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

Email: lukas.klus@vsb.cz

Abstract. This paper presents the results of a research dealing with the testing of the properties of wastewater forming during the production of concrete mixture in a concrete plant. The test results are compared with the limit values of concrete mixing water according to ČSN EN 1008 in order to use this waste water as a partial replacement of mixing water during the production of concrete.

1. Introduction

The cost-effective management of raw materials and recycling materials by returning them into the production processes is a trend that is nowadays present in almost all fields. This trend is also evident in the building industry, where recycled materials are widely used as substitutes for the primary raw materials of newly developed building elements. One of the main reasons is reducing the environmental loads and cutting the manufacturing costs of products. This article deals with the issue of wastewater from concrete mixture production. It describes its properties according to ČSN EN 1008 [1] with an emphasis on the possible use as a substitute for mixing water in the production of concrete composites.

At present, we already know the results of a research dealing with the utilization of wastewater from a car wash as a substitute for the mixing water in the production of concrete [2, 3], household waste water used as the mixing water in the production of concrete [4]. The use of sludge water from a concrete plant as a substitute for mixing water in the interval of 10 - 50% and its impact on the concrete strength parameters are described in [5].

A concrete plant in Ostrava, which has the production capacity of 85 m³/h of concrete mixture, was chosen for the experimental research of the properties of waste water from the production of concrete mixture. Sedimentation tests and tests of the following properties were performed using the samples of waste water: pH, temperature, conductivity and the concentrations of chlorides, sulphates, and nitrates. The determined concentrations were compared with the concentrations of pure mixing water (surface water from a water tank) and with the contamination limit values of the mixing water, which are defined in the ČSN EN 1008 standard [1].
2. Methods

2.1. Sampling
Two types of samples (sludge water from a concrete agitator rinse and pure mixing water) were taken within the scope of the experimental research. The samples were taken at five time intervals during one working day. The samples were stored and subjected to laboratory tests over the next 14 days. 5 samples of sludge water and 5 samples of pure mixing water were taken during one day of sampling. The samples of sludge water had to be modified for further tests by means of a filtration process using a ChS Vacccspace vacuum pump.

2.2. 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.

2.3. Sedimentation test
A sedimentation test of sludge water was performed on 5 samples from 1 day of sampling in 2000 ml graduated cylinders for 30 minutes. The sludge sediment was measured at 5-minute intervals.

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 ČSN ISO 9297 [6] 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 ČSN 75 7477 [7] 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 ČSN ISO 7890-3 [8] was used to determine the concentration of nitrates in the samples of sludge water and pure mixing water.

3. Results and discussion
The table 1 presents the average values of 5 samples used to determine pH, temperature and conductivity. Significant differences in the values of pH and conductivity are clearly visible when the values of sludge and pure mixing water are compared. The increase in the pH value to approximately double value in case of sludge is caused by the binder component of the concrete mixture entering the sludge water. The dispersed particles of the binder component and the fine share of the filler in the concrete mixture cause a significant reduction of the conductivity in sludge water, by app. 26 times, when compared with the conductivity value of pure mixing water.
Table 1. Results of the values of pH, temperature and conductivity.

|                  | pH  | t [°C] | Conductivity [µS/cm] |
|------------------|-----|--------|----------------------|
| Sludge water     | 12.56 | 20.76  | 13.00                |
| Pure mixing water| 6.77  | 18.78  | 336.12               |

The figure 1 presents the settling curves of the wastewater samples from the concrete plant taken at different time intervals during one day. It is clear that the sludge settling values show a linear decrease in all samples over a time interval of 5 to 30 minutes. However, they vary in the settling values in the individual points of the time interval. The value of the variation range from five samples in the time interval of 5, 10, 15, 20, 25 and 30 min. reaches the values of 22, 29, 30, 31, 32, 34. It is therefore apparent that the particles that are capable of settling in the form of sludge are unevenly distributed in the waste water from the concrete plant. The average settling values of 5 samples of sludge water in the time interval of 5 - 30 min. are shown clearly in tables 2 and 3 that the average density of the sludge water from the concrete plant has reached the value of 1098 kg / m³ and the sludge content in 1 m³ represents about 60 kg (5.5%).

