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USING WATER UTILITY PERFORMANCE INDEX (WUPI) FOR MEASURING COMPANY'S PERFORMANCE

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A b s t r a c t: This paper proposes a water utility performance index (WUPI) to measure the performance of water supply utilities in Republic of Macedonia. WUPI is based on 12 key performance indicators (KPIs) grouped into three components (economic sustainability, operational sustainability and quality of services). The WUPI was calculated on 4 different ways using two weighting systems and two different functional forms to aggregate the indicators (additive aggregation and hybrid aggregation). Performance of 12 water utilities is measured by calculating WUPIs for a period from 2013 to 2016. The results obtained indicate that the performance level between the analyzed water supply utilities is heterogeneous, with water supply utilities earning both high and low scores of the WUPI. The lowest value of WUPIs are recorded for operational performance, while service quality component showed the best performance. Findings urged for immediate actions in the sector, otherwise the medium- to long-term self-sustainability of water supply utilities is under the risk. To sustain the service quality in the future, focus is to be given on reducing non-revenue water, dealing with overstaffing, improving operational costs coverage and lowering fee collection period.

Key words: water utilities, indicators; WUPI; performance; benchmarking

КОРИСТЕЊЕ НА ИНДЕКСОТ WUPI ЗА МЕРЕЊЕ НА ПЕРФОРМАНСИТЕ НА ПРЕТПРИЈАТИЕТО

А п с т р а к т: Во овој труд се предлага користење на индекс за мерење на перформансите на стопанисувањето со вода (WUPI) во комуналните водостопански претпријатија во Република Македонија. WUPI се базира на 12 клучни индикатори за успешност (KPIs) групирани во три компоненти (економска одржливост, оперативна одржливост и квалитет на услуги). Вредностите на индексот WUPI беа пресметани на 4 различни начини користејќи две различни методи за одредување на тежинските вредности на одделните индикатори кои го сочинуваат WUPI, и два начина за собирање на индикаторите (адитивна и хибридна агрегација). Перформансите на 12 водоводни претпријатија беа измерени преку пресметка на вредностите на WUPI за период од 2013 до 2016 година. Добиените резултати покажуваат дека постои хетерогено ниво на перформансите кај водоводните претпријатија. Според пресметаните вредности на WUPI, најслаби се перформансите што се однесуваат на оперативната одржливост, додека компонентата за квалитет на услуги покажува најдобри резултати во анализираниот период. Наодите сугерираат да се преземат итни мерки во секторот, бидејќи во спротивно постои ризик за средно- и долгорочната одржливост на претпријатијата. За да се одржи квалитетот на услугите и во иднина, фокусот треба да се стави на намалување на недоходната вода, справување со превработеноста, подобрување на покриеноста на оперативните трошоци и намалување на периодот на наплата.

Клучни зборови: водоводни компании; индикатори; WUPI; перформанси; benchmarking

1. INTRODUCTION

Over the past two decades, the use of performance indicators has emerged as the main tool for measuring and monitoring the performance of water utilities (Canneva and Guérin-Schneider, 2011) [7] and benchmarking techniques have become a strategic tool for water regulators. Benchmarking is used: (i) to promote and motivate "competition" between different water utilities in order to improve

their performance, (ii) to identify the strengths and weaknesses in the performance of water utilities, (iii) to promote information sharing and improve transparency in the reporting process, (iv) to identify performance trends, and (v) to provide information regarding the performance of water utilities to water consumers (Alegre et al., 2009; Padowski, 2008) [4, 21].

In order to increase the business performance, each company must work effectively and efficiently and this applies for public sector companies as well (Wisniewski and Donnelly, 1996; Andreassen, 1994) [27, 5]. There is no doubt that different business aspects are inter-correlated to each other and those relations have ultimate impact over companies' performance and quality of products and services. For example, in a metaanalysis carried out by Capon et al. (1990) [8] some 20 studies were identified that find a positive relationship between quality and business performance. A research conducted by Albert and Leyland (1997) [2] on a sample of UK service firms "*suggest that the service quality delivered by a business does have an effect on performance*" (p. 613). Therefore they advise the managers to seek for improving the service quality of their business in the efforts to improve profitability. However, the authors add that this does not imply that a firm should continue to strive for quality at any cost. Hackl and Westlund (2000) [16] stated that customer satisfaction is essential for customer retention and loyalty, but also for improving an organization's performance. Others (Barnes and Cumby, 1996) [6] also claimed that increased customer satisfaction can contribute to performance. Similarly, Fornell (1992) [11] documents that customer satisfaction has a direct impact on an organization's performance and suggests that the managers are keen to improve customer satisfaction and thus business performance. However, they all relay on the link between satisfaction and quality, and accordingly, that is the reason why companies are constantly seeking for service quality improvement.

Urban water utilities commonly operate in a natural monopoly environment and missing market competition defocusses those utilities from continuous improvement of their performance. Therefore, water regulators in both developed and developing countries usually conduct performance evaluations of water utilities using benchmarking techniques (Marques et al., 2011) [18]. Furthermore, in developing countries where major efforts have been made to improve water services, consumers are paying high tariffs for those services, considering their socioeconomic context (Hoque and Wichelns, 2013) [17]; yet, according to some authors, these services are usually of poor quality (Mugabi et al., 2007) [19].

Recently established national regulator in the Republic of Macedonia has just pioneered with regulating the sector by setting tariff limits for the utilities supplying more than 10,000 inhabitants and intends to introduce a benchmarking framework to evaluate the performance of the main urban water supply utilities in the country. However, the benchmarking tool is not yet designed and the key performance indicators are still to be defined, so the system does not provide an integrated evaluation of overall performance or enable comparison of the different utilities until now.

The main objective of this research study is to develop a water utility performance index (WUPI) to evaluate the performance of the urban water supply utilities in the Republic of Macedonia. The use of composite indicators should enable the evaluation of performance in an integrated manner. Empirical application focused on the performances of water supply utilities in the years 2013 – 2016. The results of this study are intended to serve as a support tool for the managers and decision makers of water supply utilities to implement the most appropriate actions for improving performance and provide ideas to national regulator in designing a national benchmarking platform.

The paper is structured as follows. The next Section 2 briefly presents the sector context. The methodology for construction (weighting, normalization and aggregation) of four composite WUPI indicators is presented in Section 3. Section 4 calculates and discusses WUPIs results including statistical analysis. The concluding remarks are presented in Section 5.

2. CONTEXT

Provision of water supply and sanitation services in Macedonia is the sole responsibility of municipalities. To fulfil its legal obligation and provide those services to citizens and businesses, municipalities establish a public (usually) multi-utility company. The term public means both – that the ownership is public (the only "shareholder" is the local government) and the services provided are considered to be of public interest. According to the European Commission (2004) [10], the delivery of such service of public interest must fulfil the principles

of: universality, continuity, quality, affordability, as well as user and consumer protection.

Established and owned by municipalities, however, the public utilities operate as separate legal entities. The employees are not civil servants and utility's financial operation is not part of the municipal budget. Water utilities are managed by Directors General, appointed by the Mayor, while governing structure (Management and Supervisory Boards) are appointed by municipal Council. The appointed members, according to the existing legislation "must be experts in the area", however, in the reality, the political affiliation of the appointed board members is probably the decisive criteria. Thus, the top management and governing structures of public communal companies somehow "owe" their position to political parties. The ongoing decentralization process has transferred many of the responsibilities for the delivery of public services to local levels, but it was not followed by adequate financial transfers to perform and upgrade service delivery. This put even stronger pressure for more efficient financial and operational performance of water utilities.

Macedonia has traditionally had a high level of water supply service coverage, and just a slightly lower level of sanitation services in rural areas. Nowadays, water and sanitation services in Macedonia are provided through 68 public municipal utilities (ADKOM 2014) [1]. According to the World Bank (2015) [28], over 98% of the urban population and about 80% of the rural population is connected to piped water supply systems. Similar figures apply for access to sanitation services. However, access to waste water treatment is much lower, at 13% of the population and 21% of the total waste water produced. With an average population served of 23,241, the market is more atomized than the average in the region, and is dominated by the Skopje Water Company, which serves about 30% of the population. Seven water-only utility companies, serve an additional 17% of the population, and 45% are served by 60 smaller municipal multi-utility companies (including solid waste management, greenery, public cleanness, etc.). The rest of the population has access to self-provision (12.5%). There is only one private operator serving less than 10,000 inhabitants (World Bank, 2015) [28].

There is currently no reliable, country-wide, publicly available source of information on water services performance in Macedonia. The Association of Communal Service Providers (ADKOM) recently launched a project supported by the Danube Water Program to establish an internal system for performance data collection from its members, which, among others, is to be used for benchmarking [29]. Twelve (12) utilities participating in the program are selected for this study as presented in Table 1.

T a b l e 1

Communal companies participating in the survey

Municipality	Population	Region GDP/capita in EUR	Gini (2013/2014)	Region
Bitola	92,550	3,703		Pelagonija
Veles	54,758	3,713		Vardar
Vinica	19,456	3,362		East
Gostivar	83,361	1,719		Polog
Kavadarci	38,946	3,713		Vardar
Kičevo	57,170	2,638	37.0 / 35.2	South-west
Kočani	37,903	3,362		East
Kriva Palanka	20,180	2,367		North-east
Negotino	19,384	3,713		Vardar
Ohrid	52,262	2,638		South-west
Gevgelija	24,312	4,199		South-east
City of Skopje	668,515	5,228		Skopje
Total	1,168,797			

The selection criteria aimed to secure representation of the majority of country population (57% of total population in the country are served by these 12 utilities), then balanced regional representation (utilities from all eight statistical regions are represented), and to utilities that participate to IBNET (The International Benchmarking Network for Water and Sanitation Utilities is the world largest database for water and sanitation utilities performance data that supports and promotes good benchmarking practice among water and sanitation services) benchmarking platform, which secures that at least basic data validation has been performed [30].

3. METHODOLOGY

The water utility performance index (WUPI) used to assess the performance of the Macedonian water utilities was developed following the OECD-JRC (2008) [20] recommendations for building composite indicators in 10 steps: (i) development of a theoretical framework; (ii) selection of the basic indicators; (iii) imputation of missing data; (iv) multivariate analysis; (v) normalization; (vi) weighting and aggregation; (vii) robustness and sensitivity; (viii) back to the details (indicators); (ix) association with other variables; and (x) dissemination. Despite the fact that composite indicators are widely used, some authors criticise their relevance. Saisana and Tarantola (2002) [24] have summarized the pros and cons of the composite indicators as presented in Table 2.

According to WB's State of the Sector Report (2015) [28], WUPI is a best practice indicator due to its construction. For given cost/expenditures, higher values of WUPIs represent better performance. The indicator is therefore similar to APGAR (water utility status index) indicator by IBNET (Van der Berg and Danilenko, 2011) [26], which assesses a utility's health based on five indicators (or six, if the utility also provides sewerage services) and provides insight into the utility's operational, financial, and social performance.

T a b l e 2

Pros and cons of composite indicators

PROS	CONS
Can be used to summarize complex or multi-dimensional issues, in view of supporting decision-makers.	May send misleading, non-robust policy messages if they are poorly constructed or misinterpreted.
Provide the 'big picture'. They can be easier to interpret than trying to find a trend in many separate indicators.	The simple 'big picture' results which composite indicators show may invite politicians to draw simplistic policy conclusions.
Can help attract public interest by providing a summary figure with which to compare the performance across countries and their progress over time.	The construction of composite indicators involves stages where judgement has to be made: the selection of sub-indicators, choice of model, weighting indicators and treatment of missing values, etc.
Could help to reduce the size of a list of indicators or to include more information within the existing size limit.	The selection of indicators and weights could be the subject of political challenge.

Adapted from Saisana and Tarantola (2002) [24]

Another composite indicator that is used by IBNET is a Water Utility Vulnerability Index (WUVI), which is an aggregation of individual variables to provide an easily understood and communicable prediction of a water utility's future. The WUVI actually estimates the probability that a water utility will experience a performance problem as measured by its APGAR score in the future. Using the WUVI as an early warning device provides managers and policy makers an indication that further diagnostics are needed to determine the issues faced by a particular utility so that remedies can be put in place. It is worth noting that all these indicators (WUPI, WUVI and APGAR) ignore the inputs necessary to achieve the performance, thus they are only indices *what* critical aspects need further and deeper analysis. Therefore, these composite indicators only diagnose the performance, but do not provide tools *how* to address the weaknesses.

One issue when constructing WUPI is how to deal with missing data. Missing data would typically make calculation of a WUPI score impossible if one or several sub-indicators are missing. Anyhow, a study conducted by Danube Water Programme (2015) [9] showed that correlation between WUPI based on the full set and WUPI where one, two or three indicators are missing, is very high (above 0.90). Even in the case where 3 WUPI sub-

indicators were missing, only one out of 35 correlations showed correlation of 0.88, i.e. below the 0.90 threshold. These findings give confident that calculating WUPI based on only a subset of the indicators does not introduce significant bias. However, in this study all needed sub-indicators were available and there was no need to consider the effect of missing sub-indicators.

The WUPI used in this study utilizes the approach as used by Gallego-Ayala et al. (2014) [13] for calculating WUPI of water utilities in Mozambique. This approach fits better to the purpose of this study as it considers quality of services as a separate component into the composite WUPI index, while APGAR, as mentioned above, focuses on operational, financial, and social performance. Gallego-Ayala et al. (2014) [13] followed the theoretical frameworks developed by Alegre et al. (2006) [3], and Van der Berg and Danilenko (2011) [26] to obtain a coherent structure of the WUPI that reflects the main dimensions linked to the performance of water supply utilities. They used an expert group to debate and harmonize each of the main aspects involved in the construction of the WUPI. Both approaches are based on the water utility functions that should be implemented and provide a set of performance indicators. Alegre et al. (2006) [3] divided the functions of water utilities into 6 different categories, while Van der Berg and Danilenko (2011) [26] used 12 categories. Both suggested that selection of categories and indicators to measure performance should be based on their relevance to the particular water utilities' context. Therefore, it is not compulsory to implement the full spectrum of categories and indicators and these should be adapted to the local context. As utilities develop, some indicators become less relevant, others more relevant. For example, in many developed countries, service coverage is almost universal and, as such, the indicator on service coverage will likely be less important as a measure of performance.

The indicators used in this study are separated into 3 main components to assess performance, the same as used by Gallego-Ayala et al. (2014) [13]: (i) economic sustainability, (ii) operational sustainability, and (iii) quality of the services. In order to better fit the local context in Macedonia, one more indicator "collection period" was added to "economic sustainability" component; then, indicators for "network performance" sub-component were included into the "quality of the services" component instead of "consumer attendance". Thus, 12 key performance indicators were selected (Table 3).

T a b l e 3

12 key performance indicators used for WUPI construction [13]

Component	Sub-component	Performance indicator (measure unit)	Indicator polarity
Economic sustainability		Collection ratio (%)	+
		Collection period (days)	–
		Operating cost coverage (ratio)	+
Operational sustainability		Number of employees per 100 water connection (#/'000 connections)	–
		Non-revenue water (%)	–
Quality of service	Service to the consumers	Total water coverage (%)	+
		Total sewerage coverage (%)	+
		Percentage of sold water that is metered (%)	+
		Continuity of water service (hour/day)	+
	Water quality	Percentage of conformed samples analyzed (%)	+
	Network performance	Sewer system blockages (blockages/km/year)	–
		Pipe breaks (breaks/km/year)	–

+ more is better, – less is better

a) *Indicator normalization*

Indicator normalization transforms the set of base indicators expressed in different units of measurement into a homogeneous set of variables expressed in the same unit, which can then be used for comparisons and arithmetic operations. For this study, the max–min technique is used, as this is one of the most common normalization procedures used for the construction of composite indicators. It uses the minimum and maximum values of a given sample (in our case, the selected base indicators for the 12 water supply utilities considered) to rescale the base indicators; the base indicators are then

measured on a scale that ranges from 0 (the worst possible performance) to 1 (the best possible performance). The minimum and maximum threshold values for each base indicator were determined from actual indicators' values.

The mathematical calculation of the max–min technique is done depending on whether the indicator has a positive (more is better, formula (1)) or negative (less is better, formula (2)) polarity, as presented in Table 3.

$$I_k = \frac{x_k - \min(x_k)}{\max(x_k) - \min(x_k)} \quad \text{"more is better"} \quad (1)$$

$$I_k = \frac{\max(x_k) - x_k}{\max(x_k) - \min(x_k)} \quad \text{"less is better"} \quad (2)$$

where:

I_k refers to the normalized value of the indicator k,

x_k is the value of indicator k without being normalized,

$\max(x_k)$ is the maximum value of k without being normalized,

$\min(x_k)$ is the minimum value of k before the normalization

b) *Indicator weighting*

The indicator weighting step aims to identify the relative importance of the base indicators selected to build the WUPI. *Positive approaches* use statistical techniques to identify the weights of the base indicators, using the information provided by the performance indicators sample. *Normative approaches* use participatory methods that integrate expert opinions to obtain the relative importance of the base indicators. Given that the aim is to establish specific weights relevant to the local context, the normative approach was used in this study through the opinions of technical experts of water utilities in a session organized by ADKOM. As the weights obtained may vary depending on the technique used to identify the importance of each indicator, and can thus affect the results and conclusions derived from WUPI, two different weighting systems were applied. Firstly, the Analytic Hierarchy Process (AHP) as a normative technique was used. The AHP is a multi-criteria decision-making tool developed by Saaty (1980) [23] to obtain the relative importance of the criteria under analysis (in our case, the performance indicators) based on expert opinions using a pair-wise comparison system. Secondly, an equal weighting (EW) system, which according to (OECD-JRC, 2008) [20] is the most common approach used to weight composite indicators. This approach assumes that all of the base indicators have equal weights, i.e. the same relative importance. In the water sector, the EW approach has been applied to construct composite indicators by Sullivan (2002) [25] and Garriga and Perez-Foguet (2010) [14], among others.

The weights used to construct the WUPI through the AHP and EW approaches are given in Table 4.

T a b l e 4

Weights of the base key performance indicators [23]

Performance indicator (measure unit)	Weights AHP (%)	Weights EW (%)
Collection ratio (%)	12.3	8.33
Collection period (days)	5.1	8.33
Operating cost coverage (ratio)	14.7	8.33
Number of employees per 100 water connection (#/'000 connections)	4.4	8.33
Non-revenue water (%)	20.1	8.33
Total water coverage (%)	3.2	8.33
Total sewerage coverage (%)	8.6	8.33
Percentage of sold water that is metered (%)	2.1	8.33
Continuity of water service (hour/day)	1.9	8.33
Percentage of conformed samples analyzed (%)	14.3	8.33
Sewer system blockages (blockages/km/year)	4.8	8.33
Pipe breaks (breaks/km/year)	8.5	8.33

c) *Aggregation of the indicators*

The next and final step in calculating WUPI is aggregation of all of the normalized indicators into a single index. As for previous steps, there is a wide variety of methods available. According to Marques et al. (2011) [18], the selection of the functional forms for aggregation is one of the most controversial aspects of the construction of composite indicators, because, depending on the algebraic alternative, different degrees of compensation among the indicators is assumed. Thus, the results and conclusions derived from the composite indicator could be affected by the aggregation method selected during the construction of the composite indicator (Gomez-Limon and Riesgo, 2009) [15]. In spite of this limitation, and with the aim of obtaining more consistent results and conclusions, the indicators were aggregated using two different aggregation forms to allow various compensation degrees among the indicators as presented below.

Alternative 1*:*
Weighted sum of indicators

The weighted sum of indicators is a representative functional form of additive mathematical formulations, which assumes total compensation among the indicators. This linear aggregation of the indicators is calculated using formula (3).

$$\mathrm{WUPI}_{\mathrm{additive}} = \sum_{k=1}^{k=12} w_k \cdot I_{k,i}\,, \qquad (3)$$

where:

i refers to the specific water utility,
w_k is the relative importance of indicator k,
$I_{k,i}$ is the normalized value of the indicator k for water utility i.

Alternative 2*:*
Hybrid aggregation of the indicators

The application of hybrid aggregation rules implies the integration of different aggregation forms for the construction of the composite indicator. In this study the WUPI is constructed by integrating additive and multiplicative functions at 2 different levels of aggregation. In the first step, an additive aggregation function to aggregate the indicators within the three components (economic sustainability, operational sustainability, and quality of the services) was constructed that compose the structure of the WUPI. Thus three independent composite indicators are obtained that measure the performance of the water utility within each of the WUPI components using the mathematical expression (4).

$$\begin{aligned}
\mathrm{WUPI}_{\mathrm{eco,I}} &= \left(\sum_{k=1}^{k=3} w_k \cdot I_{k,i}\right)/\left(\sum_{k=1}^{k=3} w_k\right) \\
\mathrm{WUPI}_{\mathrm{eco,I}} &= \left(\sum_{k=4}^{k=5} w_k \cdot I_{k,i}\right)/\left(\sum_{k=4}^{k=5} w_k\right) \qquad (4) \\
\mathrm{WUPI}_{\mathrm{eco,I}} &= \left(\sum_{k=6}^{k=12} w_k \cdot I_{k,i}\right)/\left(\sum_{k=6}^{k=12} w_k\right)
\end{aligned}$$

For the second step, a multiplicative aggregation function is used to combine the three components obtained in the previous step to obtain the single WUPI through the formula (5).

$$\mathrm{WUPI}_{\mathrm{hybrid}} = \prod_{j=1}^{j=3} (\mathrm{WUPI}_{\mathrm{j,i}})/\hat{}\, w_j\,, \qquad (5)$$

where:

j refers to each of the components used to construct the WUPI,
w_j is the weight of component j.

4. RESULTS AND DISCUSSIONS

The data needed to calculate the set of base indicators that form the WUPI were obtained from IB-Net database and ADKOM has provided information on some missing indicators that were not publicly available. Gallego-Ayala et al. (2014) [13] suggested that, before analyzing the results obtained for the WUPIs at the water supply utility level, it is important to summarize the basic descriptive statistics for the different composite indicators calculated as presented in Table 5.

Comparison of the mean values obtained for WUPIs reveal that the performance in 2014 are improved comparing with 2103 with slight decrease in 2015 and improvement again in 2016. Because, there are different factors affecting the final results of the composite WUPI index obtained, i.e. the two weighting technique (EW and AHP) and the two aggregation procedure selected (additive and hybrid), the WUPIs were calculated in four different ways. Therefore, it is important to check whether, regardless of the techniques selected to build the WUPI, the outputs obtained are not in conflict with each other.

Pearson's correlation (Tables 6 and 7) was used to check the consistency of the WUPIs, and two main conclusions revealed are that:

1. WUPIs indicated a positive and significant correlation among all of the WUPIs calculated. Therefore, from a statistical point of view, there are no significant differences between the WUPIs obtained using different heightening and aggregation techniques.

2. Correlation indices are much higher when comparing the WUPIs obtained using AHP weighting system regardless the aggregation rules applied. Therefore, the study affirms that the construction of the WUPI is influenced more by the weighting system used then by the selected functional form of aggregation.

Table 5

Descriptive statistics of WUPIs, 2013 – 2016 [31]

Composite indicator	Min	Max	Mean	St. deviation	Variance	Kurtosis
2013						
WUPI $_{additive\_EW}$	0.470	0.795	0.659	0.104	0.011	-0.387
WUPI $_{hybrid\_EW}$	0.080	0.796	0.555	0.191	0.037	2.694
WUPI $_{additive\_AHP}$	0.415	0.759	0.614	0.110	0.012	-0.784
WUPI $_{hybrid\_AHP}$	0.096	0.706	0.548	0.179	0.032	2.930
2014						
WUPI $_{additive\_EW}$	0.450	0.815	0.678	0.114	0.013	0.221
WUPI $_{hybrid\_EW}$	0.377	0.771	0.602	0.127	0.016	-0.399
WUPI $_{additive\_AHP}$	0.363	0.826	0.625	0.138	0.019	-0.115
WUPI $_{hybrid\_AHP}$	0.320	0.820	0.579	0.156	0.024	-0.683
2015						
WUPI $_{additive\_EW}$	0.484	0.796	0.620	0.097	0.009	-0.957
WUPI $_{hybrid\_EW}$	0.455	0.761	0.573	0.099	0.010	-0.776
WUPI $_{additive\_AHP}$	0.421	0.730	0.580	0.101	0.010	-0.570
WUPI $_{hybrid\_AHP}$	0.375	0.721	0.551	0.114	0.013	-0.709
2016						
WUPI $_{additive\_EW}$	0.524	0.816	0.659	0.099	0.010	-1.113
WUPI $_{hybrid\_EW}$	0.481	0.787	0.619	0.102	0.010	-0.718
WUPI $_{additive\_AHP}$	0.469	0.763	0.635	0.104	0.011	-0.727
WUPI $_{hybrid\_AHP}$	0.412	0.756	0.611	0.119	0.014	-0.782

Table 6

Pearson correlation coefficients for WUPIs (2013 and 2014) [31]

	WUPI $_{additive\_EW}$	WUPI $_{hybrid\_EW}$	WUPI $_{additive\_AHP}$	WUPI $_{hybrid\_AHP}$
WUPI $_{additive\_EW}$		0.788	0.903	0.734
WUPI $_{hybrid\_EW}$	0.931		0.780	0.955
WUPI $_{additive\_AHP}$	0.930	0.864		**0.849**
WUPI $_{hybrid\_AHP}$	0.877	0.890	**0.961**	

White cells refer to 2013, grey to 2014

Table 7

Pearson correlation coefficients for WUPIs (2015 and 2016) [31]

	WUPI $_{additive\_EW}$	WUPI $_{hybrid\_EW}$	WUPI $_{additive\_AHP}$	WUPI $_{hybrid\_AHP}$
WUPI $_{additive\_EW}$		0.897	0.857	0.820
WUPI $_{hybrid\_EW}$	0.931		0.800	0.832
WUPI $_{additive\_AHP}$	0.826	0.815		**0.985**
WUPI $_{hybrid\_AHP}$	0.812	0.831	**0.994**	

White cells refer to 2015, grey to 2016

As it can be seen from Table 8, at the beginning of the analyzed period, the poorest performances are non-revenue water, the operating costs coverage, the number of employees and the fee collection period. These actually represent the biggest challenges of the sector in the Republic of Macedonia. It can be noticed that two of the four worst performances show a slight improvement trend (number of employees and non-revenue water), the collection period shows a trend of more significant improvement, while operating costs coverage does not have a linear trend and the results in 2016 are weaker than those in 2013 which suggests that the biggest challenge for the sector remains the coverage of operating costs. On the other hand, the continuity of services and water quality (product quality) maintain constant high values. This means that these two indicators constantly contribute to higher values of the WUPI index, and given that the values of these indicators are constant and high in all the analyzed companies, one can conclude that these two performance indicators are irrelevant in case continuous improvement strategies are to be introduced. Interesting are the results of the trend of the indicators on water supply and sewage service coverage, which at the first glance are surprisingly, as both show a downward trend in the analyzed period. This is due to the fact that in this period, communal enterprises were legally obliged to undertake under their jurisdiction the remote and isolated, mostly rural, systems for water supply and sewage, which previously were not under the competence of utility companies. As this increases the territorial scope of the competence of companies, and the coverage of services is lower in the rural areas, results to lower values of these indicators. However, this provides a more realistic picture of the sector and suggests that these two indicators should still be taken into account under the quality component of the WUPI index and when introducing strategies for continuous improvement.

The trends of the other three indicators that are interesting for analysis are the percentage of sold water being measured, the number of sewerage system blockages and the water supply system defects (pipe breaks). Namely, during the analyzed period, two indicators (the percentage of sold water that was measured and the number of sewage system blockages) show decreased performance. In the case of the number of sewage system blockages, most likely it points to the insufficient maintenance of the sewage systems, and in particular to the need to separate the sewage systems for communal waste water and the systems for collecting atmospheric waters. An increased quantity of water delivered that has not been measured can, in turn, be an indicator of an increasing number of non-functional water meters. It is therefore necessary to regularly calibrate the water meters and replace the defective water meters with a new and more modern ones, for example, with remote reading capabilities. This indicator may also be a clue of stealing water, that is, the illegal connections or unregistered consumers in the system. However, since this phenomenon is covered by the non-return water indicator, which in turn shows a trend of improvement, it can be concluded that the correctness of the water meters remains the key factor for the reduced amount of water measured.

T a b l e 8

Mean average values of KPIS for the period 2013 – 2016 [31]

	2013	**2014**	**2015**	**2016**
Collection ratio (%)	0.775	0.749	0.787	0.788
Collection period (days)	0.474	0.561	0.614	0.692
Operating cost coverage (ratio)	0.396	0.462	0.209	0.338
Number of employees per 100 water connection (#/'000 connections)	0.445	0.482	0.497	0.515
Non-revenue water (%)	0.383	0.411	0.470	0.537
Total water coverage (%)	0.772	0.780	0.697	0.697
Total sewerage coverage (%)	0.737	0.724	0.585	0.579
Percentage of sold water that is metered (%)	0.659	0.798	0.555	0.505
Continuity of water service (hour/day)	0.917	0.917	0.917	0.917
Percentage of conformed samples analyzed (%)	0.856	0.824	0.832	0.846
Sewer system blockages (blockages/km/year)	0.802	0.781	0.665	0.692
Pipe breaks (breaks/km/year)	0.698	0.650	0.616	0.807

The indicator for the number of defects in the water supply system shows a non-permanent trend – a decrease in 2013 and 2014, and an improvement trend in 2015 and 2016. So, according to the obtained results from the analysis, these four indicators – non-revenue water, the percentage of water sold that is measured, number of sewage system blockages, and water supply pipe breaks – are all relevant indicators of performance and should be used in calculating the WUPI index.

Finally, the fee collection percentage shows a relatively stable high value during the analyzed period. However, in order to measure the economic viability of companies, this indicator alone is insufficient, since as mentioned above in the analysis, very long collection period affects the financial solvency of companies affecting company's cash flows, hence this key indicator should be considered in the construction of the WUPI index.

The mean values of the WUPI indices of the analyzed companies from 2013 to 2016 are given in Table 9.

As can be seen from the Table 9, only two companies – Skopje and Ohrid – show constant improvement trend in the analyzed period, Ohrid – a trend of slight improvement, and Skopje – a trend of rapid improvement. All other companies show inconsistency in the trend, which is characterized by decreasing or increasing performances from year to year. The case of Vinica is to be noticed, which shows a trend of improvement in 2014 (and completes the year with the best performances from all the companies analyzed), but in 2015 shows a trend of a sharp decrease in performance which in the end of 2016 results with the third weakest performance after Gostivar and Kičevo.

According to the WUPIs' results, it could be said that the performance level of water utility companies is heterogeneous. However, it should be noted that the WUPI calculations are very consistent. WUPI indices, on average and in the analyzed period, either all increase or decrease for each company individually. This is another confirmation that any option for normalization and aggregation can give a satisfactory assessment of the performance of companies.

Analyzed companies can generally be divided into four groups:

- Communal companies with stable good performance. The companies from Bitola, Veles and Gevgelija can be included in this group. The average value of the WUPI index for this group in 2016 is 0.73.

