Pricing of water and sewerage charge rates of a selected water management company in the Czech Republic – a case study

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Abstract. The article deals with water and sewerage charge rates issues in the Czech Republic over the last 4 years. This article is focused only on part of the research. Research is based on data collection. The data were obtained from the internet portal eAGRI.cz. The aim of the article is to describe the development of water and sewerage charge rates in the Czech Republic during the last 4 years (2018-2021) and to analyse the pricing of a selected company in the Czech Republic. First, analyse the average water and sewerage charge rates system in the Czech Republic in the monitored period, then define the average water and sewerage charge rates system for the individual regions in which the selected water management company operates. The goal of the research is the analysis of the individual components of the calculation formula of the selected water supply and sewerage operator in the Czech Republic, namely the joint-stock company Brněnské vodarny a kanalizace, a.s. The vertical analysis methodology is chosen for data evaluation. The analysed operator has the largest representation in other direct costs and material in the calculation formula.

1 Introduction

The price of water and sewerage charge rates in the Czech Republic is constantly increasing. The eagri.cz website (www.eagri.cz) and the website of the Czech Statistical Office (CSO) provide prices of water and sewerage charge rates summarised for the entire Czech Republic and for individual regions of the Czech Republic [1, 2]. Since water supply and sewerage operators transformed from state-owned enterprises to mostly joint stock companies in the 1990s, i.e. capital companies that aim to satisfy their shareholders through dividends paid, it is not always the case that an efficient region also has higher prices of water and sewerage charge rates than underperforming regions [3 Drinking water services have been provided to the people by public services [4]. In the past decades, several countries around the world have either privatised water services completely, such as England and Wales and Chile, or increased private sector involvement in water services through public-private partnerships (PPPs), such as Spain, France and Portugal [5, 6]. In particular, the privatisation of water companies as natural monopolies requires the establishment of a regulatory body to guarantee

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the protection of customers and the environment and the financial sustainability of water companies. The concept of natural monopoly in the water sector is linked to the optimal organisation of the sector (economies of scale and scope) and efficiency and productivity. In the Czech Republic, the Ministry of Finance is the price regulator in the water supply and sewerage sector, which regularly reassesses the price regulation settings, and the Ministry of Agriculture is the substantive regulator.

Decision-making on environmental projects can be a complex and challenging task due to the trade-offs between environmental, socio-political and economic factors. Jajac, Marović, Rogulj and Kilić (2019) explore a systematic approach to develop a decision support concept that includes analysis of wastewater treatment problems, knowledge acquisition, and identification and evaluation of criteria that yield optimal solutions for wastewater treatment plant (WWTP) siting [7]. Liu, Wu, Xu, and Pan (2018) examined the relationship between wastewater discharge, river water quality in the Pearl River Delta, and GDP per capita. They used a Logarithmic Mean Divisia Index decomposition model as well as an Environmental Kuznets Curve model for their research [8]. Maziotis, Saal, Thanassoulis and Molinos-Senante (2014) looked into changes in profit, productivity and price performance in the water and sewerage industry: an empirical application for England and Wales. This study analysed the impact of regulation on the financial performance of water and sewerage companies in England and Wales over the period 1991-2008 [9]. In another paper, Molinos-Senante and Maziotis (2021) examined productivity growth, economies of scale and assortment in the water and sewerage industry: The Chilean case. In this paper, they focused on performance evaluation and cost factor analysis of water utilities, where they used quadratic cost functions to investigate the existence of economies of scale in the Chilean water and sewerage industry during the period 2010-2017 [10].

It is not only economic and environmental development that affects water companies. A previously neglected aspect is now also the social aspect, which is the key to solving today's problems. Why the social aspect has not been taken into account can be explained by the fact that it is difficult to measure. The social aspect is referred to here as welfare and prosperity. Average wages and employment can be used as proxies for social sustainability. The issue of social sustainability in Portuguese water companies has been addressed by Santos and Moreira (2022). The study provides an opportunity to reveal average sectoral trends in social sustainability and paves the way for future research examining firm heterogeneity [11].

