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THE PROPOSED METHODOLOGY FOR ANALYSIS OF ECOLOGICAL PROBLEMS CONCERNING THE TECHNICAL INFRASTRUCTURE OF MOTOR TRANSPORT

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Summary. The most crucial threats found in facilities of the technical infrastructure of motor transport have been presented in the article. There are also issues concerning modelling an ecological strategy using a taxonomic method for the technical infrastructure as well as applied methods and techniques selected depending on particular problems and chosen objectives. The article describes criteria and basic assumptions of the taxonomic method as well as its application to assess ecological issues.

Keywords: technical infrastructure of motor transport, ecological problems, taxonomic method

INTRODUCTION

Nowadays motor transport plays a very important role in shaping the world's economy. It gives an easy access to modern products and technologies on all continents, thus improving effectiveness of each country's functioning [11]. However, the share of the individual regions of the world in the international trade traffic and the industrial cooperation is dependent on the technical condition of basic elements of motor transport, i.e. transport means and their infrastructure.

To keep transport means in a suitable technical condition, an adequate technical infrastructure of motor transport is required, equipped with specialty tools and diagnostic devices. The service and repair operations performed for internal combustion transport means in the technical infrastructure affect the proper operation of vehicles, but also generate pollution, which has a negative effect on the natural environment [3,14].

The ecological aspect of the subject matter is really crucial; sadly, the analysis of the actual status confirms that these issues are paid little attention to in technical infrastructures of motor transport. The problem related to the protection of environment is located at the bottom of the priority list for technical infrastructures. The economic effect from selling services, supported by expenditures on the marketing sphere and focused on maximisation of profits is still of the dominant significance [17]. The situation in the technical infrastructure can only be improved by appropriate normalisations and legal regulations, which are in force in the EU and which Poland will have to conform to as well.

ECOLOGICAL THREATS CONCERNING THE TECHNICAL INFRASTRUCTURE OF MOTOR TRANSPORT

The dynamic development of motor transport has had an adverse influence on the natural environment in recent years, because it has contributed to deterioration of conditions for living, working and relaxing as well as to the generation of important ecological problems of global range, i.e. acid rains, pollution of water and global warming [1,4]. The influence of motor transport on the environment may have a socio-economical character connected with the economic growth of individual regions, as well as a physical one, connected with multiple serious threats. The most important dangers are [20]:

- air pollution with toxic components of exhaust fumes,
- atmosphere pollution with used tyres and road surface products as well as dusts emerging from utilization of clutch and brake linings,
- a toxic influence of engine fuels during transport, distribution, storage and operation in motor vehicles,
- pollution of soil and water with washing and maintenance agents for a car body,
- a danger of leakages of fuels, oils and operating fluids,
- a noise and a road surface vibration danger caused by movement of vehicles,
- pollution of the natural environment caused by the recycling of retired vehicles and frequent replacing of spare parts (gaskets, filter cartridges etc.)

The pollutants from exhaust fumes of motor vehicles are the greatest burden for the atmosphere, due to the effect of combustion of various kinds of fuels containing many toxic compounds [15]. Pollutants generated in technical infrastructures of motor transport, which are the key elements in the system for proper operation of vehicles, also have a negative influence on the natural environment. The wide range of services of the technical infrastructure which cause pollution are warranty, periodic and according to a client's requirements inspections, comprehensive or selective diagnostics of functional blocks, periodic technical inspections, routine or accident repairs, sale or rent of vehicles as well as possible collecting of retired vehicles for recycling [5,6,10].

A technical infrastructure of motor transport functioning within a network structure of a given automotive consortium or a trade and service organisation is characterized by an established specificity imposed by the administration of these companies, resulting from the accepted concept for management. However, all these companies share similar ecological problems. The most crucial ecological threats concerning the technical infrastructure of motor transport are as follows [19]:

- air pollution with exhaust fumes in places for servicing or repairing vehicles (operating engines),
- noise emission in aforementioned places (operating engines),
- management and possible recycling of operating fluids (motor oil, gear oils, brake and power steering oils, brake fluid, cooling fluids, AC fluids etc.),
- management of used and replaced units, subsets and elements (steel elements, non-iron metals, polymers, rubber elements etc.) during inspections or repairs,
- protection of the environment against harmful influence of disposal sites for used vehicles designated for recycling.