Table 9

Mean values of WUPI indices of the analyzed companies from 2013 to 2016 [31]

	2013	**2014**	**2015**	**2016**
Veles	0.706	0.790	0.694	0.673
Gostivar	0.459	0.383	0.447	0.476
Kavadarci	0.618	0.606	0.643	0.661
Bitola	0.727	0.701	0.747	0.781
Kičevo	0.306	0.540	0.457	0.482
Kočani	0.687	0.662	0.590	0.626
Kriva Palanka	0.674	0.674	0.562	0.618
Ohrid	0.551	0.548	0.580	0.630
Negotino	0.630	0.638	0.529	0.648
Skopje	0.396	0.424	0.627	0.737
Vinica	0.663	0.798	0.448	0.501
Gevgelija	0.712	0.689	0.649	0.739

$$\text{Mean} = \frac{WUPI_{aditive\_FW} + WUPI_{hybrid\_EW} + WUPI_{additive\_AHP} + WUPI_{hybrid\_AHP}}{4}$$

- Utility companies with stable medium performance. In this group are the companies from Kočani, Kriva Palanka, Kavadarci and Negotino. The average value of the WUPI index for this group in 2016 is 0.64.
- Utility companies with constantly poor performance – Gostivar, Kičevo and Ohrid. The average value of the WUPI index for this group in 2016 is 0.52.
- Utility companies with unbalanced performance. These include Vinica and Skopje. Namely, as can be seen from the tables, Skopje shows the weakest performance in 2013 and the second weakest result in 2014, but shows a trend of constant improvement reaching the sixth position in 2015 and the third in 2016. Unlike Skopje, Vinica shows a lot of inconsistency, and ranks the first in 2014, finishing the 10th in 2016.

The findings arising from the WUPI index calculations mostly coincide with the WUVI index of IBNET. For example, for 2016, the two best-ranked companies with the highest values of WUPI (Bitola and Gevgelija), at the same time have the smallest WUVI indices as calculated by IBNET. Similarly, the companies with the lowest performance (Kičevo and Gostivar) have the highest values of WUVI, which is why they are very likely to face serious problems in the future and their sustainability is at serious risk. Interestingly, in the third place, in both the best and the lowest ranked companies, in 2016, are the two utility companies with unbalanced performance, Skopje in the top three best ranked, and Vinica the third worst ranked (Table 10). Even more interesting is the fact that contrary to the findings of the WUPI index, the WUVI index shows high value for Skopje (potential sustainability problems), and low value for Vinica (potentially sustainable company). This is probably due to the historical results of these two companies, i.e. Vinica as a company with historically good performance, and Skopje as a company with historically poor performance. This indicates that the publicly available data does not always reflect the actual situation in the companies or the publicly available data are not updated in a timely manner.

T a b l e 10

The three best and worst performers in 2016 [31]

Rank		WUPI	WUFI (%)
1	Bitola	0.781	22
2	Gevgelija	0.739	42
3	Skopje	0.737	69
⋮	. . .		
10	Vinica	0.501	28
11	Kichevo	0.482	95
12	Gostivar	0.476	100

Similarly, it is important to analyze the performance level of each of the three components of the WUPI as calculated by using hybrid aggregation. The results obtained for this analysis are shown in Table 11 and Figure 1.

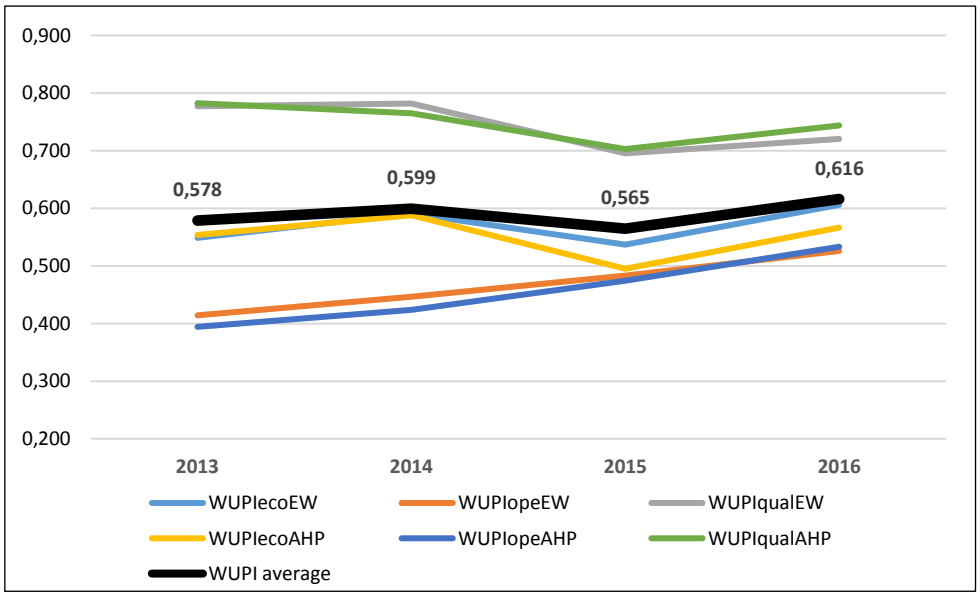

Fig. 1. Mean values of WUPI components [31]

T a b l e 11

Values of WUPI components [31]

		EW			AHP		
		$WUPI_{eco}$	$WUPI_{ope}$	$WUPI_{qual}$	$WUPI_{eco}$	$WUPI_{ope}$	$WUPI_{qual}$
Veles	2013	0.587	0.434	0.906	0.581	0.524	0.937
	2014	0.605	0.694	0.909	0.607	0.890	0.930
	2015	0.655	0.525	0.730	0.569	0.829	0.793
	2016	0.691	0.402	0.735	0.616	0.617	0.818
Gostivar	2013	0.255	0.482	0.607	0.316	0.358	0.634
	2014	0.250	0.420	0.544	0.232	0.180	0.563
	2015	0.333	0.500	0.563	0.458	0.180	0.562
	2016	0.333	0.474	0.635	0.458	0.170	0.653
Kavadarci	2013	0.812	0.294	0.706	0.843	0.294	0.658
	2014	0.676	0.333	0.748	0.663	0.342	0.690
	2015	0.588	0.379	0.819	0.537	0.456	0.841
	2016	0.649	0.394	0.810	0.613	0.471	0.807
Bitola	2013	0.787	0.809	0.795	0.707	0.687	0.608
	2014	0.651	0.888	0.806	0.529	0.816	0.602
	2015	0.722	0.640	0.872	0.618	0.596	0.869
	2016	0.747	0.684	0.884	0.654	0.690	0.885
Kičevo	2013	0.280	0.000	0.853	0.324	0.000	0.868
	2014	0.643	0.226	0.766	0.618	0.081	0.787
	2015	0.431	0.286	0.656	0.361	0.133	0.691
	2016	0.460	0.316	0.666	0.367	0.185	0.706
Kočani	2013	0.691	0.372	0.931	0.674	0.251	0.938
	2014	0.776	0.217	0.927	0.796	0.160	0.916
	2015	0.525	0.320	0.808	0.473	0.283	0.870
	2016	0.563	0.389	0.806	0.504	0.355	0.893
Kriva Palanka	2013	0.683	0.760	0.664	0.619	0.641	0.702
	2014	0.686	0.782	0.650	0.659	0.715	0.635
	2015	0.535	0.717	0.481	0.517	0.753	0.541
	2016	0.615	0.860	0.486	0.580	0.950	0.543
Ohrid	2013	0.358	0.443	0.806	0.395	0.260	0.820
	2014	0.376	0.441	0.809	0.404	0.264	0.768
	2015	0.399	0.325	0.868	0.373	0.346	0.897
	2016	0.477	0.393	0.871	0.427	0.428	0.918
Negotino	2013	0.622	0.294	0.776	0.608	0.357	0.885
	2014	0.810	0.244	0.734	0.850	0.282	0.777
	2015	0.597	0.180	0.628	0.629	0.296	0.688
	2016	0.768	0.285	0.652	0.837	0.468	0.760
Skopje	2013	0.200	0.227	0.655	0.247	0.187	0.667
	2014	0.221	0.268	0.679	0.255	0.232	0.691
	2015	0.569	0.654	0.741	0.477	0.464	0.745
	2016	0.692	0.735	0.853	0.611	0.565	0.838
Vinica	2013	0.516	0.530	0.801	0.431	0.831	0.782
	2014	0.834	0.403	0.925	0.848	0.662	0.902
	2015	0.483	0.558	0.463	0.379	0.689	0.300
	2016	0.572	0.597	0.482	0.480	0.731	0.344
Gevgelija	2013	0.793	0.323	0.826	0.901	0.341	0.890
	2014	0.562	0.443	0.884	0.595	0.465	0.918
	2015	0.606	0.712	0.715	0.549	0.668	0.636
	2016	0.703	0.783	0.763	0.655	0.769	0.762
Average 2013		6.58	4.97	9.33	6.65	4.73	9.39
Average 2014		7.09	5.36	9.38	7.05	5.09	9.18
Average 2015		6.44	5.80	8.34	5.94	5.69	8.43
Average 2016		7.27	6.31	8.64	6.80	6.40	8.93
WUPI 2013 6.94		**WUPI 2014 7.19**		**WUPI 2015 6.77**		**WUPI 2016 7.39**	

Figure 1 shows that the composite WUPI index in the analyzed period increased from 0.578 to 0.616, representing a relative increase of about 6.5% over a period of four years. Furthermore, all three components exhibit equal tendencies regardless of the method used to normalize the key baseline indicators, but the results, although closely related, still differ. This means that, in addition to the influence of the selected method for determining the weight values, the method of aggregation has also an impact on the results of the WUPI index.

Component performance analysis shows that operational sustainability (WUPIope) has the lowest value over the whole period, but there is a continuous improvement trend – from 0.4 in 2013 to over 0.5 in 2016. The other two components that reflect the performance of economic sustainability and service quality do not show a continuous trend, but it is noted that the two components have common growth or decline trends regardless of the chosen method of normalization. For example, the two components have a downward trend from 2014 to 2015, and an upward trend from 2015 to 2016. The values of the quality component show the best performance throughout the analyzed period, but on the other hand, it is the only component that shows a reduction of the performance in absolute terms, i.e. a decrease of 9.33 in 2013 to 8.64 in 2016 (according to the EW method) and from 9.39 in 2013 to 8.93 in 2016 (according to the AHP method), see Table 11.

The findings of this research are in line with the World Bank (2015) report and confirmed that operational and economic efficiency requires urgent and immediate interventions. The general conclusion is that companies should focus on solving problems with non-revenue water, operating costs coverage, overstaffing and the long fee collection periods. Otherwise, the medium and long-term sustainability of utility companies and their ability to provide continuous and high-quality services is questioned.

5. CONCLUSIONS

The composite WUPI allowed to measure the performance of water supply utilities in Macedonia in a more integrated and comprehensive manner than could be obtained through a comparison of separate single indicators. The study presents four different ways to construct a composite WUPI as a measurement tool for assessing performance of water utilities. The WUPI composite index should obtain more consistent results and conclusions compared with the results obtained using a single methodological method of different KPIs. The study affirms that the construction of the WUPI is influenced more by the weighting system used then by the selected functional form of aggregation. Also, the findings are in line with Gallego-Ayala et al. (2014) [13] that *"the most suitable way to construct the WUPI for real-life applications seems to be by using the AHP and hybrid form as weighting and aggregation techniques"*, due to the fact that AHP allows for identification of importance of each KPI in a local context, while the hybrid aggregation does not allow for full compensation between different components, as in case of additive technique.

Based on the result obtained using a composite WUPI, the conclusion is that the performance of water utilities in Macedonia has evolved positively from 2013 to 2016. The WUPI values among the 12 water supply utilities are heterogeneous, however, the results suggest that the water supply utilities, even those with high WUPI values, are not sustainable from operational point of view. Contrary, the service quality measured from the internal metrics of utilities shows higher level of performance than economic and much higher than operational performance. These findings are also in line with World Bank (2015) [28] report which results showed that both technical (operational) and financial (economic) efficiency need urgent, immediate action, mainly in the urgent reconstruction and rehabilitation of water supply and sewer networks. Otherwise, if the observed trend persists over time, this finding raises some doubts regarding the medium – to long-term self-sustainability of water supply utilities and their availability to continue delivering reliable and good-quality services and to maintain operational water systems. Clearly, in order to improve overall performance and to sustain the service quality in the future, focus is to be given on non-revenue water, overstaffing, operational cost coverage and fee collection period.

Findings of the study could be useful for water supply utility managers and decision-makers to opt for improvement measures in order to improve efficiency and service quality. National water regulator could use the presented approach for designing a composite WUPI and adapt it as needed for easy monitoring of, and accountability for, the performance of water supply utilities over time. Actually, the regulator could establish certain WUPI levels that should be achieved by each water supply utility over time. Achievement of the pre-set performance level, for example, could be further used as a criteria for funds allocation from the central budget to incentivize performance improvement.

There are also some limitations. First, not all water utilities in the country were involved thus generalizing findings for the whole country should be cautiously taken. Second, as mentioned earlier, the study does not consider inputs that contribute to particular indicator, and finally, the externalities that might influence the indicators in a particular context (for example, the GDP of GINI in different country's regions) were also not considered. Thus, further research in this direction might be useful to provide for a clearer picture on performance of water services in Republic of Macedonia.

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CREATION OF THE SYSTEM FOR PERFORMANCE MANAGEMENT AND IMPROVING OF THE QUALITY SERVICES FOR CUSTOMER SATISFACTION

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A b s t r a c t: Quality on the service is the basic characteristic for every product or service that is used. It is characteristic that every organization use it as major advantage to be different from the competition and give to the clients much more from the service they use and everything with goal to get more market share. The development on the quality on the service gets its upper level with the communication brake trough everywhere in the world so now every company can hear the needs from the customers. There is also many more companies that give only service for every type of product or after sales service. In the organization it is commitment that they will achieve the expectation for the customers and the market and that commitment is changing from the past until now. When it comes word for quality of the service it is very dependable on the human reason in every organization, their employees and clients. Motivated human reason gives much more for the quality of the service than unmotivated employees, so if the company wants to have team that will give quality on the service that will have upgrade all the time it must be with motivated employees, basicly it means when someone will say proudly that he is from that company. The company goal for every organization is to do the quality of the service that the market ask for and to try to upgrade its demands. That road can be very difficult but with help from the system and performance measurement they can do that. The goal on this study is to show the worth of the company from system for performance measurement for the employees and the business goals for the organization. In the study it is shown the part for building a strong basic for delivering and creation of system for performance measurement that will give constant quality on the service, with upgrade on the time with the performance measurement system and direction for it. The quality of the service is something that can make the companies different from the competition and that is the reason for the companies to give effort for much more all the time for their products or service. With excellent system for performance measurement they can give all that and give satisfaction for their customer with continuous upgrade.

Key words: quality; service; system; performance; management; organization; relationship; relation; motivate

СОЗДАВАЊЕ СИСТЕМ НА УПРАВУВАЊЕ СО ПЕРФОРМАНСИТЕ И ПОДОБРУВАЊЕ НА КВАЛИТЕТОТ НА УСЛУГИТЕ ЗА ЗАДОВОЛСТВО НА КОРИСНИЦИТЕ

А п с т р а к т: Квалитетот на услугите е основна карактеристика на секој производ или услуга која се користи. Развојот на квалитетот на услугите добива високо ниво со развојот на глобализацијата и информациската технологија преку која компаниите сè повеќе ги слушаат барањата на купувачите и се фокусирани на нив. Сè повеќе се јавуваат и компании на кои главна дејност е услугата или постпродажната услуга за одредени производи или концепти. Секоја организација се обврзува дека ќе ги исполни сите очекувања на купувачите. Таквата обврска со текот на времето од минатото па до денес се менува. Кога станува збор за квалитетот на услугата, тоа многу зависи од самиот човечки фактор, т.е вработените во организацијата. Мотивирани вработени е многу

поразлично од спротивното. Затоа, доколку организациите сакаат да имаат квалитетна услуга која постојано ќе се надоградува, мораат да имаат вработени кои со задоволство ќе кажат дека се дел од една организација. Целта на организациите е да имаат систем кој ќе овозможи вработените да им ја дадат бараната услуга на клиентите и дури да ги надминат нивните очекувања за нејзин квалитет. Патот за постигнување може да биде многу тежок, но со помош на системски пристап на целата организација преку мерењето на перформансите на вработените и на организациските цели тоа може да се постигне. Целта на овој труд е да ги покаже вредноста на системот на перформансите на организацијата и влијанието на квалитетот на услугата. Наведени се сите клучни критериуми кои мора да бидат запазени, почнувајќи од основниот квалитет на услугата до креирањето добри односи со купувачите. Преку креирањето на систем за мерење на перформансите на организацијата се добива главен показател за тоа каде организациите имаат лоши перформанси, а можат да бидат подобри и каде се добри, а можат да бидат уште подобри, сè со цел кон постојано подобрување.

Клучни зборови: квалитет; услуга; систем; перформанси; менаџмент; организација; однос; релација; мотивација

1. INTRODUCTION

Quality of the service that one company gives to the clients is the basic for the customer relationship trough the years that come. The subject is very big and endless and it is in every segment of human existing and is in every company. Every organization is looking to offer to their clients and customer a lot of improvements for the quality and the service that they have and get for the products and service depends from the business channel of the company. With the rapid development of technology for telecommunication upgrade the competition on the market is bigger than the earlier years. What was ten years ago market key reason for success, now is very different and it depends on the service and after sales of the product or service that customer and clients get. Quality and service are what today and in the future will give the main differences between companies.

The positive and very strong relation with clients and suppliers in the chain for distribution for all kind of customers' needs is one of the basic characteristics for total quality management. Build the relation that will be a friendship and partnership in the future for the clients and suppliers and gives satisfaction for clients in the chain of distribution. The main goal is to give to the clients and their needs in the modern world and so round environment. The companies in the world must deserve and earn the recommendation trough constant offer for limitless service to the clients. The organizations that in surround environment and technology acchive to go with local trends will secure to give the clients and customers product and service according their perception for good service and much beyong that. The managers that take and effective get human skills to use them in the primary business function with main goal to got and motivated employee with customers that are repeating, have what is crucial for competitive advantage in 21 centure [2]. Start for the business relation for the organization and customer it is with the customer relation with their employees and customers. Trough the years the thing to be checked for every business is service and after sales process. Basic for every company for quality of the service process are their employees.

Building the spirit of the organization is a ledears responsibility and should be included in all the organizational departments and every employee. The spirit of the company is also a picture about the service that the company gives to their clients and customers. But performance on the employees can be better or stay at the same level or worse. For the performance to be better the organizations must first adjust the strategy and give tools for improvement. It is very important for success to know the capacity on the workers and to use their potential and motivate them because they have the relations with company's client. The basic on every organization for products or service is good customer relationship management.

This system it is two in one strategy and tool for getting the job done on the perfect way. It is a fully approach that gives and seek creation, maintains and expand clients with continous improvement.

Performance management system for organization is the key for motivation of employees and including them and their influence in the quality of the service and customer satisfactions.

The system is backup and basic for taking control for the customer relationship system and system for quality that organization provide for the customers. With proper use of the data from the system the company management can get real picture about the

process and how to complete the mission and vision that top management gives and providing improvement on the processes in the company or out from it.

2. STATE-OF-THE-ART OF LITERATURE REVIEW

In the paper are used literature data from authors that give their opinion and review about quality service and quality management, management for customer relationship and the human reason in the quality with the impact that system for performance management has on quality. There are difference between quality on the product and quality on the service. Analysis based on the human decision for value judgment and definition for different aspects for quality on the service and main attribute for the customers [1]. In the text from authors [2, 3] are analyse and different researches how the needs for perception about what customers like in the quality on the service. The values for customers are the perceptions that they have from the companies. There are three basic types on organization from the type of benefits and power and structure with all changes in the functionality on the companies [4, 5, 6, 7, 8].

Very important for companies is customer relationship management because it is basic for creating the customers, what kind of profile there are and how different companies create their politics for quality with their customers [9, 10, 11]. The connection with the quality on the service with product or service is very important and how it impacts on the customers. The customer satisfaction is most important for customers. The measurement on the satisfaction has impact in the part for strategy on the company. Measurement on the satisfaction for itself has some steps that depend from companies' product or service. For all it is clear that to achieve good and very good measurement for customer satisfaction there are difficulty that companies must go beneath them [12, 13].

The human reason for start, the product and service with the quality that companies give for the customers create the management for relationship for clients and customers. Basic for every company and organization is to use and have system for performance management and to use it for improvement. The power and the size on the company it is not important if there are employees that aren't motivated or motivated but in the wrong direction according with performance. The goal for the company is in relation with the system for performance measurement. It is the system that must be used from every department in the company from top management to bottom employees. That direction is from the system for performance management and motivation for all human resources in the company. Very often, companies have system but it isn't used very much or the it's used in the wrong direction. System for performance management will give the right direction and will save cost and efficiency will be on improvement level [14, 15]. System for performance management demands labor and commitment, on the road for creation and use there is very big difficulty from the human reason or from the upper level for power in the companies and what all them must fight is their own ego and get thinking that every business evolves and to learn how to read markets demands and get direction to them. The steps for creating the system for performance management also get to difficulty from the employees how are resistance for changes and thinking that is a tool that managers will use against them. That way the management task is to explain to them that it is very important for every company to achieve to install the system in the all levels of the organization [15, 16, 17].

Systems for performance management must be in steps and there is very important to give good reversible information from the employees that are included in all process and just any other system, it is very important to get good information in the start to give good information at the end of the system. If that isn't correct the information on the end will be bad or it will not satisfate the demands that should be out from the system. The relation on the managers and employees must be very good for the implementation. Modeling the system for performance must include all the employees in the companies. From the model for motivation comes out that the companies must have small number of employees but well motivated than bigger number of employees but not motivated at all. System should be fair and justified for all the employees with no prejudeces or favorites of anyone in the companies [19, 20, 21]. In the text there are lot of analyses and literature about creation on system for performance management. There are steps that every system demands to be part from it and there is explanation about every step [22, 23]. Also there are a lot of analyses about system for performance management with customer satisfaction and quality service from the social media and internet [10, 26, 27, 28]. All that is explained with practical creation on system for performance management and how to use it for improvement on the quality service management [30].

3. CREATING PERFORMANCE MANAGEMENT SYSTEM

Creating and modeling on performance management system is the basic for every organization. With the system for performance management the organization can put all main indicators for business, mission and vison. On Figure 1 is shown the process with five ongoing steps that system demands for implementation [23].

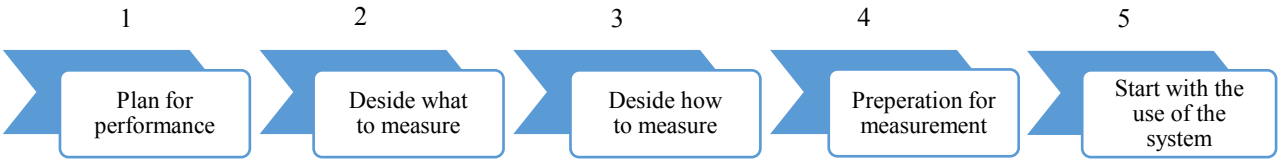

Fig. 1. Proces for creation of the system for performance management [23]

Before starting the creation of the system all employees must be part of the team for the first steps for basic of the system. There are three steps in this process [23]

3.1. *Step 1: Plan for perfromance*

In the first step target that have be achive [23]:

1. Form working groups for measurement on the performance on the organization. For start, with the process there must be working group that has team responsible and key representative from every deparment and sector.

2. Use and having personal file for measurement performance. Use of that file will build system on the old that company used to use.

The answer on the asked question will give start point for the system for performance management for the other steps. Before going to the second step there must be only a check for all parameters and data for the first step and they are applied or there should be getting back if there is demand for that.

3.2. *Step 2: Deside what to measure*

The goal in step 2 is to chooce indicators for the processes and companies' goals with mission on the organization. This step includes use of main list for indicators. According to this there must be use of the indicators which are main for the organization. Also in this step some indicators are used like a start point for some other indicators that will be measured in the system.

- **Understanding on the indicators.** The analysis and literature [23] for non-profit measurement and evaluation gives a lot of way of thinking for indicators. To be more simple the system must include three categories for indicators and they are shown on the Figure 2 [23].
- **Organizational basic indicators** are those which are basic capacity that companies have for the mission, included the going forward with financial stability trougth delivering the resources that provide the life for the companie in the few years. All incomes and outflow are included in analysis and profit, from fonds, or some ways. This indicator includes the human factor and the working department and their capacity.

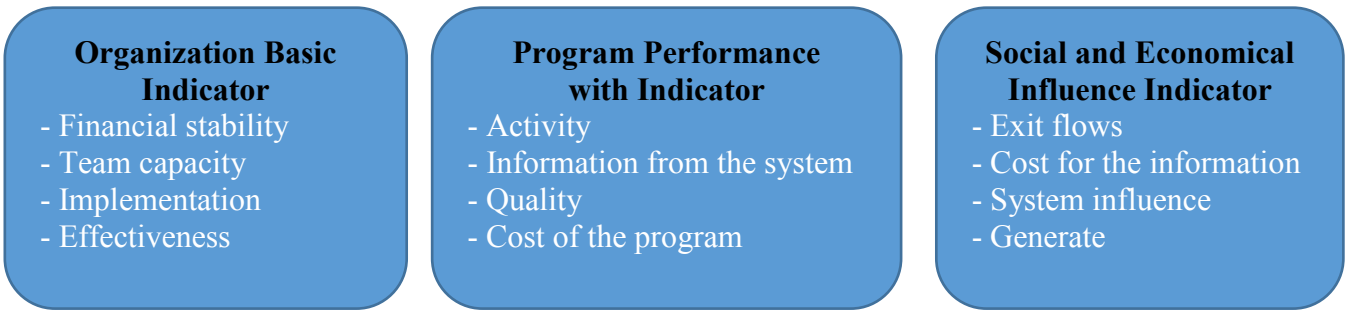

Fig. 2. Three main categories for indicators [23]

- **Program performance indicators** are indicators of the organization's activities and outputs, and the results and objectives of those activities. Depending on the nature of the organizations, program performance indicator can include individuals involved in their program, members of associations, individuals through their own efforts, or individuals who participate through a communication campaign.
- **Social and economically influential indicators**. These indicators make it possible to access public production information, that is the products or services provided by the organization. Social and economic indicators can also be measured through the cost of achieving the objectives. The influence and participation of the work can be measured through the organizational influence of other organizations in their work addressed to the required social problem. This type of influence is always difficult to anticipate, and maybe data will be needed for new qualitative systematic outputs and targets that will arise.

3.3. *Step 3: Deside how to measure*

Objective: Determining the method of data collection for each indicator, and selecting appropriate methods for storing data. Determine when each indicator is measured and who will be responsible for the indicators being measured. Once the indicators have been determined, a focus can be given to monitoring them. In this step will identify the measurement tools that will be used to collect data, it will be selected how the data will be stored and processes that will enable the organization to monitor the data on a regular basis after the performance measurement system has been established.

The organization collects much of the data required for the indicators. In this step, it will be possible to capture and use already existing methods of measurement and that [23]:

1. **Preparation of measurement tools.** It is necessary to have a direction towards the main list that was made at the end of the previous step and look at the column "Instant monitoring". For each indicator that has not been followed so far, it will be necessary to determine how to do it in the future. The tools and measurement processes that are selected will depend on the specific needs and areas in which the organization is located. Organizations focused on human services, for example, often use search and input to collect data about user acceptance processes in one or more programs.
2. **Research**. For any type of organization, research is a particularly valuable measurement tool that helps in determining the range of future entrants. They are particularly useful for social and economic impact indicators, which often can be challenging to track.
3. **Key to success in setting the indicators.** Sometimes a prospector will appear that is difficult to measure with some of the mentioned tools. When this happens, this indicator is not completely rejected. Instead, we need to find a way for an accurate estimate of how to improve in the future.
4. **Deciding where to store data.** While data-tracking methods are chosen, it is also important to store data in a centralized location that is easily accessible. Ideally, the processes for monitoring the indicators that have been created should be indicated directly to the data storage tools, so that they are entered as soon as they are received. As a result, the data will be input in real time, and they can be integrated into daily activities and the organization itself.

3.4. *Step 4: Preperation for measurement*

In this step, it is necessary to prepare preparation for data usage, which reflects a number of ways methods and tools for managing them. Good data management always leads to the creation of good reports that lead to good conditions. The first step is to create a managerial table and some additional tables at the program level that should be used. It is necessary to establish a team and schedule for revision of the managerial table and the additional tables in order to finalize the measurement and the responsibilities of the reports. This step is preparing the organization for using the collected data. It is necessary to create a report tool, a managerial table and possibly additional tables at the program level. Also, members of the teams who oversee the performance are regularly appointed with the establishment of a schedule. By the end of this step, team members assigned responsibilities for measurement indicators in the previous step should have the information needed to finalize the process and further allocate tasks if needed.

When the performance measurement system is already set up and active, the tables will become the primary tools for analyzing data and giving conclusions. The goal of each table is to provide an image

of the organization's progress on the road to success. The table includes a marked selection of indicators in the list of main indicators where for each indicator it imposes immediate results in relation to [23]:

- *Baseline, or initial measurement.* In some indicators, the baseline is defined immediately if data from previous months or years are available. If there are no data yet, it should wait until the measurement system has been established and active to collect data from the first measurement.
- *The result that is to be achieved in a defined period.* Goals should be based on the organization itself. Where possible, they should be compatible with existing standards in the area.

There are two main types of tables:

1. **Manager chart.** All performance measurement systems should include such a managerial level measurement tool that provides a view of a greater perspective on the organization's performance by selecting key indicators from the main list. The management of the organization should analyze the management chart regularly to ensure success at the level of the entire organization and fulfill the challenges for achieving the mission.
2. **Table on program level.** If the organization is large enough to be able to include more programs from different departments, it is recommended that you create an additional table at the program level, which monitors the performance of individual programs, initiatives, areas of operation, or departments at a more detailed level. It will only contain information relevant to managers and other key team members working in a particular area.

3.5. *Step 5: Start with the use of the system*

Putting the system for performance measure in use is the launch of the performance measurement system. It is necessary to upgrade the lines and goals and to adjust the performance measurement system. The previous steps lead to the development of the system. The final step is to discuss how to launch the system and how to make adjustments after the first few cycles are made.

The framework for the performance measurement system of the first part of the introduction gives and allows to see the tasks that an organization will perform on a daily basis, repeating the progress through the cycles of the organizational performance measurement system shown in Figure 3 [23]:

– *Measurement*. Certain members will collect the data for the indicators selected in step 2 through the processes and measurement tools developed in step 3.
– *Report.* Certain members will complete and send lists to all program levels developed in step 4 depending on which team.