In 2010, the average water and sewerage charge rates in the Czech Republic was 55.40 CZK/m^3 [†](water charge rate 29.10 CZK/m^3; sewerage charge rate 26.30 CZK/m^3) without value added tax (VAT), in 2020 the average water and sewerage charge rates was 77.90 CZK/m^3 (water charge rate 41.40 CZK/m^3; sewerage charge rate 36.50 CZK/m^3) without VAT. The price of water and sewerage charge rates will also increase significantly in 2022. Water companies attribute this to rising costs and the need to invest in infrastructure. The coronavirus pandemic has also had an impact on water price calculations from 2020. The war in Ukraine in early 2022 triggered a new wave of rapid price increases for goods and services, so that price increases affected all sectors of the economy. This implies that the war in Ukraine also has an impact on the price of water. At the moment and in the given situation, it is very difficult to estimate the development of water and sewerage charge rates in the Czech Republic in the future. However, some mathematical models can predict their course under appropriately set calculation conditions. Oblouková and Vítková (2023) discussed the issue of water and sewerage charge rates in the Czech Republic and the prediction of future prices of water and sewerage charge rates. The aim of the study was to predict the development of average water and sewerage charge rates in the Czech Republic in 2022-2026 using the selected mathematical method. The most suitable method for this research is the

[†] Kurz 1Euro = 25 CZK

linear trend method. This method has been previously verified for relevance and suitability in previous research [12]. However, it should be said that the chosen method does not take into account any external macroeconomic influences. Nor does it consider the huge increase in inflation since February 2022, when the rapid price rises caused by the war in Ukraine began. The increase in the inflation rate is only considered at the end of the calculation, where the effect of inflation on prices of water and sewerage charge rates is shown [13]. Volf, Sušanj Čule, Žic and Zorko (2022) in their studies reported the prediction of water quality index for improving treatment processes at drinking water treatment plant. Thus, the obtained models can help in optimizing the treatment processes, which are dependent on the raw water quality, and the overall sustainability of the water treatment plant [14].

This article focuses only on part of the research, namely the analysis of water and sewerage charge rates of a selected water management company. A suitable water management company was selected as one that meets the conditions of a large account unit. The aim of the article is to describe the development of water and sewerage charge rates in the Czech Republic during the last 4 years (2018-2021) and to analyse the pricing of water and sewerage charge rates of a selected water management company in the Czech Republic. Firstly, analyse the average water and sewerage charge rates in the Czech Republic over the period under review, then define the average water and sewerage charge rates for each region covered by the selected water management company.

The research then concludes with an analysis of the individual components of the costing formula of the selected water supply and sewerage operator of the Czech Republic, namely the joint stock company Brněnské vodárny a kanalizace, a.s. The methodology of vertical and horizontal analysis, arithmetic mean and median is chosen for data evaluation. The article is only a case study, it is an insight into the calculation formulas of one selected water management company, therefore it is not a statistical evaluation of the analysed data. The total number of samples that were examined prior to the case study was 100 operators of water supply and sewerage systems in the Czech Republic. The case study itself is narrowed down to only one operator of water supply and sewerage system that supplies water to 18 cities or municipalities and discharges wastewater from 8 cities or municipalities. Thus, the total number of calculation formulas examined is 104, thus analysing more than 26,000 items of data.

2 Material and methods.

The Ministry of Finance is the price regulator in the water supply and sewerage sector, which regularly rearranges the price regulation settings, and the Ministry of Agriculture is the substantive regulator. The Act No. 274/2001 Coll., on water supply and sewerage for public use as amended, regulates certain relations arising in the development, construction and operation of water supply and sewerage systems intended for public consumption in the Czech Republic [15]. A Decree of the Ministry of Agriculture implementing Act No 274/2001 Coll., on water supply and sewerage for public use as amended was also issued for the purpose, which is Decree No 428/2001 Coll [16].

The primary source for determining the development of average water and sewerage charge rates in the Czech Republic was the Czech Statistical Office. This is the central government body of the Czech Republic. It was established on 8 January 1969 by Act No 2/1969 Coll., on the establishment of ministries and other central bodies of state administration. The Czech Statistical Office collects and processes data for statistical purposes and provides statistical information to the state authorities, local authorities, the public and abroad. It guarantees the comparability of statistical information at national and international levels. The Water supply and sewerage act as well as the price regulation uses a unit price in CZK/m^3 [2].

The case study deals with the analysis of water and sewerage charge rates in the Czech Republic and focuses on one selected operator of water supply and sewerage systems for public use, for which it examines the cost analysis of water and sewerage charge rates. All data are based on to the time horizon of the past 4 years, i.e. 2018-2021. All formulas and calculations were made using Microsoft Excel software.