The issue of environment protection, as one of basic factors for development of motor transport, goes unnoticed by an individual user or owner of a vehicle. The primary values for an individual owner of a motor vehicle resulting from marketing research, have been specified in Fig.1

Protection of the environment against the effects of development of motor transport gains a priority only in the social context, which includes the following actions [7,12]:

- protecting the environment against the effects of production and operation of vehicles, as well as the influence of the technical infrastructure of motor transport,
- reducing material and energy consumption as well as costs of production and operation of vehicles,
- increasing reliability and durability of vehicles,
- reducing material, energy and recycling costs of retired vehicles.

The influence of the aforementioned factors on the state of environment is not always directly visible. Their mutual relations are very complex, and environment is affected by many subjects, directly or indirectly, independently or dependently on each other. Durability and reliability of motor vehicles have a clear influence on the environment as well, because these qualities, among other things, cause reduction in the quantity of waste products from operation of vehicles. The material and energy consumption of production and operation processes also have a measurable influence on the environment, as well as the way of management of retired vehicles. The influence of costs of these processes on the environment is the least visible, however, it is to be remembered that pro-ecological actions are very expensive and the balance of finances is subjected to the same economic regulations in every social structure.

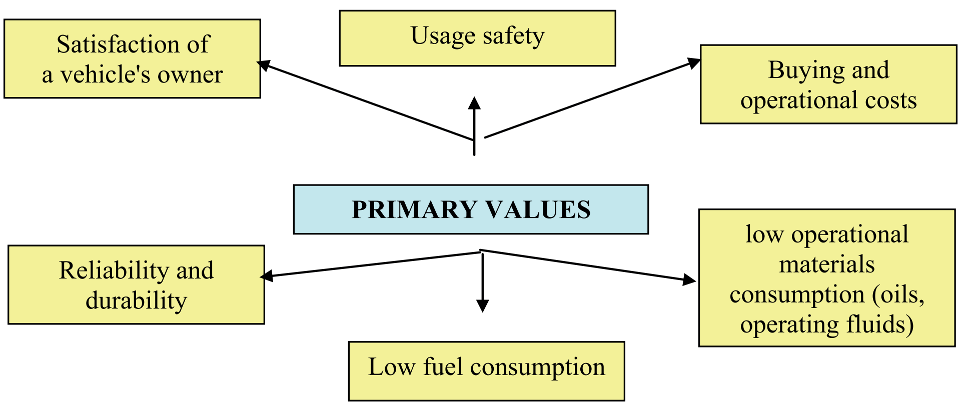

Fig. 1. Primary values for an owner of a motor vehicle

MODELLING LOGISTIC PROCESSES IN THE TECHNICAL INFRASTRUCTURE OF MOTOR TRANSPORT

Planning and controlling a logistic process in the technical infrastructure of motor transport requires a proper construction of its model. It should enable coordination between organisational units of every activity, tracking the process realisation time, the analysis of costs, the assessment of involvement and responsibility of individual units, relations between them, material goods movement, information flow, payments etc.

Different methods and techniques can be used to model logistic processes in the technical infrastructure of motor transport, chosen depending on particular problems and objectives. A model based on a taxonomic method can be employed to realize the established goals connected with the issue of the environment protection [2,8]. The choice of this method is appropriate mainly because the parameters which appear in the descriptions of technological issues and are expressed in different measurement units can be normalized receiving dimensionless values. The taxonomic method enables the dendritic arrangement, which mirrors the location of a given technology better within a multidimensional space of parameters, so it is more transparent than optimisation methods. Generally, the taxonomic method is employed in natural science to good effect. In technical applications, projects which grasp comprehensively the issues of using taxonomic methods appear very rarely [9]. Using this method to develop a logistic system with an ecological aspect in mind, establishes a new quality for technical applications.

Methodology and the range of studies

To assess pro-ecological actions in progress in the technical infrastructure of motor transport, 15 companies have been chosen including car showrooms, fuel and repair stations, specialist car garages, depots, municipal and intercity transport, transport and spedition companies etc. The acquisition of the information regarding the selected parameters of a pro-ecological assessment (Table 1) has run into serious difficulties in some companies, due to the lack of properly kept documentation, treatment of waste as a total without selection with regard to the type, competence of employees responsible for this issue etc. Repeatedly, the information has been acquired from the additional analyses of statistical data relative to the quantity of performed inspections, repairs and other services within specified time [16].