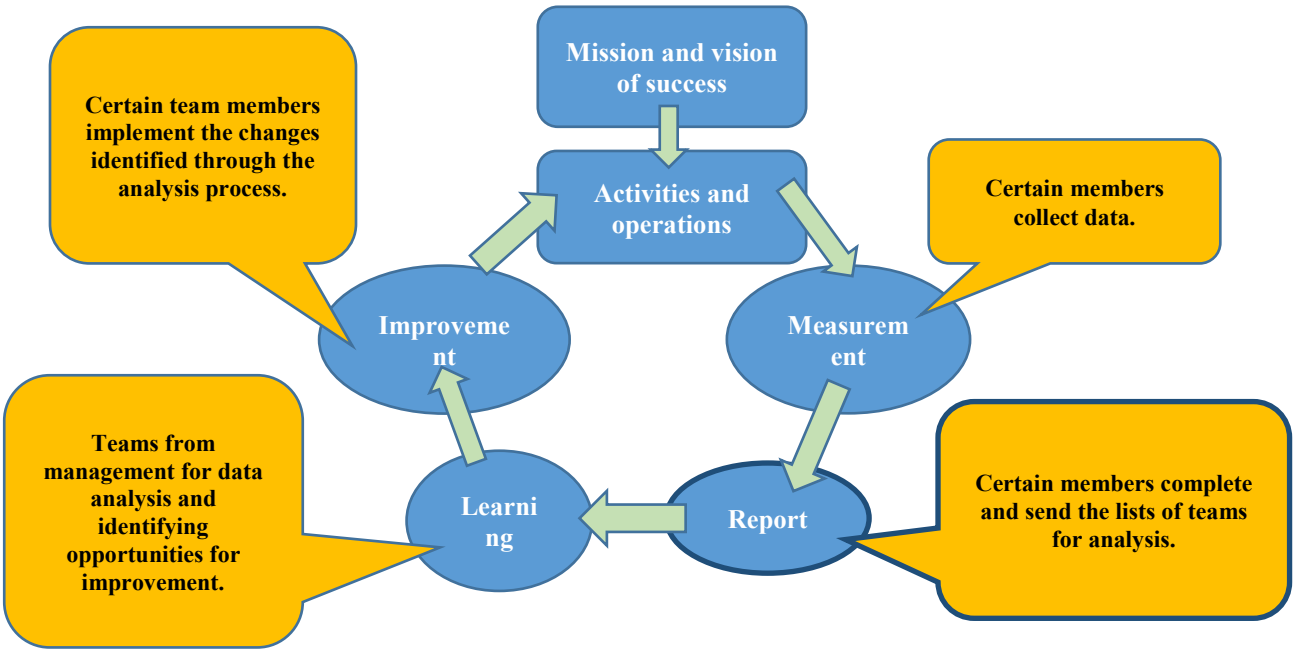

Fig. 3. Cyclus for a measure on performance [23]

– *Learning.* Following the data analysis, developed in step 4, management and program analysis teams are reviewing data.
– *Improvement.* Based on the data and conclusions from the reports, the analysis teams assign implementation responsibilities to improve organizational strategy, activities, and operations.

3.5.1. *Start the performance measurement system*

The first cycle for the performance measurement system is likely to have flaws that will be removed and complemented in the next cycles. The first cycle should be focused on what is happening [23]:

– Start measuring the indicators to be sent using the tools and processes that have been developed in step 3. If it is necessary to implement a variety of different tools and softwares, it is good to apply temporary data storage in tables.
– View and report using the main management list and program levels, in time according to the team's learning schedule.
– Collecting initial performance and review to begin with analysis and reporting, devoting partial analysis of the process and how it works.
– Making decisions relating to activities and operations based on the analysis.
– Improvement of the existing and development of new measuring instruments for the indicators and processes that are needed.

In the present, many organizations use competing models as the basis for their performance system. The competitive model includes knowledge, skill, abilities and other features that are required to achieve and achieve positive organizational results. The analysis of work techniques, such as surveillance, interviewing, focus groups, is used to identify key competences for critical work behavior. In Figure 4 [19] is given an example of an effective process for identifying competencies by a human resource manager in organizations.

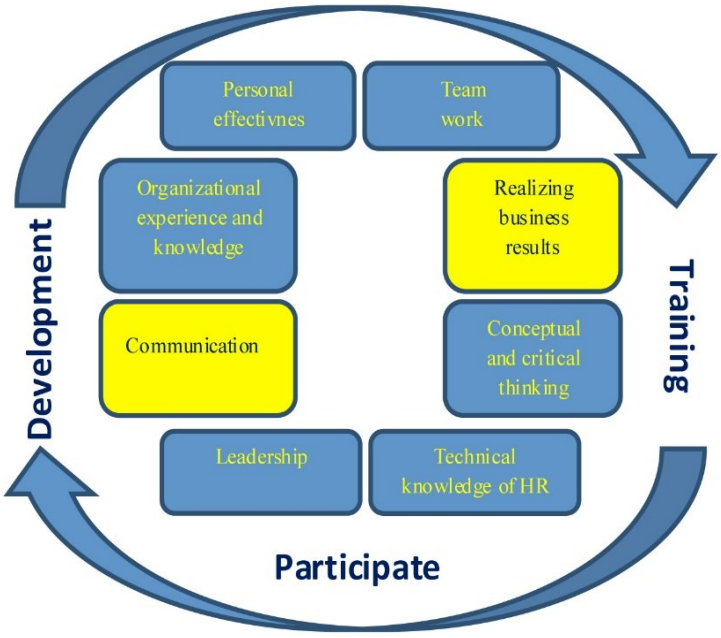

Fig. 4. Process for identifying competencies [19]

3.6. *Creating a matrix for business indicators for the particular model of the performance measurement system*

A matrix was created for the specific model for the system for measuring organizational performance [30]. The created matrix consists of business indicators as well as performance data for employeees. For the particular model, a relationship is given on the performance of the matrix and the impact and relation to the quality of the service the company provides to its clients. The matrix is created according to the previously given 5 steps.

Step 1: *Plan for performance measurement*

This step analyzes the organizational system and the way the company works. The current working structure and the system that uses it generates data that are further used to create the matrix. Taking into account this, several parameters are generated whose characteristics are used, and that is:

– Commercials use PDAs to handle orders.
– Commercials send a predetermined plan with a moving schedule.
– According to systematically registered orders, transportation for delivery of products is organized.
– All agreements for cooperation are registered systematically.
– Every movement of the devices on the ground is systematically conducted.

All these parameters together with the data from them help in creating the performance that is part of the matrix.

Step 2: *Deside what to measure*

In this step, indicators are defined through which the organization will evaluate and measure performance. Because it is an organizational structure that is aimed at achieving profit then the basic indicators that are the first set are the organizational healthy indicators. They are for the given model:

– Come on.
– Costs.
– Gross earnings.
– Net earnings.
– Current market demands.

These are the basic indicators without which the profitability of the company can not be achieved, and thus the existence of the company will be threatened.

The second type of indicators that are created are the performance indicators. These indicators are generated through the systematic data that the organization has in its previous work. They are the relationship of data and information to a given criterion. An example is that:

– Percentage of the effectiveness of visited missions according to the established plan with a schedule for movement. This is the ratio of a visit data report and a sales or cooperation agreement.
– Percentage of effective sales. This is the relation of the visited objects and the realization of the sales plan.
– Percentage of sales through a good relationship with customers. This relationship uses the market analysis for customer satisfaction through a survey and sales data for specific clients.

The second part of the program indicators has a major share in the measurement of employee performance, because all the required performance can be monitored with the proper use of data.

The third type of indicators that are being created are social and economic indicators. These indicators are created according to the data from the organization's operating system and other predefined market research and analyses for consumers. To create a particular model by looking at a working organization that is in direct contact with customers and consumers, the following data type is used:

- Average number of sold potions.
- Average number of sold potions through appliances (coffee machines).
- Percentage of sold potions sold according to predetermined sales averages.

Important for these indicators is that they are in direct contact with customers or in the concrete example with consumers. Also, all socioeconomic influences in the environment affect the measurement performance. These performances for a different environment and environment are variable.

Step 3: *Deside how to measure*

The measurement of organizational performance for the specific example is done by analyzing data using the Microsoft Excel tool in which the matrix is created with all the performance and indicators. In addition to filling parts of the matrix, all data generated from the company's existing work system has been used. Due to the analysis for which customer satisfaction is required, the performance related to the quality of the service is additionally analyzed. In order to have specific data on the assessment of customer satisfaction, a questionnaire is generated that generates the necessary information [30].

Step 4: *Preparation for measurement*

The preparation for measurement starts with the creation of the matrix and the implementation of the questionnaire for measuring customer satisfaction. The questionnaire according to the defined measurement scale from the Likert method will assess the quality of the service and the results will be analyzed through the performance of the employeees.

Step 5: Start with the use of the system

The matrix is the basis for starting the system with work. For the concrete example, together with the matrix, the implementation of the questionnaire for customer satisfaction is done for clients in Skopje and throughout Macedonia. The results and the sample of analyzed performance with suggestions for improving the quality of service are analyzed in the next chapter of this survey.

4. ANALYSIS OF THE RESULTS OF THE DEVELOPED CONCRETE MODEL

To confirm the developed model, a matrix is created [30] with business indicators that are listed for measuring the organizational performance for the HORECA sales division of a distributor from Skopje, it is used to analyze the quality of the service that the company provides to its clients.

The matrix provides basic business indicators that maintain the financial stability and business of the division, through the sale of products and services provided to customers. Through the given business indicators and performance indicators that are listed and influenced, and linked to other company structures, a performance analysis that the whole team has and can accomplish can be carried out. In this situation, we analyze several aspects of the performance and their results that affect the quality of the service that the company offers to its customers. An analysis of the performance related to the quality of the service was also carried out a survey questionnaire on the quality of the service using the Likert method [24] with the measuring scale given in Figure 5.

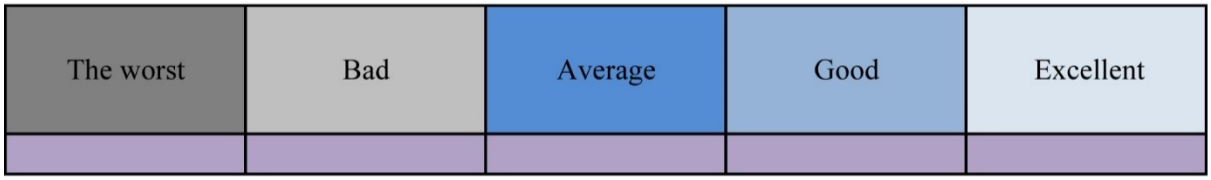

Fig. 5. Measuring ladder for a questionnaire for customer satisfaction [30]

The results of the survey on the required performance are related to the service and the quality of the team that it offers and through the analysis it can be seen what is the percentage of the overall quality service quality [30].

Figure 6 presents the overall average score of surveyed clients where a 21% average and very good grade score is obtained and 55% for a good assessment. What is positive is that the assessment of bad and very bad assessment is only 3%, which indicates that the quality of the rating for all clients and questions is more than 50% satisfactory. However, the analysis would be more detailed if it considers the participation on all issues individually, thus showing the trend of satisfactory quality service criteria. Figure 6 summarizes all the issues individually and their share in the assessment through all the polls that have been conducted. The percentage rate estimate for all issues through the assessment values is given in Figure 7. Out of the total results, some of the issues with lesser results are selected and using the business matrix is the reason why the rating is poor.

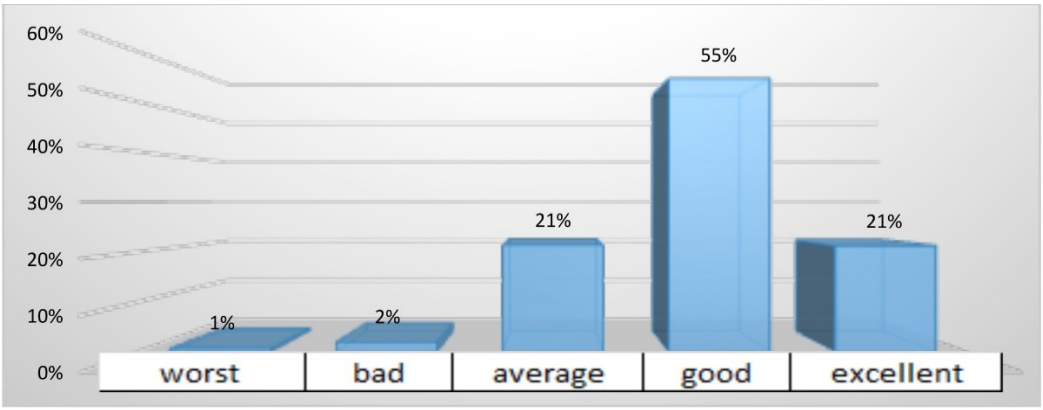

Fig. 6. Results of the conducted survey questionnaire [30]

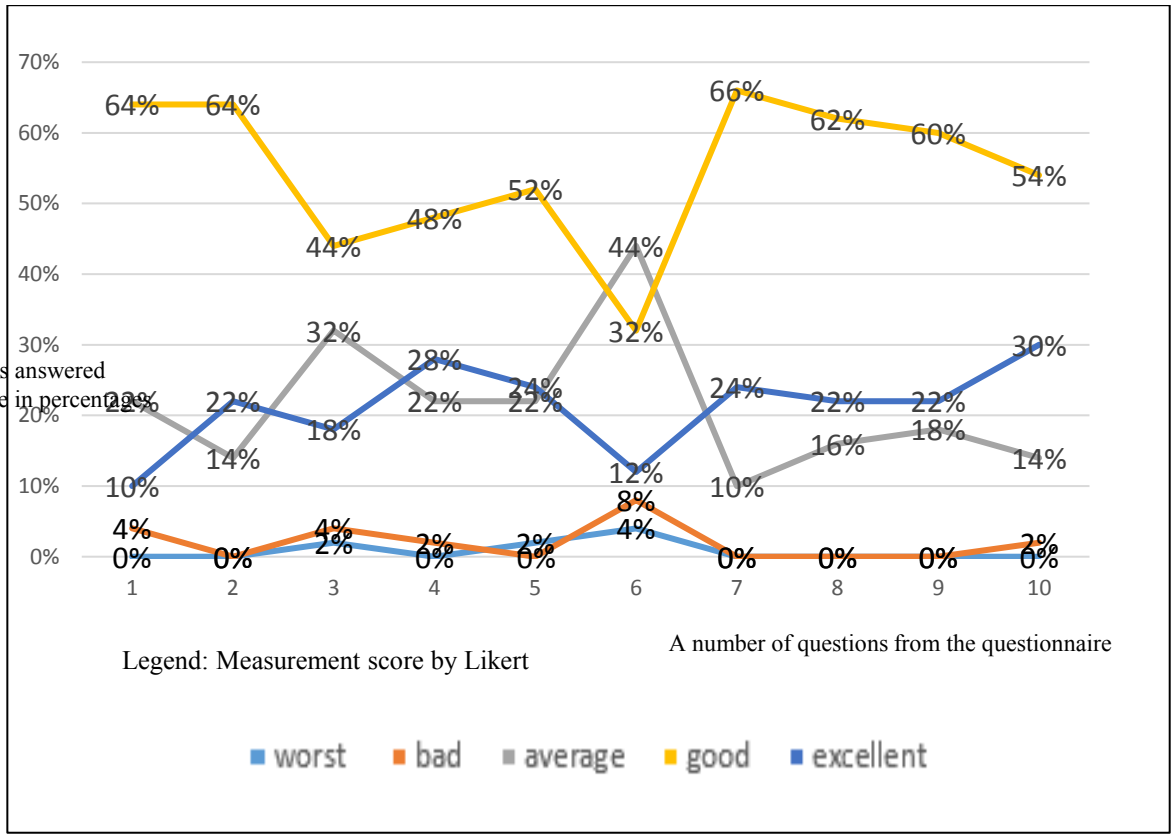

Fig. 7. Results of the questionnaire on quality of service in percent for all questions [30]

Issues that are assessed with weaker grades are analyzed through the developed matrix for analyzing the performance of employees. In the matrix, the indicators lead to several reasons for the weaker results that, with a more detailed analysis, will provide more suggestions and solutions for improving them. Through this systematic approach, there will be a process for improving the overall assessment and quality of the service.

If you want to analyze the speed of delivery, that is, the time from the moment of ordering by the clients until the moment of delivery, it is necessary to analyze the question under number 6 of the questionnaire, which is:

– Whether the delivery is always timely, according to the agreed delivery term?
– A detailed analysis of this question gives the following results that are shown in Figure 8.

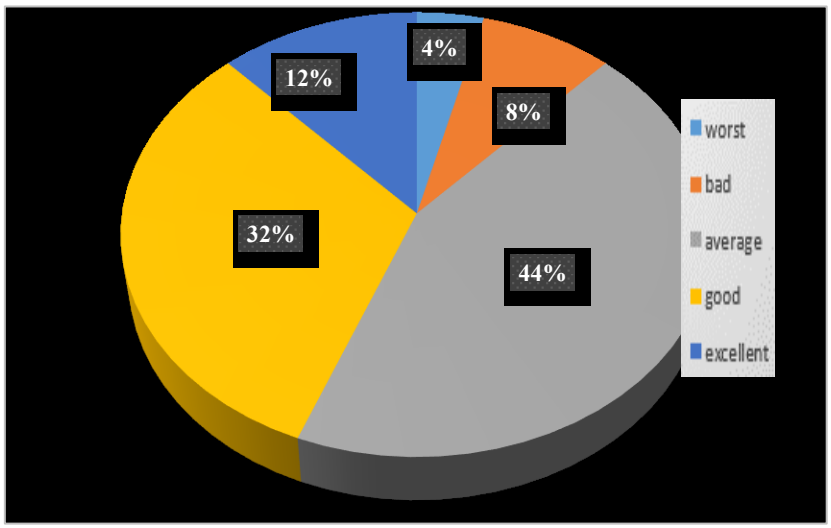

Fig. 8. Results of the 6th question from the questionnaire [30]

The results show that the delivery is 12% below the average, but that a large proportion, i.e. 44%, is average. What next needs to be checked in the matrix is to ask for the ratio of the number of orders delivered/the moment of delivery of orders, where it is possible to accurately analyze the time required for delivering the orders and the reasons that affect it. Based on the analysis, there are many potential reasons:

– Bad organization of logistics.

– Lack of sufficient time for delivery.

– An old rolling stock.

– Communication of sales with logistics.

– Systemic problems.

Through the measurement of the quality of the service it can detect where the service failed, and using the system for measuring organizational performance reveals the essence of the problem in order to reach a solution, whether it would mean reorganization, additional engagement of the vehicle, human factor and many others.

The system for measuring organizational performance, if set up well and the actual business indicators are measured, can always give direction for improving the quality of the service and, therefore, the business of the company. The speed in this case refers to the time delivery efficiency which is one of the basic characteristics of good and fast service.

5. CONCLUSION

The paper lists several aspects and examples of what it means and what are the basic parameters for the quality of the service. The satisfaction of customer and customer requirements is the basis for sustainable businesses more recently. Measurement of organizational performance should be the basis of the principle of the functioning of the organization. The organization's management must make decisions that are thorough and rely on argumentative debates and factual results they receive from the data, through the analyses they have to measure organizational performance. The overall performance measurement process does not stop, but it is a cycle that constantly lasts and changes. However, the quality of the service must always be supported by a good system for measuring organizational performance. Through the systemic process approach that is provided by the system for measuring organizational performance, it is easy to discover the reasons for the lack of quality in the service as well as the directions for their improvement, which leads to continuous improvement.

The analyses carried out and the results presented in this research provide the link between the quality of service and the measurement of organizational performance for the concrete case study analyzed. In doing so, several issues were analyzed for which a survey questionnaire was created, the quality of the service is measured. Determining the quality of service is by expressing the sum of all aggregate results with a more detailed analysis of the answers to all questions from the questionnaire. Focus is given to those questions that have results that are insufficient for the required average, i.e. they are not rated above 50% (average grade) of the total results, using the Likert method.

From the conducted analysis of the questions from the questionnaire, some of the analyzed issues are presented. A more detailed analysis of each question means linking the issue with the business indicators that are given in the matrix.

The influence of each indicator in its own way shows and gives direction as to which performance is being pushed and what is needed to improve it. To this end, ie to achieve better quality of service, improvement was achieved [30]:

- Delivery time – improving performance improves by more than 50% of the average time.
- Buyer relationships - by improving customer relationship management performance, a 50% better relationship has been achieved and this ratio should go towards constant increase.
- The impact of the quality of the sales service – the measurement of customer relationship performance directly affects sales performance, which, as the growing appraisal of this relationship increases more than 50%, generates more sales.
- Analysis of the performance measurement indicators that affect the quality of the service – shows a more detailed analysis of the indicators that influence the organizational performance of the service and how to change to the improvement considered for each issue individually from the questionnaire.
- Indicator connectivity and interaction with one another – clearly shows the connection of one indicator to another and the directions for improving performance.

Through the analysis done for the HoReCa sales division, it comes to the conclusion that while the overall quality service quality is well above the

required minimum of 50%, it does not always apply to all questions from the questionnaire. It is therefore necessary to always associate this analysis with a system for measuring organizational performance, which shows the correct score and reason for that certain performance is failing. The system through the analysis of the reasons always gives the directions for improving those performances, which lead to improvement of the quality of service in the sales division that the organization gives.

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ALGORITHM FOR INTRODUCTION OF THE QUALITY COSTS DETERMINATION SYSTEM

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A b s t r a c t: This paper proposes an algorithm for introduction of the quality costs determination system. The algorithm development employs a descriptive method and applies to all phases of *product* life *cycle* in an environment of limited knowledge and limited resources. The introduction of a quality costs determination system aims at achieving systematic implementation of the methodological approach comprising the following consecutive phases: deciding to introduce a quality costs determination system, preparation and development of the basic system introduction elements, system testing, system operation and deciding to implement the quality costs determination system.This research suggests the need for an organized raising of awareness of the quality cost concept and how such costs fit within the organization strategic goal structure, while the senior management has the overall competences and responsibilities to successfully introduce the quality cost determination system by taking informed decisions.

Key words: quality; costs; system; algorithm

АЛГОРИТАМ ЗА ВОВЕДУВАЊЕ СИСТЕМ ЗА ОПРЕДЕЛУВАЊЕ НА ТРОШОЦИТЕ ЗА КВАЛИТЕТ

А п с т р а к т: Во трудот е предложен алгоритам за воведување на систем за определување на трошоците за квалитет. Алгоритамот е развиен со користење на дескриптивен метод и се однесува на сите етапи од настанувањето на производот во услови на ограничено знаење и ограничени ресурси. Воведувањето на систем за определување на трошоците за квалитет својата цел ја постигнува преку воведување на систематичност во имплементацијата на методолошкиот пристап кој се состои од следниве последователни фази: фаза на донесување одлука за воведување на систем за определување на трошоците за квалитет, фаза на подготовка и разработка на основните елементи за воведување на системот, фаза на пробно тестирање на системот, фаза на функционирање на системот и фаза на носење одлука за спроведување на системот за определување на трошоците за квалитет. Од реализираното истражување се констатира дека е потребно организирано будење на свесноста за постоење на концепт за трошоците за квалитет и нивната позиција во структурата на стратешките цели на организацијата, додека високото раководство ја има целосната компетенција и одговорност за успешно воведување на системот за определување на трошоците за квалитет со донесување одлуки засновани на аргументирано докажување.

Клучни зборови: трошоци за квалитет; систем: алгоритам

INTRODUCTION

The first half of the 20th century features an ever more scientifically based cost management [1], as a result of the ever greater competitive advantage requirements and the development and sustainability needs of the strategic decision-making systems. Top management focuses on implementing advanced approaches, philosophies, paradigms [2], in order to ensure continuous tracking of the cost structure in all of the stages of the process of product creation and utilization. This particularly applies to the

structure of costs related to the quality activities, i.e. the quality costs, as an important segment in the overall cost structure in the organization. In spite of the numerous dilemmas and arguments related to the structuring and determination of the quality cost elements in the quality cost definition models, nevertheless costs of quality justifiably and undoubtedly do exist [3, 4]. The strategic goal of the organization involves decentralizing costs as much as possible, separate them and review them by a few comparable characteristics which accurately determine the value transferred by the use of the resources in all stages of production. In an environment of unpredictable changes for acquiring a competitive advantage, when management focuses on introducing practices for continuous improvement of the organization processes [4, 5], the introduction of a system for determining quality costs creates the prerequisites for identifying the areas of poor quality [2, 6], optimal utilization of the available resources, increasing the level of quality and reducing the quality costs with a view of increasing the organization's profits. The algorithm for introduction of the quality costs determination system incorporates an integral and inclusive approach to acquiring deep knowledge of the area that elaborates the definitions of quality, the concept, the properties, the definitions, the subdivision and the role of the costs of quality, as well as the area related to the models that define the quality costs measurement system and structure and the current quality management systems. The structure of the quality cost determination system introduction algorithm requires a mastery and application of theoretical and practical knowledge in all areas related to "quality".

Therefore, this paper presents an quality cost determination system introduction algorithm, created on the basis of an advanced Object Oriented Quality Management Model (OQM model), which incorporates the concept of quality areas, presented by the object of quality (activities, processes, system, staff, infrastructure etc.) and their associated characteristic (accuracy, relevance, timeliness, consistency, competency, reliability etc.) [7].

METHODOLOGICAL APPROACH TO INTRODUCTION OF THE QUALITY COST DETERMINATION SYSTEM

This paper employs a descriptive and analytical methodological approach to introducing a quality cost determination system. This methodological approach features a synergy between: the universal quality improvement methodologies, the Deming circle (PDCA, Plan-Do-Check-Act [6, 8]) and the Trilogy of Juran [2]; quality management principles: the team work principle and the continuous improvement principle [5]; and the selected areas of quality [7] (Figure 1), which contribute to the systematic development of algorithm for introduction of the quality costs determination system.

According to the methodological approach, the quality cost determination system introduction algorithm entails five phases:

- the decision to introduce the system phase,
- the development and elaboration of the basic elements for introducing the system phase,
- the system testing phase,
- the system operation phase, and
- the decision to rollout the quality costs determination system, phase.

Recognizing, understanding and interpreting the areas of quality with a view of creating the quality cost determination system introduction algorithm, entails a deep understanding of what should be identified, described, analyzed and managed. In this regard, the following need to be taken into account:

1) Understanding that shape and explain the quality cost concept, such as:

- Quality costs aim at achieving quality [2].
- Quality costs relate to the production phase [9].
- Quality costs relate to the process [2].
- Quality costs relate to the entire life cycle of the product [9].

2) Understandings taken into account in order to provide for a proper approach to the elaboration of the costs of quality, such as:

- The structuring of the quality costs reporting is of particular importance [9].
- The quality cost structure is consistent with the identified objectives [9, 10] (management by objectives).
- The quality cost information and data should be relevant, verified and validated [1, 9].
- Quality costs indicate successful management performance [1].
- IT support flexibility provides the prerequisites for analysis and structuring the costs of quality [9, 10].
- Quality cost management requires theoretical and practical knowledge [1].
- Quality costs are reviewed by cost holders, i.e. the entities responsible for incurring the cost [1].

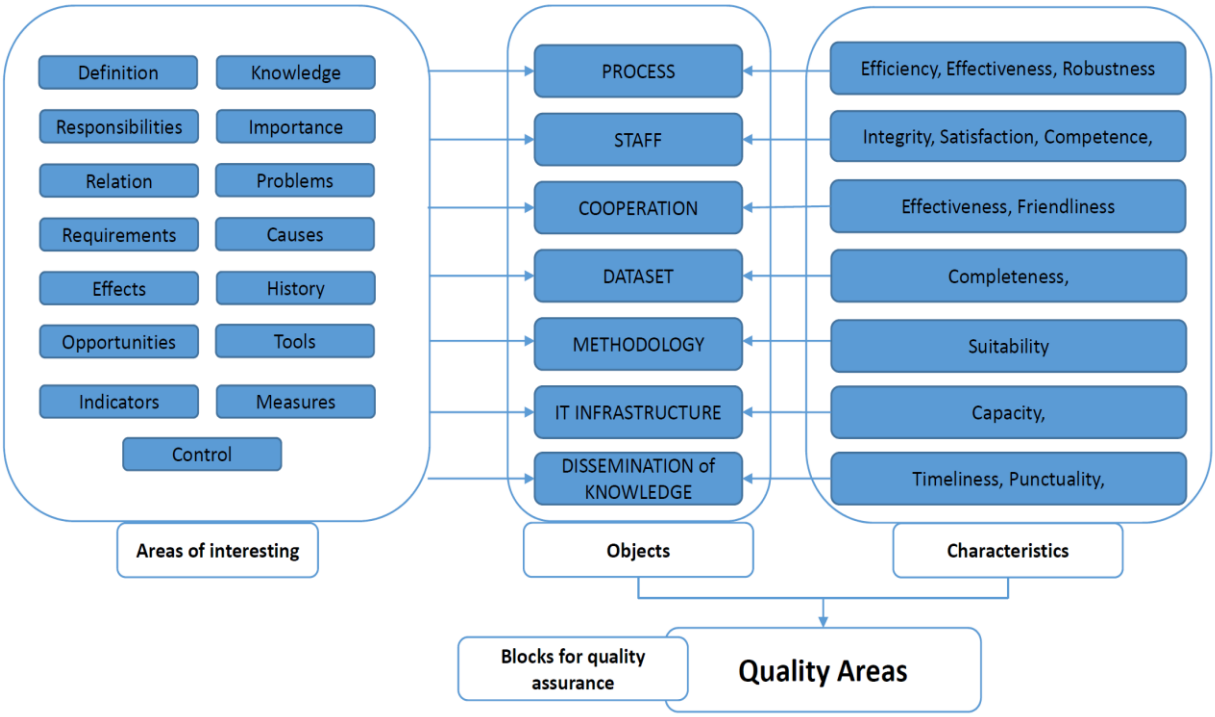

Fig. 1. Structure of the selected areas of quality

ALGORITHM FOR INTRODUCTION OF THE QUALITY COSTS DETERMINATION SYSTEM

The introduction of the quality cost determination system represents a complex, responsible and continuous commitment, primarily of the top management [2, 3] dedicated to achieving the objectives of effective and efficient performance [10], achieved by systemic planning, execution, control and improvement work performance [2]. This approach requires full understanding and motivation of every staff member [2], by demonstrating job specific knowledge, skill and competences and readiness to accept the introduction of the system. Every organization, depending on the level of development of the existing information and accounting infrastructure, as well as the knowledge acquired by the human resources and the existence of methodological resources, decides about the scope of the quality costs considered by the system that determines them. Figure 2 shows the quality cost determination system introduction algorithm [11–13], which applies to product development stages, including the following phases: PHASE I – decision to introduce the quality costs determination system, PHASE II – development and elaboration of the basic elements for introducing the quality costs determination system, PHASE III – quality costs determination system testing, PHASE IV – functional introduction of the quality costs determination system at the organizational level, and PHASE V – decision to implementation the quality costs determination system at the organizational level. Every phase comprises stages systematized in accordance with the implementation sequence. The top management monitors the phases and the stages, based on the reporting plan devised by the operations team.

PHASE I – refers to the decision to introduce a quality cost determination system, made by the top management [2, 14]. This decision is not intuitive, nor is it a result of personal experiences, but rather it is documented, transparent, clear and unequivocal and it is made and promoted after conducting comprehensive research and analyses corroborating the benefits of making such a decision.

The organization devotes special attention to the timely and successful implementation of the decision. The staff cannot get accustomed to poor and failed attempts and practices, which casts doubt on the propriety and viability of the decision made by the top management. If the employees acquired such practices and mindsets then it is very difficult to change them over time.