The article first examines the analysis of the development of average water and sewerage charge rates in the Czech Republic as a whole. Next, the operator of water supply and sewerage system of the Czech Republic is selected according to the size of the enterprise. The searched operator was a large company (large account unit).

According to the Accounting Act No. 563/1991 Coll., companies are divided according to the number of employees, the amount of assets and revenues from the sale of goods and services into:
- micro account units,
- small account units,
- medium-size account units and
- large account units.

A micro account unit is one that does not exceed at least 2 of the above thresholds as of the balance sheet date - total assets of CZK 9,000,000, annual aggregate net turnover of CZK 18,000,000, average number of employees during the accounting period 10. A small account unit is one that is not a micro account unit and does not exceed at least 2 of the above thresholds as at the balance sheet date - total assets of CZK 100,000,000, annual aggregate net turnover of CZK 200,000,000, average number of employees during the accounting period 50. A medium-size account unit is one that is neither a micro account unit nor a small account unit and does not exceed at least 2 of the above thresholds at the balance sheet date - total assets of CZK 500,000,000, annual aggregate net turnover of CZK 1,000,000,000, average number of employees during the accounting period of 250. A large account unit is one that exceeds at least 2 of the thresholds at the balance sheet date - total assets of CZK 500,000,000, annual net turnover of CZK 1,000,000,000, average number of employees during the financial year of 250 [17].

The size of the selected water management company was verified on the internet portal JUSTICE.CZ, where the Ministry of Justice of the Czech Republic presents legislation that affects the life of every citizen in the areas of civil, commercial, criminal and procedural law. The Ministry of Justice is also the source of the regulations governing professions such as judges, lawyers, notaries and executors. On this portal, among other things, each company is required to publish its annual final accounts, where the information on assets and sales can be found. The assessment is based on the 2021 financial statement. According to the 2021 accounts, the operator of water and sewerage system has been split into the appropriate company size [18].

According to the above criteria, the operator, Brněnské vodárny a kanalizace, a.s., was chosen as a large account unit.

The joint-stock company Brněnské vodárny a kanalizace, a.s., which supplies water to 18 towns or villages and discharges wastewater from 8 towns or villages. The water supply system for public use is provided by the town of Brno, Kuřim, Modřice, Březová nad Svitavou, the municipalities of Štěpánov nad Svratkou, Doubravník, Lelekovice, Moravany, Česká, Vranov, Moutnice, Měnín, Švařec, Koroužné, Želešice, Skorotice, Dolní Loučky, Černvír and the Vírský regional water supply system, an association of towns, municipalities and associations of municipalities. Sewerage for public use is available in the territory of the town of Brno, Kuřim, Modřice, Štěpánov nad Svratkou, Česká, Moutnice, Švařec, Želešice. It is a municipal operator with a separate operating model. It has an overlap into 4 regions - Pardubice Region, South Moravian Region, Vysočina Region, Central Bohemia Region. In 2021 it had 533 employees, total assets of CZK 2,381,573,000 and revenues of CZK

2,094,767,000. Based on these figures, it can be clearly stated that it is a large accounting unit.

Furthermore, it was necessary to obtain data on the basis of which it is possible to carry out a cost analysis for the years 2018-2021. Information on the costs of individual water management company was obtained from the eagri.cz website. According to the provisions of Section 5(3) of the Act on Water Supply and Sewerage, owners of water supply and sewerage systems are obliged to submit annually the selected data from the Property Register of Water Supply and Sewerage Systems, the so-called "VÚME", and the selected data from the Operational Register of Water Supply and Sewerage Systems, the so-called "VÚPE", to the water authorities in whose territorial jurisdiction the property is located. It should be said that the VÚME and VÚPE data provide data beyond the scope of the CSO survey. An important difference from the data of the Czech Statistical Office is mainly the definition corresponding to the territorial division according to the competence of the water administration authorities [1, 2].

The water authorities forward the data to the Ministry of Agriculture, where it is imported into a common database, checked and sorted. The publications issued by the Ministry of Agriculture make it possible to see the development of the water supply and sewerage sector over the years. These publications provide data mainly of an economic nature, including the impact of the scale of infrastructure assets operated by a single operator on the efficiency of operations. It should also be said that the clear data analysis performed on the Czech Republic's operators of water supply and sewerage systems, where all information is included, was first produced in Microsoft Excel in 2018. This is one of the main reasons why this entire case study is focused on the period 2018-2021.

