QUALITY OF SEPTIC TANK WASTEWATER

Kateřina Petrušková[*,1], Petr Hluštík[1]

[*]Katerina.Petruskova@vutbr.cz
[1]Brno University of Technology, Faculty of Civil Engineering, Department of Municipal Water Management, Žižkova 17, 602 00 Brno

Abstract

This article focuses on the quality of septic tank wastewater, with an emphasis on its chemical analysis. Key parameters such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrogen compounds and organic pollutants were examined. The results indicate significant variability in wastewater composition, influenced by factors such as storage time and source characteristics. This was evident in the determination of, for example, BOD and COD, where samples with higher residence time exhibited high values for these parameters. The findings provide insight into the treatability of septic tank wastewater in aerobic treatment systems.

Keywords

Septic tank wastewater, pollution indicators, septic tank, analysis

1 INTRODUCTION

A septic tank is a traditional household wastewater treatment device that uses a tank as the main element for containment and primary treatment. The tank is commonly designed for underground installation and consists of two or more interconnected modules and a piping system. The septic tank pre-treats wastewater before it is taken to the wastewater treatment plant [1].

Septic tank wastewaters are a specific category of wastewater that is generated mainly in decentralized wastewater disposal systems, such as septic tanks or cesspools. They are heavily polluted wastewaters containing high concentrations of organic and inorganic substances, pathogenic bacteria, viruses and other microorganisms. [2] They are referred to as ‘septage or septic tank effluent’ by the professional community but are not fully defined in any legislation.

The quality of septage is a key factor in determining the appropriate technology for its treatment and safe disposal. The quality depends on its origin, composition and method of accumulation. The composition is variable and depends on the water use patterns and dietary habits of the connected population, and other factors [3]. Septic tank wastewaters usually include fecal waste, food residues, fats, detergents and other impurities. Proper management of these waters is important to protect the environment and public health.

In order to determine whether septic waters are bio-treatable at aerobic wastewater treatment plants, a project was announced under designation No. 028K8G, OP TAK PROOF OF CONCEPT. In this project, water analyses were carried out in cooperation with the Brno-venkov division of the Vodárenská akciová společnost, a.s. (Waterworks Joint Stock Company). A total of 7 septic water samples were taken, and selected chemical indicators of wastewater quality were determined. The article contains information about specific analyses and their results.

2 METHODOLOGY

Seven septage samples were collected for this project. The samples were always homogenized before collection from the fecal truck.

Analyses for samples number 1, 2, 3, 4 and 7 were carried out at the Department of Chemistry at Brno University of Technology’s Faculty of Civil Engineering, and for samples number 5 and 6 the analyses were performed at Vodárenská akciová společnost, a.s., Brno-venkov division.

The aim of analyses 1 to 4 was to determine the optimum wastewater age and the corresponding quality parameters for the wastewater treatment technology in question (aerobic treatment). Based on these analyses, it was

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determined that the optimum age of septic effluent for effective treatment is between 1 and 1.5 months. Samples 5 to 7 were collected from the same producer at different time intervals, with effluent ages ranging between 14 days and 6 weeks.

Tab. 1 contains general information on the type of samples.

Tab. 1 Characteristics of septage samples [4].

Sample	Analysis	Sample age	Location	Type of wastewater
1	BUT	6 months	Karolín	municipal
2	BUT	3 weeks	Žďárná	from a sports hall
3	BUT	3 years	Voděrady	municipal
4	BUT	3.5 days	Letovice – Letoplast	municipal + industrial
5	VAS	14 days	Hradčany	municipal
6	VAS	6 weeks	Hradčany	sales warehouse, 4 people
7	BUT	4 weeks	Hradčany	sales warehouse, 4 people

Selected chemical indicators of wastewater quality were determined for individual samples. The indicators are:

- pH, oxidation-reduction potential,
- organic pollution: BOD_5, COD_{Cr};
- nitrogen forms: $N\text{-}NO_2$, $N\text{-}NO_3$, $N\text{-}NO_x$, $N\text{-}NH_4$, $N\text{-}N_{KJ}$,
- total inorganic and organic nitrogen, total nitrogen: TIN, TON, TN,
- total phosphorus: TP,
- suspended solids: SS,
- total substances: TS-105, TS-550,
- loss by annealing: LOD.

Performed analysis

The determination of pH and oxidation-reduction potential was performed using pH and ORP probes with a HACH-LANGE instrument. The analysis of biochemical oxygen demand (BOD) was performed using the standard dilution method according to [5]. Chemical oxygen demand (COD) was determined by semimicro analysis on a HACH-LANGE spectrophotometer. Nitrogen forms were determined by various methods such as distillation, probe or spectrometer, or calculation. Nitrite ($N\text{-}NO_2$) was determined via the spectrophotometric determination of nitrite by α-naphthol, and nitrogen oxides ($N\text{-}NO_x$) were determined by probe. From these values, the value for nitrate ($N\text{-}NO_3$) was further calculated. Ammoniacal nitrogen ($N\text{-}NH_4$) was determined by distillation, while Kjeldahl nitrogen ($N\text{-}NK_j$) was determined by mineralization. Total inorganic nitrogen (TIN) was determined as the sum of $N\text{-}NO_2$, $N\text{-}NO_3$ and $N\text{-}NH_4$, and total organic nitrogen (TON) was determined by subtracting $N\text{-}NK_j$ and $N\text{-}NH_4$. Total nitrogen (TN) was then determined by the sum of $N\text{-}NO_2$, $N\text{-}NO_3$, $N\text{-}NH_4$ and $N\text{-}NK_j$. Total phosphorus (TP) was determined using ascorbic acid solution. The determination of total suspended solids (SS) was carried out by filtration. Total solids (TS) were determined by drying and annealing, and loss on annealing (LOD) was then determined by calculation.