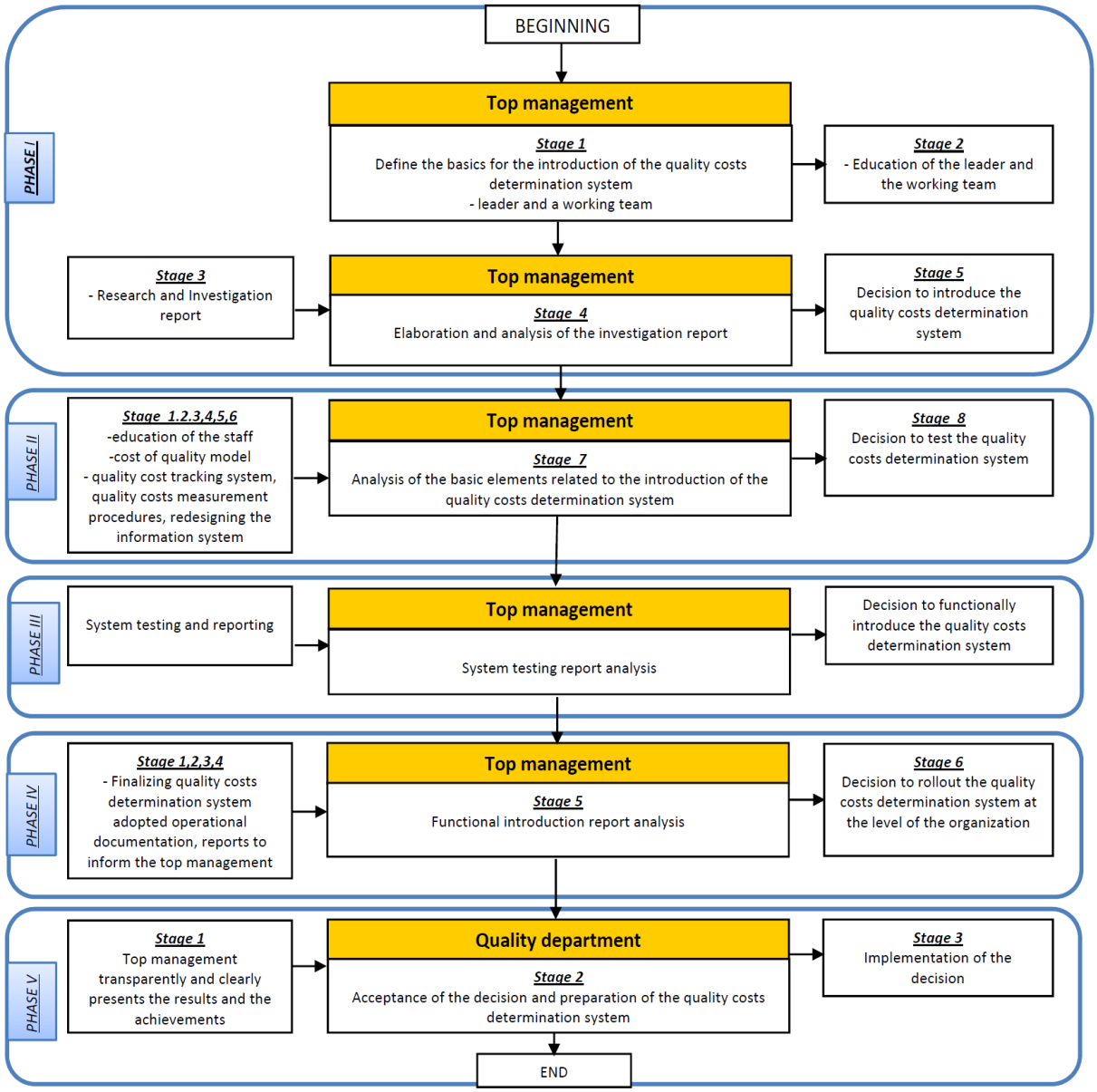

Fig. 2. Algorithm for introduction of the quality costs determination system

Stage 1 – comprises activities for defining the basic requirements for the introduction of the quality costs determination system by top management. This involves selecting a leader [15] and a working team, responsible for implementing the planned activities, with guidelines and recommendations for the object of investigation, the expected results, the form and the content of the analyzed and presented investigation results, with a defined budget for the working team and timelines for regular reporting and completion of the work. Considering the heterogeneity of the work, the working team comprises experts from the field of quality management, information technology, modern accounting systems, scientific and practical achievements in the area of quality costs, legal and regulatory norms on the national and international markets, production engineering, human resource management, as well as current and investment financial resources planning [5].

Stage 2 – comprises quality planning activities in the field of educating the leader and the working team [15] acquire specific knowledge [8] for the entire subject matter and terminology relevant to the modern perception of "quality", the existing descriptive, standardized models of the quality costs structure and elements, quality costs measurements, practical knowledge related to the application of the models in the relevant industries, knowledge related to quality costs and quality standards, the expected

results from the implementation of the quality costs determination system and known practices and experiences related to the surmounting of the difficulties when determining the quality costs. The responsibilities of the working team comprise the following tasks [15]**:**

Task A – Prepare a report about the investigation regarding the viability of the decision to introduce a quality cost determination system, with developed alternatives and recommendations for follow-up activities.

Task B – Prepare a plan of activities, responsibilities and deadlines for introducing the quality costs determination system, as well as a training plan for the staff and reporting to top management.

Task C – Control the quality cost determination system introduction process.

Task D – Prepare a final report from the introduction of the quality cost determination system, emphasizing the identified weaknesses, chronic anomalies, with developed alternatives and recommendations for future improvement of the introduced system.

Stage 3 – comprises activities of the working team related to: investigating the internal environment for the implementation of the quality costs determination system; analyzing the current cost structure, assessment of the usefulness of the accounting and information system and the overall resources (material, human and financial) required to successfully implement the system [5]. In addition, the working team also analyzes the external environment, the benefits of the scientific and practical achievements and experiences, the impact of the quality standards and the legislation. For every activity, the working team shall prepare an investigation report – task A.

Stage 4 – refers to the activities of the top management, which, based on the quality control of the implementation process for stages 1, 2 and 3 of the algorithm, as well as the investigation report – task A, compares the planned against the actually implemented activities.

Stage 5 – top management makes the decision to introduce the quality cost determination system.

PHASE II – refers to the preparation and elaboration of the basic elements required to gradually introduce the quality costs system [14] in particular:

Stage 1 – comprises activities and planning of training and education of the staff [15] regarding the quality costs determination system introduction process [5]; its justification; the purpose for introducing the system; the expected implementation results and the significance of the application of the system to the performance of the organization and the need for the quality costs to become part of the quality creating culture within the organization [5]. During the training, the employees acquire knowledge about the following: preparation of a quality costs structure definition model; identifying the elements of the quality costs structure; determining who incurred the quality costs and where; the methodology for tracking and calculating the quality costs; development of the procedures and instructions; as well as testing of the process for introduction of the quality costs system.

Stage 2 – refers to the adoption of a model for defining the structure of the quality costs [3, 4] and identifying and tracking all of the quality costs structure elements. This process employs different approaches to model creation, such as PAF categorization, the process model or the Informal semi-structured approaches (departmental quality costing method and problem-solving method) [5]. This involves the preparation of quality costs lists [15], according to the "need to know" criterion, rather than the "nice to know" criterion [10], ranking and sorting the quality costs according to predetermined criteria using quality management tools.

Stage 3 – comprises activities related to the decision for selection and definition of a quality cost tracking system, within the automatic data processing system based on an analysis of the current situation and the capabilities within the organization [5].

Stage 4 – comprises activities for: selection and definition of a quality costs measurement and calculation system [15]; analysis, ranking and sorting of the quality costs; calculation of the quality costs indicators, analysis of the conclusions and follow-up activities.

Stage 5 – refers to activities for development of procedures [15] for the quality costs determination system. The procedure defines the main goal of the quality costs determination system, the applicability scope, the responsibility, as well as the procedure algorithm, identification method, record keeping, quality costs measurement, calculation, ranking, sorting, as well as reporting and reporting of the quality cost indicators. In addition, the working instructions contain the operational steps of the respective processes and activities in the organizational units.

Stage 6 – comprises activities for redesigning the information system in order to upgrade it and adapt it to the needs of the system for determining the new structure organization's total costs, including the new structure of the quality costs and its elements.

Stage 7 – comprises activities of the top management for analysis of the developed basic elements [15] required for the introduction of a quality costs determination system.

Stage 8 – refers to decision for testing the system.

PHASE III – refers to testing [14, 15] of the quality costs determination system within the organizational unit, by selecting activities which feature a lot of diverse inconsistencies, deficiencies and errors. This phase ends with the preparation of a report on the analysis of the system test [15]; drawing relevant conclusions; identification and recording of the deficiencies [6]; optimal resources (material and human) assessment, assessment of the staff knowledge and awareness about the quality costs determination system; development of alternative solutions and recommendations for future improvement of the quality costs determination system and decision to functionally introduce the quality costs determination system.

PHASE IV – refers to the functional gradual introduction of the quality costs determination system in the entire organization [14] in particular the following:

Stage 1 – comprises activities whereby the working team finalizes the quality cost determination system based on the initial system test and the top management's decision to functionally introduce the quality costs determination system.

Stage 2 – comprises activities related to the preparation and introduction of an adopted operational documentation for the quality costs determination system [15].

Stage 3 – refers to the activities whereby the staff obtains information about the course and the result of the quality costs determination system test [15], the likelihood of success and development of the organization of the system is understood, accepted and implemented through teamwork.

Stage 4 – comprises activities for rolling out the quality costs determination system throughout the entire organization. The employees implement the quality costs determination activities in accordance with the quality costs determination procedures and instructions. The working team prepares daily, weekly and monthly reports to inform the top management [15] about course of the implementation of the quality costs determination system. After the timeline envisioned for the operationalization of the quality costs determination system, the working team prepares a final system operations reports, emphasizing the identified weaknesses, chronic anomalies, with developed alternative solutions and recommendations for future system improvements.

Stage 5 – comprises activities of top management related to the analysis of the report on the functional introduction of the quality costs determination and

Stage 6 – decision to rollout the quality costs determination system throughout the entire organization.

PHASE V – refers to the implementation of the decision to rollout the quality costs determination system [14].

Stage 1 – includes activities whereby the top management, transparently and clearly presents the results and the achievements of the functional application of the quality costs determination system [15] to all the employees, in a form appropriate for the working units and jobs, promotes and develops management with knowledge, which entails acquiring, sharing, developing and applying the knowledge about quality costs [8].

Stage 2 – comprises activities of the quality department, related to the acceptance of the decision and preparation of the quality costs determination system for further implementation [15].

Stage 3 – implementation of the decision for the quality costs determination system

CONCLUSION

The research work and the related analyses suggest that the process of introduction of the quality costs determination system, presented by an algorithm, provides clarity in the understanding and systematizing of the interrelated complex processes, application of the methodological approach elements when implementing each of the algorithm phases, placement the top responsibility with the top management, argument based decision-making, risk management, with a view of continuous process improvements. In addition, the algorithm comprises processes of continuous planning, identification, recording, measuring, and analysis of the quality costs within a specific time interval. Apart from the

benefits of the quality costs determination system introduction process we should also expect risks of failure, usually related to limited knowledge and understanding of the quality costs and the existing communication practices between the different organizational units.

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APPLICATION OF THE "VITAL FEW AND TRIVIAL MANY" PHENOMENON AS A FUNCTION OF THE QUALITY COSTS CONCEPT

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A b s t r a c t: The paper presents an interpretation of the "vital few and trivial many" phenomenon and the significance of the application of its integral elements (Pareto chart, Lorenz curve, 80/20 principle and ABC technique) in the qualimetry methodology using deductive methods. The graphic presentation and the analysis of published quality cost data will present the "vital few and trivial many" phenomenon as a function of the quality cost concept. The presented methodology comprises sorting, cumulation and differentiation of the quality costs, aimed at determining the significance of the quality costs (in accordance with a predetermined criterion) and contributing to a more effective and efficient decision-making process, proactive problem-solving process and risk based thinking by management. The suggested methodology facilitates priority setting, problem analysis, identification of areas for improvement and benefit verification in order to improve the processes and the overall quality with a view of reducing the quality costs.

Key words: Pareto chart; Lorenz curve; 80/20 principle; ABC technique

ПРИМЕНА НА ФЕНОМЕНОТ „ВИТАЛНО МАЛЦИНСТВО И УПОТРЕБЛИВО МНОЗИНСТВО" ВО ФУНКЦИЈА НА КОНЦЕПТОТ ЗА ТРОШОЦИТЕ ЗА КВАЛИТЕТ

А п с т р а к т: Во трудот се дадени интерпретацијата на феноменот „витално малцинство и употребливо мнозинство" и значењето на примената на неговите интегрирани елементи (дијаграм на Парето, Лоренцова крива, принцип 80/20 и техника АВС) во методологијата на решавање на квалиметриските проблеми, со примена на дедуктивната метода. Преку графичка презентација и аналитичка анализа на публикувани податоци за трошоците за квалитет се претставува феноменот „витално малцинство и употребливо мнозинство" во функција на концептот за трошоците за квалитет. Презентирана е методологијата на подредување, кумулација и диференцирање на трошоците за квалитет, чија цел е да ја утврди значајноста на трошоците за квалитет (согласно претходно утврден критериум) и да придонесува за поефективно и поефикасно носење на одлуки, проактивност во процесот на решавање на проблеми и размислување базирано на ризици, од страна на менаџментот. Предложената методологија овозможува поставување на приоритети, анализа на проблеми, идентификација на области за подобрување и верификација на придобивки кои се во насока на унапредување на процесите и севкупниот квалитет, а во функција на процесот на редукција на трошоците за квалитет.

Клучни зборови: дијаграм на Парето; Лоренцова крива; принцип 80/20; техника АВС

1. INTRODUCTION

The knowledge, understanding of and familiarity with the cause and effect relationships in the decision making process and the effect evaluation process, are of great importance primarily for management and the company management process [1]. This means that

management should apply principles, methods and tools to ensure the identification of the problem, undertaking of the necessary measures, implementation of changes, the elimination of causes and the identification of the new situation [1]. The existence of the phenomenon that within the set of items contributing to common effects, the relative minority is responsible for a larger percent of the effects [2], i.e. the few are vital (important) and the many are trivial [3, 4], had been noticed in everyday life [2]. The Italian economist Vilfredo Pareto (1848–1923) noted this phenomenon in 1897 [3] while researching the inadequate wealth distribution, created a mathematical model to quantify such inadequacies, as well as the logarithmic law on income distribution [2, 5], also known as "Pareto distribution" [5]. He concluded that 80% of the Italian population holds 20% of the income in Italy, while the remaining 20% of the population hold 80% of the income [5–8]. It is worth noting that from Pareto distribution resulted the famous principle known as "Pareto Principle" [5], "80–20 Rule" [4, 6, 8], "80/20 Principle", "Pareto Law", "Principle of Least Effort" and "Principle of Imbalance" [3], "Pareto 20:80" [7]. Vilfredo Pareto's principle did not have a universal character and applied only in the field of economics [1, 2], although he stated that "in a system, a relatively few failure reasons are responsible for the catastrophically many failures" [9], which created the conditions for universality.

J. M. Juran, for the first time identified, in writing, this phenomenon as universal and applicable in dealing with the causes for the effects in the biological and the physical world [1, 2, 4]. He popularized this phenomenon and its application in the area of quality improvement, for the first time in his "Quality Control Handbook" (1951), where he called the universality of the unequal distribution principle as it applies to wealth and quality loss, the "Pareto Principle" [2, 5], or the "Rule of the Vital few" [3]. Furthermore, J. M. Juran additionally established this principle by also calling it "Vital few and useful many" and presenting it in graphical form [2]. The professor of Harvard University, George K. Zipf also contributed to the further elaboration of Vilfredo Pareto's principle and the recurrence of predictable imbalance. In 1949 he discovered the "Principle of Least Effort", according to which a larger portion of the distributed resources (products, people etc.) corresponds to a small portion of the overall activities, i.e. 20–30% of the resources correspond to 80–70% of the activities using those resources [3]. The famous quality guru, Edwards Deming also continued the popularization of the 80/20 principle and, more broadly, the "vital few and trivial many" principle, from a quality manage- ment standpoint. In his seminars in Tokyo, Deming contributed to the understanding of the principle and its broad application by Japanese companies [8]. The works of J. M. Juran and Edwards Deming [8], contributed to the fact that the 80/20 principle, as a significant concept in the management thinking process and the decision-making process [1], found its rightful place in the center of the global quality revolution between 1950 and 1990 [3].

In addition to the scientific and research circles, the world of information technology also recognized, understood and practically applied the 80/20 principle during the period from the 1960s to the 1990s, particularly companies like IBM, Apple, Lotus, and Microsoft [3].

2. METHODOLOGY FOR SOLVING QUALIMETRY PROBLEMS BY APPLYING THE "VITAL FEW AND TRIVIAL MANY" PHENOMENON

The "Vital Few and Trivial Many" phenomenon applies to the qualimetry problem solving approach methodology by the consecutive integration of the four elements: the Pareto chart, the Lorenz curve, the 80/20 principle and the ABC technique, as well as the functions that these integrated elements perform: sorting, cumulation, differentiation and significance (Figure 1).

The phenomenon applies to both quantitatively and qualitatively expressed qualimetry problems [10]. This methodological approach will facilitate the determination of the significance of a specific qualimetry phenomenon during problem identification, problem significance analysis, and, after the undertaking appropriate correction actions for results evaluation [11].

The Pareto chart got its name from Vilfredo Pareto's principle [10]. In 1976, the Japanese professor Kaoru Ishikawa [12] identified it as one of the seven traditional (statistical) tools for product and process quality improvement [10]. The Pareto chart represents a graphical problem-solving methods [11], comprising graphical presentation of the factors on a histogram [4], sorting the factors by

their occurrences in a descending order [4, 10, 13], and presentation of the relative and absolute distribution of the occurrences [14]. The Pareto chart contains the cumulative curve (Lorenz curve) [10, 11, 14], used to present the cumulative values of certain factors in the Pareto chart [10, 14]. Therefore, the Pareto chart can also be references as a Pareto-Lorenz chart (method) [7].

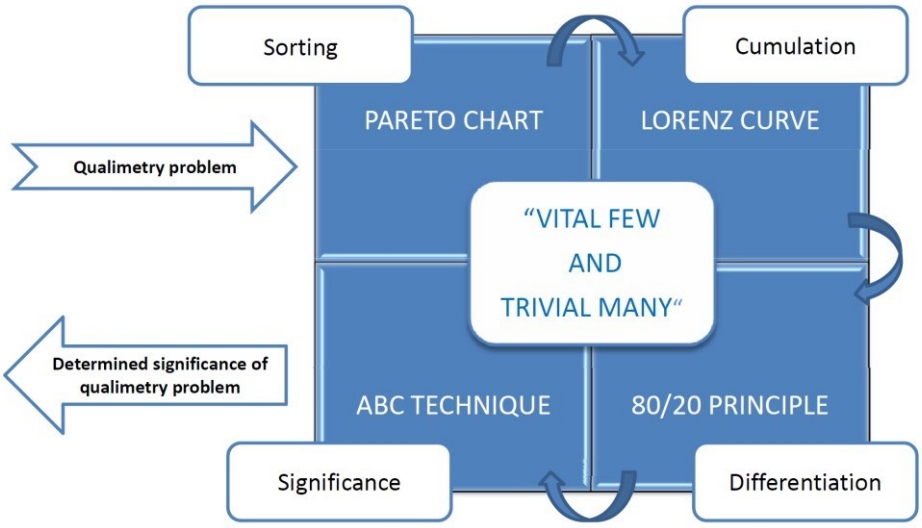

Fig. 1. Methodology by applying the "Vital Few and Trivial Many" phenomenon

The Lorenz curve represents a cumulative line for graphical presentation of cumulative sum of the observed features applied to the horizontal axis of the Pareto chart, developed by the researcher M.O. Lorenz [2].

The 80/20 principle fonded on the universal uneven factor distribution, facilitates the differentiation of the few vital from the many less vital (trivial) causes of a certain event, thus determining priorities for the decision making process [4, 8].

The ABC technique (method) represents a method for analyzing economic phenomena, developed on the basis of an understanding of the 80/20 principle [15]. This technique employs the graphical representation of the Pareto chart and the Lorenz curve and the field under the Pareto-Lorentz diagram divides into three areas:

- Area A – group factors with the greatest impact [10], comprising 20% of the factors that contribute for 80% of the cumulative value of the frequency of the factors [14].
- Area B – group factors with relevant impact [10], containing another 30% of the factors, which contribute for another 10% of the cumulative value of the frequency of the factors [14].
- Area C – group factors with very low impact [10], comprising the remaining 50% of the factors which contribute for the remaining 10% of the cumulative value of the frequency of the factors [14].

The ***ABC technique*** provides an easy and an understandable way to fragmenting the big picture into three areas of problems with different significance, which suggests that we should solve the most significant problems, and not the easiest ones first, followed by the slightly less important and eventually the least important problems [15].

The justification for the application of the **"Vital Few and Trivial Many"** phenomenon lies in the fact that not all problems that occur in the product or during the process have are equally important or significant [8]. The application of this phenomena aims at focusing on solving the problems whose resolution makes the way to deal with the problems, most efficient [8]. Focusing on the vital problems in group A (events with the greatest occurrence or numeric value) represents the best way to use the existing resources and get the greatest return on the investment in quality improvement [16].The methodology by applying of this phenomenon is simple and easy, it can be implemented independently or as a predecessor or a follow-up of some other statistical methods (tools) for quality improvement [10].

3. APPLICATION OF THE "VITAL FEW AND TRIVIAL MANY" PHENOMENON AS A FUNCTION OF THE QUALITY COST CONCEPT

The universal application of the "Vital Few and Trivial Many" phenomenon facilitates its application in the area of quality cost management as a function of quality costs. This phenomenon offers an opportunity to examine all of the categories (elements) of quality costs, with a view of identifying the quality costs most responsible for the biggest spending [17] in companies, departments [13], and job positions, thereby creating the prerequisites for systematic identification of the priority actions [18] aimed at reducing the costs of quality.

The paper will illustrate the practical application of the "Vital Few and Trivial Many" phenomenon as a function of the costs of quality using data from an example involving an administrative sector problem [15], in an insurance organization, which refers to the appearance of a large number of documents with significant errors (failures). The incidence of many errors in the documentation implies that they have to be reviewed and corrected, which increases the quality costs, i.e. the costs in the category of internal error costs of the organization.

The resolution of this problem, i.e. the determination of priority actions to reduce the high error

T a b l e 1

incidence and thereby reduce the quality costs (the costs involved in correcting a certain error), begins with a table view of the 25 identified error types and sorting these errors by the frequency of occurrence in a descending order. Figure 2 represents an appropriate graphic interpretation (Pareto chart) where the types of errors (shown on the horizontal axis) have been sorted by the error frequency.

Then, based on the calculated cumulative percentage of error incidence (Table 1), which serves as a basis for constructing the cumulative curve (Lorenz curve), Figure 2 also shows the cumulative error distribution.

Next we differentiate the errors using the 80/20 principle and determine three groups of error significance (groups A, B and C) deriving from the application of the ABC technique, also shown on Figure 2.

Overview of the 25 error types

No.	Error type	Frequency of occurrence	Cumulative sum of the frequency	Cumulative frequency percentage	Error percentage
1	G	10456	10456	30,22	4
2	U	7684	18140	52,43	8
3	J	5361	23501	67,92	12
4	Z	3523	27024	78,11	16
5	R	1956	28980	83,76	20
6	L	1286	30266	87,48	24
7	P	702	30968	89,51	28
8	C	673	31641	91,45	32
9	X	501	32142	92,9	36
10	K	498	32640	94,34	40
11	A	398	33038	95,49	44
12	E	364	33402	96,54	48
13	F	297	33699	97,4	52
14	B	256	33955	98,14	56
15	V	196	34151	98,71	60

16	Q	97	34248	98,99	64
17	W	78	34326	99,21	68
18	N	50	34376	99,36	72
19	D	45	34421	99,49	76
20	T	42	34463	99,61	80
21	I	35	34498	99,71	84
22	Y	32	34530	99,8	88
23	S	27	34557	99,88	92
24	M	23	34580	99,95	96
25	H	19	34599	100	100

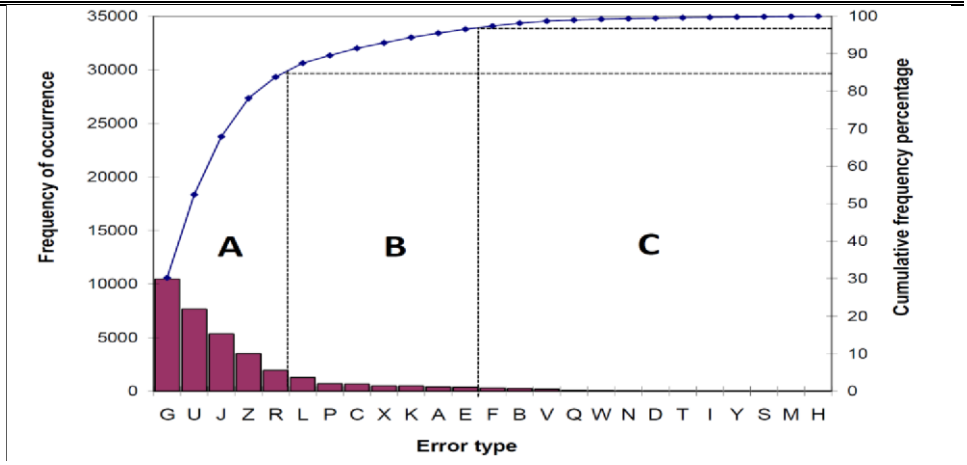

Fig. 2. Application of the "Vital Few and Trivial Many" phenomenon in the error frequency analysis

The methodological approach continues with the determination of the total cost for rectifying a particular type of error (quality cost) and tracking the errors by sorting them by the quality cost value in a descending order (Table 2). Figure 3 represents an appropriate graphic interpretation (Pareto chart) where the types of errors (shown on the horizontal axis) have been sorted by the quality cost value.

T a b l e 2

Then, based on the calculated cumulative percentage of quality cost value (Table 2), Figure 3 also shows the cumulative quality cost distribution. Next we differentiate the errors using the 80/20 principle and determine three groups of error significance (groups A, B and C) deriving from the application of the ABC technique, also shown on Figure 3.

Overview of the 25 error types

No.	Error type	Total cost of correction	Cumulative sum of the total cost of correction	Cumulative percentage of the total cost of correction	Cumulative percentage of error
1	E	181272	181272	49,76	4
2	X	35070	216342	59,39	8
3	P	34398	250740	68,83	12
4	U	23052	273792	75,16	16
5	G	20912	294704	80,9	20
6	B	13568	308272	84,62	24
7	L	12860	321132	88,15	28
8	J	10722	331854	91,1	32
9	R	7824	339678	93,24	36
10	A	5174	344852	94,66	40

11	F	3564	348416	95,64	44
12	Z	3523	351939	96,61	48
13	D	3015	354954	97,44	52
14	K	2988	357942	98,17	56
15	H	2128	360070	98,84	60
16	C	1346	361416	99,21	64
17	I	875	362291	99,45	68
18	V	392	362683	99,56	72
19	S	324	363007	99,65	76
20	W	312	363319	99,73	80
21	Q	291	363610	99,81	84
22	T	252	363862	99,88	88
23	M	184	364046	99,93	92
24	N	150	364196	99,97	96
25	Y	96	364292	100	100

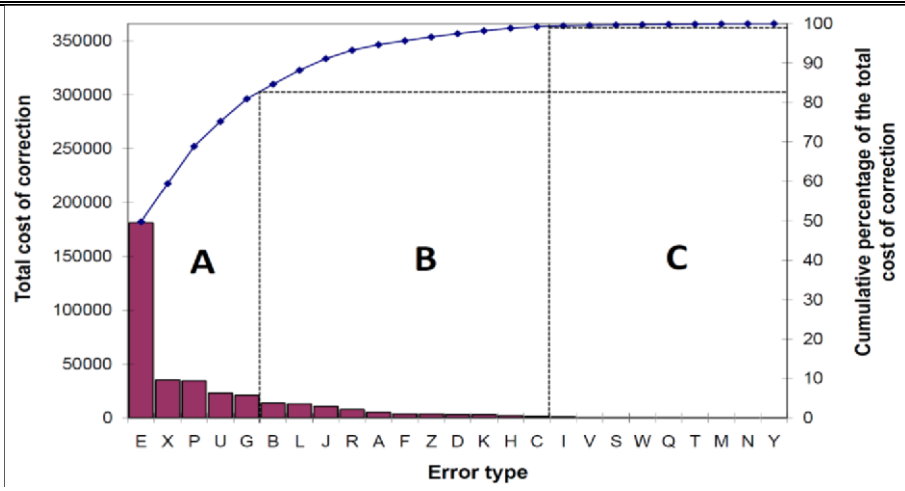

Fig. 3. Application of the "Vital Few and Trivial Many" phenomenon in the cost of quality analysis

4. RESULT ANALYSIS

After we sort the errors and draw the cumulative line, the application of the 80/20 principle on Figure 2 shows that 20% of the all the errors belong to the five error types (G, U, J, Z, R) whose cumulative frequency percentage amounts to 83.76% [19]. These errors belong to the area A, most significant errors, i.e. errors that occur the most. Area B comprises 30% of all the errors (L, P, C, X, K, A, E, F), and they account for 13.64% of the cumulative frequency percentage. Area C contains the remaining 50% of the errors (B, V, Q, W, N, D, T, I, Y, S, M, H) which account for 2.6% of the cumulative frequency percentage.

The diagram on Figure 3 shows that five types of errors (E, X, P, U, G) which represent 20% of all the 25 error types, contribute for 80.9% of the total cost of quality [19]. These errors count as "important", but not numerous errors, which need special attention in order to significantly reduce the total cost for their correction. Area B contains the errors that contribute for 16.54% of the cumulative percentage of the quality cost, and area C contains the remaining errors that contribute for 2.56% of the total costs of quality.

We should not ignore the errors from areas B and C, but rather consider their influence on the achievement of the overall effect and possibly the priorities for correcting them, as not very significant, but rather numerous.

5. CONCLUSION

The reduction of errors and the costs of correcting the errors, also known as the costs of quality, is a very important segment in assuring the quality of the process, product and the overall performance. The "Vital Few and Trivial Many" phenomenon, as a technique for promoting quality, strongly contributes to a more efficient decision-making process, a more proactive problem-solving process and risk based thinking by management,

because, through statistical identification of the important errors, it facilitates *problem* analysis, identification of areas for *improvement, priority* setting and implementation of corrective actions in order to discover the main causes for such errors, detect the roots of such causes and eliminate as efficiently and effectively as possible, implementation of preventive actions to preclude recurrence, as well as identification of a new situation by verifying the *benefits*. By evaluating the error correction costs, managers can recognize the operational and organizational shortfalls that underlying the high quality costs and the unattained economic benefit, and, in turn, they can make informed short-term and long-term decisions.

The "Vital Few and Trivial Many" phenomenon as a function of the quality costs, relies on continuous improvement and innovation principle, an effort which never ends.

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Original scientific paper

INTEGRATED REVERSE ENGINEERING AND ADDITIVE TECHNOLOGY SYSTEMS

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A b s t r a c t: The form of integration of Reverse Engineering (RE) and Additive Technologies (AT) now has the line of the steps that are usable. Basing that Reverse Engineering (RE) technology enables us to create CAD models of new or existing products by capturing surface data, while AT is a technology that uses a layered manufacturing technique for finalizing a detail. The realization of the connection between RE and AT is made possible by some credible software s that are specific to the respective destinations. In this paper will be presented two softwares for each phase from 3D scanning to AT production preparation and try to make opportunity to preserve the original form of the existing part, to reduction of the size of STL file and to make acceleration of realization in the solid detail, will be the main points of this work.