Based on the analysis of the above-mentioned database, it was found that the selected operator of water supply and sewerage system, Brněnské vodárny a kanalizace, a.s., operates services in 4 regions of the Czech Republic. Based on this fact, an analysis of average prices of water and sewerage charge rates in the regions of the Czech Republic was also carried out, namely Pardubice Region, South Moravian Region, Vysočina Region, Central Bohemia Region. Furthermore, a cost analysis has already been carried out for the water and sewerage charge rates of the selected water management company.

The basic methodology chosen for the cost analysis of the water charge rates of the selected Czech operators is called vertical analysis. It is one of the basic methods of financial analysis. Vertical analysis describes the representation of individual items related to the whole. It is expressed as an absolute number or as a percentage. The second elementary indicator is the horizontal analysis, which describes the year-on-year change of items in absolute terms or as a percentage and expresses how the items have changed compared with the previous year. In other words, it is a horizontal, i.e. a line-by-line comparison of the absolute or relative changes in the items of a given statement over time. It is a useful indicator for determining the year-on-year change (increase or decrease) in the average price of water and sewerage charge rates in the Czech Republic as a percentage.

$$\text{Horizontal analysis} = \frac{(indicator_t - indicator_{t-1})}{indicator_{t-1}} * 100, \quad (1)$$

Where:
$horizontal\ analysis$ - the year-on-year change of items [%],
$indicator_{\mathrm{t}}$ - the price of water charge rates in the year under review [CZK/m³],
$indicator_{\mathrm{t-1}}$ - the price of water charge rates in the previous year [CZK/m³].

$$\text{Vertical analysis} = \frac{indicator_i}{indicator_x + indicator_y} * 100, \quad (2)$$

Where:
$vertical\ analysis$ - the representation of individual items related to the whole [%],
$indicator_i$ - the individual cost component in the year under review [CZK],
$indicator_x$ - the full own cost for calculating water charge rates in the year under review [CZK],
$indicator_y$ - the calculation profit of the year under review [CZK].

The mathematical function median was also used in the Microsoft Excel calculations. The median is a value that divides a series of results into two halves. Thus, at least 50% of the values are less than or equal to the median and at least 50% of the values are greater than or equal to the median. The arithmetic mean was used to determine the average values:

$$\bar{x} = \frac{1}{n}\sum_{n=1}^{n} x_i, \quad (3)$$

Where:
$\bar{x}$ - the average values [CZK],
x_i - the sum of all values to determine the average [CZK],
n - the number of values to be summed [-].

3 Results and discussion

All outputs listed below were processed as individual steps, namely:
- data collection,
- data processing and
- their assessment using MS Excel.

All prices quoted in this article are exclusive of value added tax (VAT) at the exchange rate of 1 Euro = 25 CZK.

The table below shows the development of average water and sewerage charge rates in the Czech Republic over a time horizon of 4 years, i.e. in the years 2018 to 2021 (see Table 1.). The given values were collected from the internet server of the Ministry of Agriculture eAGRI.cz, this data was checked for relevance on the website of the Czech Statistical Office. The data given in the table shows that the average price of water and sewerage charge rates in the Czech Republic has been increasing year by year and it can be expected that prices continue to increase in the coming years as well. A horizontal analysis was subsequently compiled from the average prices of water and sewerage charge rates in the Czech Republic, i.e. the year-on-year change in the average water and sewerage charge rates in the Czech Republic. In 2019 the average price of water and sewerage charge rates increased by 3.50%, in 2020 it increased by 5.27% and in 2021 it increased by 5.75%.

Based on the formula given in the methodology of this article, the percentage of component ratio of the average water and sewerage charge rate in the Czech Republic for the monitored period was determined. An average value for the entire monitored period was calculated from the percentage of water and sewage charge rate components in individual years. The average national ratio of water and sewerage charge was 53.19% and 46.81% in all monitored years. It is clear that the average price of water charge rate in the Czech Republic is higher than the average price of sewerage charge rate in the monitored period.

The ratio of the average water charge rate component in the monitored years ranged from 53.11 to 53.29% and the ratio of the average sewerage charge rate component in the monitored period ranged from 46.71 to 46.89%.

Table 1. Average prices of water and sewerage charge rates in the Czech Republic in CZK/m³ without VAT Republic for the 2018-2021 period.