![Figure 1. Sedimentation curves of sludge water samples from the concrete plant.](image)

Table 2. Average settling values of the concrete plant sludge water from 5 samples.

| Time [min.] | Sludge settling [cm] |
|-------------|-----------------------|
| 5           | 1.86                  |
| 10          | 2.40                  |
| 15          | 2.96                  |
| 20          | 3.26                  |
| 25          | 3.62                  |
| 30          | 3.86                  |

Table 3. Sedimentation test result.

| Sample | Weight of sludge water in 1 litre [g] | Weight of solid share in 1 litre of sl. water [g] |
|--------|--------------------------------------|--------------------------------------------------|
| 1      | 1126.20                              | 19.6                                             |
| 2      | 1067.80                              | 45.6                                             |
| 3      | 1109.60                              | 125                                              |
| 4      | 1099.60                              | 93.8                                             |
| 5      | 1087.80                              | 15.6                                             |
| Average| 1098.20                              | 59.92                                            |

The figure 2 presents the average values of mineralogical composition of the sludge acquired from the waste water produced by the concrete plant. Limestone, which is calcium carbonate CaCO₃ with a hardness of 3 and a density of 2.7 g/cm³ and which decomposes in acids, has the highest share among the identified minerals. Other minerals with the lower percentage share are:

- bassanite - CaSO₄.0.5H₂O, hydrates to gypsum, density is 2.5-2.7 g/cm³,
- quartz – SiO$_2$, hardness 7, density 2.6 g/cm$^3$, soluble in hydrofluoric acid,
- portlandite – Ca(OH)$_2$, hardness 2.5-3, density 2.26 g/cm$^3$,
- oligoclase An16 – (Ca,Na)(Al,Si)$_2$O$_8$, hardness 6-6.5, density 2.65 g/cm$^3$,
- chlorite Iib – (Mg,Fe)$_n$ (Si,Al)$_3$O$_{10}$ (OH)$_6$, hardness ~, density 2.5 g/cm$^3$,
- muscovite – K$_2$(AlSi$_3$O$_{10}$(F,OH)$_2$, hardness 4, density 2.76-3 g/cm$^3$,
- orthoclase - KAlSi$_3$O$_8$, hardness 6, density g/cm$^3$,
- anhydrite – CaSO$_4$, hardness 3.5, density 2.95 g/cm$^3$, the highest content was found in the last sample,
- sylvite – KCl, hardness 2, density 1.49 g/cm$^3$.

![Figure 2. Mineralogic composition of waste water sludge from a concrete plant.](image)

**Table 4.** Measured concentration values and limit concentrations according to ČSN EN 1008.

| Properties  | Measured concentrations of sludge water [mg/l] | Measured concentrations of pure mixing water [mg/l] | Limit concentrations according to ČSN EN 1008 [mg/l] |
|------------|-----------------------------------------------|-------------------------------------------------|-----------------------------------------------|
| Chlorides  | 251.7                                         | 14.2                                           | < 4500                                        |
| Plain concrete |                                     |                                                 | < 2000                                        |
| Reinforced concrete |                       |                                                 | < 600                                         |
| Pre-stressed concrete |                                |                                                 |                                               |
| Sulphates   | 1702.1                                        | 40.3                                           | < 2000                                        |
| Nitrates    | -                                             | 9.4                                            | < 500                                         |

The table 4 shows a comparison of the tested properties of the waste water from the concrete plant and the pure mixing water with the recommended concentrations according to ČSN EN 1008. At first glance, it is evident that the measured average concentrations of chlorides, sulphates and nitrates meet the limit concentrations. The concentration of chlorides in sludge water compared to the limit value according to ČSN EN 1008 reaches the percentage value of 5.6% for plain concrete, 12.6% for reinforced concrete, and 42% for pre-stressed concrete. The sulphate concentration is represented by the percentage share of 85.1% when compared to the limit value.
4. Conclusion
This article presents the results of the tests of sludge water from the concrete plant and pure mixing water. It presents the average values of five samples, because the composition of the waste water from the concrete plant varies during the day and directly depends on the type of concrete being produced at the concrete plant. The tested properties included pH, temperature, conductivity, the mineralogical composition of waste water sludge, and the content of chlorides, sulphates and nitrates. The results meet the requirements for concrete mixing water as set out in ČSN EN 1008. The direction of further research will be focused on the replacement of pure mixing water with 20% and 50% of sludge water from the concrete plant and its impact on the strength characteristics of cement composites.

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