Key words: reverse engineering (RE); additive technologies (AT); CAD; 3D scanning; STL

ИНТЕГРИРАНО РЕВЕРЗНО ИНЖЕНЕРСТВО И СИСТЕМИ ЗА АДИТИВНА ТЕХНОЛОГИЈА

А п с т р а к т: Формата на интеграција на реверзното инженерство (RE) и адитивните технологии (AT) има линија на чекори низ коишто се употребува. Реверзното инженерство (RE) овозможува создавање CAD модели на нови или постојни производи со зафаќање на површини, додека AT користи слоевита производна техника за финализирање на деталите. Реализацијата помеѓу RE и AT е овозможена со софтверски програми кои се специфични за соодветните области. Во трудот се претставени две софтверски програми за секоја фаза, од 3D скенирање до подготвување на моделот AT за производство, но и обид со можност за зачувување на оригиналната форма на постојниот дел со намалување на големината на датотеката STL и забрзување на реализација на деталите од волуменскиот модел. Тоа се главните точки на овој труд.

Клучни зборови: реверзно инженерство (RE); адитивни технологии (AT); CAD; 3D скенирање; датотека STL

1. INTRODUCTION

It is very useful to know how additive fabrication systems such as 3D printers, rapid prototyping systems, and direct digital manufacturing systems are changing future product development and manufacturing [12, 13].

Dynamics of development regarding innovative applications of manufacturing technologies is within the last years growing rapidly. Respecting still more and more sophisticated customer requirements as far as quality of purchased products and price a need to implement integrated processes for manufacturing, measurements and control fulfilling these wishes without production time and price pressure emerges. Competitiveness puts it even further to mini-maze manufacturing prices and uses fast, effective and non-destructive measurement and control systems [1].

To complete a cycle from start to finish, some steps have to be taken. The steps followed by the physical detail to the production technology are shown in Figure 1. First, a model needs to be

scanned to gain in the Virtual Model (VM). Once the virtual model is obtained, it is possible to use the VM format to improve the shape of the work piece, since the surface appears on three angles that need to be minimized ore to eliminate to create a solid detail. In the end, the given model should be converted to STL format for realism in one of the AM technologies.

Fig. 1. Chart-flow of the experimental proceduee [2]

2. 3D SCANNERS

The measurement technique has now changed; they are very accuracy and have speed processing and already as a technology are developed so fast. A 3D scanner acquires geometry data from an existing physical object. This data is used to construct a virtual three-dimensional model of the scanned object that can be used for various applications [3]. There are already several fields where three-dimensional scanning is an established method of data acquisition. In mechanical engineering, 3D scanners are often used for work piece inspection, deformation analysis, additive manufacturing, reverse engineering, reengineering of molds and dies and general quality control procedures.

There are many types of 3D scanners and 3D scanning technologies. Some are ideal for short range scanning while others are better suited for mid or long range scanning. The 3D scanner and technology needed to 3D scan a very small object is very different from and to 3D scan a large parts. Below we can see some different types of 3D Scanners (Figures 2, 3, 4):

Fig. 2. Creaform HandySCAN handheld 3D laser scanner [4]

Fig. 3. Steinbichler comet structured light blue LED 3D scanner [4]

Fig. 4. Arm based 3D scanner and probing system [4]

It is very important the format that is taken from the 3D scanner where most of them possess the respective software, but in this paper we will analyze line between 3D CAD model and the STL file.

3. STL FILE

The most common file types for traditional and additive manufacturing respectively are STL and STEP. Emerging formats include 3DMF and AMF. The latter two are under development.

STL: Stereo Lithography or Standard Tessellating Language initial 3D plastic printing format. It is usually included as an export option using no additional licensing and import to 3D-printing codes is a standard procedure [5].

STEP: ISO 10303 standards is mathematically exact data format. Several application protocols (AP) exist where AP203 and AP214 are most common for exchanging 3D geometry data. Depending on software capabilities 3D annotations may be included in STEP AP203/214 protocols. Later protocols like AP242 will carry semantic and associative

3D annotations. AP242 edition 2 also introduces curved triangle patches similar to the Additive Manufacturing Format (AMF) [5]. There are initiatives to handle lattice definitions; a possible cost reduction and performance increasing design theme made possible by AM.

AMF: ISO/ASTM 52915:201 is a new additive manufacturing file format under development. It allows for curved triangle patches that can increase geometric accuracy by subtessellation [5]. It also has data structures to allow different materials and different densities in the same part.

3MF: A Microsoft and industry-driven initiative. It has similar features to AMF but seemingly no address of geometric accuracy by using curved triangle patches like AMF [5]. Table 1 shows the summary of the geometry formats above.

T a b l e 1

3D data files formats [5]

	STEP ISO 10303	STL	AMF	3MF
Type	Exact (203/214) Exact & approximate (AP242)	Approximate	Approximate	Approximate
Units of measure	Yes	No	Yes	No
License based export	Yes	No	No	–
Curved surface patches?	Yes, exact & approximate (242)	No	Yes	No

The STL file format has become the additive manufacturing industry's standard data transmission format for the moment. This format approximates the surfaces of a solid model with triangles. For a simple model such as the box shown in Figure 5, its surfaces can be approximated with twelve triangles, as shown in Figure 6. The more complex the surface, the more triangles produced, as shown in Figure 7.

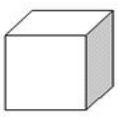

Fig. 5. Box [6]

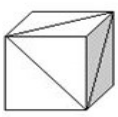

Fig. 6. Surface [6]

Fig. 7. Complex part [6]

Almost all of today's CAD systems are capable of producing a STL file. There are two storage formats available for STL files, which are ASCII and BINARY. ASCII file is human-readable and can be modified by a text editor if required. The ASCII format is used for debugging, or when one has to transfer the file over a 7-bit channel. The binary format uses the IEEE integer and floating point numerical representation. Binary STL files are organized as an 84-byte header followed by 50-byte records each of which describes one triangle facet [7]. The larger the STL file, the more triangles placed on the surface of the model. For simple geometry (not a lot of curves), the file may only be a couple hundred kilobytes and for complex models, files sizes are in the range of megabytes.

The facets define the surface of a 3D object. As such, each facet is part of the boundary between the interior and the exterior of the object. The orientation of the facets is specified redundantly in two ways which should be consistent. First, the direction of the normal is outward. Second, which is most commonly used now-a-day, list the facet vertexes in counter-clockwise order when looking at the object from the outside (Figure 8) [7].

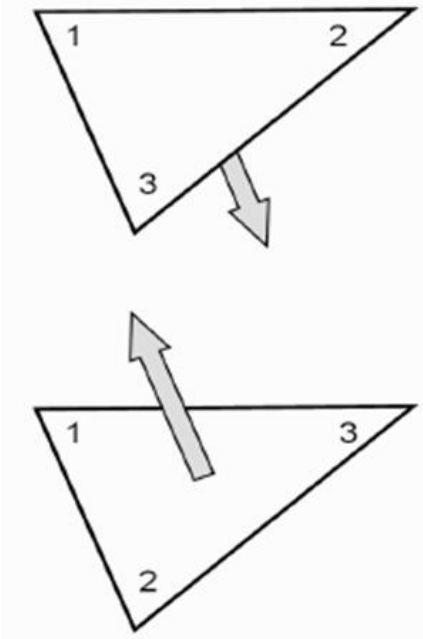

Fig. 8. Counter clockwise order of STL facets [7]

Each of the triangles must share two vertexes with each of its adjacent triangles. In other words, a vertex of one triangle cannot lie on the side of other (Figures 9 and 0). Because of the vertex-to-vertex rule, we know that a legal solid will have 3/2 edges for each face. This gives us three consistency rules against which to check [7]:

- Nr. of faces (FA) must be even.
- Nr. of edges (ED) must be a multiple of three.
- 2×(ED) must equal 3×(FA).

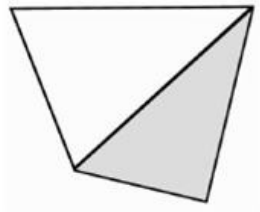

Fig. 9. Adjacent triangles [7]

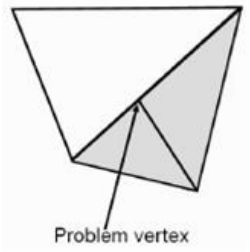

Fig. 10. A violation of the vertex-to-vertex rule [7]

Test parts

For evaluation of the shape complexity two various models were chosen. One is used in medical field (small part) (Figure 11) and another in industrial field (medium part) (Figure 12).

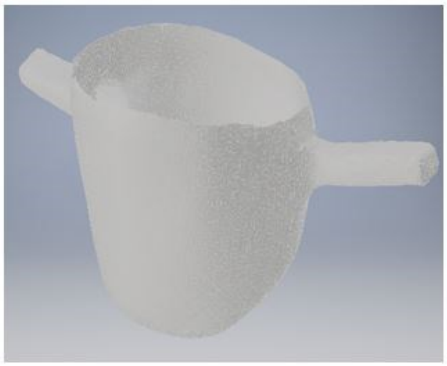

Fig. 11. Medical part (dental cap) [13]

Fig. 12. Industrial part (gear) [15]

For dental part is used medical scanner and for the gear is used 3D Scanner (Artec S. Spider) [15].

Mesh components of tested parts are shown in Table 2 and Figure 13:

T a b l e 2

Mesh components

Gear	Points	250000
	Edges	750000
	Faces	500000
Medical part	Points	9755
	Edges	29160
	Faces	19399

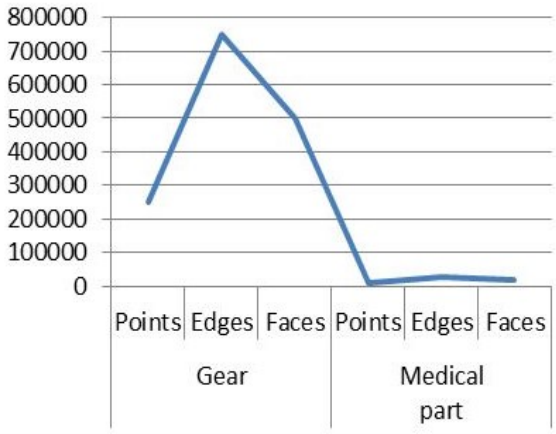

Fig. 13. Diagrame of mesh components (gear, medical part)

4. CAD SOFTWARE

CAD or computer-aided design is technology for design and technical documentation, which replaces manual drafting with an automated process.

Today CAD systems are covering most of the activities in the design cycle, they are recording all product data, and they are used as a platform for collaboration between remotely placed design teams [8]. The relationship created with the AM has shown that improvements have been made as far as possible to intervene in the scanned objects. Almost all professional softwares now have their own extra packages for using to intervention and making reverse engineering in different forms in the model and specifically in the design process for AM technologies.

The possibility of direct conversion of scanned detail (STL format) in the CAD model so far is not

recommended but in some case it can use, so from direct conversion there is a greater deviation than allowed for industrial application, so the shape of the model will remain the same but the size and complexity of its representation will increase by orders on magnitude. It preferred to use the reverse engineering (RE) strategy:

– Using the faceted surface as a guide to rebuild a new CAD model.

– Solid geometry can be created from section planes of the model.

RE applied for creating CAD solid model from STL model is shown in Figure 14.

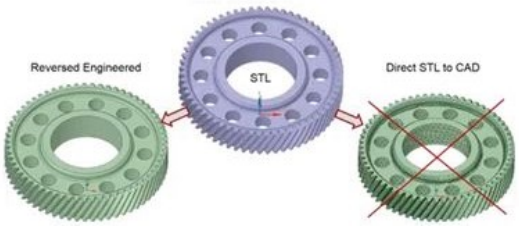

Fig. 14. Creating CAD solid model [14]

In our case, we have used the *ANSYS 18.2 SpaceClaim* software to implement the CAD model for gear and *FreeCAD 0.16* software for implement the CAD model for medical part.

In gear case we make reverse engineering in actual model with implementation of reconstruct the section plane line (Figure 15a) and create a surface plane in tooth (Figure 15b) and in sections of gear that are more complicated. Gear is an industrial part and need to be precise so we select this method to rebuild it.

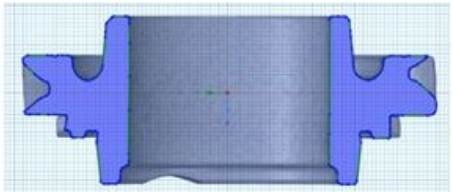

Fig. 15a. Gear in section

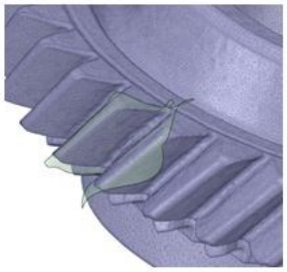

Fig. 15b. Gear with surface plane

Resurface with this method it's quite slow and depends of the experience of the user with software, but in the end need to check the deviation between the original parts and recreated part.

In medical part we use to create it by automatically method to rebuild it from existing mesh model (Figure 16a) to solid model (Figure 16b) because of the complex shape and not to precise part, so first the model converts to mesh form and after that need to make solid from shell.

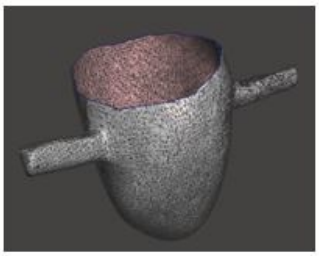

Fig. 16a. Mesh model [13]

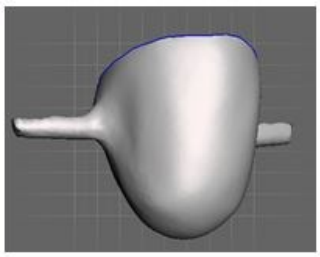

Fig. 16b. Solid model

The tolerance for sewing shape is 0.1 mm. For realizing this part need time to execute and the file is large (MB).

5. 3D PRINTING SIMULATION

3D printing simulations help to understand and visualize the complex thermo-mechanical phenomena taking place during manufacturing, resulting in the production of high-quality, and high-accuracy parts.

Simulating the 3D printing process is very valuable, because it helps to:

- Avoid print failures and parts rejected for geometric issues, saving time and reducing overall cost.
- Evaluate the risk of production and give pointers to mitigate the probability of failure.
- Understand the physics of the manufacturing process.
- Predict the microstructural characteristics of the end part.
- Optimize production to improve manufacturing speed, reduce post-processing operations or improve accuracy by reducing the part and support deformation [9].

Starting from the fact that many software are in use for 3D printing, we have used *Autodesk Netfabb Standard 2017.3* for medical part and *Ultimaker Cura 3.2.1* for gear. Those softwares allow import of STL files, preparation and modifi-

cation details for production as well as automatically necessary repairs.

The reason why in this paper are selected two softwares above is that, as we see in Table 3 and Figure 17, the medical part needs to make repair in shell and holes also as we see in visually in Figure 18, and the gear is corrected from scanning so no need to make any repair. In this case the Autodesk Netfabb is used to simulate the medical part, but before it need to repair shell and holes that are came from 3D scanning. Ultimaker Cura is used to simulate the gear, so no need reparation.

T a b l e 3

Status of STL parts

	Status of parts	
Medical part	Shells	21
	Border fdges	0
	Inv. orientation	0
	Holes	76
Gear	Shells	1
	Border edges	0
	Inv. orientation	0
	Holes	0

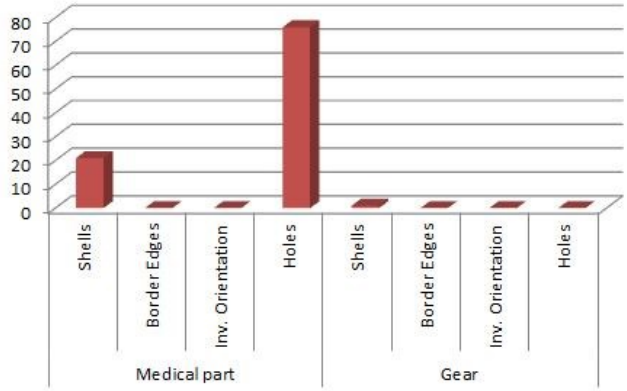

Fig. 17. Diagram of STL parts (medical part, gear)

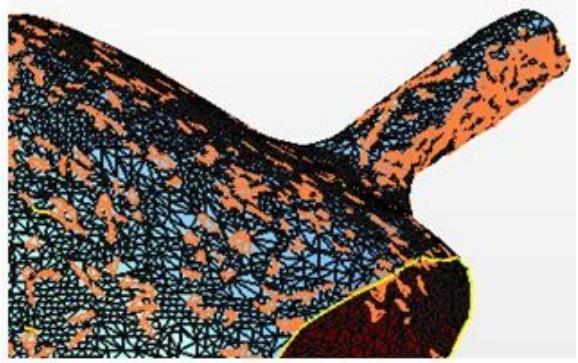

Fig. 18. Mesh surface needed for repair

To start the 3D printing simulation first need to load the machine workspace so it's depends on machine that needs to use also in practice. The second step is to make the orientation of the STL part in the area of machine working. The third step is to make support for detail and to make optimization of the area for raw material that it used to realize the part. The last step is to choose the 3D printer settings and send the data to current 3D printer or save it in the G code.

The process of 3D printing of medical part is showed in Figure 19. The machine called *Type A Series 1 Desktop FDM Printer* [10].

The second part (gear) in this paper select to realize in *MAKEiT Pro-L* [11] as we see in Figure 20. Main characteristics of two machines are shown in Table 4.

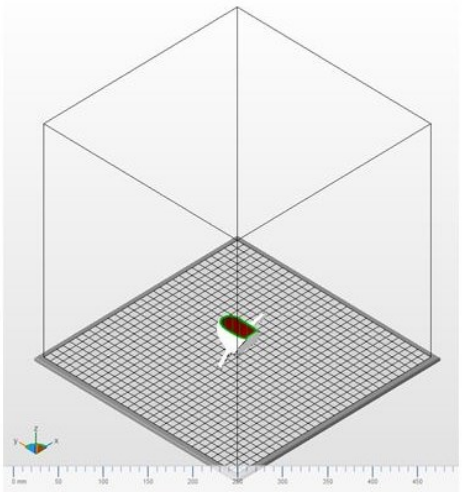

Fig. 19. Medical part – process of 3D printing

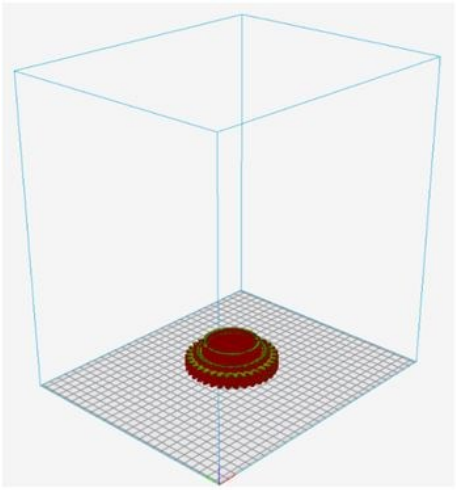

Fig. 20. Gear – process of 3D printing

It is very important the material that it used in two cases, PLA and ABS are the most frequently used materials for these printers. ABS has a main

problem: Its high rate of thermal expansion, which means that it expands and contracts with temperature changes quite easily. Layers closest to the extruder are warmer and contract causing tension in the lower layers. PLA, however, does not have this disadvantage, but its machining is more difficult. The general defects analyzed in two materials confirm that there are no major differences. In both cases general quality is the same and defects are similar [2].

T a b l e 4

Characteristics of two machines [10, 11]

Type A Serie 1 Dektop FDM Printer	
Technology	FDM
Build volume	305 mm × 305 mm × 305 mm
Material	PLA
Min. layer thickness	0.05 mm
MAKEiT Pro-L	
Technology	FFF
Build volume	305 mm × 254 mm × 330 mm
Material	ABS
Min. layer thickness	0.01 mm

The simulation in two softwares is made in different conditions. We can see *layer height "0.06 mm"* (means the quality of surface) is very important factor to increase and decrease the estimate printed time. Even if the print speed and travel speed can be almost 100% increased the total estimate print time is high than the part who is with medium accuracy "*0.3 mm"*. Print setups for both machines are shown in Table 5.

T a b l e 5

Print setup

	Type A Series 1 Desktop FDM Printer (medical part)	MAKEiT Pro-L (gear)
Layer height	0.3 mm	0.06 mm
Wall thickness	1.5 mm	1.5 mm
Infill density	20 %	20 %
Printing temp.	220 °C	210 °C
Diameter	1.75 mm	1.75 mm
Flow	100 %	100 %
Print speed	70 mm/s	140 mm/s
Travel speed	200 mm/s	300 mm/s
Size	72.242 × 51.022 × 50.00	97.4 × 97.5 × 38.8
Estimated print time	1 hr 16 min	9 hr 30 min

6. DISCUSSION

After analyzing two different parts with specific shape, application and characteristics we see some advantages and disadvantages during the flow from the beginning in to the finalizing. More clear is shown in Figure 21 the workflow step by step.

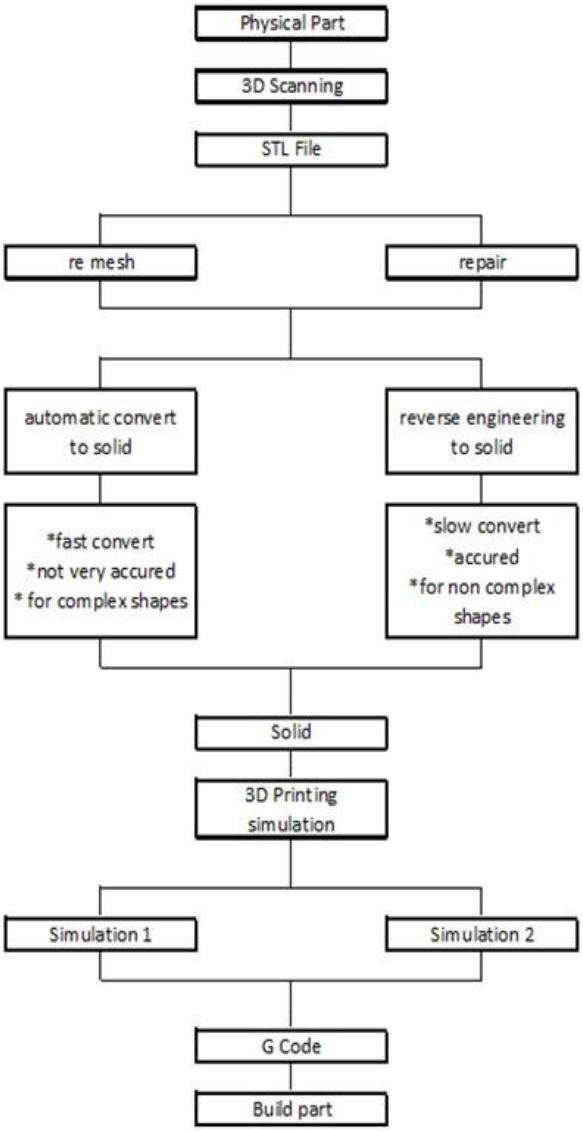

Fig. 21. Workflow structure

7. CONCLUSION

Two of methods for converting the STL file from 3D scanning to CAD solid part are presented in this paper. When we use the automatic converter form STL to solid, we have the shape not very accurate because of tolerance of sewing shape that is almost in all softwares 0.1 mm. If we decries this value in some cases the part start to lose the original

surface. When we use the reverse engineering method to resurface the sections and make different plane in surfaces, we can make the part more accurate but always to follow the right lines. *SpaceClaim* software has option to fit curves and reverse engineering option to rebuild the part very successful. It easy now to create it in solid form and save like STL file with some kilobytes.

Moreover, when the part is well resurfaced it is reasonable to make simulation before 3D printing in any machine, so making all optimizations for production. *Autodesk Netfabb* has a very good machine library, technical options and detailed preview. The results shown that accuracy of surface is main factor for making parts more reasonable economically and technically.

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Original scientific paper

COMMUNICATION FOR INNOVATION IN THE CONTEXT OF CORPORATE CULTURE – COMPETITIVENESS RELATIONSHIP*

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A b s t r a c t: The purpose of this article is to present the theoretical aspects of the problem the importance of organizational communication for the creation and introduction of innovations. The understanding of the importance of innovation for the successful development of the company is predetermined by the perception and management of an innovation culture as an integral part of the corporate culture. The presumption is the understanding of the role of corporate culture in enhancing the competitive advantages of the company. The theory is supported by an analysis of the results of a nationally representative survey of 1000 companies carrying out business activities in Bulgaria.

Key words: organizational communication; innovation; corporate culture; culture of innovation; competitiveness

ИНОВАЦИОНИ ЧЕКОРИ ВО ВРСКА СО ОДНОСОТ КУЛТУРАТА НА КОРПОРАЦИЈА – КОНКУРЕНТНОСТА

А п с т р а к т: Целта на оваа статија е да ги претстави теоретските аспекти на проблемот на важноста на организационите чекори за создавање и воведување иновации. Разбирањето на важноста на иновациите за успешен развој на компанијата е предодредено од перцепцијата и управувањето со иновативната култура како составен дел на корпоративната култура. Презумпцијата е разбирање на улогата на корпоративната култура во подобрувањето на конкурентските предности на компанијата. Теоријата е поддржана со анализа на резултатите од репрезентативната анкета на 1000 компании кои вршат деловни активности во Бугарија.

Клучни зборови: организациска комуникација; иновации; корпоративна култура; култура на иновации; конкурентност

1. INTRODUCTION. LITERATURE REVIEW

Corporate culture, communications, and relationships between the various processes in the organization have a significant impact on the realization of innovation in companies [1]. Communications are at the core of the organization, without them being impossible. Corporate culture is the one that determines the way you will realize communications and the extent to which attaches importance to the role for the effective development of the company. Communications, on the other hand, contribute to the smooth running of the overall management of the corporate culture in the organization – from its creation to its retransmission and maintenance, to its change.

a) *Innovation*

Innovation exists only in the context of the organization. Amabil and others [2] emphasize innovation as the successful implementation of the crea-

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tive ideas generated by members of the organization. Many definitions of innovation have been created, and what we will use is that "Innovation is: production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome" [3].

Innovation types are a product, process, marketing, and organizational. It is radical and incremental. Also viewed as open and closed. Open innovation requires an understanding of the importance of open communication with all groups of stakeholders in the organization, carried out transparently. Innovation is directly related to organizational learning, knowledge management, the ambidextrous nature of the organization and its manifestations as "learning" [4]. Innovation is a prerequisite for maintaining a longterm competitive advantage for the company. Some empirical studies prove the positive nature of the relationship innovation – the competitive performance of the organization [5].

Companies that focus on innovation activities are much more successful than others in the market.

b) *Corporate culture and innovation. Culture of innovation.*

Corporate culture is the framework that covers all processes in the organization, directly related to its strategy and structure. Corporate culture and organization management are interdependent. Corporate culture is the "social glue" that unites members of the organization and defines organizational behavior, organizational climate and communication climate. It supports the adaptation of the organization in the conditions of the constantly changing requirements of the environment and, hence, the enhancement of its competitive advantage [6].

Corporate culture is built up of values, norms, and beliefs that contribute to the introduction and application of innovation in the organization. Tushman and O'Reilly (1997) [7], who studied in depth management approaches culture of innovation, agree that management culture is the most overlooked and simultaneously the most appreciated tool that facilitates innovation and change.

For the competitiveness of the organization, its employees contribute greatly, which means that it is essential for companies to associate their goals with their own, stemming from the coincidence of personality and organization. It is the corporate culture that stimulates innovation behavior among the members of the organization. It directs employees in perceiving innovation as a core asset in the organization and can encourage their dedication to it.

To support innovation in the organization's corporate culture should ask for understanding innovation as an integral part of the constant change, i.e. innovation must be embedded in its "invisible levels" – the basic assumptions and values.

Essential elements of the innovation-supporting process are the empowerment of employees in the organization through open communication and information sharing, their participation in decision-making, the shared vision and common goals [8]. Innovative processes depend directly on the creative capabilities of the employees, the professionalism, the specialized knowledge they possess, acquire and apply, as well as their dedication to the realization of plans whose realization leads to the creation of value. Therefore, the organization gains a significant competitive advantage thanks to its employees, and this requires support and promotion of the opportunities for raising and developing their knowledge, skills, and talents. Those processes are an essential part of the conditions needed to perceive a culture of innovation as an integral component of corporate culture.

The culture of innovation must encourage the processes of creating and adopting new ideas that originate within or outside the organization. The presumption is the need to adapt to the everchanging requirements of the environment and the ability to gain competitive advantage. Communication is an essential part of the culture of innovation [4].

c) *Communication and innovation*

The communications of the organization are subdivided into internal and external, including management communication practices [9]. Modern trends in communications science and related research emphasize the importance of integration of the organization's communications that the separation between internal and external communications no longer exists [10].

Communication, with an emphasis on innovation, should present the value-creation capability of the company [11] to all groups of stakeholders to which it is bound. By communicating with internal stakeholders – managers, shareholders, and employees, it helps to understand the importance of innovation for the overall successful development of the organization, encourages support for its implementation. It is also necessary to increase the motivation for sustainability of attitudes towards innovation

[12]. Communication on innovation requires interactivity and continuous feedback. Internal communication is needed at every stage of the introduction of the culture of innovation [13].

For a long period, the approaches used by Media richness theory [14] are applied in the implementation of internal communication. From a strategic management point of view, this theory requires efficient managers to make rational choices by identifying the appropriate communication medium for the specific task and the degree of access it provides, depending on the specificity of the task itself. The modern development of communication theory leads to the essential conclusion that classification for the most accessible media is not necessary. In connection with the opportunities offered by new media whose development and widespread use make the onedimensional approach of Media Access Theory insufficient to cover all the parameters in which they can find expression [15]. The above requires the media to be used to implement communication processes with employees to be selected by the specific situation, the degree of ambiguity that the communication, the corporate culture and the available resources of the organization can cause.

More and more organizations use so-called unified communications as a service which involves the integration of audio and video conferencing, communication between members of the organization/organizations via web-based applications – chats, messenger, the applications mentioned above, mobile phones etc. are moving increasingly towards cloud technologies. Innovation in web-based technology also offers members of the organization and the other stakeholders a variety of communication channels – blogs, podcasts, wikis etc. – to increase communication efficiency by shortening the time for information exchange, facilitating knowledge management and overall communication effectiveness is positive. Social media are already an equal participant as a communication channel for realizing communication within the organization and between the organization and its key stakeholders. Leonardi et al. (2013) indicate that most organizations, regardless of their size, are introducing and using corporate social networking sites [16]. This type of technology allows and facilitates the consistency of interactive employee relationships. Social media is also an essential tool for managing customer relationships (CRM). Social media are extremely useful in the context of so-called "boundary spanning" functions, in fact, they remove the boundaries of the organization, no matter how contingent they are. The mentioned above enhances the absorption capacity of the organization and supports the generation of new ideas and innovation accordingly.