Indicator	2018	2019	2020	2021
Water charge rate	38.10	39.30	41.40	43.84
Sewerage charge rate	33.40	34.70	36.50	38.54
Total	71.50	74.00	77.90	82.38

1 Euro = 25 CZK

As already mentioned in the introduction of this article, the selected operator Brněnské vodárny a kanalizace a.s. has an overlap into 4 regions of the Czech Republic - Pardubice Region, South Moravian Region, Vysočina Region, Central Bohemia Region. In total, the Czech Republic consists of 14 regions (see Fig. 1).

Fig. 1. Regions of the Czech Republic.

Therefore, an analysis of the average prices of water and sewerage charge rates was carried out in the regions where the operator Brněnská vodárny a kanalizace a.s. intervenes (see Table 2.). The average price of water and sewerage charge rates in the Central Bohemia Region increased by CZK 11.20 per cubic metre in the period under review, in the Pardubice Region there was an increase of CZK 9.10 per cubic metre, in the Vysočina Region there was an increase of CZK 7.70 per cubic metre.

Table 2. Development of the average price of water and sewerage charge rates in the selected regions of the Czech Republic in CZK/m³ without VAT for the 2018-2021 period.

Indicator	2018		2019		2020		2021	
	Water charge rate	Sewe-rage charge rate	Water charge rate	Sewe-rage charge rate	Water charge rate	Sewe-rage charge rate	Water charge rate	Sewe-rage charge rate
Central Bohemia Region	40.90	33.10	41.90	34.20	45.20	36.60	47.10	38.10

Pardubice Region	34.10	36.20	35.90	37.30	37.40	38.60	39.40	40.00
Vysočina Region	37.10	28.30	38.50	28.80	40.10	30.20	41.80	31.30
South Moravian Region	34.50	34.50	36.10	36.20	39.40	37.20	41.60	39.60

1 Euro = 25 CZK

To the analysis of the calculation formulas for the price of water and sewerage charge rates, operator of water supply and sewerage system characterised as a large accounting unit, Brněnské vodárny a kanalizace a.s., was selected. This operator supplies drinking water to 18 locations in the Czech Republic and discharges wastewater from 8 locations in the Czech Republic (see Table 3).

From Table 3. it is therefore clear that Brněnské vodárny a kanalizace a.s. supplies drinking water and at the same time discharges wastewater from 7 locations (Kuřim, Štěpánov nad Svratkou, Česká, Moutnice, Švařec, Želešice and Brno), only wastewater is discharged from Modřice and only drinking water is supplied to 11 locations (Březová nad Svitavou, Doubravník, Černvír, Dolní Loučky, Koroužné, Lelekovice, Měnín, Moravany, Nebovidy, Skorotice and Vranov).

Table 3. Drinking water supplied and wastewater discharged by the operator Brněnské vodárny a kanalizace a.s.

No.	Location	Drinking water	Wastewater	No.	Location	Drinking water	Wastewater
1	City of Modřice	No	Yes	11	Village Měnín	Yes	No
2	City Březová nad Svitavou	Yes	No	12	Village Moravany	Yes	No
3	City Kuřim	Yes	Yes	13	Village Moutnice	Yes	Yes
4	Town Doubravník	Yes	No	14	Village Nebovidy	Yes	No
5	Town Štěpánov nad Svratkou	Yes	Yes	15	Village Skorotice	Yes	No
No.	Location	Drinking water	Wastewater	No.	Location	Drinking water	Wastewater
6	Village Černvír	Yes	No	16	Village Švařec	Yes	Yes
7	Village Česká	Yes	Yes	17	Village Vranov	Yes	No
8	Village Dolní Loučky	Yes	No	18	Village Želešice	Yes	Yes
9	Village Koroužné	Yes	No	19	Statutory city of Brno	Yes	Yes

10	Village Lelekovice	Yes	No				

The analysis of the representation of the individual cost components was carried out separately for the 18 locations to which Brněnské vodárny a kanalizace a.s. supplies drinking water and separately for the 8 locations from which wastewater is discharged. For all calculation formulas, a vertical analysis was carried out, for which the types of costs were monitored and analysed for the 2018-2021 period. For these costs, which were narrowed down to the main item costs such as material, energy, wages, and other direct and operating costs, an average was determined for each location in the Czech Republic where the operator of water supply and sewerage system under review has a presence for the entire period under review. From these established averages, an analysis was made of the intervals at which each cost component occurs. Abnormal values have been removed and an average of the cost components has been established for the locations where drinking water is supplied and, separately, averages of the cost components have been established for the locations where wastewater is discharged. In order to make the results of the analysis more precise, intervals, i.e. minimum and maximum values of the individual cost components of the water or sewerage charge rates, are established at the end of the analysis.