Table 1. The parameters for a pro-ecological assessment of the technical infrastructure of motor transport selected for analysis

No.	PARAMETER SYMBOL	PARAMETER TYPE	MEASUREMENT UNIT
1	P1	Emission of volatile components from exhaust fumes (CO, HC, NO_x) to atmosphere	[kg/year]
2	P2	Emission of carbon dioxide ($CO_{2)}$ to atmosphere	[kg/year]
3	P3	Used tyres and rubber elements waste	[kg/year]
4	P4	Select plastics waste	[kg/year]
5	P5	Select non-iron metals waste	[kg/year]
6	P6	Iron metals waste	[kg/year]
7	P7	Select glass and ceramics waste	[kg/year]
8	P8	Select lubricant waste (motor and gear oils)	[dm^3/year]
9	P9	Other select operating fluids (cooling, brake, wiper and AC fluids)	[dm^3/year]
10	P10	Asbestos brake and clutch linings	[kg/year]
11	P11	Lead and NiCad batteries	[kg/year]
12	P12	Paint and lacquer waste removed during lacquering	[kg/year]
13	P13	Total quantity of material waste	[kg/year]
14	P14	Overall “quality” of generated waste	[0-1]*

15	P15	Emission of noise to surroundings (on average)	[dB]
16	P16	Level of pro-ecological investments per year	[thousands/PLN]
17	P17	Employment at jobs connected with ecological activities	[quantity of people]
18	P18	Level of employees' training in an ecological aspect	[0-1]**
19	P19	Implementation of management logistics system in an ecological aspect	[0-1]***
20	P20	Monitoring system and procedures for studies on threats to environment	[0-1]****
21	P21	Energy demand with reference to pro-ecological works (on average)	[kWh/month]

*0 - lowest, 1- highest; ** 0 - lowest, 1 - highest; *** 0 - lack of system, 1 - system implemented; **** 0 – lack of system, 1 - existing system

In the chronological order, the study methodology has included the following scope of tasks [18]:

- establishing and acquiring the cooperation of transport companies,
- analysing the kinds of services taking into consideration pro-ecological aspects in selected companies,
- selecting parameters for a pro-ecological assessment, which are possible to analyse and common for the studied companies,
- gathering data for established parameters for a pro-ecological assessment from every company,
- performing calculations using the taxonomic method,
- preparing a dendrite presenting the smallest differences between individual parameters for all studied companies,
- analysis of the study results.

The calculations have been performed using the taxonomic method for 15 companies (technologies), characterized by 21 parameters selected for analysis, using the following procedure*:

- determination of values of individual parameters for each technology according to the accepted measurement units (acc. table 1),
- addition of 4 exemplary technologies bearing WP2, WP13, WP14, WP21 (Table 2) signatures,
- design of the total dendrite for all 15 pro-ecological technologies, illustrating the accepted study procedure.

Multiple consultations with technical supervision and directly with the employees engaged in specific work types in the selected companies allowed to gain the most reliable and adequate values for individual parameters for each of the 15 technologies. The most essential parameters, because of a pro-ecological assessment of the technical infrastructure of motor transport, have been assigned exemplary technologies, choosing WP2 (emission of carbon dioxide to atmosphere), WP13 (total quantity of material waste), WP14 (overall "quality" of waste) and WP21 (the amount of energy demand).

* applicable to this article

THE STUDY RESULTS

Using the taxonomic method to assess pro-ecological problems in the technical infrastructure of motor transport allows for the description of a large amount of parameters in order to perform their proper analysis and correct reasoning [13]. While drawing conclusions from the performed analysis for the dendritic arrangement, the basic role is played by the sequence of connected points and the values of average differences between these points. Proximity and grouping of the particular technologies indicate the similarity among the examined parameters. In the final effect, the calculation results using the taxonomic method have enabled the construction of a dendrite, presenting distances within the space of the examined parameters (Fig. 2).

