Biological Treatment of Greywater for Organic Matter Removal and Water Recovery

J. Walczak[1], W. Borowska[1], K. Miszta-Kruk[1], M. Zubrowska-Sudol[1]

[1] Faculty of Building Services, Hydro and Environmental Engineering, Warsaw University of Technology, Poland
Keywords: water recovery, circular economy, greywater, biological treatment
Presenting author email: justyna.walczak@pw.edu.pl

Introduction

Ongoing climate change and the increasing scarcity of water resources require the implementation of solutions that support sustainable water management. One of the key approaches involves the use of alternative water sources for utility purposes. Greywater represents a valuable, yet still underutilized, source of non-potable water. After appropriate treatment, it can be reused for applications such as toilet flushing, irrigation of plants, and household cleaning activities. The quality of greywater strongly depends on its source and is characterized by significant variability in the concentrations of organic compounds and nutrients. Therefore, effective water recovery requires the selection of treatment technologies capable of efficiently removing organic matter. Biological processes constitute a promising method for the removal of organic compounds from greywater. The aim of this study was to evaluate the effectiveness of biological removal of organic compounds from greywater originating from different sources.

Material and methods

The study was conducted within the framework of the HYDROSTRATEG-II/0020/2023 project. The analysis focused on greywater that had been pretreated using a sand filtration bed. The greywater originated from the following sources: (1) a bathtub, (2) a washing machine, (3) a washbasin, and (4) mixed greywater (72% bathtub, 17% washing machine, 11% washbasin).

Batch tests were carried out in laboratory reactors with a working volume of 2 L. The reactors were inoculated with activated sludge collected from a local wastewater treatment plant designed for the removal of C, N, and P compounds. The concentration of activated sludge in the reactors was approximately 2 g TSS/L. Prior to the experiments, the sludge was rinsed with settled tap water to remove residual organic compounds. The contents of the reactors were mixed using magnetic stirrers and aerated with laboratory air pumps. The test reactors were supplied with activated sludge and greywater from sources (1-4). Additionally, a control test was conducted using an acetic acid solution (5). The initial SCOD concentration in the reactors was adjusted to 200 mg O_2/L (except for biological reactors fed with greywater characterized by lower initial SCOD values). The experiment was conducted for 3 hours at a temperature of 20°C. Samples were collected every 30 minutes and immediately filtered.

The scope of the analysis included: 1) in the filtered raw greywater, in the reactor at the beginning of the test, and at the end of the test: SCOD, BOD_5, TOC, TN, NH_4-N, N-NO_2-N, NO_3-N, PO_4-P, and alkalinity, 2) in each sample collected from the reactor during the experiment: SCOD and BOD_5. The analyses were performed in accordance with standard procedures using a DR 3900 spectrophotometer (HACH Lange) and a TOC-L CSN analyzer (Shimadzu). All determinations were carried out in duplicate.

Results

The analysis of the results showed that the quality of greywater strongly depends on its source (Table 1). The highest concentrations of organic pollutants were found in washing machine greywater, while the lowest were observed in bathtub greywater. Figure 1 presents the results of the kinetic tests of organic compound removal. For each type of greywater, a rapid decrease in SCOD was observed during the first 30 (60) minutes of the experiment, indicating the presence of a readily biodegradable fraction. Washing machine greywater exhibited a more complex pattern of organic matter transformation and a higher residual SCOD concentration after 3 hours of treatment, which may be attributed to the presence of surfactants and more slowly biodegradable compounds. In the control test with the addition of an acetic acid solution, a rapid decrease in SCOD concentration was observed, confirming the high activity of the activated sludge and the proper operating conditions of the experiment. Changes in TOC followed a trend similar to that of SCOD; however, the rate of mineralization was slightly lower, which may indicate the formation of intermediate biodegradation products during the course of the test.

Conclusions

The results of the batch tests demonstrated that biological treatment of greywater using the activated sludge process may constitute one of the stages in its treatment.

The implementation of biological greywater treatment systems may significantly support sustainable water resource management and reduce potable water consumption, provided that appropriate technologies are selected and continuous water quality monitoring is ensured.