The first group is therefore locations where Brněnské vodárny a kanalizace a.s. supplies drinking water. Vertical analyses for the years 2018-2021 are compiled from the calculation formulas of all 18 locations. In other words, research is conducted on the representation of individual cost components entering into the price of water charge rates in a 4-year horizon. For the sake of clarity, one location (the city of Kuřim) has been selected for which the complete calculation formula is shown and the percentage representation of individual cost items and other items constituting the price of water charge rates (Table 4). The table highlights the main items of the calculation formula that were examined towards the end of the research carried out. These main components of the calculation formula served as the basis for research on vertical analyses of their sub-components. Ultimately, this means in the example given that the energy costs in the city of Kuřim in 2021 were made up of 91.52% electric energy and the remaining 8.48% was gas.

Table 4. Percentage representation of individual cost items and other items constituting the price of water charge rates in Kuřim for the 2018-2021 period.

No.	Cost items	2018 %	2019 %	2020 %	2021 %
1.	**Material**	**46.47**	**45.92**	**44.84**	**42.21**
1.1	- raw groundwater + surface water	0.00	0.00	0.00	0.00
1.2	- drinking water collected	100.00	99.95	99.98	99.99

1.2	- chemicals	0.00	0.00	0.00	0.00
1.4	- other material	0.00	0.05	0.02	0.01
2.	**Energy**	**2.50**	**2.61**	**2.44**	**2.18**
2.1	- electric energy	89.17	89.78	9203	91.52
2.2	- other types of energy (gas)	10.83	10.22	7.97	8.48
3.	**Wages**	**3.94**	**3.99**	**4.20**	**4.20**
3.1	- direct wages	73.91	73.82	74.59	74.45
3.2	- other personal costs	26.09	26.18	25.41	25.55
4.	**Other direct costs**	**38.18**	**42.35**	**40.26**	**44.12**
4.1	- depreciation	0.00	0.00	0.00	0.00
4.2	- repairs	10.30	13.92	9.32	15.50
4.3	- rental of infrastructure assets	89.70	86.08	90.68	84.50
4.4	- water delivered	0.00	0.00	0.00	0.00
5.	**Operating costs**	**5.45**	**4.76**	**5.26**	**4.07**
5.1	- wastewater discharge charges	0.00	0.00	0.00	0.00
No.	Cost items	2018 %	2019 %	2020 %	2021 %
5.2	- other external operating costs	55.28	38.19	42.69	34.32
5.3	- other own costs	44.72	61.81	57.31	65.68
6.-9.	Financial income and expenses, production and administrative overhead	0.86	1.02	0.94	0.96
10.	Full own costs	97.40	100.67	97.94	97.74

11.-12.	**Calculation profit**	**2.60**	**-0.67**	**2.06**	**2.26**
13.	Total	100.00	100.00	100.00	100.00

From the summaries thus generated for each location, average values were determined, defined only for the main items of the calculation formula, i.e. material, energy, wages, other direct costs, operating costs, profit. For illustrative purposes, the village of Lelekovice was selected (see Table 5.).

Table 5. Percentage representation of the main cost items constituting the price of water charge rates in Lelekovice for the 2018-2021 period.

Main items of the calculation formula	2018 %	2019 %	2020 %	2021 %	Average %
Material	46.16	48.71	47.76	45.50	47.03
Energy	6.67	5.42	5.59	4.81	5.62
Wages	7.86	7.69	6.41	7.06	7.25
Other direct costs	28.28	27.42	32.29	28.25	29.06
Operating costs	11.97	7.66	12.94	10.37	10.74
Calculation profit	-2.07	2.10	-6.19	3.01	-0.79

Subsequently, the abnormalities were removed. Specifically, for the locations to which the operator supplies drinking water, the city of Březová nad Svitavou had to be removed from the overall analysis because it does not have drinking water collected. In addition, villages of Skorotice and Švařec were removed from the overall analysis because of the calculation of the profit in higher negative values, while the village of Skorotice has drinking water collected, but to an insufficient extent. The last excluded locality is the statutory town of Brno due to high rental of infrastructure assets. A final analysis was made of the other 14 locations. It was created in representation of the main item costs such as material, energy, wages, other direct costs and operating costs, from these costs their averages of values were determined. For the remaining 14 locations, the ranges, i.e. the lowest interval values considered and maximum interval values within which each cost component falls, were established for clarification. The median of the values was determined for all 18 locations to which Brněnské vodárny a kanalizace a.s. supplies drinking water (see Table 6.).