The constructed total dendrite for the differentiation of the technology for all the 15 selected companies enables to draw the following conclusions:

- with reference to CO_2, in the group of low emissions, the No. 6 technology has the lowest value, which under the project assumptions concerning the building of the technical infrastructure means that the other companies should aim at obtaining the values similar to the WP2 exemplary technology, or implement the existing and proved technology in the company, encoded under No. 6.
- among the companies of the lowest values of the sum of waste, the most advantageously located is the No. 4 technology, because it appears a short taxonomic distance away from the WP13 exemplary technology,
- the least harmful influence of waste on the natural environment is indicated by the company encoded as No. 2, which is located a short taxonomic distance away from the WP14 exemplary technology within the taxonomic space,
- from among the surveyed companies, the No. 8 technology shows the lowest energy consumption, which means that it is the least energy-intensive and appears very close to the WP21 exemplary technology within the taxonomic space.

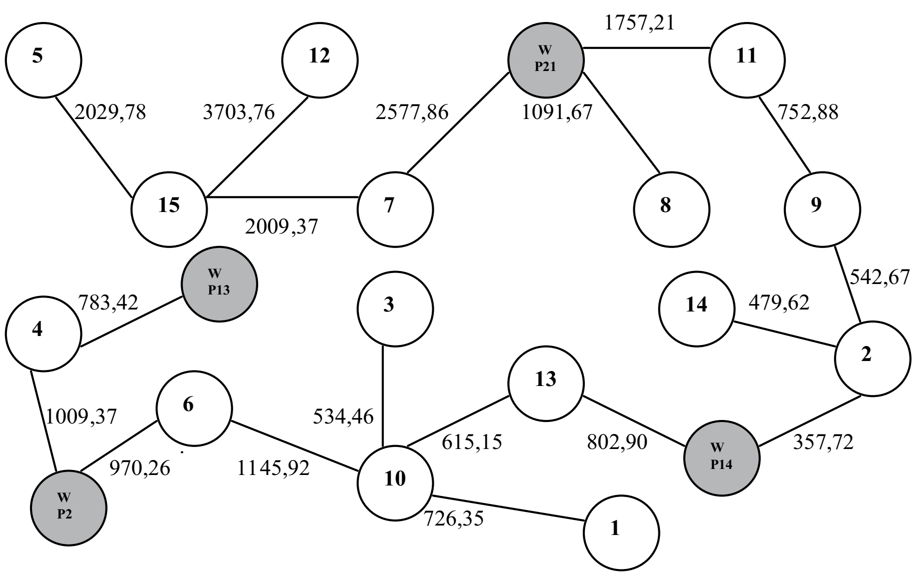

Fig. 2. The total dendrite for the differentiation of the technology for all of the 15 surveyed companies

Table 2. The total list of parameters for all of the surveyed companies

T \ P	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
min																					
max																					
min lub max		896,29											#######	0,87							250,00
60 % min		537,78											#######	0,52							150,00
1	131	929	10 809	1 016	2 119	26 696	1 720	3 867	3 976	3 667	4 032	615	58 518	0,35	60	41	4	0,20	0,95	0,67	800
2	90	1 328	7 279	1 209	1 787	31 339	1 666	6 996	3 755	4 614	4 134	594	63 372	0,72	78	66	4	0,85	1,00	0,79	900
3	71	1 679	6 637	1 098	2 982	29 997	1 406	4 693	4 306	1 666	2 399	662	55 846	0,27	68	36	5	0,49	0,66	0,95	950
4	46	1 000	5 233	402	698	17 245	856	2 816	1 630	1 992	914	197	31 982	0,26	110	76	2	0,98	0,17	0,13	600
5	136	2 647	9 533	1 807	2 866	78 595	2 504	5 587	5 362	4 115	2 527	619	113 516	0,13	120	85	6	0,26	0,71	0,73	975
6	52	1 221	7 489	970	2 651	19 658	1 559	6 716	3 660	3 265	1 987	332	48 288	0,49	79	79	3	0,28	0,69	0,50	740
7	248	3 017	13 336	2 814	3 378	58 771	2 771	9 248	3 157	6 978	5 200	771	106 424	0,31	69	92	7	0,27	0,89	0,11	250
8	142	1 921	8 261	1 916	2 930	41 464	2 571	12 316	4 747	4 142	6 111	504	84 961	0,87	50	75	5	0,97	0,60	0,18	1000
9	70	1 395	5 656	1 240	2 050	33 823	952	8 341	1 952	4 104	3 388	777	62 282	0,59	62	36	4	0,45	0,76	0,92	430
10	70	896	6 263	529	1 290	28 544	790	6 044	4 063	3 032	4 325	543	55 423	0,70	122	78	4	0,75	0,96	0,54	740
11	114	1 093	4 300	1 275	1 212	39 882	1 040	6 772	3 299	2 928	2 051	472	63 230	0,18	54	66	3	0,63	0,56	0,94	800
12	250	4 329	21 099	2 751	6 179	88 923	2 693	15 982	8 884	8 079	5 384	1 354	161 326	0,19	58	58	9	0,30	0,78	0,49	940