3 RESULTS

As part of the septage analysis project, septage samples were collected and evaluated to assess whether they are biologically treatable in aerobic treatment plants. The results of the laboratory analyses provide an overview of the chemical parameters of these waters and their comparison with the indicative values for wastewater, which can be seen in Tab. 2 and Tab. 3. The indicative values were taken from [6].

This chapter gives an overview of the data obtained, which are then described and evaluated. The main focus is on pH, oxidation-reduction potential (ORP), chemical and biochemical oxygen demand (COD and BOD) and the content of key nutrients such as nitrogen and phosphorus.

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Tab. 2 Selected septage indicators – part I. [4].

Sample	pH (-)	ORP (mV)	COD_{Cr} (mg/l)	BOD_5 (mg/l)	TP (mg/l)	TS-105 (mg/l)	TS-550 (mg/l)	LOD (mg/l)	SS (mg/l)
1	6.52	-300	13 970	≈ 3 000	120	28 666	3 848	24 818	---
2	7.37	-377	780	520	19.6	1 339	769	570	---
3	6.42	-226	12 430	---	67.9	35 368	5 018	30 350	---
4	8.36	-398	1 260	860	26	1 773	913	860	---
5	9.60	-130	754	289	10.2	---	---	---	270
6	8.30	-279	1 450	512	16.3	1 600	---	1 600	512
7	7.71	-197	1 390	359	30.03	2 044	1 032	1 012	960
Indicative values	6.5-8.5	-500-500	250-800	150-400	5-15	---	---	---	<500

Tab. 3 Selected septage indicators – part II. [4].

Sample	$N\text{-}NO_2$ (mg/l)	$N\text{-}NO_x$ (mg/l)	$N\text{-}NO_3$ (mg/l)	$N\text{-}NH_4$ (mg/l)	$N\text{-}NK_J$ (mg/l)	TIN (mg/l)	TON (mg/l)	TN (mg/l)
1	0.017	10.79	10.77	105.6	1 123.2	116.4	1 017.6	1 239.6
2	0.017	2.2	2.18	124.4	202.4	126.6	78	329
3	0.031	6.46	6.43	0.8	549.6	7.3	548.8	556.9
4	0.01	3.77	3.76	72.5	285.6	76.3	213.1	361.9
5	<0.006	---	<0.20	112.2	---	112.4	63	175
6	<0.006	---	0.20	27.6	---	37.81	210	246
7	0.97	---	1.26	21.85	320.5	24.1	298.7	344.6
Indicative values	---	---	---	20-45	---	---	---	30-70

The permissible range of pH values in the effluent is from 6 to 8.5, a criterion which is met by all samples except sample 5, which has a strongly alkaline pH. The ORP values are negative, indicating anaerobic conditions are present in the waters. The indicative ORP values range from -500 mV to +500 mV.

The measured total nitrogen values reach up to hundreds of mg/l and do not correspond to the indicative values for wastewater. This can be attributed to the high organic matter content of the sewage flowing into septic tanks and cesspits. The total phosphorus indicator for samples 1 to 4 also exceeds the indicative range for wastewater.

Samples 1 and 3 show extreme COD_{Cr} values. This is probably due to the high ages of the samples and the high content of organically degradable substances in these waters. It was not possible to determine the BOD_5 value for sample 3, as a large dilution of the sample would have been required, which would have caused an exponential error in the determination. The assumed value was above 6000 mg/l.

By refining the sampling of septic tank wastewater, a sample age of 21 to 30 days was recommended for the treatment technology in question (aerobic treatment). The composition of this wastewater is most similar to that of municipal wastewater.

4 DISCUSSION

Comparison of the above analysis results with the work of [3] shows several similarities and differences. In that study, the performance of septic systems in Nigeria with different wastewater compositions was analyzed, ranging from systems receiving only sewage to systems including water from kitchens and bathrooms. The authors found that the combination of sewage water with kitchen and bathroom water leads to improved water quality at the

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outfall, especially with regard to BOD_5, COD and total organic carbon. Our results suggest a trend where samples with longer storage time show higher concentrations of organic matter.

Interesting differences between the two studies can be seen in terms of the measurement conditions and sample composition. While study [3] analyzed the efficiency of existing septic systems with different types of connected wastewater, this study focused on the chemical composition and biodegradability of septic tank wastewaters with respect to their age. In addition, study [3] identified the need for the pre-treatment of kitchen water before its discharge into septic tanks due to its high organic content, an aspect that was not investigated in detail in this study, but which could be an interesting direction for future research.

5 CONCLUSION

The results of this research confirmed the initial assumptions about the variability of septic tank wastewater quality and its influence on the effectiveness of biological treatment. The study showed that all samples analyzed contained organic matter, confirming their potential for biological treatment.

Overview of the results:

- The high age of some of the samples and the high content of organically degradable substances caused some indicators to reach extreme values.
- Samples with a higher age have a more acidic pH: It is assumed that acidogenic processes have taken place.
- High-aged samples exhibit depletion and decomposition of $N\text{-}NH_4$ with conversion to methane, sulphane and mercaptans.
- High-aged samples show extreme values of organic pollution COD_{Cr} and BOD_5, due to the high proportion of organic matter.
- Negative ORP prevails in the high aged samples.

This research has contributed to a better understanding of septage composition. The analyses also highlight the need to optimize treatment processes, especially for older wastewater. The study also highlighted the importance of the regular maintenance and monitoring of septic systems to prevent excessive accumulation of organic matter and nitrogenous compounds.

Future research should focus on developing and testing technologies that can effectively treat septage. The data obtained in this study provides a valuable basis for improved treatment strategies and the more effective management of septic systems.

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