Table 6. Average percentage representation of the main cost items in the calculation formula for water charge rates over the 2018-2021 horizon, median, minimum and maximum interval value.

Indicator	Material %	Energy %	Wages %	Other direct costs %	Operating costs %

Median	46.73	1.43	7.63	37.97	11.08
Lowest interval value considered	34.08	0.08	3.40	16.98	4.89
Maximum interval value	58.08	7.74	24.49	48.43	27.63
Average	46.28	1.96	8.25	35.12	12.94

It can be seen from the above that after separating the abnormalities, that is, after separating the most frequently occurring values from the less frequent or exceptional ones, it can be said that within the case study:
- Material ranges from 34.08-58.08% of the total cost and profit; it is represented by the cost of raw groundwater and surface water, potable water collected, chemicals and other materials; material has the highest percentage of cost representation,
- Energy is the lowest cost item, consisting of electricity and other energy and ranging from 0.08-7.74%,
- Wages range around 3.40-24.49% and are represented by direct wages and other personal costs,
- Other direct costs range from 16.98-48.43% are represented by depreciation, repairs, rent of infrastructure assets and water supplied,
- Operating costs, which include sewage discharge charge rates, external operating costs, and own overheads, range from 4.89-27.63%.

The same procedure was carried out at 8 locations from where the operator Brněnské vodárny a kanalizace a.s. discharges wastewater. For the final analysis, the villages of Moutnice and Švařec and the town of Štěpánov nad Svratkou were excluded from the calculations because they show a negative profit in the calculation formula. However, these three places are included in the median calculation (see Table 7.).

Table 7. Average percentage representation of the main cost items in the calculation formula for sewerage charge rates over the 2018-2021 horizon, median, minimum, and maximum interval value.

Indicator	Material %	Energy %	Wages %	Other direct costs %	Operating costs %
Median	31.72	3.07	6.02	52.13	5.73
Lowest interval value considered	27.14	0.03	1.41	36.23	1.71
Maximum interval value	55.67	4.16	7.39	57.35	5.80

Average	37.60	1.65	3.70	48.16	4.24

Table 7. shows that after separating the abnormalities, that is, after separating the most frequently occurring values from the less frequent or exceptional ones (in this case removing the locations Moutnice, Švařec and Štěpánov nad Svratkou from the calculations due to high negative calculation profit), it can be said that within the case study:
- Material ranges from 27.14-55.67 % of the total cost and profit; it is represented by the cost of raw groundwater and surface water, wastewater collected, chemicals and other materials; material is the second largest cost group in the pricing of sewerage charge rates,
- Energy is the lowest cost item, consisting of electricity and other energy and ranging from 0.03-4.16 %,
- Wages range around 1.41-7.39 and are represented by direct wages and other personal costs,
- Other direct costs range from 36.23-57.35 % and are represented by the depreciation, repairs, the rental of infrastructure assets, and funds for the renewal of; other direct costs are the largest group of costs in the formation of the sewerage charge rates of the operator Brněnská vodárny a kanalizace a.s,
- Operating costs, which include sewage discharge charge rates, external operating costs, and own overheads, range from 1.71-5.80 %.

Table 8. Order of the main cost components, ranked from the highest to the lowest, constituting the price of water and sewerage charge rates of the operator Brněnské vodárny a kanalizace a.s.

Drinking water		Wastewater	
1.	Material	1.	Other direct costs
2.	Other direct costs	2.	Material
3.	Operating costs	3.	Wages
4.	Wages	4.	Operating costs
5.	Energy	5.	Energy

In conclusion, it should be said that the highest telling value in this research is not the average values, but the median of the values, which, on the scale of all the data, considers the middle value that better illustrates the given fact. In this case the average percentage representation of the main cost items in the calculation formula of the monitored locations in the Czech Republic, to which the studied operator supplies drinking water and discharges wastewater.

4 Conclusions

The aim of the paper was to determine, by means of a vertical analysis, the percentage representation of the individual components of the calculation formula forming the price for water and sewerage charge rates for a selected operator of water supply and sewerage system in the Czech Republic in the period 2018-2021, i.e. for a period of 4 years. First, operator of

water supply and sewerage system that falls under a large account unit was found, the average prices of water and sewerage charge rates of the Czech Republic in the period under study were analysed, then the average prices of water and sewerage charge rates for the regions that the selected operator of water supply and sewerage system covers were defined. The research concluded with an analysis of the individual components of the calculation formula of the selected operator of water supply and sewerage system of the Czech Republic, Brněnské vodárny a kanalizace, a.s.