2. QUESTIONNAIRE SURVEY

For this article, we will look at the results of the *National Business Survey July–August 2015*. It is based on a closed-ended questionnaire including a representative sample of 1,000 companies doing business in Bulgaria. The ratio of micro / small / medium / large businesses is 60 : 30 : 10. Respondents are owners and top managers of companies. The method used is a standardized interview. We emphasize understanding of the importance of communication and innovation in the context of corporate culture as a prerequisite for enhancing competitive performance.

The respondents in the study predominate the representatives of the micro and small companies, followed by the medium ones, the largest number being the ones that represent the representative sample of the companies doing business in Bulgaria. According to the area of activity, medium and large firms operate primarily in industry, construction, transport, and communications (Figure 1).

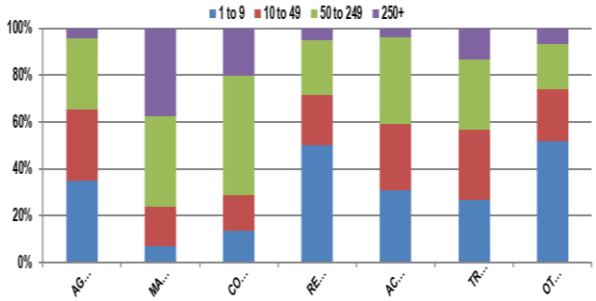

Fig. 1. Main business of the company / Number of employees

Regardless of the size of the companies, the majority of survey respondents (approximately 70%) are aware of the positive impact that corporate culture has on the competitive performance of the company. The most difficult is the definition of its character by microcompanies, and in the case of the big positive character, it finds the strongest confirmation (Figure 2).

Regardless of the sphere in which the companies surveyed take into account the positive impact that corporate culture has on the competitive perfor-

mance. Respondents from different spheres are beginning to realize the need to apply best practices in governance, leading amongst which is the creation and management of corporate culture (Figure 3).

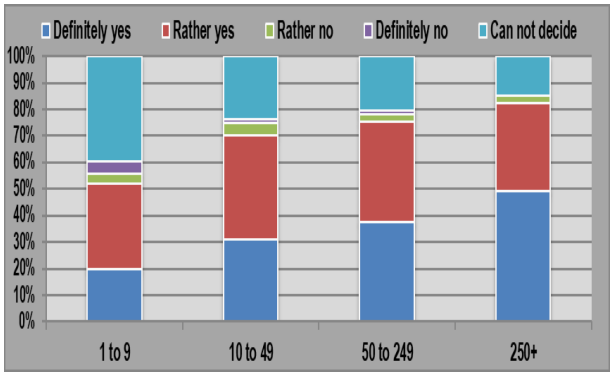

Fig. 2. Number of employees
Does your company's corporate culture support its economic performance (results)?

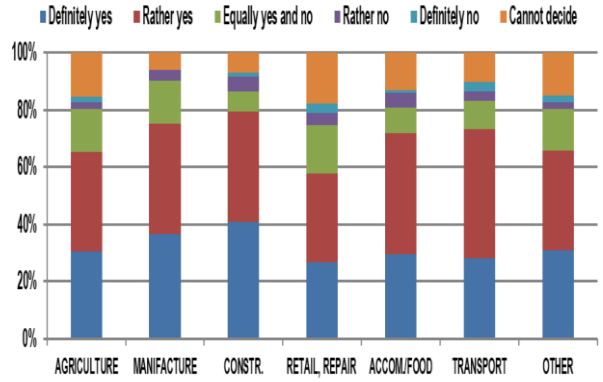

Fig. 3. The main business of the company
Corporate culture of your company does it support its economic performance (results)?

For the survey, we need to look at the distribution of innovative products and services developed in the last three years by the respondents. According to the number of employees in the surveyed enterprises, large companies are the ones that are most important in the creation and introduction of innovative products and services. They are followed by medium, small and, finally, by microcompanies. By answering this question, it is possible to trace the link between the processes of innovation and the resources owned by the companies. More important are resources of the larger and the smaller of the small companies, as well as the fact that among the Bulgarian business still, the application of good practices is most typical for large and medium sized companies (Figure 4).

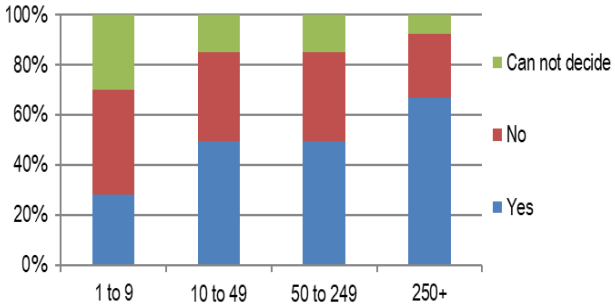

Fig.4. What is the number of employees in your company? / Has your company developed innovative products and services?

Positive support finds the link between developed innovative products in respondent firms and the relationship between corporate culture and competitive advantage. Approximately 20% of the companies surveyed develop innovative products; the other respondents are not oriented towards action in this direction. The reasons for this can be found in the lack of sufficient financial resources to implement innovations, lack of the necessary qualified human capital for their realization, incomprehension of the importance of innovation by the decision-makers in the companies, i.e. from top management (Figure 5).

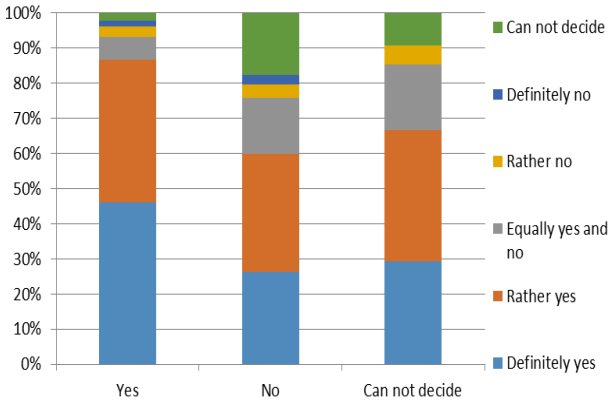

Fig. 5. Does your enterprise have innovative products and services developed?
Does your company's corporate culture support its economic performance (results)?

From the figures above we can note the following: Regardless of the size of the company, the preferred channel for the realization of the internal organizational communications is the direct manager, i.e. face-to-face. The e-mail and regularly conducted briefings are the next most preferred communication channels within the organization, followed by specialized training and the presence of an

intranet. The organization of seminars is among the priority communication channels of the medium and large companies, carrying out their business activities in Bulgaria. The use of print communication channels is deficient, the respondents who rely on them are mostly microcompanies. The positive trend is that a small number of respondents do not have a policy for realizing internal organizational communication (Figure 6).

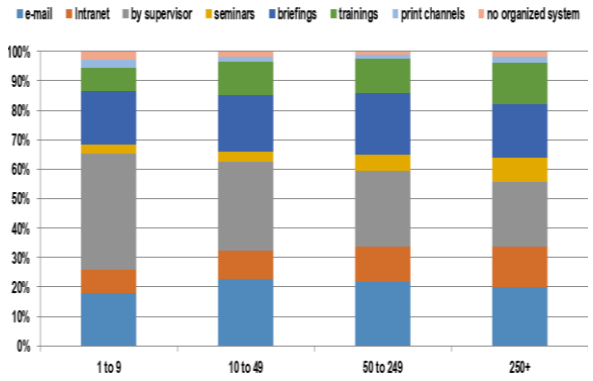

Fig. 6. What is the number of employees in your company? How do internal communications work in your company? _ E-mail, intranet, by supervisor, seminars, briefings, training, print communications, no policy

Regarding the use of the Internet and the social media, we can state that, according to data of the National Statistical Institute, by December 2015 the enterprises in Bulgaria with access to the Internet are 91.3%. Those with a corporate webpage are 48, 2%. Social media users for the organization, are 30% of the respondents (http://www.nsi.bg/bg/content/11652). There is still a small number of enterprises using socalled cloud services, according to NSI data – in 2015 they are 5.4%. Data for 2016 (http://www.pariteni.bg/index.phtml?tid=40&oid=203053) indicate that Internet access have 91.3% of the respondents, a corporate webpage created and maintain 50.7% of them; 31.7% of Bulgarian companies do not use social networks and every second company in our country has no own corporate website. The data reveal that more and more enterprises in Bulgaria provide handheld devices for their employees. By 2017, NSI (http://www.nsi.bg/bg/content/2841) data indicate that businesses in Bulgaria with access to the Internet are 94.6. Those with active web pages are 50.8%, social media users are 34.4% of respondents. The use of cloud services has increased compared to 2015, and the percentage is now 8. Of the large companies, 28.6% confirm that they use 11.7% of the average and 6.7% of the small ones.

According to various studies, e-mail is becoming an increasingly important channel for organizational communication, and face-to-face communication in a real environment is diminishing. Emphasis should be placed on the use of mobile applications, social media, text messaging, and social interaction tools to communicate in the organization and maintain the brand http://www.theemployeeapp.com/infographic-2016-digital-workplace-communications-survey/.

The channels for which investments are made are social intranet applications, corporate social applications, intranet, electronic newsletters, video and team meetings (https://www.slideshare.net/GrahamHollinger/internal-communications-survey-2017-infographic).

The global trend is towards unification of communication, which is an opportunity to overcome the information overload that can create the use of a variety of communication channels as well as a response to the expansion of the range of channels used to implement communication in organizations.

Regardless of the sphere in which the respondent companies carry out their business activities, the preferred channel of communication is by supervisor. The respondents from the tourism and hotel services sectors, from the transport sector and retail and repair of automobiles, rank it almost equally with the implementation of internal organizational communication through e-mail. The indicators of the companies in the construction sector are similar to those presented. The branches above also emphasize training for their employees.

The organization of seminars is primarily a priority for the representatives of industry and trade (Figure 7)..

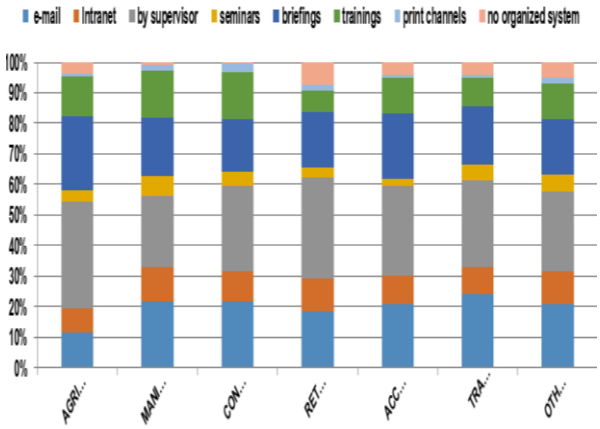

Fig. 7. What is the main activity of your company? How do internal communications are implemented in your company?

The results represented by the answer to the questions about the relation between the relationship between the corporate culture – competitiveness and the implementation of the internal communications traces the relationship between the understanding of the corporate culture of the company and the implementation of a planned internal organizational communication policy. Those who fully support the assertion of the positive impact of corporate culture are mostly communicating with internal stakeholder groups through the use of a variety of communication channels. This statement is largely valid for respondents for whom corporate culture has a positive impact on the performance of the company.

Respondents who deny the link are the minimum number.

The relationship between the understanding of the role of competently implemented internal organizational communication and its motivating importance for the employees of the company is traceable. Respondents of the companies that have a defined internal communications policy implemented through a variety of communication channels strongly confirm its importance.

A small number of respondents hesitate, the deniers are an insignificant percentage, and they are the main number of respondents who do not have a planned communication policy with internal stakeholders (Figures 8 and 9).

Respondents in the research that develop innovative products and services implement an internal organizational communication policy through a combination of different communication channels. A significant percentage of them focus on training and seminars as well as intranet use. Nonperforming innovators also carry out organized intracommunications policy but among them a large number of respondents who do not have one, while there is virtually no such companies, indicating the relevance of the relationship between the implementation of innovation and the communication policy of organizations (Figure 10).

The orientation towards innovation in companies also correlates with the understanding of the motivating effect of the internal organizational communication, which is directly related to its competent planning and implementation. Companies that realize innovative products and services support the strongest claim to the motivating effect of communication in the organization on employees to successfully carry out their day-to-day activities and to understand the vision of the organization.

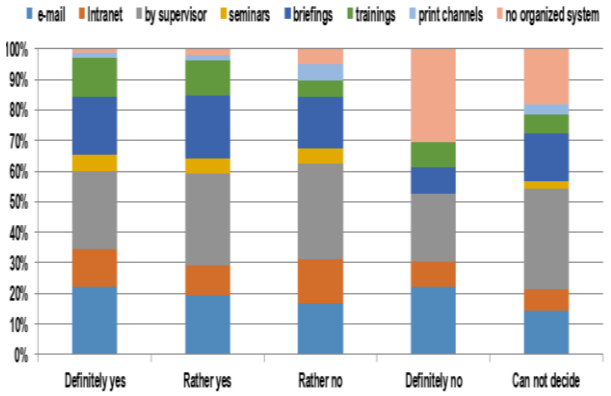

Fig. 8. Does your company's corporate culture support its economic performance (results)?
How do internal communications work in your company?

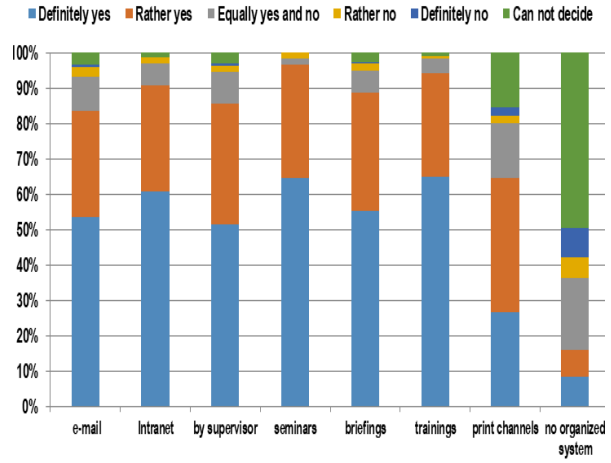

Fig. 9. How do internal communications work in your company?
Does the internal communication system in your company motivate employees to perform their duties?

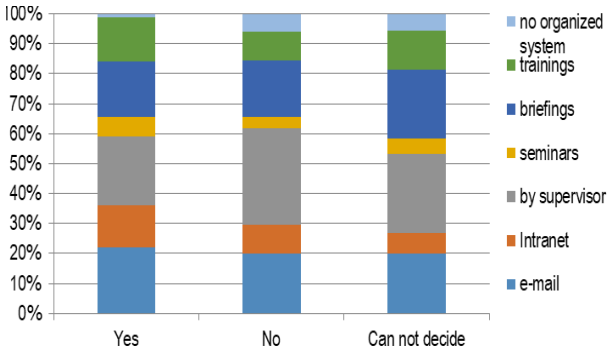

Fig. 10. Does your enterprise have innovative products and services developed? How do internal communications are implemented in your company?

A minimum number of respondents categorically deny the existence of such a link. Respondents who did not innovate and those who can not judge also supported the claim for the incentive effects of

internal organizational communication to employees, but to a lesser degree, as they expressed in a significant proportion of fluctuating valuation of influence. Those who categorically deny the introduction of innovation are the highest percentage and strongly reject the statement of communication – motivation (Figure 11).

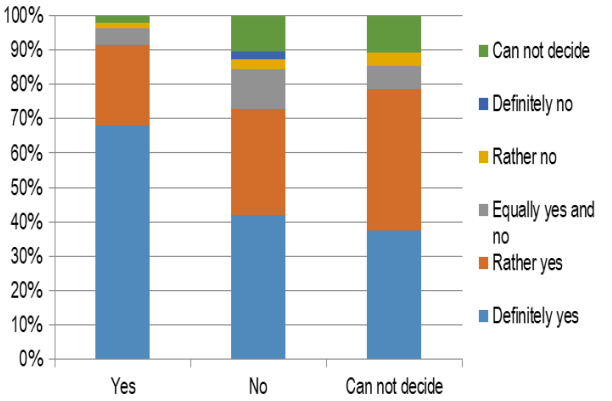

Fig. 11. Has your enterprise developed innovative products and services? Does the internal communication system in your company motivate employees to perform their duties?

3. CONCLUSION

In conclusion, we can say that among the Bulgarian business, the tendency to innovate is still not widely supported. As a development recommendation for innovation, emphasis should be placed on access to research results, research laboratories, knowledge transfer and technology transfer.

In the context of the concept of open innovation, it is necessary for Bulgarian companies to orient themselves towards different forms of cooperation – not only with companies of similar size and scope but also with research and educational institutions, as well as with the establishment of partnerships of different sizes companies.

There is a clear link between the attitude towards innovation and the understanding of the positive impact that corporate culture has on the overall competitive performance of the company, as well as the implementation of a competently planned internal communication policy and the understanding of its motivating effect for employees.

For the equal presentation of Bulgarian companies in the international markets, it is necessary to adopt and apply the innovations as an essential part of the positive organizational performance and development.

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Original scientific paper

SELECTION OF A SUPPLIER OF THERMOPLASTIC INTERLINING BY NUMERICAL EVALUATION MATRIX*

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A b s t r a c t: In this paper the methodology for supplier selection of fusible interlining for men's shirts is presented. The first step of supplier selection starts with the identification of suppliers of support materials, evaluation of quality, and the evaluation of economic and commercial performance of potential suppliers by the following criteria: quality of fusible interlining, procurements cost, supplier operational capability, financial stability and additional services offered. Evaluation of suppliers is made by numerical evaluation of sub-criteria, and the final selection is made by summation of the "weight" of particular features.

Key words: supplier evaluation; quality; procurements cost; operational capability; financial stability; additional services

СЕЛЕКЦИЈА НА ДОБАВУВАЧ НА ТЕРМОПЛАСТИЧНА МЕЃУПОСТАВА СО ПРИМЕНА НА МАТРИЦА ЗА НУМЕРИЧКА ЕВАЛУАЦИЈА

А п с т р а к т: Во трудот е претставена методологија за избор на добавувач на помошниот материјал термопластична меѓупостава за фиксирање на машка кошула. Процесот на селекција на добавувач започнува со идентификација на претпријатија кои работат како добавувачи на помошни материјали и испитување на квалитетот, а потоа се прави евалуација на економските и комерцијалните перформанси на идентификуваните добавувачи преку критериумите: квалитетот на термопластичната меѓупостава, трошоците за набавка, оперативната способност и финансиската стабилност на претпријатието и дополнителните технички услуги кои тоа ги нуди. Оценувањето и селекцијата на добавувачите се направени преку нумеричка евалуација на супкритериуми, а крајниот избор на добавувач е направен преку сумирање на „тежините" за одделни карактеристики.

Клучни зборови: термопластична меѓупостава; евалуација; добавувач; квалитет

INTRODUCTION

Suppliers have a critical role in achieving quality objectives. It is clear that if the quality of the raw materials is low, a high quality finished product cannot be achieved. Therefore, companies pay great attention to the quality of the purchased materials by inspecting the materials for: spotting scraps, faults, operation performance, etc. [1]. Decisions made concerning the selection of a supplier are different from one enterprise to another. Companies that understand the supply management well, base the selection decision on the attributes of their needs. The selection process includes strategy and development, assessment, long-term contacting and negotiation. Each selection decision has some degree of uniqueness, i.e. there is not only one way to evaluate and select suppliers. However, all selection decisions should follow a particular law of logic, from the identification that there is a need for selection to the extension of the contract with the selected supplier. Decisions on selection of suppliers are made by monitoring the lists created during the pre-classification phase of the supplier. These are complicated decisions because different criteria are taken

* This work was presented at the *International Scientific Conference Green Development, Green Infrastructure, Green Technology - GREDIT2018,* 22–25 March 2018, Skopje.

into account. A significant number of quantitative and qualitative attributes of the supplier are examined, and the evaluation of suppliers is realized by using objective and subjective criteria [2]. In this paper a selection of a supplier of thermoplastic interlining casual men's shirt was made based on the previously set criteria. Companies, potential suppliers are evaluated through the quality of the products offered and their economic commercial performance.

EXPERIMENTAL SECTION

1. *Defining needs and identification of potential suppliers of thermoplastic interlining*

A large participation in the overall production of men's shirts is the creation of a casual men's shirt. The specification of the fabric for which we require a compatible thermoplastic interlining for fusing of the collar, under collar and cuffs of a men's shirt is given in Table 1. For fusing of the fabric, *we need white, woven, soft, lightweight, thermoplastic interlining, with cotton base and high density polyethylene coating.*

T a b l e 1

Characteristics of the fabric used in tests

Composition	Weight g/m^2	Warp density cm^{-1}	Weft density cm^{-1}	Color
100% cotton	125	56	38	Blue

By contacting the managers of the clothing companies from the wider eastern region of the Republic of Macedonia, and by searching supply portals, three companies, potential suppliers of thermoplastic interlining, have been identified. Company data is collected from web portals, their product catalogs and in direct contact with their managers. The first company is the company "Coats" from Bulgaria, which is part of the family of the group "Coats" with headquarters in England. The interlining assortment the company "Coats" is produced by manufacturers "Wendler" from Germany and “Permess” from Netherlands.

The second enterprise is "Elviet" from Štip. It is a trading company that works only with auxiliary materials for ready-made production. This is a Greek company founded in 2006 in Štip, the Republic of Macedonia. In regard to the thermoplastic interlining, the company "Elviet" has a direct cooperation with manufacturers of thermoplastic interlining from France and Spain. It has cooperated with the manufacturer "DHJ Internacional" from France since 2009, and since 2010 it has been cooperating with the manufacturer "Staflex" from Spain.

The company "Niko 2002" was founded in 2002 in Štip. This is a trading company that sells retail and wholesale of base and auxiliary materials for ready-made production. What is specific about this company is that it has not established cooperation with any manufacturer of thermoplastic interlining. Since there is no continuous cooperation with manufacturers of thermoplastic interlinings, the quantities they have from a particular manufacturer are available for a certain period. Therefore, in this case, the re-supply of thermoplastic interlining of a particular type may be a problem in the event deficiency in production. The manufacturer of the thermoplastic interlining is “Freudenberg” from Germany.

The specifications of the thermoplastic interlinings offered by the companies potential suppliers are given in Table 2.

T a b l e 2

Specification of thermoplastic interlinings offered by identified potential suppliers

Supplier	“Coats“ – Bulgaria	“Elviet“– Macedonia	“Niko2002“-Macedonia
Article	*“Wendler“* DV 31	*“*Staflex“	Freudenberg
Composition	Base:100% cotton, woven; Coating: PE HD, microdots	Base:100% cotton, woven; Coating: PE HD, microdots	Base:100% cotton, woven; Coating: PE HD, microdots
Weight, g/m^2	100	110	80
Width, m	0.9	0.9	0.9
Touch	Very soft	Very soft	Very soft
Fusing conditions	T = 160 – 165°C P = 2 – 3 bar t = 12 – 18 s	T = 150 – 170 °C P = 1.8 – 2.5 bar t = 12 – 17 s	T = 143 – 166°C P = 0.8 – 3 bar t =12 – 18 s
Care instructions	Washing T = 95°C Ironing: T = max. 150°C	Washing T = 95°C Ironing: T = max. 150°C	Washing T = 95°C Ironing: T = max. 150°C
Density, cm^{-1}	Warp 23, Weft 21	Warp 23, Weft 21	Warp 24, Weft 21

2. Criteria for evaluating the supplier

Evaluation of suppliers is obtained as a complex assessment based on several criteria. The quality of the product is always taken as one of the criteria. Other criteria that are evaluated are in fact the economic and commercial performance of the supplier. Accordingly, the evaluation of the supplier of thermoplastic interlining is made on the basis of the following criteria: quality of the thermoplastic interlining offered by the companies; procurement costs; operational capability of companies; financial stability of companies; additional services offered by companies. The data based on which the analysis of the companies was carried out according to the above criteria and their evaluation are obtained from experimental pre-production testing and in direct conversation with the companies' managers. Preproduction testing is essential for comparing the quality of different types of interlinings, i.e. interlinings from different suppliers.

3. Examination of the quality of the selected thermoplastic interlinings

The evaluation of the quality of the selected thermoplastic interlinings is done by examining the properties: the bonding strength before and after fusing, banding rigidity and dimensional stability of the laminate of the fabric with the thermoplastic interlining. The testing of the bond strength of the fixed textile material is done according to the standard ASTM D 2724 – (07)2015 [3]. The standard ISO 3759:2011 is applied to determine the dimensional changes in textile materials [4]. The method of this standard is intended to examine the dimensional stability of the fabric and the laminate, before washing and after washing. The standard BS 3356:1990 is applied to determine the banding rigidity of textile materials [5]. The selected fusing parameters are part of the factors intervals in the specifications of the individual thermoplastic interlinings given by the manufacturers, Table 3.

T a b l e 3

Fusing parameters

Type of interlining	Weight, g/m^2	Fusing parameters		
		T, °C	*P*, bar	*t*, s
Freudenberg	80	160	2	15
Wendler DV 31	100	160	2	15
Staflex 3620	110	160	2	15

Legend: *T* – temperature; *P* – pressure; *t* – time

RESULTS AND DISCUSSION

1. *Evaluation of companies potential suppliers*

Through numerical evaluation, all sub-criteria of a particular criterion are analyzed individually and independently, i.e. isolated from other sub-criteria and are rated with a certain number of points from which the sum is ultimately calculated. The number of points by which the sub-criteria are evaluated ranges from 1 to *n*, where *n* is the number of potential suppliers that are compared according to the criterion. One point is assigned to the supplier for which the evaluator considers that it least meets the sub-criterion or does not meet it at all, and the highest number of points, or *n* points, is assigned to the supplier for which the evaluator considers that it most meets the sub-criterion. The points of the criterion are calculated as the sum of the points of the sub-criteria for each supplier respectively. Suppliers are ranked according to the criterion points. The values of the numerical evaluation of potential suppliers in relation to the sub-criteria of a particular criterion are entered into the matrix [6].

- *Evaluation of companies according to the criterion "**quality**"*

For the evaluation of companies according to the criterion "**quality**", a matrix has been created in which the values of the numerical evaluation for each quality sub-criterion are written. The quality of the offered thermoplastic interlinings as a criterion for the evaluation of companies, potential suppliers, is analyzed through: bonding strength before and after washing, dimensional stability and banding rigidity. The results of testing the bonding strength are given in Table 4.

T a b l e 4

Bonding strength between the fabric and the thermoplastic interlinings (cN/cm)

Properties	Laminate		
	Freudenberg	Wendler	Staflex
Bonding strength before washing,	236.6	142.3	218.3
Bonding strength after washing	266.4	127.7	174.3

According to the results, the highest bonding strength has the laminate “Fabric/Freudenberg”, then “Fabric/Staflex”, while the weakest bonding strength has the laminate “Fabric/Wendler”. The standards for testing bonding strength of the laminate do not indicate the minimum strength of bond. However, in the literature and in practical experience, it can be found that the bonding strength should be at least 10 N/5cm or 200 cN/cm [7]. If this value is taken into account, the laminates “Fabric/Freudenberg” and “Fabric/Staflex” generally have the required bonding strength. The laminate “Fabric/Wendler”, in all cases, has a bonding strength weaker than the minimum.

The results of the banding rigidity test are given in Table 5. Samples cut in warp direction have greater banding rigidity than samples cut in weft direction. This is due to the higher density of the warp yarns in the structure of the thermoplastic interlining and the outer fabric. All the analyzed thermoplastic interlinings have a higher density by warp than by weft, and therefore this is a phenomenon found in all examined samples. It can be concluded that the application of interlining with an appropriate surface mass, can influence the banding rigidity of the laminate, and hence the aesthetic properties of the clothing. The data on the banding rigidity of the laminate can be used as a parameter in the process of selecting a thermoplastic interlining in relation to the aesthetic appearance of the clothes we want to achieve.

T a b l e 5

Calculated a banding rigidity of the outer fabric and the three laminates

Sample		Fabric (A)	Staflex laminate (B)	Freudenberg laminate (C)	Wendler laminate (D)
Weight, g/m^2		125	110+125	80+125	100+125
Banding rigidity, cN cm	warp	1.06	14.58	6.12	10.55
	weft	0.94	9.76	5.57	8.29

From the testing of the dimensional stability, there is no dimensional changes in the examined samples after washing. From the results it can be concluded that the base fabric and the thermoplastic interlinings are dimensionally stable. If the two components in the laminate have a different shrinking ability, a dimensional change will occur under the influence of the component that has a lower dimensional stability.

Evaluation of potential suppliers is shown in Table 6.

T a b l e 6

Evaluation matrix of potential suppliers according to the criterion "quality"

Criterion with subcriteria	Potential supplier of thermoplastic interlining					
Quality	“Coats“ (“Wendler“)		“Elviet“ (“Staflex“)		“Niko 2002“ (“Freudenberg“)	
Bonding strength before washing	lowest	1	medium	2	highest	3
Bonding strength after washing	lowest	1	medium	2	highest	3
Dimensional stability	excellent	3	excellent	3	excellent	3
Banding rigidity	low	3	medium	3	high	3
Sum		8		10		12

The banding rigidity of the collar and the cuffs of a men’s shirt, as an aesthetic feature, depends on the type of shirt produced, but it mostly depends on the designer's idea of the product’s appearance. In practice, the assessment of the banding rigidity of the fused parts of clothes is the result of an internal evaluation within the clothing company during product development. Based on this, when we evaluate the companies according to the sub-criterion "banding rigidity", although the values obtained from the banding rigidity test are different, all companies are rated with the highest number of points.

- *Analyzing and evaluating companies according to the criterion **"costs"***

The procurement costs are composed of the price to be paid for the product and of the additional costs consisting of the costs of transport, customs and interest. Effective reduction of the procurement costs of raw materials can greatly contribute to increasing the economy in the production process. Procurement costs as a criterion for evaluating companies, potential suppliers, are analyzed through: product price, transport costs, payment method, discount opportunities.

For fusing a parts of casual men's shirt as cuffs, collar and undercollar, the average consumption of thermoplastic interlining of 0.9 m width is 0.1 m. For the evaluation of companies according to the criterion "**costs**", a matrix has been made in which the values of the numerical evaluation for each sub-criterion are entered. Evaluation of potential suppliers according to the criterion "costs" is shown in Table 7.

- *Analyzing and evaluating companies according to the criterion "**operational capability**"*

The operational capability of suppliers is defined by the ability to meet the demands of textile companies, then their efficiency, the way they work and their capacities. Operational capability as a criterion is analyzed through the following sub-criteria: number of employees in the company, assortment of thermoplastic interlinings, mode of operation, time required for delivery (Table 8).

- *Analyzing and evaluating companies according to the criterion "**financial stability**"*

The supplier's good financial condition gives the clothing company confidence that the supplier company will operate while the cooperation agreement lasts. The profit and financial stability of the suppliers is linearly dependent on the number of associates and the sales made by the company.