Table 1. Characteristics of greywater after the sand bed filtration process.

	bathtub (1)	washing machine (2)	washbasin (3)	mixed greywater (4)
SCOD [mg/L]	176	1829	255	495
BOD_5 [mg/L]	79.8	118.9	86.5	182.8
TOC [mg/L]	29.36	433.4	41.96	68.25
TN [mg/L]	2.956	23.64	4.204	6.628
Norg [mg/L]	1.285	20.039	2.865	5.423
NH_4-N [mg/L]	0.806	1.37	0.892	0.714
NO_2-N [mg/L]	0.035	0.241	0.062	0.141
NO_3-N [mg/L]	0.83	1.99	0.385	0.35
PO_4-P [mg/L]	0.077	1.63	0.090	0.16
alkalinity [mval/L]	3.8	4.0	3.0	5.5

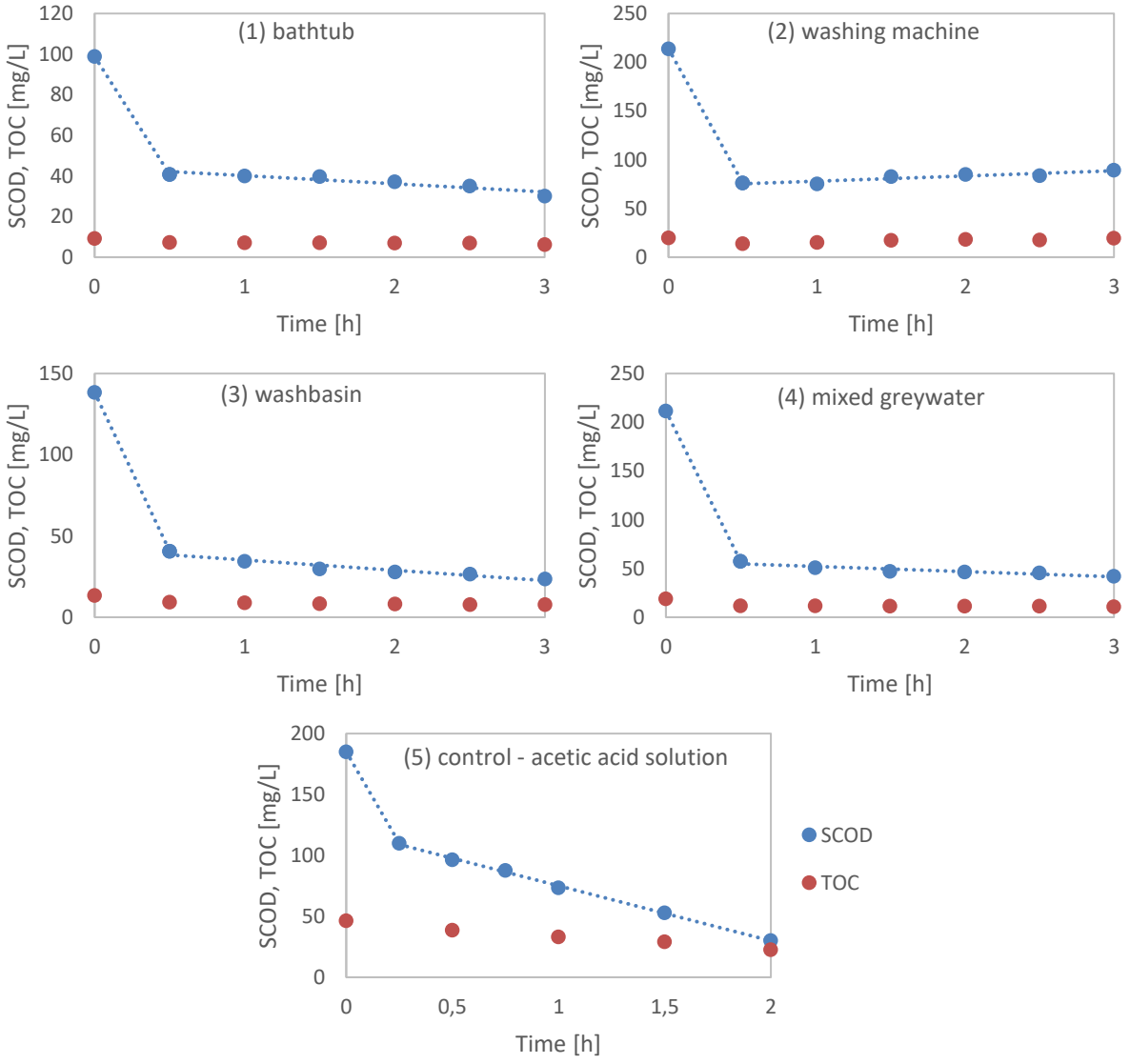

Figure 1. Results of the kinetic tests for the removal of organic compounds.

Acknowledgements
The presented research results were obtained within the framework of the project HYDROSTRATEG2/0020/2023 Innovative system of rainwater, snowmelt and grey wastewater collection with treatment processes, funded by the NCBR II competition of the Government Strategic Program - Hydrostrateg "Innovations for Water Management and Inland Waterways - Urban Water". 2023-2027.