The joint-stock company Brněnské vodárny a kanalizace, a.s. supplies water to 18 locations and discharges wastewater from 8 locations of the Czech Republic. According to the internet server JUSTICE.CZ, it was verified that the selected operator of water supply and sewerage system falls under large account units. The verification was carried out according to the financial statements from 2021, when the company Brněnské vodárny a kanalizace, a.s. had 533 employees, total assets of CZK 2,381,573,000 and revenues of CZK 2,094,767,000.

For the selected water management company, a total of 26 locations in the Czech Republic where Brněnské vodárny a kanalizace a.s. drinking water or discharges wastewater were examined. In total, 104 calculation formulas were taken into the research, which amounted to a work of over 6,760 data. A vertical analysis was performed for all calculation formulas, for which the types of costs were monitored and analysed for the 2018-2021 period. For these costs, which were narrowed down to the main item costs such as material, energy, wages, and other direct and operating costs, an interval within which the given values range was set at the very end. This interval was determined on the basis of the minimum and maximum values that occurred in the vertical analysis. The average values was calculated from these values.

It should be said that the median values in this research was of the highest indicative value, as all the research data could be considered in its calculation and there was no need to remove possible abnormalities from the calculations, which are described in detail in the previous section of this article.

The analysis was carried out separately for the calculation formulas for water charge rates and for sewerage charge rats. The first group analysed was 18 places in the Czech Republic (Kuřim, Štěpánov nad Svratkou, Česká, Moutnice, Švařec, Želešice and Brno, Březová nad Svitavou, Doubravník, Černvír, Dolní Loučky, Koroužné, Lelekovice, Měnín, Moravany, Nebovidy, Skorotice and Vranov), where Brněnské vodárny a kanalizace a.s. supplies drinking water. The following conclusions were drawn from the analysis:

- The highest percentage representation of costs is found in material; it is represented by the cost of raw groundwater and surface water, potable water collected, chemicals and other materials; the median value is 46.73%; the material is mostly represented by drinking water collected,
- The second highest percentage representation of costs is found in other direct costs, where the largest burden is in the rental of infrastructure assets; in addition, other direct costs are represented by depreciation, repairs and water supplied; the median value is 37.97%,
- The third highest percentage representation of costs is found in operating costs, which include sewage discharge charge rates, external operating costs, and own overheads; the median value is 11.08%.
- Wages are represented by direct wages and other personal costs, the median value is 7.63%,
- Energy is the lowest cost item, consisting of electricity and other energy; the median value is 1.43%.

The second group analysed were 8 locations in the Czech Republic (Kuřim, Štěpánov nad Svratkou, Česká, Moutnice, Švařec, Želešice, Brno and Modřice), from where the selected operator Brněnské vodárny a kanalizace a.s. discharges wastewater. The following conclusions were drawn from the analysis:

- The highest percentage representation of costs in the formation of the sewerage charge rate of the operator Brněnské vodovody a kanalizace a.s. is found in other direct costs, where the largest burden is in the rental of infrastructure assets; other direct costs are represented by depreciation, repairs, and funds for the renewal of infrastructure; the median value is 52.13%,
- The second highest percentage representation of costs is found in material, it is represented by the cost of raw groundwater and surface water, wastewater collected, chemicals and other materials; the material is mostly represented by wastewater collected; the median value is 31.72 %,
- The third highest percentage representation of costs is found in wages; wages are represented by direct wages and other personal costs, the median value is 6.02 %,
- Operating costs, which include sewage discharge charge rates, external operating costs, and own overheads, are the second smallest group of main costs, which as a result shape the price of sewerage charge rates of the operator Brněnská vodárny a kanalizace a.s.; the median value is 5.73%.
- Energy is the lowest cost item, consisting of electricity and other energy; the median value is 3.07 %.

It is clear from the research to date that in both cases, water and sewerage charge rates, the material and other direct costs are the most represented of the water and sewerage charge rates. Therefore, further research will lead to an analysis of these two cost items and determine their impact on the performance of water management companies. In all circumstances, it should be mentioned that the price of water and sewerage charge rates must be socially acceptable to end customers.

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