The following sub-criteria were taken as indicators of the "financial stability" of companies - potential suppliers: number of realized cooperation agreements as a supplier, number of newly agreed cooperation agreements per year, quantity of thermoplastic interlining delivered annually and realized profit (Table 9)

T a b l e 7

Evaluation matrix of potential suppliers according to the criterion "costs"

Criterion with subcriteria	Potential supplier of thermoplastic interlining					
Procurements cost	"Coats"	("Wendler")	"Elviet"	("Staflex")	" Niko 2002"	("Freudenberg")
Price / piece	10.1 denars	1	9.8 denars	2	6.2 denars	3
Transport	Included in the price	3	At the buyer's expense	1	At the buyer's expense	1
Method of payment	In cash/with invoice	3	In cash/with invoice	3	In cash/with invoice	3
Discount	2% in cash	3	No	1	By agreement	2
Sum		10		7		9

T a b l e 8

Evaluation matrix of potential suppliers according to the criterion "operational capability"

Criterion with subcriteria	Potential supplier of thermoplastic interlining					
Operational capability	"Coats"	("Wendler")	"Elviet"	("Staflex")	"Niko 2002"	("Freudenberg")
Number of employee	70 (seventy)	3	6 (six)	1	28 (twenty eight)	2
Assortment	Wide	3	Medium	2	Small	1
Method of operation	Stock/Order/Prediction of the buyer needs	3	Order	1	Stock/ Order	2
Delivery time	Stock: 2–3 days Order: 1–2 weeks	2 3	There is no stock Order: 1–2 weeks	1 3	Stock: 1 day Order: 2–3 weeks	3 2
Sum		14		8		10

T a b l e 9

Evaluation matrix of potential suppliers according to the criterion "financial stability"

Criterion with sub-criteria	Potential supplier of thermoplastic interlining					
Financial stability	"Coats"	("Wendler")	"Elviet"	("Staflex")	"Niko 2002"	("Freudenberg")
Number of contract	1500	3	400	1	500	2
Number of new contract/year	100	3	60–70	1	70–80	2
Shipping (m/year)	1.5 million	3	30 thousand	1	60 thousand	2
Profit (eur/year)	10 million	3	20 thousand	1	500 thousand	2
Sum		12		4		8

- *Analyzing and evaluating companies according to the criterion **"additional services"***

Additional technical services offered by companies as suppliers are considered to belong under the criterion "**additional services**". Suppliers from the textile industry that work for some time with some product need to know the quality of the product, and, in the event of some unwanted situations in the production process, they should help the manufacturer to remove them and advise them how to avoid these in the future.

The company "Coats" from Bulgaria has distributed managers in respective regions (countries) who once a week or once in two weeks visit clothing companies in the region. They talk with production technicians about the problems that arise during the fixing process and the production process and give different advice on how to solve them. The manager of "Coats" for Macedonia visits all the clothing companies that cooperate with the company "Coats" every week.

The company "Elviet" does not offer any additional technical services, except the supply with auxiliary material.

T a b l e 10

Evaluation matrix of potential suppliers according to the criterion "additional services"

Criterion	Potential supplier of thermoplastic interlining		
Additional services	"Coats" ("Wendler")	"Elviet" ("Staflex")	"Niko 2002" ("Freudenberg")
Participates in the production process	yes 3	no 1	no 1
Sum	3	1	1

The company "Niko 2002" deals only with sales, it does not offer any other services that would be helpful to the clothing company in the production process.

Based on the above explained, the company "Coats" was rated with the highest number of points 3, while the other two companies were rated with 1 point. In fact, these are the points according to which the companies were ranked according to the criterion "**additional services**" (Table 10).

2. Supplier selection

The final ranking of companies is done by comparing their total "weights". The total "weight" of a company is calculated as the sum of the multiplication product of the "weight of the criterion" and "weight coefficients of the company for each criterion". The allocation of "weight coefficients to the criteria" in order to determine the "weight of the criteria" is based on the experience and expertise of the evaluator. In the process of evaluation, it is desirable that a larger number of persons take part in order to make the evaluation more objective.

The "criterion weight" is calculated for each criterion according to which the evaluation of the companies is made, which are: quality, costs, operational capability, financial stability, and additional services.

A comparison of the criteria in pairs has been made. The criteria of each pair are given a "weight coefficient" 1 or 0, based on the significance of the evaluation criterion according to the evaluator, Table 11. The "weight coefficient" 1 is given to the criterion that is considered to be of greater significance for the evaluation of potential suppliers, and "weight coefficient" 0 is given to the criterion which the evaluator considers to have less significance for the evaluation.

T a b l e 11

Comparison of evaluation criteria of potential suppliers

		Criteria				
		I	II	III	IV	V
No	Combination	Quality	Cost	Operational capability	Financial stability	Additional services
1	I:II	1	0			
2	I:III	1		0		
3	I:IV	1			0	
4	I:V	1				0
5	II:III		1	0		
6	II:IV		1		0	
7	II:V		1			0
8	III:IV			1	0	
9	III:V			1		0
10	IV:V				1	0
	Sum	4	3	2	1	0

The number of comparisons between the criteria is calculated according to the following equation [1]:

$$\frac{n(n-1)}{2} = \frac{5\cdot(5-1)}{2} = \frac{20}{2} = 10\ldots, \qquad (1)$$

where: n is the number of criteria that are taken into account for the evaluation of companies.

The "weight coefficients" given to each criterion in comparison with the others are added and then the sum (Σ) is divided by the total number of comparisons made, equation (2). The calculated value is the "*weight of the criterion*".

$$W_c = \frac{\sum C_{W_c}}{n}. \qquad (2)$$

The calculated values for the "weight of the criteria" (W) are:

W_c (quality) = 4/10 = 0.4

W_c (financial stability) = 1/10 = 0.1

W_c (procurement cost) = 3/10 = 0.3

W_c (additional services) = 0/10 = 0

W_c (operational capability) = 2/10 = 0.2.

The next step is to calculate the total "company weight". In order to determine the "weight coefficients of a company" for each criterion, companies are compared in pairs in relation to each individual criterion. The determination of the "weight coefficients of a company" for each criterion is based on the previously made ranking of potential suppliers through the numerical evaluation of the sub-criteria. The company, from one pair, which is ranked at a higher level, receives a "weight coefficient" 1, and the second company from the pair is given a "weight coefficient" 0, Table 12 [8, 9].

T a b l e 12

Comparison of potential suppliers according to the evaluation criteria

	Potential supplier					
Criteria	A : B		B : C		A : C	
Quality	0	1	0	1	0	1
Cost	1	0	0	1	1	0
Operational skills	1	0	0	1	1	0
Financial stability	1	0	0	1	1	0
Additional services	1	0	1	0	1	0

Legend: A – Company "Coats" , B – Company "Elviet", C – Company "Niko 2002"

In relation to the "additional services" criterion, the company "Elviet" and the company "Niko 2002" do not provide any additional technical services. When comparing these two companies by the criterion "additional services", Table 12 shows a "weight ratio" 1 given to the company "Elviet" and 0 to the company "Niko 2002"

because the responsiveness and access to customers by the General Manager and the employees in “Elviet” are at a higher level.

After calculating the "weight of the criteria" and after determining the "weight coefficients of the companies”, for each criterion the total "weight" of potential suppliers is calculated. The calculations for the total "weight" of potential suppliers are given in Table 13.

T a b l e 13

Calculation of the total "weight" of potential suppliers

Criterion	A	B	C
Quality	0×0.4 = 0	1×0.4 = 0.4	2×0.4 = 0.8
Procurement cost	2×0.3 = 0.6	0×0.3 = 0	1×0.3 = 0.3
Operational skills	2×0.2 = 0.4	0×0.2 = 0	1×0.2 = 0.2
Financial stability	2×0.1 = 0.2	0×0.1 = 0	1×0.1 = 0.1
Additional services	2×0 = 0	1×0 = 0	0×0 = 0
Total weight	1.2	0.4	1.4

Legend: A – Company "Coats" , B – Company "Elviet", C – Company "Niko 2002"

The total "weight" of the companies is the criterion according to which the companies are ranked and on the basis of which the final selection of the company with which cooperation will be established as a supplier of thermoplastic interlining for partial fixation of a men's shirt. The company "Niko 2002" from Štip has the largest "weight" and is ranked number 1.

1. Company "Niko 2002" from Štip.
2. Company “Coats“ from Bulgaria.
3. Company “Elviet“ from Štip.

For a simpler explanation of the impact of the criteria in the overall "weight" of a company, that is, in the final decision on the choice of the supplier of thermoplastic interlining, the distribution of the criteria in the total "weight" of each company are graphically presented in Figure 1.

Figure 1 shows that in the total "weight" of the company "Niko 2002", which is also our choice for the supplier of thermoplastic interlining, the quality of the offered interlining has the biggest participation, 57.14%. In the total weight of this company the criterion "costs" has a participation of 21.43%, the criterion operational capability 14.29%, and the criterion of financial stability 7.14%.

The "Coats" company has a greater weight in the "costs", "operational capability", and "financial stability" criteria compared to the company “Niko 2002”, but in the criterion “quality” it has no weight, i.e. the value for the weight of the quality is 0. The total "weight" of the company "Elviet" is formed only from the quality of the thermoplastic interlining offered by this company.

From the above explanation, it is clear that for the selection of a supplier of thermoplastic interlining, as well as of some other auxiliary material, the most important criterion to be satisfied is the quality. However, we should not rely solely on quality, since the quality only is not sufficient in choosing a supplier of thermoplastic interlining, as is shown by the results of the analysis of the company "Elviet".

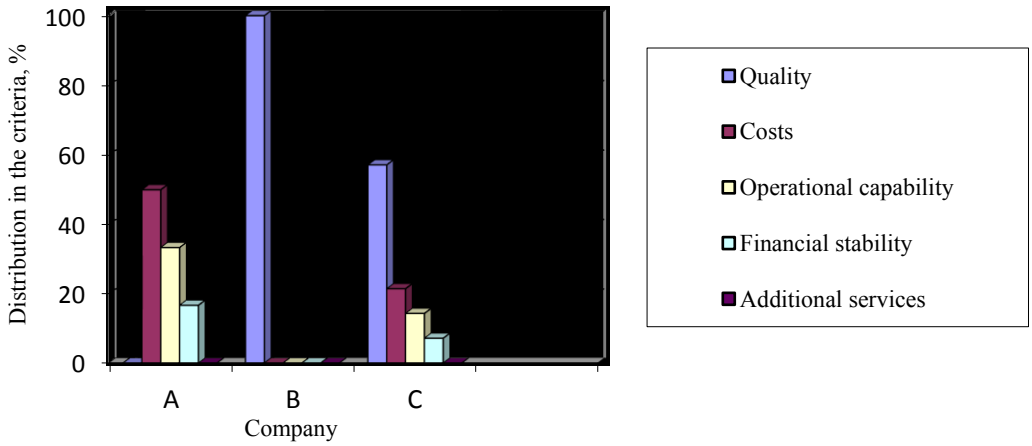

Fig. 1 Distribution of the criteria in the total "weight" of companies
A – Company "Coats", Bulgaria, B – Company "Elviet", Štip, C – Company "Niko 2002", Štip

It should be noted that the standards for testing the bonding strength and the quality standards of ready-made clothing products do not give the value of the minimum bonding strength. The value of the minimum bonding strength of 200 cN/cm resulted from industrial practice. Accordingly, the minimum bonding strength, in most cases, for respective types of clothing will be defined by the clothing manufacturer in the product development process. In this sense, if the bonding strength is not discussed in terms of the mentioned minimum bonding strength, the supplier "Coats", as it shows by far the best assessment for economic commercial performance, would certainly be the first choice for a supplier.

CONCLUSION

The selection process and the decision which supplier to choose for auxiliary materials in the fashion industry, such as production of clothing, is a rather complex process. In conditions of high competition in this sector, the inclusion of engineering and scientific methods is of great help in forming a comprehensive assessment of the quality of suppliers. From the evaluation of potential suppliers on the basis of the defined criteria, it can be concluded that quality is the criterion that usually has the largest participation in reaching the final decision on the choice of the supplier. Nevertheless, in order to select an appropriate supplier, other criteria must be taken into account in order to obtain a complex assessment based on multiple criteria.

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Original scientific paper

TREATMENT OF WASTE WATER IN LEATHER INDUSTRY*

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A b s t r a c t: A very important issue in the leather industry is the use of a variety of chemicals that are harmful if released into the environment especially the effluents that are released in the rivers. In the leather manufacture and processing industry, a vaste amount of water is used where the quantity depends on the type and technological treatment employed. Therefore, the effluents from the different treatments vary in the type and content of various chemicals. In order to prevent the environmental pollution of the rivers-recipients of these effluents, it is necessary to develop and employ appropriate waste water treatment procedures for their purification prior to release in the environment. In this article, several concepts are suggested that may be employed for waste water treatment in the leather industry. These concepts use both classical and modern methodologies for waste water treatment by handling the overall combined effluent after homogenization and precipitation or by using separate treatments of effluents from different leather production phases. Special attention in this study has been paid to the treatments for elimination of chromium and sulphides from the waste waters from leather industry.

Key words: leather industry; waste water treatment; chromium; sulphides

ТРЕТМАН НА ОТПАДНИТЕ ВОДИ ВО КОЖАРСКАТА ИНДУСТРИЈА

А п с т р а к т: Многу важно прашање во кожарската индустрија е употребата на различни хемиски супстанци кои се штетни доколку се испуштаат во животната средина, особено ако отпадните материи се испуштаат во реките. При производството и преработувачката на кожа се користи огромно количество вода, при што количеството зависи од видот на кожата и од применетиот технолошки третман. Затоа отпадните материи од различни третмани се разликуваат по видот и содржината на различните хемиски супстанци. Со цел да се спречи загадувањето на реките реципиенти на овие отпадни материи, неопходно е да се развијат и да се применуваат соодветни постапки за третман на отпадните води за нивно прочистување пред испуштањето во животната средина. Во овој труд се предлагаат неколку концепти кои можат да се користат за третман на отпадните води во кожарската индустрија. Овие концепти ги користат и класичните и современите методологии за третман на отпадни води при ракување со целокупните отпадни материи по хомогенизација и таложење, или при користење на посебни третмани на отпадните материи од различни фази на преработката на кожа. Посебно внимание во ова испитување е посветено на третманите за елиминација на хромот и сулфидите од отпадните води од кожарската индустрија.

Клучни зборови: кожарска индустрија; третман на отпадни води; хром; сулфиди

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1. AIMS AND BACKGROUND

Releasing harmful effluents into the environment especially into surface waters has been recognized as the main environmental issue of the leather industry [1–4]. Vast amount of technical water is utilized in the leather manufacturing and individual processes, and the quantity depends on the specific type of processing and the technological procedures. The leather treatment technology involves several processes that are carried out in separate departments that differ in the quantity of water needed. The largest quantity of the water is used in the phases of washing the leather.

The effluents obtained in the leather processing procedures differ in the type and content of chemicals used in the different leather processing facilities. These effluents contain huge amounts of inorganic chemicals, mostly NaCl, $Ca(OH)_2$, Na_2S, chromium salts etc. Also, in the phase of preparing the leather for tanning, a lot of proteins and other organic compounds come into the water effluent. The main characteristics of the pooled aqueous effluent are the variable composition, high contents of total solid, dissolved and suspended matter, sporadic high concentrations of chromium and sulfides, high concentrations of chlorides and sulfates, susceptibility to biochemical degradation processes in the presence of high organic matter contents, etc. All these chemicals in the leather industry effluents have an enormous negative environmental impact [5–7].

The quality of waste waters depends not only on the technological process, but also on the nature of the raw material that is being processed. For example, when processing the calf leather there is much higher concentration of organic matter in the effluent compared to the effluent from cow leather processing. On the other hand, the effluents from fur processing facilities, compared to the ones from leather processing ones, are less alkaline and do not practically contain suphides. However, they have the highest hydraulic and organic loading and the highest chlorides content.

The main feature of the effluents from the leather industry is the high concentration of solid suspended and dissolved matter. The fraction of the inorganic suspended matter is variable and specific for every facility. Also, sulphides are sporadically found in all effluents from the leather factories in very high concentrations.

Trivalent chromium is permanently present in the leather industry waste waters and it can seriously harm the environment in such high concentration [1–4, 8]. The hexavalent chromium that is several times more toxic than the trivalent chromium is advantageously found in the waste waters in low concentrations.

The water temperature in the leather factories is usually not above 30 °C [9, 10], whereas the pH value is in the range between 6 and 9, and rarely above 9 [1, 2, 4, 10].

To protect the environment and the recipients of the effluents from the leather processing industry, it is necessary to apply different waste water clean-up treatments before their releasing in the environment.

In this work data from the studies of the waste water treatment in leather industry in the Republic of Macedonia that were carried out in the period when several leather factories were active: "Godel" in Skopje, "KPK" in Kumanovo, "Metodija Mitevski-Brico" in Delčevo, "Dimko Mitrev**"** in Veles, "Velur" in Tetovo and "Kožara" in Bitola are presented. At the moment today only one leather factory, "Dimko Mitrev**"** in Veles, is still in working condition. In our work, special attention was given to the waste water treatment of the leather factories in Delčevo, Veles and Skopje. The offered solutions for the improvement of the waste water treatment give the opportunity to introduce processes for the purification of the waste waters from one side, and on the other to reuse some of the chemical substances used in certain technological processes in the leather industry.

2. EXPERIMENTAL

Waste waters from various processes in the leather factories of "Metodija Mitevski-Brico" from Delčevo, "Dimko Mitrev**"** from Veles, and "Godel" from Skopje were analyzed. The following parameters were monitored: color, temperature, total dry matter, total organic dry matter, total inorganic dry matter, dissolved matter, dissolved organic matter, dissolved inorganic matter, suspended matter, hardness, electroconductivity, consumption of $KMnO_4$, chemical consumption of oxygen, anions (chlorides, sulphates, nitrates, nitrites), phenols, Cr(VI), and several cations (Ca, Co, Cr, Cu, Fe, K, Na, Mg, Mn, Ni and Zn) (Table 1). All of the applied methods for the analysis of the specified parameters are according to the standardized analytical methods [11].

T a b l e 1.

Results from the analyses of collected waste waters from the leather industries "Metodija Mitevski Brico", Delčevo, „Dimko Mitrev", Veles, and "Goce Delčev", Skopje (average values)

Parameter	Delčevo	Veles	Skopje	MPC* [12]
Turbidity	Opaque	Opaque	Opaque	No
Color	White	Gray–blue	Dark gray–blue	No
Temperature, ^oC	25	19	17.6	30
pH	8.0	3.75	7.89	6.5–9.0
Total dry matters, mg/l	1730	22532	1567	–
Total organic dry matters, mg/l	726	2306	615	–
Total inorganic dry matters, mg/l	1004	20226	952	–
Dissolved matters, mg/l	1656	22335	1192	–
Dissolved organic matters, mg/l	674	2034	389	–
Dissolved inorganic matters, mg/l	982	20301	802	–
Suspended matters, mg/l	74	197	375	80
Hardness, dH^o	35,2	36.2	19.9	–
Electroconductivity, mS/cm	1.33	24.3	1.77	–
Consumption of $KMnO_4$, mg/l	632	937	499	–
Chemical consumption of oxygen, mg/l	1193	2121	759	125
Chlorides, mg/l	120	–	274	–
Sulphates, mg/l	13.6	–	147	500
Sulphides, mg/l	–	–	34.1	0.5
Nitrites, mg/l	0.01	<0.01	<0.01	1
Nitrates, mg/l	8.25	<0.01	<0.01	2.0
Phenols, mg/l	1.46	<0.01	0.37	0.1
Total Cr, mg/l	0.10	108	101	1
Cr^{6+}, mg/l	<0.001	0.70	0.002	0.1
Fe, µg/l	<0.01	<0.01	8.01	2.0
Mn, µg/l	<0.01	<0.1	0.32	2.0
Ca, mg/l	165	126	117	–
Mg, mg/l	52.5	37.5	15.5	–
Na, mg/l	2401	–	227	–
K, mg/l	5.59	–	9.44	–
Cu, µg/l	<0.01	<0.1	4.53	0.5
Ni, µg/l	<0.01	<0.1	9.43	0.5
Co, µg/l	<0.01	<0.1	3.48	1
Zn, µg/l	<1.0	< 1.0	1.17	2.0

*MPC – Maximal permitted concentrations

3. RESULTS AND DISCUSSION

The results given in Table 1 indicate that the concentrations of many of the measured parameters in the waste waters are much above the maximal permitted concentrations that are also given in the Table 1. This especially refers to the considerably high concentration of total solid matter in the effluents including both inorganic and organic matter. Additionally, very high concentrations of sulfides and chromium have been detected, and in some samples for Cr(VI) as well. Having these findings in mind, special attention was paid to designing the possible solution that would enable removing chromium and sulfides from the effluents from the leather industry facilities in Macedonia that could be further used in other analogous industrial facilities with similar effluents composition.

One of the specific measures that can be used refers to chromium removal in the effluents and its reuse in the leather tanning process. It is based on separation and collection of the tanning solution, precipitation of the chromium with alkaline solution and reaction of the obtained chromium(III) hydroxide with sulphuric acid. This process involves collection of all used chromium tanning solutions in a special pool with prior mechanically removing the particulate matter by passing of the effluent through a special colander. Precipitation of Cr(III) can be carried out in the pool by adding a variety of alkaline substances, according to the reaction given by the following equation:

$$Cr_8(OH)_{12}(SO_4)_6 + 6MgO + 6H_2O = 8Cr(OH)_3 + 6MgSO_4$$

There are different possibilities for using various alkaline substances, but the best results have been obtained by using magnesium oxide (MgO). The dissolution and regeneration of chromium must be performed with sufficient quantity of sulfuric acid to obtain a solution that can be then reused in the tanning process. On industrial scale, the collection and regeneration of chromium to be reused would be carried out in such a way to firstly introduce the used tanning solution from the tanning reservoir through a special moving tube to the collection reservoir by passing through a special colander. From the collection reservoir, the chromium solution is introduced in the reactor where the alkaline magnesium oxide suspension is added, the reaction mixture is thoroughly mixed and the reaction takes about 1 hour. The mixing is then stopped and the obtained chromium(III) hydroxide precipitates as a compact deposit on the bottom of the reactor. To obtain a more compact deposit, the reaction mixture should be left for 3–4 hours. The clear solution above the deposit can be removed using stop-cocks on the reactor at different levels. The deposit is drained by opening the stop-cock at the bottom of the reactor. This dense suspension of $Cr(OH)_3$ is then introduced in a special reactor for regeneration in which a sulfuric acid solution is then added. This process is also performed with continuous mixing with a mixer. After finishing with adding the H_2SO_4 solution, the reaction mixture is left to cool down to room temperature (3–4 hours) and is then pumped off in a special reservoir from which $Cr(OH)_3$ can be used again in the leather tanning process (Figure 1).

Analogously to the described removal of chromium, a special procedure is here suggested as a possible solution for oxidation of the sulfides from the effluents after liming process. This solution is based on collection of the effluent after liming in a separate reservoir and elimination of the sulfides in the waste by their catalytic oxidation with the ambient oxygen in the chemical reaction (Figure 2) given by the following equation:

$$Na_2S + 2O_2 = 2Na_2SO_4$$

It has been shown that best results are obtained when using manganese(II) sulfate ($MnSO_4 \cdot 5H_2O$) as the catalyst of this reaction.

Furthermore, highly contaminated effluents are obtained in the other departments of the leather and fur processing facilities. These waste waters also contain various substances above the maximal permitted values according to the regulation in Macedonia. For that reason, it is absolutely necessary to use suitable treatments for purification of all the various waste water types obtained in the leather industry before their release in the environment. The optimal solution for this would be to collect all the waters from all departments (not only tanning and liming) in one reservoir and combine them. The effluent after performed oxidation of the sulfides should also be transferred in this reservoir as well as the solution above the deposit after precipitation of chromium as chromium(III) hydroxide.

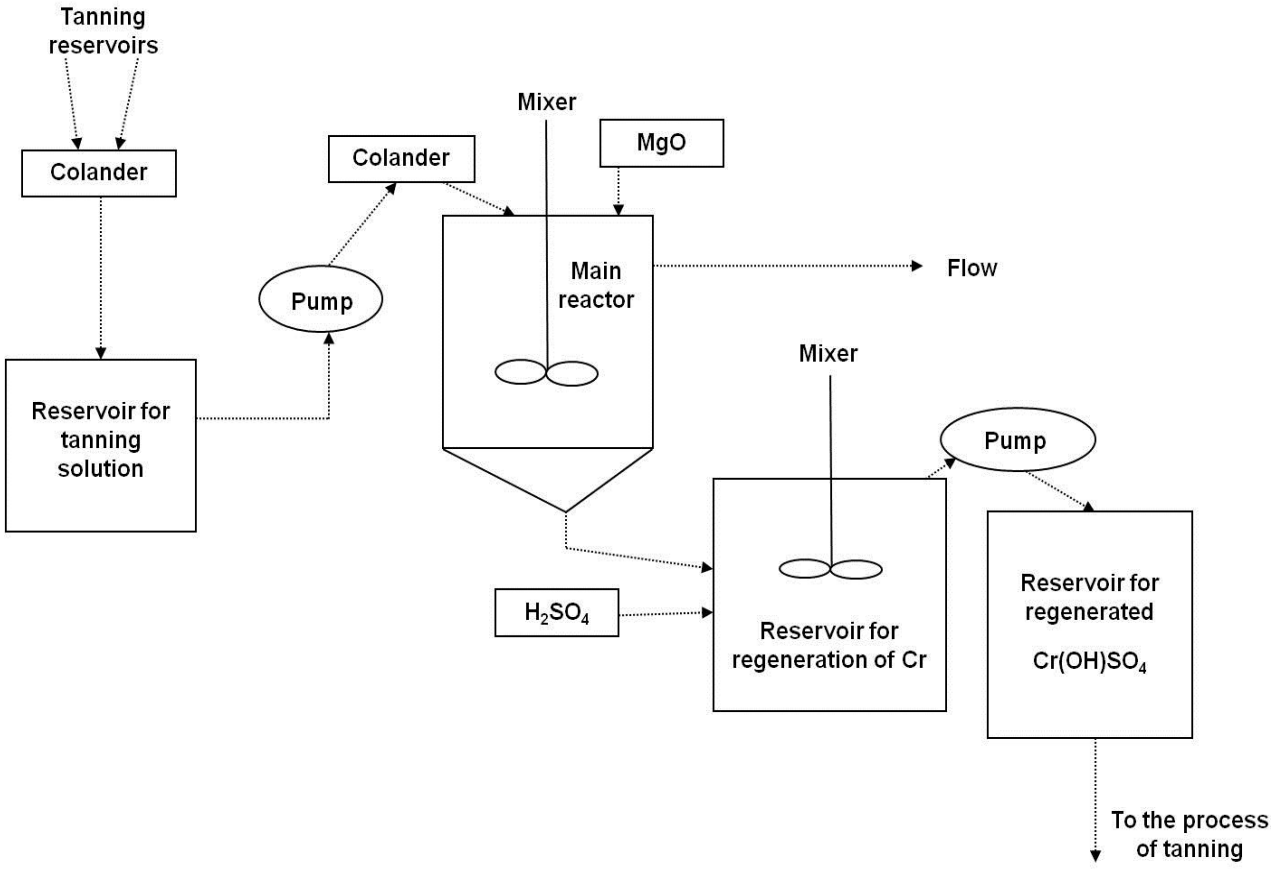

Fig. 1. Scheme for the regeneration of chromium from the waste waters of the tanning process

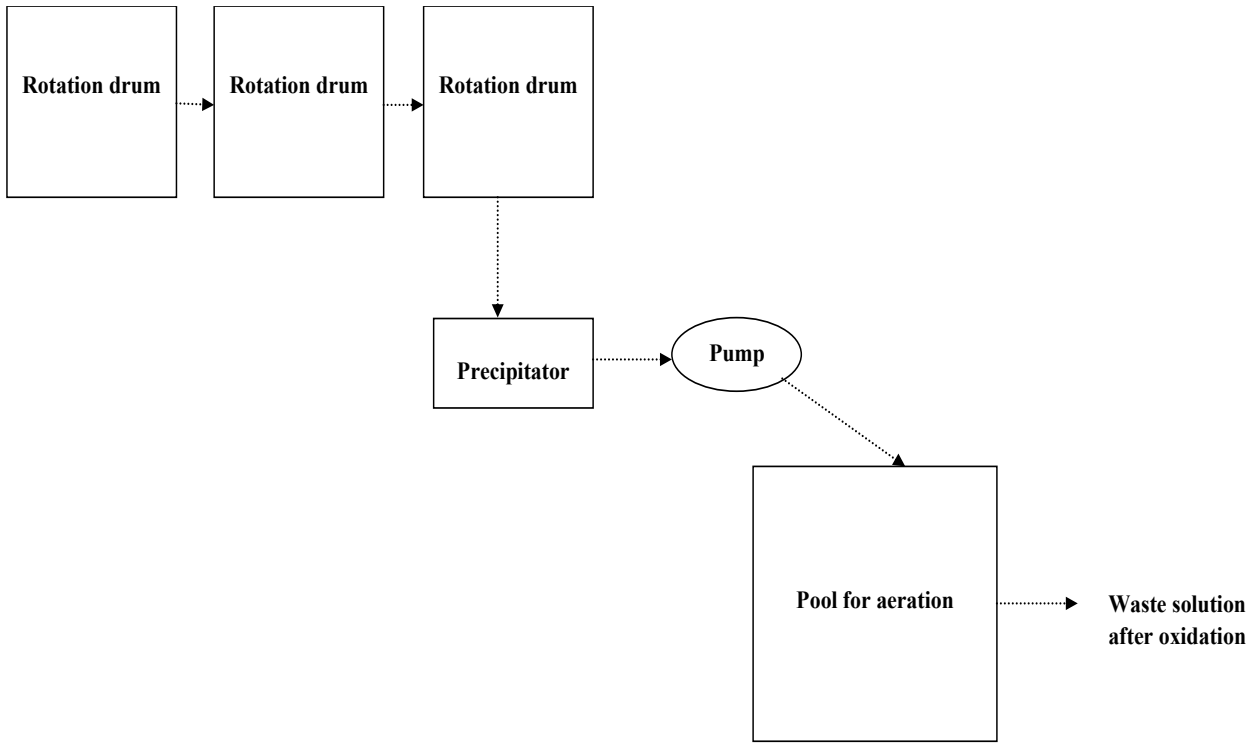

Fig. 2. Scheme of the catalytic oxidation of sulphides from the waste waters from the liming process

4. CONCLUSION

In this work the results from the study of the waste waters analyses in the leather industries in the Republic of Macedonia. Special attention was given to the waste water treatment of the leather factories in Delčevo, Veles and Skopje. Particular notice was paid to designing the proposed solutions that would enable removing chromium and sulfides from the effluents that could be further applied in other analogous industrial facilities with similar effluents composition.

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THE OCCURRENCE OF THE NEGLECT OF THE VARDAR RIVER AS A RISK FACTOR FOR THE SURVIVAL OF THE RIVER FLORA AND FAUNA

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A b s t r a c t: River currents in the Republic of Macedonia, by their nature, have a variable leak where the flows from maximum to minimal depending on the seasons and hydro-meteorological conditions that govern in certain regions where the watercourses are located vary in different time cycles. This variable river regime is followed by medium leakage through which one can determine the variation in the leakage of one stream and the entire catchment area monitored. The Republic of Macedonia belongs to the zone of semi-arid climatic characteristics. In the semi-arid climatic feature, there is a distinctive time distribution of precipitation with clustering in rainy periods and long periods of time without precipitation. Because to the direct dependence of the surface leakage from the realization of precipitation, the non-power period is followed by a period of small water in the river network. The characteristic occurrence is a low water level during the summer–autumn period in the year (July – October) and in the short winter period (January – February) mainly caused by low temperatures, which enables the transformation of the temporary accumulation of precipitation from rain in the snow.