13	126	2 247	4 764	1 407	2 430	27 656	1 420	8 677	4 122	3 389	2 596	552	57 013	0,64	89	70	4	0,36	0,23	0,80	800
14	73	1 444	8 766	849	1 770	30 114	1 836	6 207	6 054	5 242	3 749	922	65 510	0,25	48	37	6	0,60	0,60	0,78	850
15	145	2 309	18 288	1 605	3 124	70 040	3 124	8 838	4 403	7 838	6 102	1 532	124 893	0,13	116	92	9	0,95	0,83	0,60	900
WP2	**53**	**672**	**4 697**	**397**	**967**	**21 408**	**592**	**4 533**	**3 047**	**2 274**	**3 244**	**407**	**41 568**	**1**	**92**	**59**	**3**	**1**	**1**	**1**	**555**
WP13	**34**	**750**	**3 925**	**301**	**524**	**12 933**	**642**	**2 112**	**1 222**	**1 494**	**686**	**148**	**23 987**	**1**	**82**	**57**	**2**	**1**	**1**	**1**	**450**
WP14	**106**	**1 441**	**6 196**	**1 437**	**2 197**	**31 098**	**1 928**	**9 237**	**3 560**	**3 106**	**4 583**	**378**	**63 721**	**1**	**37**	**56**	**4**	**1**	**1**	**1**	**750**
WP21	**186**	**2 262**	**10 002**	**2 111**	**2 534**	**44 078**	**2 078**	**6 936**	**2 368**	**5 233**	**3 900**	**578**	**79 818**	**1**	**52**	**69**	**6**	**1**	**1**	**1**	**187,5**

P – parameters, T – technology

CONCLUSIONS

Currently, the most pressing problem is the protection of the natural environment against the effects of the dynamic development of motor transport, the functioning of which causes many serious threats. Technical infrastructures of motor transport have a large share in the degradation of the environment, due to diagnostic inspections, routine and periodic maintenance, repairs and other kinds of services concerning vehicles which are performed there (e.g. car washes, paint shops etc.).

To assess these extremely important ecological issues, the taxonomic method can be used, which enables the dendritic arrangement mirroring the location of the examined factors within a multidimensional space of parameters [13,16]. The realisation of the subject matter presented in this article makes it possible to formulate the following conclusions of a general character:

- arranging pro-ecological technologies in the technical infrastructure of motor transport, using the taxonomic method is an effective way to find the point determined by the defined criteria within the space of the selected parameters,
- verification of the results for a differentiation of pro-ecological technologies with the dendritic arrangement method is possible with the help of the diagonal matrix of Czekanowski [17],
- the dendritic arrangement using the taxonomic method and the matrix one using the Czekanowski's method give concurrent results with reference to pro-ecological technologies in the technical infrastructure of motor transport [17].

As opposed to all kinds of optimization methods, which in reality only allow for a linear arrangement of the examined ecological problems, taxonomy enables the dendritic arrangement, which mirrors the location of the examined factors better within a multidimensional space of parameters.

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PROPONOWANA METODYKA ANALIZY PROBLEMÓW EKOLOGICZNYCH W ZAPLECZU TECHNICZNYM TRANSPORTU SAMOCHODOWEGO

Streszczenie. W artykule przedstawione zostały najistotniejsze zagrożenia występujące w obiektach zaplecza technicznego transportu samochodowego. Zaprezentowane zostały zagadnienia dotyczące modelowania metodą taksonomiczną strategii ekologicznej w zapleczu technicznym oraz stosowane metody i techniki dobierane w zależności od konkretnych problemów oraz wybranych celów. Wymieniono kryteria i podstawowe założenia metody taksonomicznej oraz jej aplikację do oceny zagadnień ekologicznych.

Słowa kluczowe: zaplecze techniczne transportu samochodowego, problemy ekologiczne, metoda taksonomiczna