Key words: low voltage periods; hydrological arrays; intermittent leaks; statistic data processing

ПОЈАВАТА НА НАМАЛЕНО НИВО НА ВОДА ВО РЕКАТА ВАРДАР КАКО РИЗИК-ФАКТОР ЗА ОПСТАНОКОТ НА РЕЧНАТА ФЛОРА И ФАУНА

А п с т р а к т: Речните токови во Република Македонија по својата природа имаат променливо ниво на водата бидејќи во различни временски периоди тоа се менува од максимално до минимално, во зависност од годишното време и од хидрометеоролошките услови кои владеат во регионите каде што се наоѓаат водотеците. Од овој променлив речен режим се добива и среден проток преку кој можат да се определат варијациите во протокот на еден водотек, како и на целото сливно подрачје кое се мониторира. Република Македонија спаѓа во зоната со семиаридни климатски карактеристики. Во семиаридната климатска карактеристика постои карактеристична временска распределба на врнежите: врнежливите месеци и долгите временски периоди без врнежи. Поради директната зависност од површинските води кои, пак, зависат од врнежите, безврнежниот период е проследен со период на ниско ниво на водата во речната мрежа. Нискиот водостој на реките е карактеристичен за периодот лето–есен (јули – октомври) и за краткиот зимски период (јануари – февруари), предизвикан главно од ниските температури што овозможуваат привремена трансформација на врнежите од дожд во снег.

Клучни зборови: периоди на низок водостој; хидролошки режим; променлив проток; статистичка обработка на податоци

INTRODUCTION

River flows in the Republic of Macedonia have, by their nature, a variable flux in which, during different cycles, changes are made from maximum to minimum depending on the yearly weather and hydrometeorological conditions that govern in certain regions where watercourses are located. This changeable regime is followed by a mid-point through which one can determine the variation in the flow of a watercourse as well as the entire catchment area to be monitored.

The hydrophilic phenomenon when in the natural river flows there is a low water level, is a consequence of a long period without backwater, where, on the other hand, there are no infiltrations in the subsoil from where you feed the water. In the same period, the remaining components of the surface expiration process act with a certain intensity. These components are evaporation and evapotranspiration that drains surface flows and humidity of the ground.

Watercourses with average water supply are mainly supplied from underground reserves, which accumulated in the previous wet period. Practically, the whole period with no return is the drainage of the waters from the catchment area.

Republic of Macedonia, belongs to the zone of semi-arid climate characteristics. In the semi-solid climate characteristic, there is a characteristic time distribution of the returns with grouping in the backward months and long periods of time without backlash.

Due to the direct dependence of the surface expulsion from the realization of the returns, the non-reliant period was passed with a period of small water in the river network. The characteristic phenomena of the low water level occur in the course of the summer–autumn period in the year (July–October) and the short winter period (January–February), mainly caused by low temperatures, which enables the transformation of the temporary accumulation of rainfall returns [1].

In addition to the annual occurrence of small water, we also have long-term flood events, which are mainly due to the global hydrometeorological changes in the western region of the Western Balkans. Within the Republic of Macedonia there are also local phenomena of low voltage, with their specificities, mainly caused by the volatile variability of the returns and the characteristics of the space.

The phenomena of the periods of rivers low water level in the Republic of Macedonia was a subject of numerous studies and special attention was paid to the river Vardar.

One of the first analyses of this phenomena was completed within the period of 1924 to 1966. May be considered to be less than $Q = 20$ m^3/s [1].

Table 1 shows the duration of the low water level per day for the years studied and the minimum flow that was registered at that time. The tabular presentation refers to the Vardar river on the measuring profile at the center of Skopje.

T a b l e 1

Presentation refers to the Vardar river on the measuring profile at the center of Skopje. [1]

Year	Duration from – to	Qmin (m^3/s)	Days duration
1925	7.7 – 23.12	14.6	131
1944	20.7 – 5.11	14.0	108
1946	17.7 – 29.9	15.1	75
1948/9	4.12 – 15.5	13.2	102
1950	2.7 – 2.10	13.3	94
1952	19.6 – 1.11	6.1	136
1956	23.7 – 2.11	10.1	103
1958	15.7 – 8.11	12.2	137
1961	23.7 – 12.10	14.4	81
1962	9.7 – 30.11	11.3	83
1966	24.7 – 1.11	11.3	101

METHOD AND MATERIALS

Also, it should be noted that the longest period of mining in the Republic of Macedonia is the period from 1988 to 1994, where as a direct consequence of this dry period of our two natural lakes, the Prespa and Dojran, experienced its greatest decrease in the level of water. The Dojran lake was on the job of total destruction, and was saved only by direct intervention of the human factor.

The negative consequences of the long drought are enormous and affect the functioning of Vodostopanstvo. Almost all of the accumulations are completely emptied, restrictions on water supply are applied to some areas, the supply of water for irrigation is limited, and many river and lake ecosystems suffer from reusable damage.

In the recent studies of the low water level, it was concluded that the level of the Vardar river is reduced by 50% in relation to the mid-yearly flows, whereas in the smaller rivers the level of water levels is only 30% compared to the average annual flows [1].

In the elaboration of this learned effort for the effects of the low water level on the river ecosystems, a detailed analysis of the water profile of Raduša on the Vardar river was made. The choice of the radius profile of Raduša is obtained according to the following criteria:

1. The water profile of Raduša is located in front of the entrance to the Skopje basin and provides an opportunity for analysis of the variation of the waters in the Vardar river without affectting the waters of the larger tributaries, such as Treska and Lepenec.
2. The profile is located immediately after the exit from the Derven Gorge, leading to the damming of Rašče-1 and Rašče-2 from which the water is supplied by the City of Skopje.
3. This profile can be considered as the border between the regime of the flow of the Vardar river from the mountainous to the flatland river.

The geographical, morphological and hydrological characteristics of the Raduša water profile are as follows:

1. The water gauge profile of Raduša, comprising a drainage area of A = 1450 km^2.
2. The average altitude is H_{sr} = 1128 m.
3. The average drop in the river bed is J = 25.20 %.
4. The coefficient of development of the waterworks has the value m = 1.5.
5. The altitude of the water meter profile is 317.57 m.V.V.
6. The specific flow of the Vardar river equals q = 17.4 (l/s)/km^2.
7. The average annual flow of the Vardar river to the water profile is 25.121 m^3/s.
8. The mean minimum flow is 10.61 m^3/s.
9. The average value of the minimum spending for the entire period is Q = 6.57 m^3/s.
10. The absolute minimum flow that is measured is Q = 0.55 m^3/s and it is measured in the months of July and August in 1990.

In the analysis of the phenomenon of the Vardar river reef on the measuring profile of Raduša, a hydrological string of a 41-year span was used for the period from 1949 to 1990. The data processing factor is set to the following three parameters:

1. Average per year for the analyzed period, $Q_{\text{av/yr}}$ (m^3/s)
2. Minimum flows per year for the analyzed period, $Q_{\text{av.min /yr}}$ (m^3/s).
3. The average value of the minimum flows, per year for the analyzed period Q_{min} (m^3/s).

The traction application expressed in kg/s through the Raduša profile.

Table 2 gives the average annual flows for a total of 41 years, $Q_{\text{av/year}}$ (m^3/s), $Q_{\text{av.min/year}}$ (m^3/s), $Q_{\text{min av.}}$ (m^3/s) and $Q_{\text{aps min}}$ (m^3/s). [4].

T a b l e 2

The average annual flows for a total of 41 years

Flow	Average value for a set of 40 years (m^3/s)
$Q_{\text{av.}}$	25.121
$Q_{\text{av.min}}$	10.61
$Q_{\text{min av.}}$	6.57
$Q_{\text{aps.min}}$	0.55

For the processing of the three sets to obtain the probable minimum flows that can be expected on the waterfall profile of Raduša, the standard methods of mathematical statistics are used, through which the following values of the statistical parameters are obtained:

– The mean square deviation of the series S_x,

$$S_x = \sqrt{\frac{\sum (Q_i - Q_{av,})^2}{N-1}}$$

– Coefficient of variation C_v,

$$C_v = \frac{S_x}{Q_{av.}}$$

– Coefficient of asymmetry C_s,

$$C_s = \frac{\sum (Q_i - Q_{av.})^3}{(N-1)\cdot S_x^3}.$$

The calculated values of the statistical parameters for the three worked strings are given in Table 3.

T a b l e 3

The calculated values of the statistical parameters

Num.	Trained row (m^3/s)	S_x	C_v	C_s
1	$Q_{\text{av.}}$	26.266	1.0455	1.08
2	$Q_{\text{av.min}}$	12.062	1.137	1.27
3	$Q_{\text{min av.}}$	4.016	0.6113	1.40

In the Figures 1, 2 and 3 the hydrographs of the Vardar river water protection profile of the Raduša water profile for the three treated strings, $Q_{\text{av.}}$ (m^3/s), $Q_{\text{av.min}}$ (m^3/s) and $Q_{\text{min av.}}$ (m^3/s) are given.

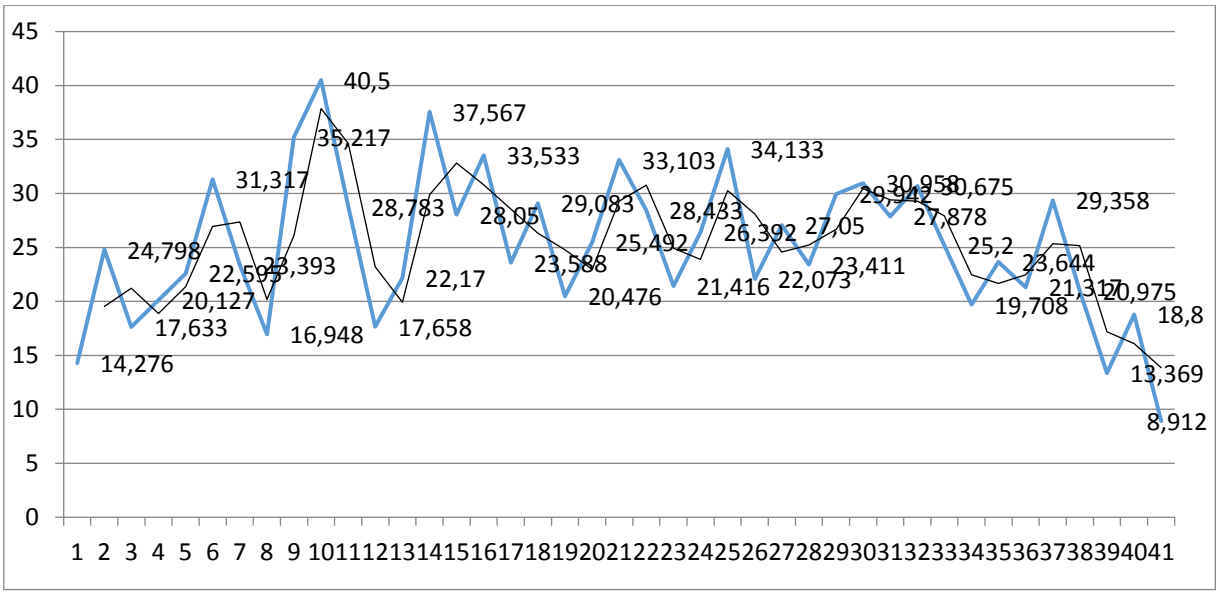

Fig. 1. Hydrogram for Q_{sr} (m^3/s)

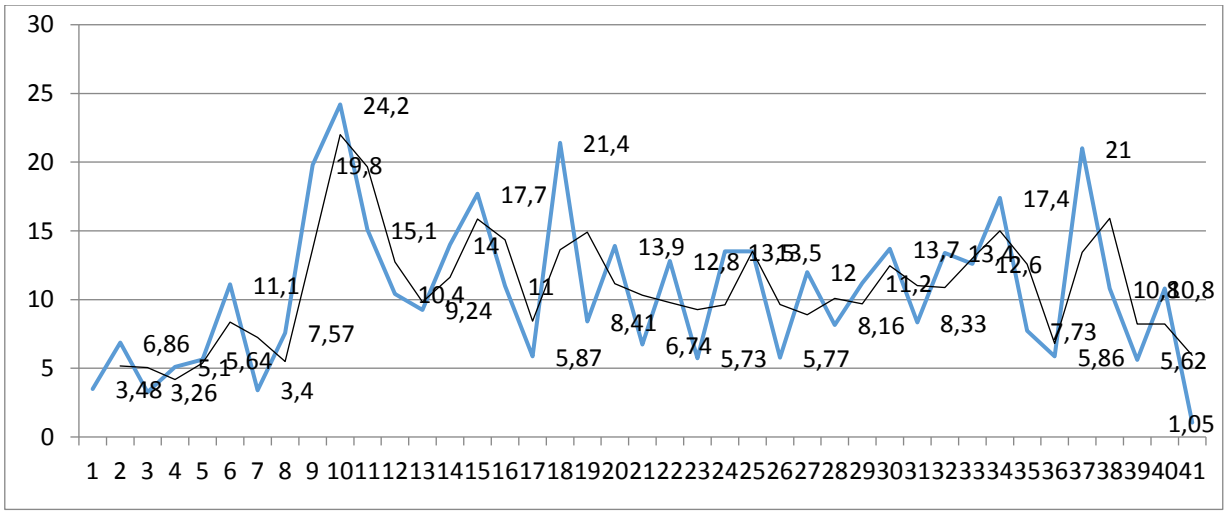

Fig. 2. Hydrogram for Q_{srmin} (m^3/s)

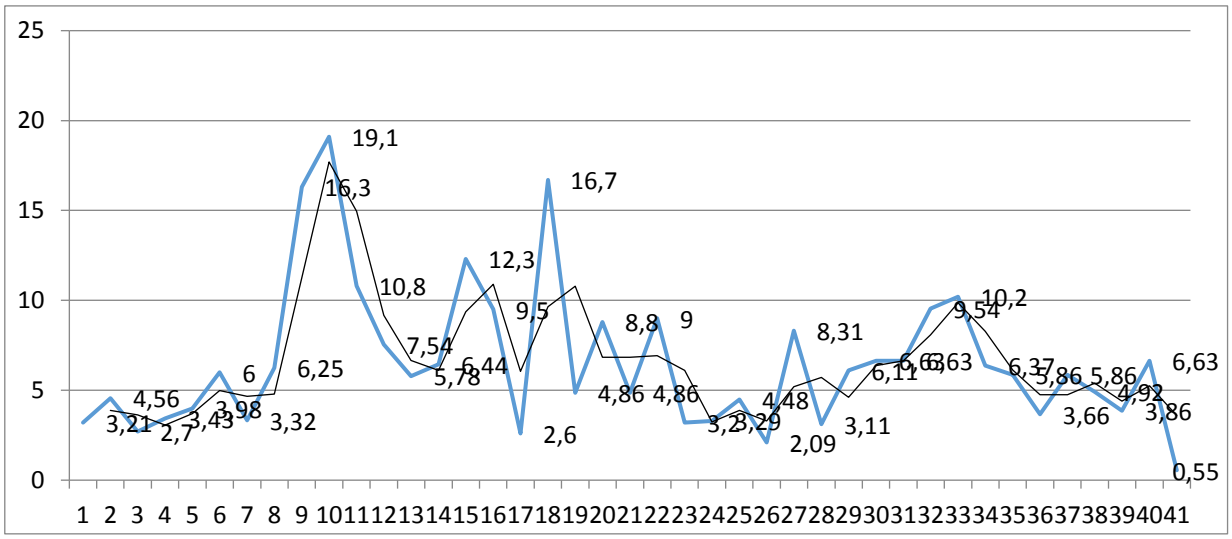

Fig. 3. Hydrogram for $Q_{min\ sr}$ (m^3/s)

With the application of the three faults from the Territory of Probability, the minimal flows of the Vardar river were obtained, through which the distribution of the low water level can be viewed, at certain intervals. The guilt through which the distribution of the holders is obtained is:

1. Gambel curve.
2. Pirson curve of the III type.
3. Log normal curve or Galton curve.

After the performed mathematical analysis, it was concluded that only with the application of the Pirson curve of the III type, satisfactory results were obtained for the minimal flows recorded on the water profile of Raduša on the Vardar river. In Table 4, the distribution of the minimum runs for the specified time intervals obtained by the following form for the Pirson curve of type III [5]

Figure 4 gives a graphical representation of the distribution of the minimum probabilities according to the theory of probability, through the Pirson curve of the III type.

T a b l e 4

Calculation with Pirson curve of the III type

Number	*P*%	*P*	*T* (year)	C_v	C_s	*Q* (m^3/s)
1	0.01	0.0001	10000	0.6113	1.40	34.16
2	0.1	0.001	1000	0.6113	1.40	27.013
3	1	0.01	100	0.6113	1.40	19.7
4	5	0.05	20	0.6113	1.40	14.36
5	10	0.1	10	0.6113	1.40	11.951
6	20	0.2	5	0.6113	1.40	9.42
7	50	0.5	2	0.6113	1.40	5.686
8	80	0.8	1.25	0.6113	1.40	3.23
9	90	0.9	1.111	0.6113	1.40	2.393
10	95	0.95	1.05	0.6113	1.40	1.87
11	99	0.99	1.01	0.6113	1.40	1.349
12	99.9	0.999	1.001	0.6113	1.40	0.987

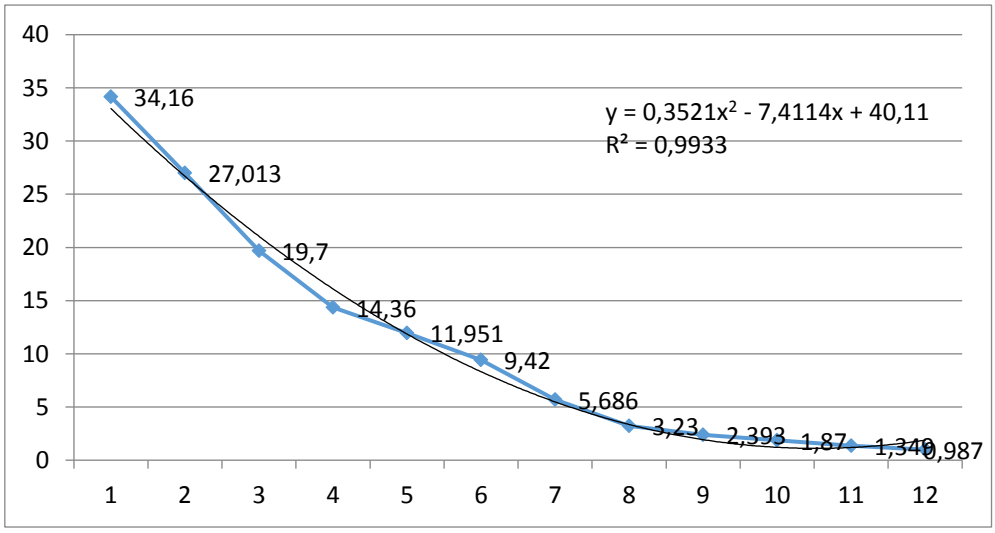

Fig. 4. Grapfic interpretation of probability curve

From the performed analysis, it can be concluded that the absolute minimum flow rate recorded on the water profile Q = 0.55 m^3/s, in the months of July and August 1990, is included in the fault as an expected regular occurrence, which only confirms the thesis that the appearances the malevolence is the beginning of a phenomenon that has its own negative consequences. The minimum average annual flow rate of Q = 6.57 m^3/s corresponds to the occurrence of occurrence between two and five years, i.e. it has somewhat higher value on the basis of the two-year Q = 6.57 > 5.686 m^3/s. The mathematical interpretation of the curve of the flow according to the time distribution of the minimum expansions is as follows:

$$Q = 0.3521H^2 - 7.4114H + 40.11\ \mathrm{m^3 \cdot s^{-1}}$$

with the coefficient of the Krivolin regression of R = 0.9933.

The watermelon profile of Raduša also obtained a specific swelling that equals q = 17.4 (l/s)/km^2. Through the specific sweep, it is possible to calculate the effective rains that enable the maintenance of the Vardar river along the Raduša water profile. The specific swelling is defined by the following form: $q = \frac{Q}{A}$ s^{-1}/km^2. The effective rainfall for the water profile is obtained according to the following form: $\frac{W\mathrm{year}}{A}\frac{\mathrm{mm}}{\mathrm{year}}$.

Table 5 gives the values of the effective rains for the average values for the period of the three characteristic years, as follows:

1. The average year is a flow of
$$Q = 25.200\ \mathrm{m^3/s}.$$
2. The drought year is an average of
$$Q = 13.369\ \mathrm{m^3/s}.$$
3. The dry season is a flow of
$$Q = 8.912\ \mathrm{m^3/s}.$$

Table 5 shows the massive decline in the effective rains in certain time periods (calendar years), on the occurrence of drought periods such as the second half of the eighties of the last century.

From the analysis of the effective incomes, it can be concluded that the percentage of the decrease in the middle-year returns relative to the middle-year year equals P = 46.95%, while the percentage of the decrease in the middle-year returns relative to the drought year equals P = 64.63%.

Reduction of the backbones directly influences the appearance of the mallee of the rivers and is reflected through the small water level of the rivers.

T a b l e 5

Massive decline in the effective rains in certain time periods

Num.	Calendar year	Q (m^3/s)	W (m^3/year)	A (km^2)	P_{ef} (mm/year)
1	1982	25.200	794707200	1450	548.07
2	1988	13.369	421604784	1450	290.76
3	1990	8.912	281048832	1450	193.83

As an illustration of the direct dependence on the appearance of the low water level from the abundance of rainfall in Table 6, the data on the effective rainfall for the four hydrological years will be given where the occasional rainfall for the 1967/68, 1968/69, 1969/70 and 1970/71 years with measured evapotranspiration, i.e. the mean values for the catchment area of the Vardar river with the water profile of Raduša.

T a b l e 6

Measured evapotranspiration

Num.	A (km^2)	P_{ef} (mm/year)	P_{isp} (mm/year)	A (km^2)	$P_{rortion}$ (%)
1	1967/68	1450	882	436	49.43
2	1968/69	1450	946	406	42.92
3	1969/70	1450	1069	591	55.28
4	1970/71	1450	1017	400	39.33

Among the tables 5 and 6, the differences between the maximum and the minimum returns for the water profile are shown clearly in the tables between the maximal annual returns and the minimum returns,

$$\frac{P_{\min}}{P_{\max}} = \frac{193.83}{1069} = 18.13\%.$$

$$100 - 18.13 = 81.87\%,$$

The real difference is between the maximum and minimum annual returns.

When the malodorous appearance of the application through the water profile is closed, the traction force of the water is correct and can not transport the application.

According to the measurements of the application through the water profile of Raduša during the

mean annual flow rate is N = 5.695 kg/s, while at the minimum flow rate the suspended application moves in the boundaries between N = 0.513 kg/s and N = 0.0 kg/s. In contrast to the minimum penetration, the linear radius profile of Raduša increased the maximum permeability to N_{max} = 999.0 kg/s.

In Figures 5, 6 and 7, the graphic presentations of the deposit will be given along the Raduša water profile for the period from 1970 to 1989, i.e. for a period of 20 years.

In Figure 5, the graph of the minimal penetration along the water profile of Raduša moves within the boundaries between N_{min} = 0.00 and 0.513 kg/s.

Figure 6 shows the graph of the medium-year penetration of the sediments through the water profile of Raduša, which moves within the boundaries between N_{min} = 0.311 and 15.61 kg/s.

The Figure 7 shows the graph of the maximum penetration of the Raduša water flow profile, which moves within the boundaries between N_{max} = 1.320 and 999.0 k/s.

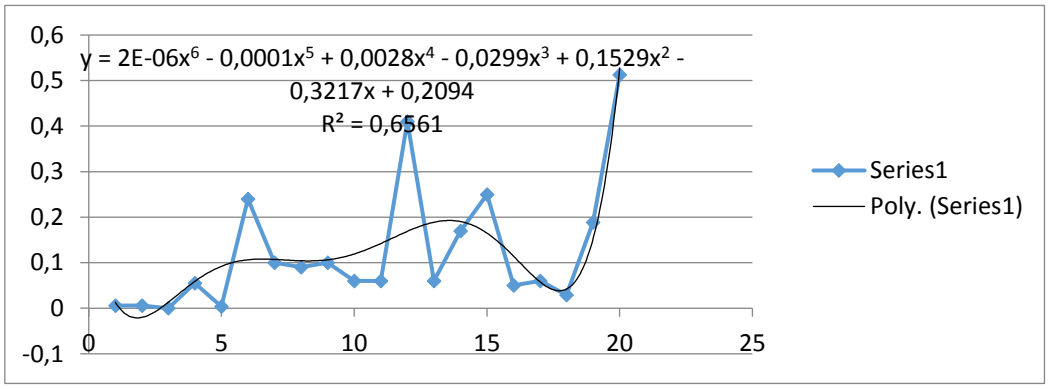

Fig. 5. Maximal flow of sediment

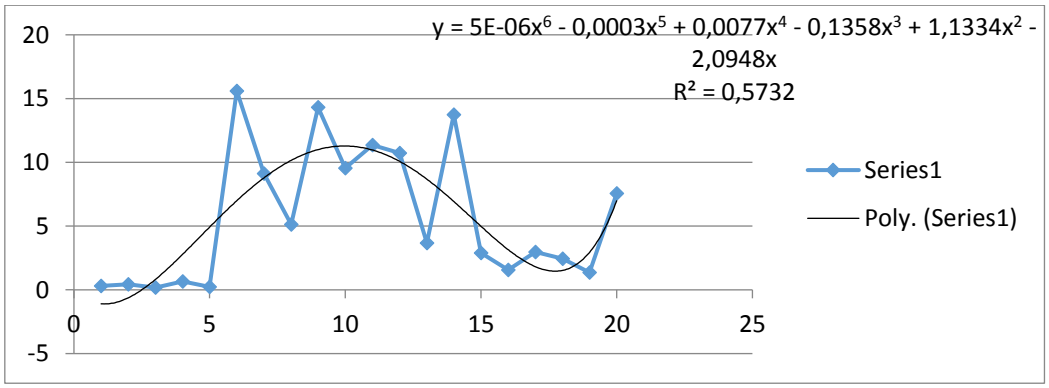

Fig. 6 Average flow of sediment

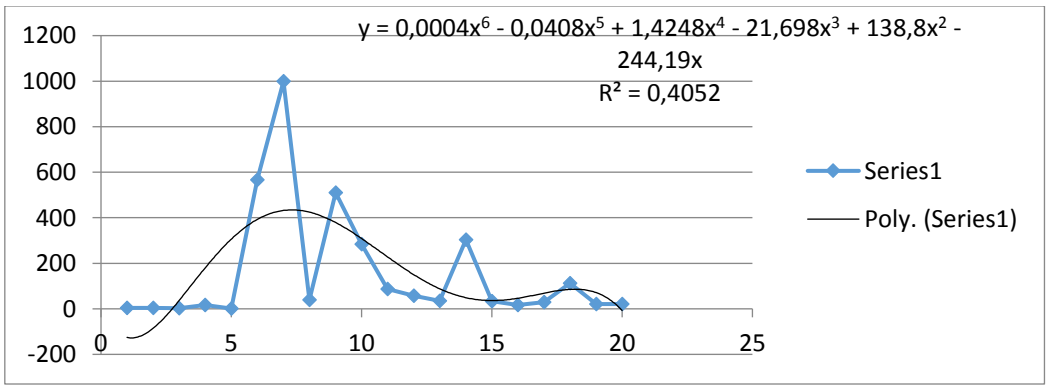

Fig. 7. Minimal flow of sediment

The yield of the suspended application along the water-gauge profile of Raduša, in the period of the low water, equals

$$N = \frac{N_{\min}}{N_{\text{av.}}} = \frac{0.513}{5.695} = 0.09 = 9\ \%.$$

This percentage correlates to a very small amount of application that permeates the water profile.

These amounts of application are too small to be able to provide regular oxygen supply and food for river flora and fauna. Likewise, with the slightest release of contaminants in the water, we can expect complete toxication of river water.

The river flora and fauna, under conditions of the low water level, is exposed to the diverse effect of the polluted water, where small flows can not provide the self-adhesion process.

From the performed analysis in the three strings, Q_{sr} (m^3/s), Q_{srmin} (m^3/s) and $Q_{min\ sr}$ (m^3/s), positive results were obtained only for $Q_{min\ sr}$ (m^3/s), i.e. for the minimum mean only Pirson curve is of the type III, while the other curves produce negative values for survival with a probability greater than $P = 90\%$.

CONCLUSIONS FROM THE CONDUCTED ANALYSIS

In this scientific work, the phenomena of the Vardar river waterfall on the water profile of Raduša were analyzed. For the needs of the analysis, a hydrological series in the length of 41 years was used for the period from 1949 to 1990. From the attached series were obtained three lines of water flowing:

- Average per year for the analyzed period, $Q_{sr/yr}$ (m^3/s).
- Minimum flows per year for the analyzed period, $Q_{srmin/yr}$ (m^3/s).
- The average value of the minimum flows per year for the analyzed period Q_{min} (m^3/s).

The traction application expressed in kg/s through the Raduša profile.

After the hydrological and statistical analysis was carried out, the following conclusions were drawn:

1. The rivers which last for two months in a year, are now increasing to three to four months, during the year.
2. The cultivated chain of 41 years shows the tendency to increase the dry periods and, therefore, to prolonged periods of mining.
3. The processed string was analyzed with three probability curves, from which the most suitable curve for the time distribution of small passages gives the Pirson curve of the III type.
4. According to the obtained results from the analysis, it can be concluded that at the flow rate $Q = 10\ m^3/s$, the water profile of Raduša can be considered as the beginning of the period of the low-flow.
5. Effective rains resulting from the analysis of the water flow profile show a large drop in the water balance, which points to serious problems that occur with the malevolence in river ecosystems.
6. The yield of the suspended application has been observed in the periods of the low water level and can reach up to $N = 0.0$ kg/s, i.e. in general, there is no transport of the application along the river bed.
7. All these occur very negatively affecting the survival of the river flora and fauna in the Vardar river, and pose a potential threat to the destruction of the living world in the river.

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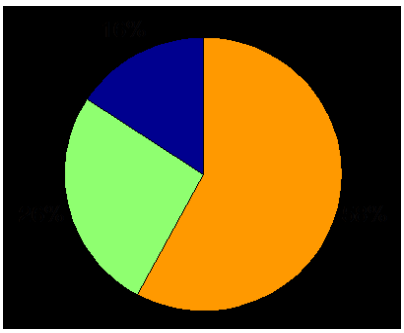

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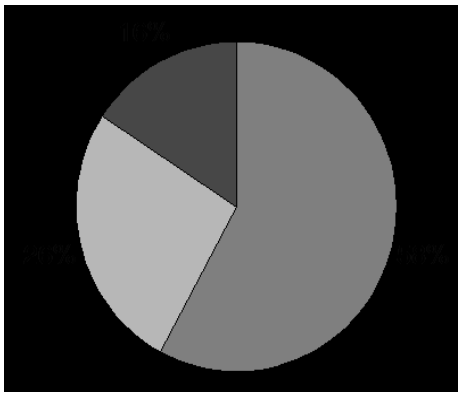

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